The Role of Productive Differentiation in the Development of Early Social Complexity in Palau, Micronesia, 200BC-1800AD.

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Submitted to the Graduate Faculty of the

Dietrich School of Arts and Sciences in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh
2022

UNIVERSITY OF PITTSBURGH

DIETRICH SCHOOL OF ARTS AND SCIENCES

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University of Pittsburgh, 2022

This dissertation evaluates hypothetical relationships between agricultural productivity, community structure and productive differentiation amongst four Pacific Island societies for the purpose of understanding the mechanisms of development of early social complexity.

In order to test the hypotheses, I reconstruct the demographic structure in the Terrace Era and the Stonework Era on the Babeldaob Island of Palau. Population estimation is based on the area of archaeological sites and density of stone structures for the mapped sites. We estimate 17,910-20,895 in the Terrace Era and 53,712-62,664 in the Stonework Era. Although the population increased three times, local community structure was persistently dispersed through both periods, without formation of compact towns. At the regional level, there were always 8-10 supra-local communities on the island of Babeldaob and no single supra-local community successfully dominated the political landscape. The dispersed residence pattern suggested that resource control plays a more important role in the societal development.

However, systematic analysis of settlement distribution with respect to agricultural productivity for both periods suggests a relatively weak correlation between environment and population density for the Terrace Era and somewhat stronger correlation for the Stonework Era, which seems counter intuitive but suggest that other social factors played more important roles. For the Terrace Era, defensive hilltops were favored settlement choices, indicating the role of warfare in shaping human relationships. For the Stonework Era, the shift from swidden agriculture to pondfield agriculture made a significant change in human relationships, which we learn from household assemblages.

Nonmetric multidimensional scaling analysis was conducted to visualize the level of dissimilarity of domestic activities for household units in the Terrace Era and the Stonework Era. In the Terrace Era, most household units emphasized fine cutting activities associated with general household activities, suggesting a high level of household self-sufficiency. In contrast modest differences in economic activities were identified between households of the Stonework Era involving multiple subsistence pursuits and construction of irrigation systems. The results also suggest that the vertical relationships between households mainly exist in the realm of social prestige and religiosity rather than the realm of material wealth.

Acknowledgement

He who began a good work in you will complete it by the day of Christ Jesus.

Philippians 1:6

The completion of this dissertation is a journey of faith. Faith is confidence in what we hope for and assurance about what we do not see. I am not a man of faith, but my ever-present friend always pours out his unmeasured love when I feel weak and defeated. His promise carries me through all the trials.

I am grateful for men and women in my life that raise up my faith because they see the value from afar. My advisor, Dr. Robert D. Drennan, is the most significant influencer in my journey. I met him in the Hongshan Community Project in Northeast China when I finished my undergraduate study. He showed me a very different way of archaeological study that discover deep social dynamics, which is much more interesting than reconstruction of cultural historical sequence. When I came to study with him, he encouraged me to follow my interest in the Pacific even though I don't have existing networks in that area. Every time when I returned from Palau, I

asked him whether or not I should continue, and he believed in me. This unreserved trust cultivated the spirit of exploration in me and carried me through difficult seasons of my study.

This dissertation will not be completed without my dissertation committee members. They all gave me constructive feedback to improve my dissertation. Dr. Scott.Fitzpatrick opened doors for me to study in the Pacific. He generously shared his experience and networks with me. He kindly allowed me to study archaeological materials in his lab. Dr. Richard Scaglion instructed me in reading Pacific anthropological works through numerous personal discussions. Dr. Liz Arkush and Dr. Marc Bermann inspired me in the process of developing research questions through courses they taught, namely, Archaeology of Warfare and Household Archaeology.

This dissertation will not be accomplished without the generous data sharing from IARII (International Archaeology Research Institute. Inc) and Palau Historic Preservation Office. Specifically, I want to thank Dr. Jolie Liston, Sunny Ngirmang, Calvin Emesiochel for helping me find materials from Compact Road Project and provide me the spatial database. Their openness and transparency enabled my dissertation research.

This dissertation will not be finished without the support from communities in Palau. Their hospitality embraced me as a foreigner. Many local friends invited me to attend the local customs and shared with me their oral histories and traditions. Specifically, I want to thank Evelyn Ngirturong, Pia Morei, Patrick Tellei and Kelvin Towai for their hospitality. I also want to thank church communities in Palau Assembly of God for helping me navigate the logistics in Palau. I owed many thanks to Pastor William Cheng, Laura Cheng, Dan Baldeo, Janice, Maya and Subash.

I also owe many thanks to the academic communities in University of Pittsburgh. I want to thank Peiyu Chen, Hugo Ikehala, Yan Ng, Wenjing Wang, Tao Li, Dongdong Li, Sarah Jolly, Sarah Kennedy, Erin Kello, John Walden, Amanda Suárez Calderón, Weiyu Ran, Gligor Dakovic, Ryan Smith, Deb Neidich, Philip Mendenhall, Jennifer Farquhar and so many others for your friendship and advice in all these years. I also owe thanks to academic communities in other institutes. I want to thank Dr. Christina Giovas. She trained me zooarchaeology in the Pacific contexts and helped me develop my research questions in my early years. I also want to thank Dr. Matt Napolitano. He generously shared his literature review for his comprehensive exams and invited me to join his fieldwork in Yap.

I also owed many thanks to my church communities in Pittsburgh. Their life-long friendship is the treasure of my life. They change my perspectives on the value of family and provide practical support. Specifically, I want to thank Julia Chu, Thomas Chu, Peihsin Chen, Fangcheng Yeh, Chenwei Zheng, Muen Yang, Reiko Tseng, George Tseng, Pastor Terence Liu, Mickey Chou, Pastor Jeff Leake, Debbie Lynch, Meiru Ooi, Eugene Ooi, Shan Wu, Li Tong, Wenchi Chen, Po-Yao Huang, Szu-Chiao Wang, Chia-Hsin Liu, Joann Walsh, Meeli Lee, Marisa Molnar, John Lee, Mia Hung, George Hung, Jen-Feng Hsu, Fei Ding, Ke Li, and Bin Gao.

Lastly, I want to dedicate this dissertation to my families. My husband, Yanbing Guo, sacrifices his own career and takes care of our young children. He is also put up with my anxiety and struggles through the years. He is an excellent cook, ever-present father, and faithful friend. I also want to thank my parents, Zicheng Cai, Xianshi Shi, and my parents-in-law, Qiusheng Guo and Caihua Guo for their generous support through the years. They gave us emotional and financial support unconditionally. I also want to thank my children, Joy Guo and Judah Guo, for their lovely companionship during my journey. Joy's consistent prayers for my defense fuel my motivation to finish well.

All the glory to the highest one who starts the good work in me and gives me strength to complete the dissertation research.

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1.0 Productive Differentiation and Social Complexity

1.1 Understanding the Variability of Social Organization in the Pacific Island Societies

The Pacific island societies exhibited a remarkable range of socio-political variation, although they shared cultural origins and had relatively short histories. Debate about the homeland of Pacific islanders continues, with linguistic and material culture support for "out of Taiwan" theories (Blust 1984; Bellwood and Dizon 2005; Carson 2018) and genetic support for broader Southeast Asian origins (Larson et al. 2007; Donohue and Denham 2011). The first contact started from the West Pacific, including the Mariana Islands (3500BP), the Lapita cultural complex on the Melanesian Islands (3500BP), and the Palau Archipelago (3100BP) (Carson 2008; Kirch 2001; Fitzpatrick 2003a). The reconstruction of the colonization process in Oceania , based on a huge collection of radiocarbon dates, supports the view that the islands of Oceania were colonized episodically rather than continuously, which matches the prediction of the ideal free distribution model (Kennett 2006). In each episode of migration, colonizers adapted to their distinctive environment and created various forms of social organization. Pacific islands were relatively isolated, not only from the world beyond, but also from each other. Interaction between archipelagos clearly did occur, but relatively infrequently and involving limited number of people. This facilitated the varied trajectories of development that anthropologists have sought to understand for decades by identifying the forces that shaped societies with different characteristics (eg.Sahlins 1958; Goldman 1970; Kirch 1984).

The theory of island biogeography outlines the relationship between the environmental variables of an island and the diversity of organism living on it. Recently this body of biogeographic theories has been criticized in various way. One of the principal critiques is the assumption of isolation. Rainbird argued that this isolation is only a western way of imagining islands contrary to facts (Rainbird 2007). New archaeological methods (e.g. petrography and XRF) are making it possible to source new materials and providing direct evidence of inter-island interaction. Geochemical study demonstrates trade between Lapita sites, although the quantities of goods that circulated were quite limited (Kirch 1990). Kirch found that Hawaiian chiefs acquired exotic lithic materials used in ritual contexts, which indicates that control of inter-island trade was a way of establishing chiefly power (Kirch et al. 2012).

While island groups in the Pacific are by no means isolated from other island groups, they do represent relatively small total land areas separated from their nearest neighbors by sometimes long distances of sea travel. We know that they were in contact with each other, but frequent and intense interaction with substantial populations in neighboring regions is more limited by the cost of transport than is often the case on continental land masses. Palau, for example, includes a total land area of only 459km^2, and 450km away from the closest neighboring island Yap, and more than 900km from islands in the southern Philippines.

With concerns about inter-island interaction in mind, the theory of island biogeography can still generate useful models for explaining the human cultural diversity in island settings. These still provide useful hypotheses for archaeologists to evaluate the patterns of evidence in the island society. Evans provided reasons that why islands can be treated as laboratories for studying human-environment interaction and the evolutionary processes of social organization (Evans 1973). For instance, islands limit the frequency of interaction with groups living elsewhere, and islands are relatively circumscribed in terms of environmental resources that might impact human perception in different ways. Sahlins argued that degree and form of social stratification in Polynesian island groups depended largely on the subsistence productivity of different islands, with greater productivity providing resources for elites to develop hierarchical organization (Sahlins 1958). He viewed social stratification as an aspect of social structure functionally adjusted to the environment and technological adaptation.

Kirch expanded Sahlins' (1958) simple correlation into a more complicated model involving inter-relationships between agricultural productivity, population pressure and social stratification (Kirch 1984). The population pressure part of this model was originally proposed by Carneiro for whom population pressure is the key condition that enables the war chiefs to transform temporary power from conflict into power that can be perpetuated and pass on to descendants (Carneiro 1998). Kirch implicitly assumes circumscription is the nature of island environments because of isolation. Agricultural productivity is the key factor that impacts adaptation when population pressure occurs in circumscribed environments. The social organization of Polynesian societies responds to the nature of technological adaptation. The classic example is Kirch's comparison between the leeward and windward sides of the Hawai'ian islands. Different modes of agricultural intensification led to different rates of population growth, until elites on the more crowded and less productive leeward side transformed the traditional Polynesian system of landholding by kinship groups into a territorial system of chiefly patronage (Kirch 2006). No such social changes occurred in the windward chiefdoms.

1.2 The Role of Productive Differentiation in the Development of Social Complexity

The role of craft specialization in the emergence and development of early complexity has received particular attention in the Pacific (Earle 1987), but much attention focuses on the long-distance exchange network and production of prestige goods. The inherently important anthropological subject of how people get the utilitarian necessities of daily life has been studied less. As societies become more complex, it is often the case that household economic self-sufficiency breaks down as productive differentiation emerges and creates new relationships (either symmetrical or asymmetrical) of mutual economic dependence between households within a local community. The term "productive differentiation" (Drennan and Peterson 2012:78) is used here to refer to differences of any magnitude in the productive activities of different households—differences that are too slight to qualify as "craft specialization" by some definitions or that involve subsistence rather than craft products. Any degree of productive differentiation involves at least minimal economic interdependence between households and many also imply unequal access to goods of social or economic value.

Productive differentiation plays an important theoretical role in early complex society development, not because it is a criterion of social complexity (although it is for some definitions), but because it plays different roles in helping to direct change in social organization onto different paths. Sometimes productive differentiation does not involve hierarchy or elites at all, but develops around goods of communal ritual use. In Spielmann's ritual model of production, for example, "the goal is not profits, but, rather, acceptable, often superlative performance and participation" (Spielmann 2002:197). In other instances, productive differentiation creates economic efficiencies and collective benefits for all, through economies of scale (Stanish 2004, 2009). Complex modes of economic cooperation can create relationships of interdependence in bottom up fashion without the involvement or even presence of elites or leaders (Scarborough and Lucero 2010:199). Sometimes, prestige goods rather than economic necessities are the main things produced by specialists, materializing social prestige and becoming the central currency of social hierarchy

(Clark and Blake 1994; Plourde 2009). And in other instances, elites may accumulate wealth and power by controlling the production and/or distribution of economic necessities. It has been argued that Moundville elites controlled the production of agricultural tools (ground stone axes) made from imported materials, and thereby indirectly controlled the subsistence economy (Welch 1996). In the case of Oaxaca, the specialized producers of luxury goods and of some utilitarian goods are associated with elite residences, showing how productive differentiation can give aggrandizing households both higher prestige and higher standards of living (Drennan 1976; Drennan et al. 2010).

1.3 A Hypothesis Based on the Comparison of Four Pacific Island Societies

It is enlightening to compare the role of productive differentiation in shaping the varied patterns of social organization in Pacific island societies. I have selected four Pacific island societies: Hawai'i, Society Islands, Mailu and Yap for comparison. Several principles underlie this selection. Effective comparison between societies should not rely just on the secondary interpretation of archaeological reconstructions because regional experts often interpret archaeological data in very different ways according to different habits of thought that have developed among specialists in different regions (Drennan and Peterson 2012). Meaningful comparison requires direct examination of lines of evidence that reflect the kind and degree of social complexity in different regions. In this dissertation, special attention has been paid to the local community, where the productive differentiation of everyday life occurred, and where different kinds of unequal relationships emerged. Specifically, attention has been paid to the compactness/dispersal of the local community, which reflects how intensively people interact with one another (or not) (Drennan 1988; Peterson and Drennan 2005; Feinman and Nicholas 2012); Unequal social relationships often show in household artifact assemblages, residential architecture and mortuary remains. The four case studies that I have examined below include these data threads for comparison (detailed local community maps and household assemblages).

Another principle of selection is the productivity of environmental resources in island contexts. The productivity of environmental resources was largely shaped by the biodiversity of an islands, which was highly correlated to the size of the island (MacAuthor and Wilson 1967). Although this has been criticized as over-simplification (Terell 2020), archaeologists have still found it useful in exploring human behavior and culture (Giovas 2006; Kuklick 1996). The Hawaiian islands and the Society islands are relatively larger (mostly greater than 1000km^2), and in turn support more species per unit of area because of habitat and resource availability. In contrast, Yap (100km^2) and Mailu island (1km^2) are much smaller in size, and have low productivity. The range of environmental productivity will impact the patterns of interaction between people and the environment, as well as between one another.

In Hawai'i, the ownership of productive land and investment in agricultural intensification secured elites' political power, which was fundamentally underwritten by the production of agricultural surplus (Earle 1997; Kirch 1990). Intensive agriculture encourages a settlement pattern of dispersed farmsteads because of the high labor requirements placed on individual farming households (Drennan 1988) and because of pressure to expand the land under cultivation (Kolb and Dixon 2002; McCoy and Graves 2010). Each residential complex in the Anahulu valley for example, occupies 1 to 4 ha of agricultural land (Kirch and Sahlins 1992). Dispersed household distribution discourages differentiation in the production of utilitarian goods at a local scale because distance interaction principles impede the high frequency interaction this requires

(Peterson and Drennan 2005; Berrey et al. 2021). Specialized production focused instead at the regional scale and involved not basic economic necessities, but rather prestige goods, which helped to construct the intangible power of chiefs, potentially legitimizing their control of productive land. Elites produced special kinds of adzes made of basalt from Mauna Kea, which were believed to carry spiritual mana and were only used in religious shrines (Bayman and Nakamura 2001; Kirch et al. 2012).

As in Hawai'i, elites in the Society Islands established institutionalized inequality though ownership of productive land and intensive agriculture. In the 'Opunohu Valley household storage facilities suggest that elites accumulated wealth through the control of productive land and the creation of agricultural surplus (Kahn and Kirch 2013). Intensive agriculture also creates a pattern of dispersed farmsteads rather than nucleated local communities in the 'Opunohu Valley (Kahn 2005:104). Most households are larger than nuclear-family size and occupy their own individual agricultural plots and residential structures. They produce basic economic necessities for their own consumption, as well as other goods for taxation (Kahn 2005:106). This dispersed household mode of economic organization again discourages intra-village productive differentiation of the utilitarian goods of daily life, indicated by scarce evidence of specialized production of economic necessities in elite households. Instead, elite households emphasize their high position by constructing elaborate ceremonial *marae* (Kahn and Kirch 2013) and hosting sacred religious events provisioned by ritual specialists (Kahn 2015). Through monumentality and ritual materialization, elite households legitimize their ownership of productive agricultural land and thus control over material wealth and surplus (Kahn and Kirch 2014:215-224).

The Mailu people are one of several ethnic groups occupying the coast of the Massim region of the New Guinea mainland and nearby islands between Amazon and Orangerie bays. In contrast to the previous two Polynesian societies, the unproductive soil and unpredictable rainfall of the Massim region limit the importance of land ownership and do not encourage intensive agriculture (Malinowski 1988[1915]:257). Unlike Hawai'i and the Society Islands, Mailu is a tiny island next to a large land mass, but the low degree of interaction with the New Guinea highlands makes it an interesting comparison. The marginal environment encourages the formation of very compact villages (around 24.5 households/ha in Mailu island village) in order to make daily cooperation in subsistence pursuits easier. Mailu Island villagers need to travel farther than people in Hawai'i and the Society Islands to hunt wild boar and collect sago and to acquire resources for making utilitarian goods (e.g., different fibers for string and rope, reeds for matting and basketry, wood for canoes and houses, sago palm leaves for thatching, and stone for cutting tools). In Mailu Island in general, it takes more time and efforts to produce food and utilitarian goods, and this encourages productive differentiation to increase efficiency, and this, in turn, results in considerable economic interdependence between households within villages (Malinowski 1988[1915]:240-255). The Mailu Island village was divided into four phratries, each of which developed differentiation in the production of food and utilitarian goods of different kinds (pottery, lithic and shell tools, bone tools) (Irwin 1985:244-245). A phratry might control access to participation in production to some extent (Malinowski 1988[1915]:256). Here local-scale productive differentiation not only improved economic efficiency and minimized agricultural risk, but also supported growth in the size and density of population (Macintyre and Allen 1990). In time Mailu Island villages became the largest settlements and central node in Mailu settlement (Irwin 1983).

Local-scale productive differentiation in Yap differs from the underdeveloped form found in the Polynesian islands, and from the non-hierarchical complex mode of economic interdependence of Mailu Island as well. Instead, local-scale productive differentiation forms the basis of political power in Yap. Although intensive agriculture exists in the coastal area, the small size of the productive coastal flats and valley bottoms limited the capacity of intensive agriculture to produce a surplus to fund a political economy. Instead, it mainly served to fulfill the needs of growing local communities (Lingenfelter 1975:5-19, 77-98). In late prehistory, most of the inhabited settlement lay in close proximity to the sea, whereas inland villages were considered less desirable because of the unproductive soil (Lingenfelter 1975:77). The growing population in the restricted agricultural land limited its capacity to create a surplus to fund emergent elites. On the other hand, the mixed subsistence economy of the coastal villages offered aspiring elites to control the political economy by encouraging productive differentiation in the realm of economic necessities. The result was political capitals that were centers of production and distribution of goods used in daily life. According to ethnographic sources, pottery manufacture was organized in elite households where lower status women made laminated pottery, a new type that was durable for longer cooking, boiling and steaming. Potters received food for their labor, and could be exiled if they refused to produce pottery for elites (Descantes 2001). Beyond supplying the residents of the local community, utilitarian goods like pottery could be exchanged for prestige goods to reinforce the social prestigious elite households, particularly *Spondylus* shell valuables and shell belts from atolls surrounding Yap. Archaeological evidence from Gachpar village reveals that households with a high density of laminated pottery also have rare shell ornaments (Descantes 2005:90-91). The high frequency interaction generated by economic interdependence in the utilitarian goods of daily life promoted the formation of compact villages in Yap; households with abundant laminated pottery lived in a clearly bounded area with a density of 10 households/ha (Descantes 2005:49).

The comparison suggests some ways in which *agricultural productivity and intensification*, *local community structure*, and *local-scale productive differentiation* may relate to each other and shape social hierarchy in different ways. Where agricultural productivity is high, as on islands with wider inland alluvial flats and stable rainfall, people tend to intensify agricultural production in response to population growth (Kirch 1984, 2006; Kirch and Rallu 2007). Intensive agriculture encourages people to live on the land that they farm rather than in compact villages father from their agricultural plots (Drennan 1988). This is likely to discourage the productive differentiation in the utilitarian goods of daily life (Peterson and Drennan 2005; Berrey 2013; Berrey et al. 2021), as in Hawai'i and the Society Islands. The power and authority of elites tends to rely on resource control without relation to productive differentiation and economic interdependence. Warfare that occurred in such societies often focused on land seizure and intended to control more farming resources.

Where agricultural productivity is low, as in Mailu and Yap, although agricultural intensification might still happen, the vulnerability of environment will eventually limit the long-term agricultural intensification and requires a mixed subsistence economy based on fishing, collecting shellfish, hunting and agriculture (Fitzpatrick and Giovas 2021). This situation might encourage more productive differentiation in the subsistence arena because of the variety of different subsistence pursuits. This, in turn, would encourage growth in the size and/or density of local communities to facilitate the economic interaction conveniently. This village living could encourage further productive differentiation in other non-subsistence utilitarian goods and thus still more compact villages. And such productive differentiation also might provide a pathway to other social changes, such as growing wealth differentiation as households that produce things for others might profit from this activity. Warfare in such societies usually focused on rapid and unpredictable raiding of movable materials. If these elements of developing social complexity regularly relate to each other in the ways suggested by the comparison of Hawai'i, the Society Islands, Mailu Island, and Yap, then we would expect the patterns observed in this comparison to repeat themselves elsewhere.

1.4 Research Questions

The proposed research aims to determine whether the patterns observed in the comparison above hold in Palau as well. Babeldaob (the largest island of Palau) lacks fertile inland alluvial flats. The lateritic soil of these highlands is less productive than alluvial valley floor deposits on other islands. In particular, because of the lack of hydromorphic processes, the lateritic soils cannot regenerate their fertility after cultivation (Barrau 1961). This situation might encourage more and more villages to locate on the coast as population increased. The mixed economy of fishing and taro cultivation suggested by these villages' location might potentially encourage the development of productive differentiation, first in subsistence products and later in non-subsistence goods. The native monetary system of Palau, documented by ethnographers in the contact period, hints at the earlier existence of a fairly intensive system of productive differentiation and economic interdependence (Keate 1788; Kubary 1895; Parmentier 2002; Ritzenthaler 1954). At the same time, the community structure is not as compact as Mailu and Yap, indicating that control of more productive agricultural land may play a more important role than that of Mailu and Yap. The following research questions are designed to evaluate the working hypothesis.

1. What was the demographic structure in Palau? Detailed questions as follows: How large was the population in Palau? How large and how compact were local communities? How large, demographically and spatially, were the supra-local communities in Palau? How strongly centralized were they? How did the demographic structure change over time? Finally, how did the demographic distribution compare with the other Pacific island societies?

2. What were the centralizing forces that attracted population? Was it the control of the most productive agricultural land? To what extent did the natural distribution of agricultural land influence the regional demographic distribution? How did the relationship between environment and demography change over time? And how did it compare with other Pacific islands?

3. To what extent did productive differentiation exist between households in the local community? If it existed, what kinds of goods were being produced by specialized producers? How did the degree of productive differentiation change over time?

4. To what extent did wealth, prestige, or ritual differentiation characterized the relationship between households in the local community? What connections were there between these and productive differentiation? What was the role of productive differentiation in the development of social complexity? How did these relationships change over time? How did it compare to other Pacific societies?

In order to address these questions, the multi-scalar analysis was conducted based on the dataset that was recovered by the Palau Compact Road Archaeological Investigation, and inventory surveys of cultural and historical sites in multiple states of Palau. First, the regional-scale analysis documents the changing pattern of regional demography in the Terrace Era and the Stonework Era. Specifically, the dissertation estimates changes in regional population levels, the scale and structure of human communities (both local and supra-local communities), and the relationship between the resource distribution and population distribution. Through regional study, the dissertation aims at understanding the underlying social forces that shape community structure and its development in Palau. Second, the local-scale analysis documents the household activity patterns in both the Terrace Era and the Stonework Era, specifically relating to the degree of productive differentiation and economic interdependence, as well as the degree of wealth, prestige and ritual differentiation. The analysis is based on the household artifact assemblages that came from the scattered test pits in the Palau Compact Road Archaeological Investigations. Some of the test pits were associated with house structures; some were not, but they still reflect the activity patterns spatially.

1.5 A Brief Settlement History of Palau

Western Micronesia and Island Melanesia were the first regions where Austronesians migrated out of their homeland (Rieth and Cochrane 2018). The Palau archipelago was amongst the first wave of Austronesian dispersal. The current radiocarbon dates show that the Mariana islands and the Palau islands were colonized between 3500-3000 BP (Carson 2008, 2010, 2011; Fitzpatrick 2003b; Clark 2004,2005), which is contemporaneous with the earliest Lapita settlements (Denham et al. 2012). Compared to East Polynesia (the comparative cases in the dissertation), they have a relatively longer settlement history. Most of the East Polynesian islands were colonized by the last wave of Austronesian dispersal, about 1000-700 BP (Mulrooney et al. 2011).

Islands in Micronesia are small compared to Polynesian and Melanesian islands; they have been referred to as a "sea of small islands". The largest islands amongst them are Guam ($550km^2$)

in Marinas and Babeldaob ($331km^2$) in Palau. This relatively small size limits the biological diversity (Evans 1973). The Western Micronesian islands lies west of the andesite line, which separates the partially submerged continental areas that contained acidic igneous rock from the deeper igneous rock of the central Pacific Basin (Fitzpatrick 2018). The acidity of the soil impacts plant health, resulting in reduced cover and lower plant density.

The Palau archipelago comprises several hundred islands. Among them the larger islands are primarily volcanic. The largest island is Babeldaob (70% of the land area of the entire island group). Some 250–300 islands with a total area of $47km^2$ consist of uplifted reefs, locally called the Rock Islands. In some ways, the resource differences between Babeldaob and the Rock Islands mimics the contrast between high volcanic islands with greater habitat diversity and low coral islands with limited resources suggested by Sahlins (1958). However, in the Palau archipelago, these two very different environments are in close proximity to each other.

The Early Colonization period lasted from about 1300 to 600BC. The earliest dates come from the Rock Islands, at the Ulong and Chelechol ra Orrak sites (Clark 2005; Fitzpatrick 2003a), showing that these low islands were not peripheral for the early immigrants. On Ulong Island, the early inhabitants relied heavily on near-shore fish and shellfish. Only two small (1 m by 2 m) sample units were excavated, but they yielded several hundred sherds and nearly 16 kg of faunal remains in the lowest layer more than 120 cm below the surface (Clark 2005, Clark et al. 2006). Paleoenvironmental evidence suggests that human colonization on Babeldaob Island might have occurred that 2500-2300BC, as indicated by savanna formation along with a rise in charcoal particles (Athens and Ward 2001), although this has not been substantiated by dated material culture. The earliest deposit (around 1000-400BC) on Babeldaob were secondary deposits near the coast or lagoons (NT-3:10 and NI-1:10), suggesting a similar marine diet (Liston 2011b:477-485).

In the earliest colonization of the Pacific, small islands are not peripheral, as in many regions of the world, because of their seasonal resource availability and defensive capability (Fitzpatrick et al. 2016).

The Pre-terrace Era lasted from 600 BC to 200 BC. Settlement continued to focus along the coast but also began to include the inland lower ridge area of Babeldaob. Still only a few sites (NA1:T5, NA2:T4, NT:30, NI1:10, NI1:15, NA1:10 and NA1:T5) have been recorded, most of them in the lower layers of subsequent occupations (Liston 2007a:334–335). The period is known mainly from radiocarbon dates on samples from low stratigraphic layers. Ceramics are not distinguishable from those of the subsequent Terrace Era.

The Terrace Era lasted from 200BC to 1200AD. Population apparently grew strongly on Babeldaob, occupying a greatly increased number of villages that were substantially larger than earlier ones (Liston 2007a:347). This population carried out extensive terracing of low hillsides and ridgelines. They modified ridges and slopes by cutting and filling hard clay into level spaces that are resistant to erosion without need of stone retaining walls. The earthworks have various forms. The more formal ones are the crown type and the step terrace type. The crown type is characterized by an ascending ridge culminating in a crown shaped summit (Figure1.5.1); the step terraced type is a hill of which the summit is levelled and of which the sides are formed into radiating gullies and step-terraced ridges (Figure1.5.2.). Less-formal ones are modified ridgelines that have been widened and flattened (Figure1.5.3).

Paleoenvironmental evidence of intensified swidden agriculture (Athens and Ward 2001:170) suggests that some terraces were cultivated as agricultural facilities, although long-term occupation is also indicated by fill containing sherds (Phear 2007:91–92), substantial amounts of charcoal (Lucking 1984:136–147) and stone paving and features are often found on the crown and the step terraces (Liston2013:72-73).

Figure 1.5.1 The Crown Type (Liston 2013)

It has been suggested that terrace sites also served a defensive function and might have been a display of political power on the landscape (Liston and Tuggle 2006). Some have argued that a high proportion of painted sherds suggests a ritual function (Phear 2007). Liston and Tuggle (2006:176) label these Babeldaob societies centralized chiefdoms because of the number and size of terraces, which they see as indicating warfare and large-scale labor management, although the degree of skill and centralized planning required can be questioned and no regional center has been reported. Most terrace sites have not been excavated and the volume of earth has not been measured. Only the Ngemeduu earthwork has been measured in Phear's excavation (Phear 2007). Liston (2013:141) calculated the labor investment in the Ngemeduu complex and suggested a work force of 55-83 people over a 30-day period could accomplish the fill of 2,500m^3 soil to level up the summit. In this case, the labor organization would have been kin-based or at the level of village cooperation. Very little demographic or organizational change is indicated for the Rock Islands during this period. Subsistence still focuses on inshore fish rather than offshore fish (Ono and Clark 2012). Compositional analysis suggests an increasing proportion of lithic and ceramic artifacts on the Rock Islands were imported from the Babeldaob Island (Fitzpatrick 2003a; Clark 2006).

The Stonework Era lasted from 1200 to 1800AD. This was a period of dramatic change in a number of ways. The subsistence economy shifted from swidden agriculture to a mixed economy of pondfield agriculture indicated by a retreat of savanna pollen. The radiocarbon dates also suggest that the building of earthworks declined

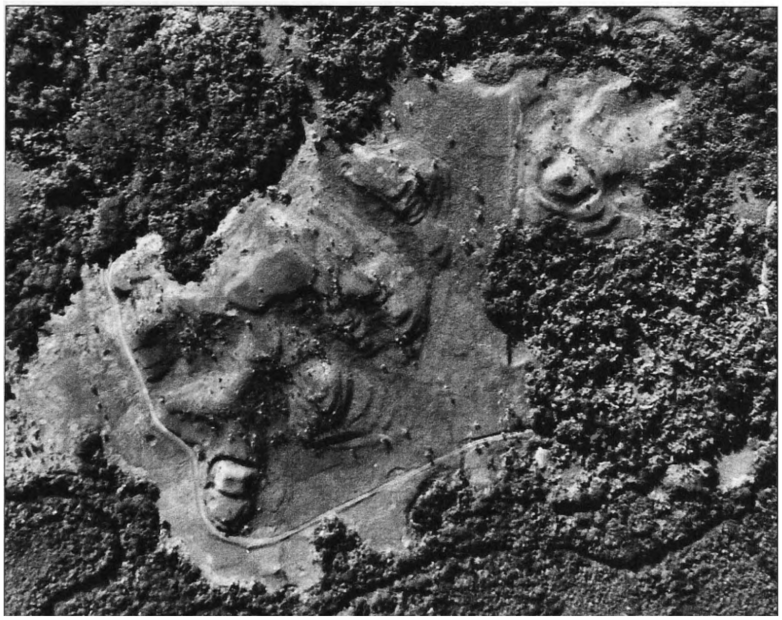

Figure 1.5.2 The Step Terrace (Liston 2013)

Figure 1.5.3 The Modified Type (Liston 2013)

as early as 850AD and gradually ceased around 1200AD (Liston 2005; Liston2011b:485-503)

The substantial abandonment of upland terraces was linked to the formation of hydromorphic soil in the lowlands which are suitable for pondfield taro cultivation (Athens and Ward 2001). Moreover, the upland soil erosion caused the depletion of coastal margins and harmed the marine resources, which was the key protein source for the growing population and thus created a need for long term sustainability (Fitzpatrick and Giovas 2021). All of these led to the innovation and adoption of pondfield agriculture in the Stonework Era, which not only increased the efficiency of agricultural production but also trapped the eroded soils and reduced the harmful effects on the marine environment.

The Stonework Era villages for which the period is named were close to mangrove swamps, lagoons, or sandy coastal plains (Liston et al. 2007a:363–365). They comprise local communities of considerable size which facilitated more intensive interaction among larger numbers of people by way of and ritual and other public facilities, public meeting houses (*bai*), and resting platforms (*iliud*) that were used for less formal gatherings that sometimes included food preparation, all connected by stone-paved pathways. (Figure 1.5.4 is an example of a resting platform (*iliud*), that is connected by multiple stone pathways.) In some villages, the stone paved pathways can be 2km long. Residential zones usually centered around the meeting house, which was usually the largest structure in the village and a central node in the network of pathways. Meeting houses often had cleared spaces or plazas in front. (Figure 1.5.5 shows people in front of a public meeting house in the early 20th century). These features of the villages all suggest communal ritual, and political or economic activities that drew the population together into these nucleated communities.

Figure 1.5.4 Stone Pathways in Airai village, photo Taken by the Author.

Figure 1.5.5 The Meeting House （Kramer 2017[1929]）

The architectural style of residences also experienced a change with the incorporation of stone platforms. Most of platforms were rectangular and constructed from unshaped basalt cobbles and boulders; and some of platforms were made of limestones and corals. The walls and the floor of the house were made of wood, and houses are raised above the ground by wood posts underneath. The thatched roof was made out of pandanus leaves. Most houses have gardens next to them and are connected to stone pathways (Figure 1.5.6). Size differences between the residential structures were recognizable.

Figure 1.5.6 Normal Residential Houses （Kramer 2017[1919]）

These changes in the form of local communities coincides with a substantial population surge on Babeldaob. The following chapters will reconstruct how the regional population level changed from the Terrace Era to the Stonework Era based on the current regional settlement database. The disparities in the number of house platforms in different sites suggest the probable existence of a settlement hierarchy and the emergence of regional polities in the Stonework Era, consistent with oral history. The following chapters will discuss the scale and structure of the supra-local communities and local communities based on the current regional settlement database.

A growing population and a change of architectural style also appeared on the Rock Islands. The colonized Rock Islands expanded to four island groups, including Ngeruktable, Ngeanges, Ngemelis and Ulong. Most of them have a rich midden deposit on the beach flat and adjacent steep hill slopes (Masse et al. 1984; Masse et al. 2006; Clark 2005). The radiocarbon dates that were collected on the Rock Islands indicate that population grew rapidly at the beginning of the Stonework Era (1200-1450AD) and dramatically declined after that. When Captain Wilson visited Palau in 1783, all of the Rock Islands were uninhabited (Keate 1788). Unlike Babeldaob, agricultural activities declined on the Rock Islands and capture of outer-reef taxa increased, likely because of depletion of marine resources in the inshore fishery (Ono and Clark 2010; Farley et al. 2018). A higher frequency of El Nino events caused by the migration of the intertropical convergence zone, which increases precipitation in the central and eastern Pacific and causes a higher frequency of drought in the western Pacific (Clark and Reepmeyer 2012). However, there is no direct evidence for a drop in sea-level or an impact from climate change on marine resources in the archaeological record (Giovas, 2010). Moreover, drought would affect agriculture more than marine resources. This suggests the abandonment of the Rock Islands might relate to the larger socio-political context of Babeldaob more than to the direct influence of environmental change.

The Historical Era Contact from Southeast Asia was likely to start earlier than 18th century as indicated by Southeast Asian/Chinese glass beads found in Palau (Liston 2011b:371-385) and by Keate's account of a Malay man encountered during his stay (Keate 1788). No historical accounts of such contacts, however, have been found in Southeast Asia. The earliest historical account of Palau was from the Spanish explorer Captain Wilson and his team members. Their trading vessel

Antelope sank in 1783 and the whole crew of 49 men stayed at Ulong, one of the Rock Islands in Palau for three months. During the initial contact, Captain Wilson interacted with people in Koror and described how the chief organized an expedition to attack another island polity, Peleliu (a low platform island 45.6km southwest of Koror). Chief Abba Thulle or Ibedul assembled 300 canoes for this attack (Wilson 1790:35). These accounts suggest that a larger scale of political integration beyond regional polities occurred at the end of the Stonework Era.

Contact with Europeans accelerated the consolidation of power by regional chiefly polities because of the introduction of guns. Amongst them two chiefly polities were believed by later ethnographers to control two dual "heavens" prior to contact: Koror controlled the lower seas (including the Rock Islands) and Melekeok controlled the high seas (including the Babeldaob Island) (Osborne 1966:460-465; Smith 1983:30-34), although little concrete evidence demonstrated this scale of political integration. But surely alliance with foreign powers enhanced the power of chiefs in Palau, particularly in the case of Koror. Keate (1783) recorded that Ibedul approached Captain Wilson and his crew for guns in their initial encounter. After the *Antelope*, many English ships came to Palau and continued their alliance with Koror chiefs. Koror chiefs provided safe harbor for the English ships in return for guns. Other foreign powers (Germany and the United States) attempted to ally with other chiefdoms, such as Melekeok and Ngerechelong, but their efforts were not as successful as those of the English with Koror. In the 1860s, Koror attempted to monopolize all foreign affairs by signing a "treaty of commerce" (Smith 1983:30-34; Parmenier 1987: 39-54). In the meantime, population fell drastically to 4000 as a result of dysentery and influenza epidemics, and the majority of villages and men's bai were abandoned at the beginning of the 1900s (Kramer 1919).

One important societal development at the time of contact was the innovation of the native monetary system of Palau. Palauan money consisted of glass and pottery beads that came from China, Indonesia and the Philippines. Money in Palau was not used primarily as a medium of exchange for utilitarian goods, although the most abundant type (kluk) could be used for ordinary economic transaction. Most money, however, was used as a medium for socio-political negotiation and life cycle ceremonies. For instance, some kinds of money were used as offerings to ancestors; some were used to pay fines collected from those who were defeated in warfare between tribes; some were used for gifts from a husband's family to the wife's family; some were used to pay for building public projects. This money, then, comprised materialized social capital to negotiate interests and conflicts rather than a medium for economic transactions. It was conspicuous in acting out social ranks as suggested by some types of money were exclusively circulated between people of high rank (Ritzenthaler 1954; Force 1959; Parmentier 2002).

2.0 Data Collection and Its Impacts on Data Analysis

The archaeological data mainly come from two projects: (1) the inventory of cultural resources from survey and mapping over the years by the Bureau of Art and Culture (previously called the Division of Cultural Affairs). (2) The Palau Compact Road Archaeological Project, which was conducted by International Archaeological Research Institute, Inc. (IARII) between 1996 and 2005. The environmental database came from soil surveys conducted by the USDA (United States Department of Agriculture) and NRCS (Natural Resources Conservation Service) in 2009.

Without these three valuable databases and the quality of their reports, I would have not been able to accomplish my dissertation research. The inventory survey and the Palau Compact Road Archaeological Project conducted survey at a regional scale on Babeldaob Island. This approach was very different from surveys on other Pacific Islands, which focused on much smaller regions (mostly under $2km^2$) and performed higher resolution data recovery. The advantage of regional-scale surveys made it possible to delineate the boundaries of both local communities and regional polities and reconstruct regional settlement demography. But at the same time the objective of these surveys is the preservation of cultural resources rather than settlement pattern analysis, so the methods of data collection have impacts on my research.

The reconstruction of demographic distribution was based on the areas of sites that have been measured and counting on the numbers of house structures in the mapped sites in the inventory surveys, as well as on the sherd density of excavated sites from Compact Road Project. The methods of measuring the areas, the residential density and the sherd density of sites are critical to the accuracy of population estimates.

2.1 Measuring Site Areas

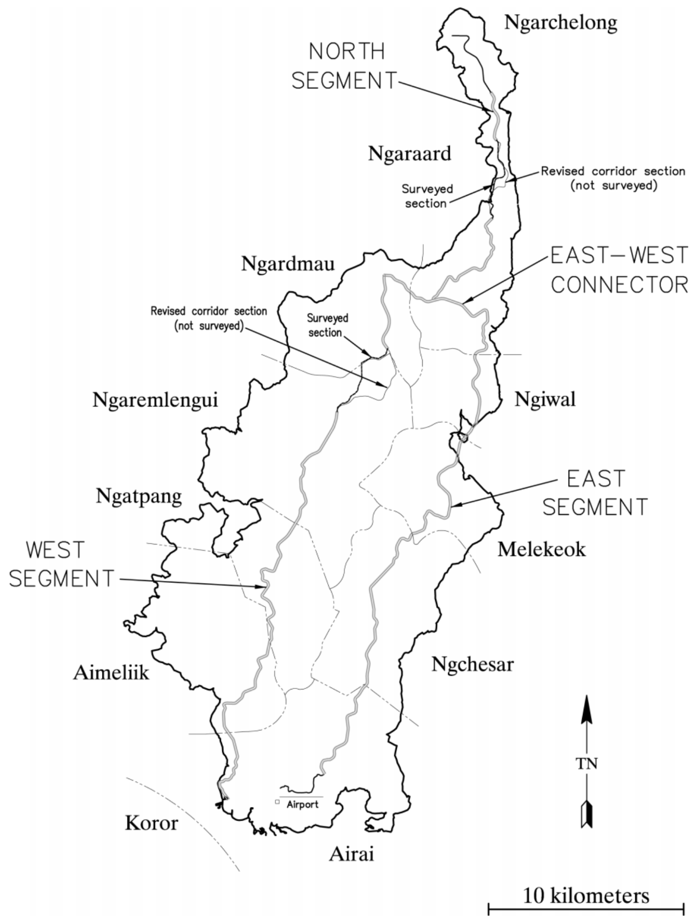

Figure 2.1.1 Palau Compact Road Alignment (from Wickler et al. 2005a:4)

The Palau Compact Road archaeological investigation identified and evaluated the cultural resources within a corridor extending 50m from the Palau Compact Road centerline. The road was 85km long and encircled the island of Babeldaob (see Figure 2.1.1). The investigation was divided into four phases. Phase I focused on site identification, detailed recording and mapping of large sites, and limited sub-surface sampling and testing. The pedestrian survey mainly occurred in Phase I. Phases II and III continued the unfinished mapping and recording of large sites that were identified in Phase I surface survey, and carried out stratigraphic excavations in areas of high artifact density or in association with substantial features. Phase IV conducted more excavation on the sites, especially the ones to be destroyed by road construction. In general, the survey and the excavation methods are consistent through all four phases. In total, 13 volumes of reports were published. (Wickler et al. 2005; Liston et al. 2007; Liston et al. 2011).

The pedestrian survey was usually performed within the constraints imposed by terrains and vegetation, by three people walking a sweep first along one side of the marked road center line and then back along the other side. The usual interval between field workers was about 10m. Occasionally the survey transects were altered or abandoned due to stream crossings, dense mangrove, taro swamp or extremely steep terrain. When sherds or features were encountered, the location was plotted on 1:10000 scale topographic map and a general description was written down, including, approximate area, number and type of surface features, and approximate size of features. If the site was small, it was mapped immediately; if the site was large, it was mapped later. After the initial pedestrian survey, some larger sites were revisited for more detailed recording and mapping. Where dense vegetation severely restricted surface visibility, limited vegetation clearing before mapping and recording.

Just how site boundaries were determined was not discussed exciptly in the report. It is very likely that the boundaries were defined by subjective judgment of field workers according to the density of artifacts. Different people might have applied different standards of just how dense the artifacts must be to qualify a scatter as a site, and to determine where a site ended. The survey also did not record the different areas covered by materials of different periods. Even a site included multiple components, only one site size was recorded. In general the approximation of site was very approximate, which can affect the accuracy of population estimation.

The other main source of data for this research is the inventory of cultural resources conducted by the Bureau of Art and Culture. The inventory began in 1997 and finished in 2001. The inventory has been completed for the states of Melekeok and Airai (Olsudong et al. 2004), Ngeremlengui and Aimeliik (Olsudong et al. 1998), Kayangel and Ngarchelong (Olsudong et al. 2005a), Ngtpang (Olsudong et al. 2005b), Ngaraard (Olsudong et al. 2007) and Ngiwal and Ngchesar (Olsudong et al. 2008). The inventory includes archival research and site visits. All available information about previously known sites was compiled and the sites were revisited. During the visits site boundaries mapped in previous reports were confirmed; and maps of features and site description were updated.

The inventory was unusual in including records of oral history. Previous maps of traditional villages were shown to elders who were familiar with the area to cross reference the information in the previous reports. Sometimes informants showed field workers additional features that were not recorded in the previous reports, and the archaeologists verified the information in the field. Sometimes intensive vegetation clearance revealed archaeological features that were reported by the informants. This survey method produced complicated biases about what was recorded. In areas where oral histories were well remembered, more archaeological features were exposed; and in the areas where oral histories had not persisted, fewer archaeological were recovered from dense vegetation.

2.2 Artifact Collection

Artifact samples were not collected in the inventory surveys, but they were in the PCR fieldwork. Stratigraphic trenches and controlled test units were not located in the PCR for the purpose of recovering regional demography or for understanding the household relationships within villages. The purpose of the fieldwork was to limit the destruction of cultural resources so sample units were concentrated along the PCR corridor.

Archaeological samples were collected in three ways: shovel tests, stratigraphic trenching, and controlled unit testing. Shovel tests were conducted in areas along the edges of sites or features in order to define site boundaries. Most shovel tests were 0.25 m in diameter and no more than 50cm deep. All visible artifacts (ceramics and lithics) were bagged. Stratigraphic trenches were primarily for exposing stratigraphy. Some of the trenches were dug by backhoes, but many were dug by hand. Sample units were dug into the side wall of the trenches and the excavated sediments were bagged and sent to the lab. These soil samples were not larger than 50 liters. Controlled test units carried out to determine site chronology or gather larger samples. Test units were 50*50cm, or 1*1m, or 1*2m in size. The units excavated in arbitrary 10 cm levels and the excavated sediments were placed in separate bags and sent to the lab. Then all the sediments were water screened through ¼" mesh. The recovered materials were sorted into the following categories: charcoal, shell, bone, lithics and ceramics.

For regional demographic study, if the residential density is not consistent, it is helpful to observe the density of archaeological remains to give some sites more demographic weight than others. The underlying logic is that artifacts show in greater density if the residential density is greater. An area-density index might be a more accurate population proxy than just the site area if the density of occupation varies from one settlement from another. In order to produce an area density index for the regional demographic analysis, we need to systematically record the density of surface artifacts across communities in the region. The sample units were very small and also concentrated in only a few communities along the PCR corridor. This limits their utility as a basis for an area-density index for regional population estimation.

In community-scale study, ideally sample units will be scattered all over the community so as to represent the full range of households within the community. For very small communities (especially in the Terrace Era), the location of sample units within the 50m PCR corridor is sufficient; but for larger communities in the Stonework Era, sample units concentrated in a small part of the community. This impacts the analysis of household variation with in the community.

A more serious problem lies in the sample size for each household unit. The sample of artifacts and ecofacts in association with each household unit should be sufficient to provide for statistical confidence in proportional differences in assemblage composition, since this is the key to identifying differentiation in household activities and status. The categories of artifacts and ecofacts collected in the PCR archaeological investigation are lithics, ceramics, and fauna remains. A sample of 150 artifacts/ecofacts of the above four categories makes it possible to estimate proportions of different items in the lithic/ceramic/vertebrate/invertebrate assemblage with an error range no larger than 6.7% at the 90% confidence level. For the ceramic assemblage, the volume of excavation for each household was large enough to recover such a sample; but the excavated volumes were too small to recover large enough samples of the other categories of artifacts and ecofacts.

2.3 Counting Houses

Population growth and decline are estimated based on the archaeological population proxies. In both the compact road project and cultural resources inventory, the areas of archaeological sites were measured, and the site area can be used as the population proxy. The logic is that settlements covering larger areas have larger populations. However, this proxy can be inaccurate because the residential density might not be the same across different settlements and different time periods. In Palau, both the cultural resources inventory and the compact road project survey not only mapped out the locations of stone platforms and stone pathways, but also measured the areas of the stone platforms. The residential density was measured as the number of house structures/ha within the mapped sites. 165 out of 311 settlements were mapped. These records provided solid foundation for estimating the relative and absolute population for the Stonework Era. By contrast, house structures were not preserved well for the Terrace Era. Only 17 out of 248 settlements were mapped in detail, which means that knowledge of residential density is less accurate in the Terrace Era.

Another population proxy that has been commonly used in demographic reconstruction is the area of the occupation multiplied by the surface sherd density to create an 'area-density index' (Drennan et al. 2015). In some settlements, the trenches and small test pits were placed near house features, which provides a good indication of the amount of garbage those households produced in the two different periods. The underlying logic is that more people produce more garbage. A settlement covering 1 ha with 50 people will produce twice as much garbage as the same settlements with 25 people. In the Terrace Era, 11 out of 248 settlements have been excavated with 48 test pits or trenches. In the Stonework Era, 5 out of 311 settlements have been excavated with 54 test pits or trenches. The small sample in both periods makes the density values less meaningful. Therefore, the former population proxy (the number of structures) was used for population estimation.

The largest concern for population estimates based on house structures is the contemporaneity of the houses. Regional scale study does not produce enough dating samples to determine the true contemporaneity of all house structures across Palau. For now the period is the best chronological control for regional settlement analysis. The span of the period is very long for both the Terrace Era (200BC-1200AD) and the Stonework Era (1200 -1800AD). It is very likely that some or all of houses were occupied for only a part of the total span. Counting houses will overestimate the population to some extent. One way to improve the population estimation is to study the average lifetime of a house structure. The total number of houses in the region can be multiplied by the proportion of average lifetime of a house structure in each period, so as to yield a more reliable absolute population estimation. However, the dated samples from the PCR project were overall dating of site occupations and did not contain sufficient charcoal samples from excavated house structures to estimate the lifetime of an average house structure.

3.0 Regional Demography and Early Complex Society Development

3.1 Population Growth and Decline on Babeldaob Island in the Terrace Era and Stonework Era

Estimating the size of prehistoric populations is a vital part of understanding social change. A growing population requires increased food production and agricultural intensification. In an island context, this sometimes results in conflicts over limited subsistence resources and becomes a fundamental force that change human relationships (including productive and other kinds of differentiation), as well as the local community structure (Kirch 2006). Even though population pressure did not occur on many islands (Athens 2007, Brookfield 2003), increased population might also drive the creation of more complex social organization to manage the growing stress of human interaction (Bandy 2004).

Given the nature of the archaeological record as discussed in chapter 2, the population proxy used in the analysis is the estimated number of house structures (earth platforms and stone platforms), which related to both the area of occupation and residential density. The total estimated number of structures for the entire island is calculated by adding up the number of house structures from the mapped sites, plus the estimated number of structures for the sites that have not been mapped. The estimated number for the unmapped sites is produced by multiplying the area of the occupation by the average residential density within the mapped sites (the number of structures/ha). In the Terrace Era, 17 out of 248 sites have been mapped with detailed information. The average residential density is 0.91 structures/ha. In the Stonework Era, 165 out of 311 sites have been mapped with detailed information. The average residential density is 1.976

structures/ha. The total estimated number of structures for the Terrace Era is 995 and that for the Stonework Era is 2984 (Figure 3.1.1).

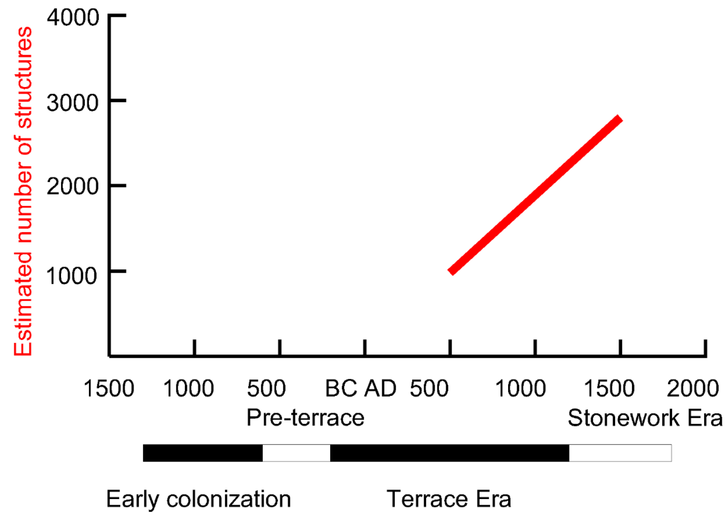

Figure 3.1.1 The Relative Population Level

The X-axis is marked off in years and also shows the time span (in years) for each period. The Y-axis is the estimated number of structures.

The estimated number of structures suggests the population level on Babeldaob in the Stonework Era increased by 2.7 times over that in the Terrace Era. This suggests a rapid population growth in the Stonework Era. As stated in chapter 2, population reconstruction based on the estimated number of structures assumes that all the structures were in use at the same time. Since cycles of occupation occurred in both periods, this estimate is maximum estimate of population.

The estimated number of house structures can be converted into an absolute population estimates by multiplying by the number of people who lived in each house structure for the Terrace Era and the Stonework Era. For the Stonework Era, I used the average areas of house structures for six Stonework Era villages (sq meters) divided by the average dwelling area per person, resulting in the average number of people who lived in the structure in the Stonework Era. Naroll (1962) estimated the average dwelling area per person as 10 m² based on ethnographic data from

18 traditional societies worldwide. Brown (1987) revised Naroll's measurement to 6 m²/person, based on 38 cross-cultural cases. The average dwelling area of houses in the six Stonework Era villages is 128.37 m² (n=177, including the *bai* public meeting house), and 109.13 (n=167, excluding the *bai* public meeting house). Sometimes adolescent men and unmarried men can also live in the public meeting house according to ethnographic sources. As a result, the average number of people who lived in the structures is

With bai: 128.37m²/6m²/person=21

Without bai: 109.13/6m²/person=18

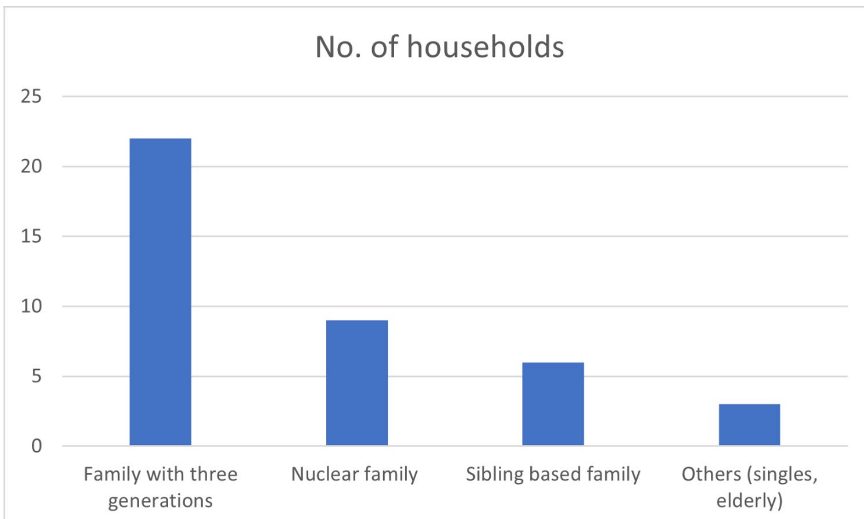

Figure 3.1.2 Household Composition of Melekeok in 1970s (converted from Smith 1983:24)

According to our calculation, the average number of people per house structure is much larger than the normal nuclear family (4-7 people). This larger household population is supported not only by the relatively large dwelling area of houses in Palau, but also by ethnographic accounts. Smith (1983:24) says that households (blai in Palauan) involve close relatedness through any means. The household is the foundation of the matrilineage. In the ethnographic study of Melekeok population structure in 1972, households with three generations are the majority of the households (see Figure 3.1.2). That means the average household population is larger than the nuclear family.

By this approach the absolute population in the Stonework Era = the average number of people per structure (18-21) * the estimated number of structures (2984)=53,712-62,664.

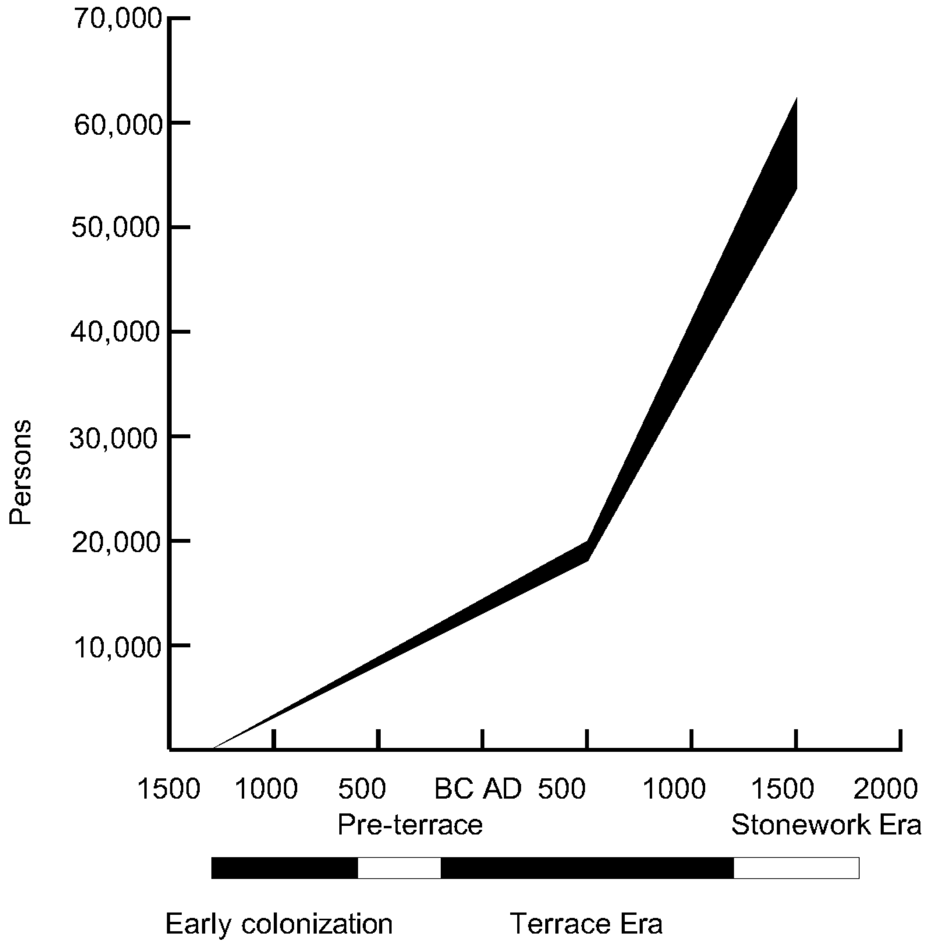

Figure 3.1.3 The Absolute Population

The X-axis is marked off in years and also shows the time span (in years) for each period. The Y-axis is the estimate of population (in persons) based on 18-21 persons per structure. The shaded area shows the increase of population between the Terrace Era and the Stonework Era.

For the Terrace Era, the structures counted are the terraces that houses were built on. In the excavation of the terrace sites, the features that have been found are mostly garbage pits, burials, and occasionally destroyed stone features. There is not sufficient information to estimate the average dwelling areas of house structures for this period, so we used the same household size as for the Stonework Era. Thus the absolute population in the Terrace Era is the average number of people per structure (18-21) * the estimated number of structures (995) =17,910-20,895. Again this population reconstruction is the maximum population level for the Terrace Era. Figure 3.1.3 shows the change in estimated absolute population in the prehistory of Palau.

3.2 Local Communities in the Terrace Era

The scale and the nature of local community structure is essential answering question 1. The definition of local communities follows Murdock's definition, which is a social group whose members engage in face to face interaction on a daily basis. In other words, local communities are places where people interact with one another in everyday life. The scale of local communities ranges from hamlets and villages to towns and cities, according to population size and spatial extent. Local communities when households are very scattered and interact infrequently in everyday life. In addition to scale, the nature of local communities affects people's decisions about where to live, based on the patterns of activities of their daily lives. In the absence of modern transportation, the inconvenience of interaction increases substantially with distance. If people engage in economic exchange with one another they may pay the cost of walking farther to their fields, and decide to settle in denser communities rather than small hamlets or scattered farmsteads. Frequent economic exchange may encourage the emergence of larger-scale organization of labor and of communal spaces such as seasonal markets. In the opposite direction, if people interact more frequently with the land or fishing territories in everyday life, they might prefer to settle in small communities that are closer to these resources. In that way, they could minimize the effort of traveling from their houses to their fields (Drennan 1988). The scale and the nature of local communities reveals the patterns of everyday interaction that generate social change.

The delineation of local communities is based on the spatial clustering of archaeological remains on the landscape of Babeldaob island. The boundaries of local communities are not the boundaries of sites that are drawn by the survey teams, because the boundaries of sites can be impacted by the survey strategies, which are not necessarily meaningful social boundaries in the past. Some sites are immediately adjacent to one another in the Terrace Era site map from the survey as a consequence of the fairly arbitrary process of separating "sites" from each other. One community which of 66 ha has a very different social phenomenon than nine communities of 6-10 ha each delineating local communities with spatial cluster analysis.

Spatial clustering was based on surfaces representing the density of house structures. The interpolation method for producing the surface was inverse distance weighting, using distance raised to the fourth power, which has no smoothing effect. The unsmoothed surface in Oaxaca has been argued to represent different individual small local communities (Peterson and Drennan 2005). In contrast, the unsmoothed surface in the Alto Megdalena has been argued to represent the dispersed distribution of farmsteads. In the latter case, there is no meaningful tendency for occupation to cluster into local communities, ie. hamlets, villages or towns (Drennan 2006).

For Palau local community structure was represented by the density surface representing the spatial distribution of house structures. Although scholars have not yet reached an agreement on the function of the step terraces and crowns, we treated these structures generally as space where domestic activities happened, including residential, agricultural and ritual activities (Killion 1992). In this research, I took each step terrace or crown to be one household. For the 17 mapped sites, the density of house structures (the number of structures/ha) was the basis for the analysis for unmapped sites the average structure density (0.91 structures/ha) was used. The density surface would be more accurate if more sites had been mapped. The unsmoothed density surface shows a forest of spikes widely dispersed along the coastline for 20,000 meters. They didn't form clusters of archaeological remains that we could clearly define as the boundaries of local communities, although these scattered farmsteads tend to cluster more in some places than others at a scale larger than that of a local community (see Figure 3.2.1).

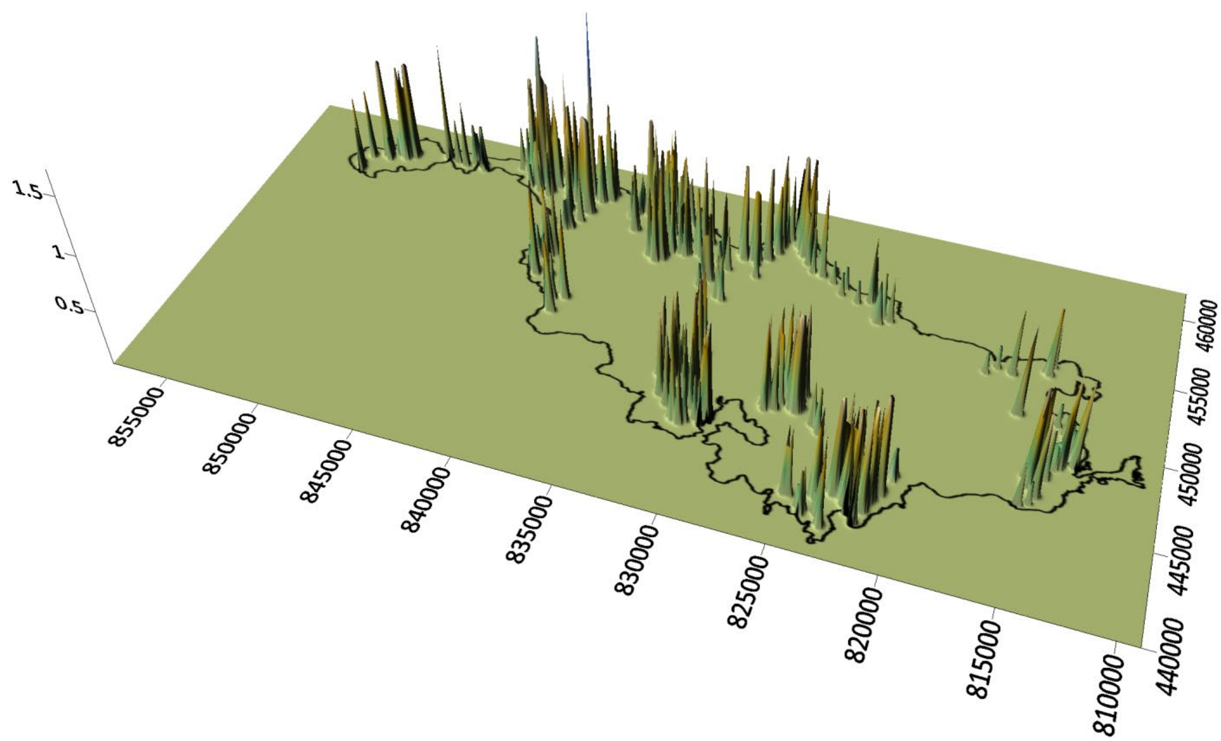

Figure 3.2.1 Unsmoothed Structure Density Surface Representing Terrace Era Occupation

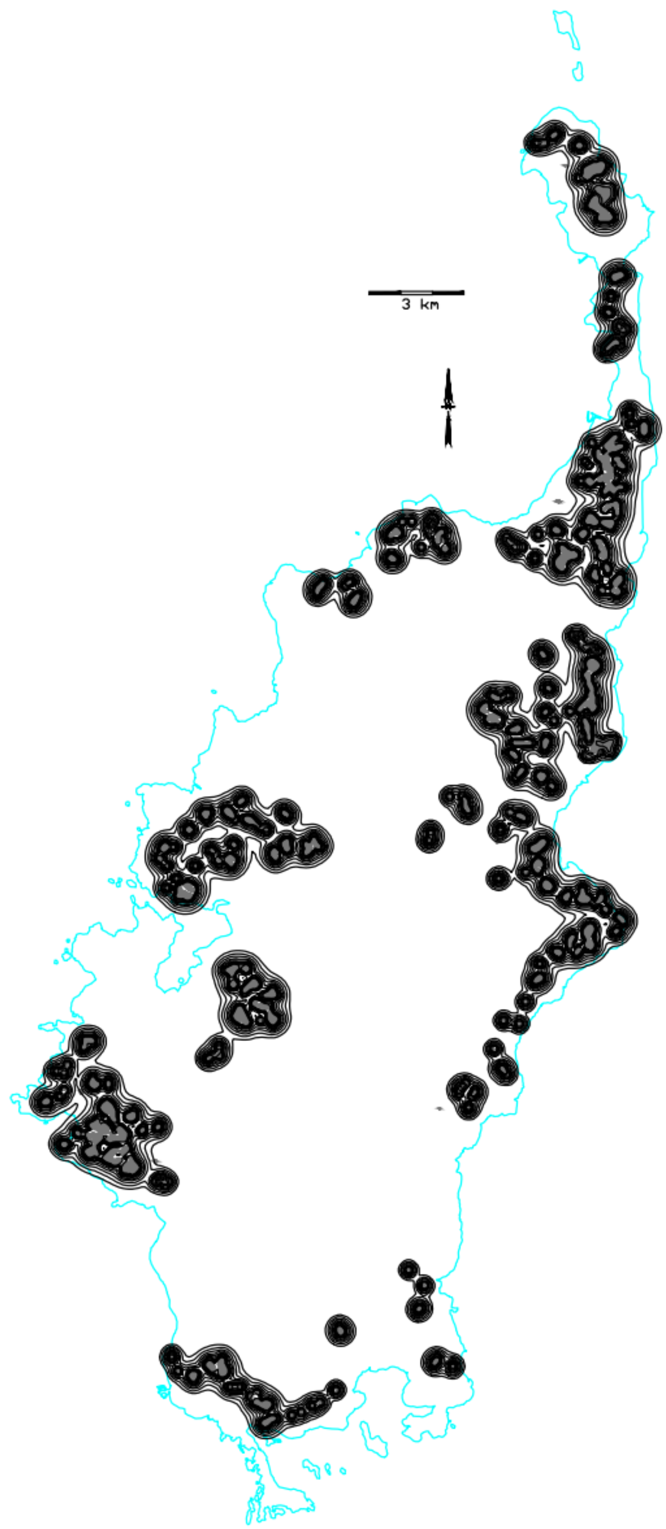

Figure 3.2.2 The Contour Map of the Structure Density Surface in the Terrace Era

The contour map of the structure density surface makes it possible to delineate the boundaries of some local communities, but it leaves some large patches with continuous occupation over a distance of 2km (see Figure3. 2.2). Therefore, no satisfactory cut-off contour can be chosen to delineate clusters of occupation that reflect the centrally focused interaction of local communities. Dispersed farmsteads and tiny hamlets were the dominant settlement pattern in the Terrace Era. At an average residential density of 17-19 people/ha, each household resided at an average distance of 100-120m from its nearest neighbor. Even in the more densely occupied region of Ngaraard, there are still about 10 households (80-200 people) in the 7 ha of settlement, which is very dispersed in nature. The local community structure in the Terrace Era is very similar to the local community structure in Hawai'i and the Society Islands.

3.3 Local Communities in the Stonework Era

The same interpolation method has been applied to produce the density surface based on structure density that represents the community structure in the Stonework Era. There is detailed residential density information for a substantial proportion of sites (165 out of 311 sites), which makes the representation of population distribution more accurate than for the previous period. We used the actual density values (the number of structures/ha) for the mapped sites and the mean density value for the unmapped sites.

The unsmoothed structure density surface in the Stonework Era is very similar to the one in the Terrace Era. The spikes of population density become taller and closer together, but they still do not form big clusters (see Figure 3.3.1). Settlements spread out along the coast of Babeldaob Island. On average, each of the individual spikes represents 10 households, spread through an area of 5 ha. In the densest region, there could be 20 to 30 households in settlements of 5-9 ha (4-6 structures/ha). The community structure seems to be tighter than the dispersed farmsteads in the Terrace Era, but it is still very diffuse and loosely organized.

No satisfactory cut-off contour can be chosen to delineate clusters of occupation that reflect closely interacted local communities (see Figure 3.3.2). The chosen contour level (marked by black shading) delineates the sparse occupation but leaves a single community that stretches to 3-4km long. In addition to this singular large community, many communities cover patches of occupation around 1km long. This suggests loosely bounded communities with relatively infrequent interaction. Thus the population still spreads out along the coast of the Babeldaob Island without forming compact communities, although the residential density has increased in local communities. Most of households resided at an average distance of 40-50 m from their nearest neighbor, resulting in the average residential density of 36-42 people/ha. The average household is connected to ten other neighboring households (180-210 people) in 5 ha, which is very loose in nature. Most of the population thus lived in small villages. These small villages were connected to one another and sprawled along the coastline. Yet it doesn't mean all the local communities had the same residential density. Some more compact local communities appeared with residential densities of 72-126 people/ha. Each household resided at an average distance of 10-20 m from its nearest neighbor. These communities reached populations of 612-714 people, which is within the range usually labeled a village. The local community structure in the Stonework Era is more compact than that in the Terrace Era, as well as the Hawai'i and Society Islands, yet it is not as compact as in Mailu and Yap.

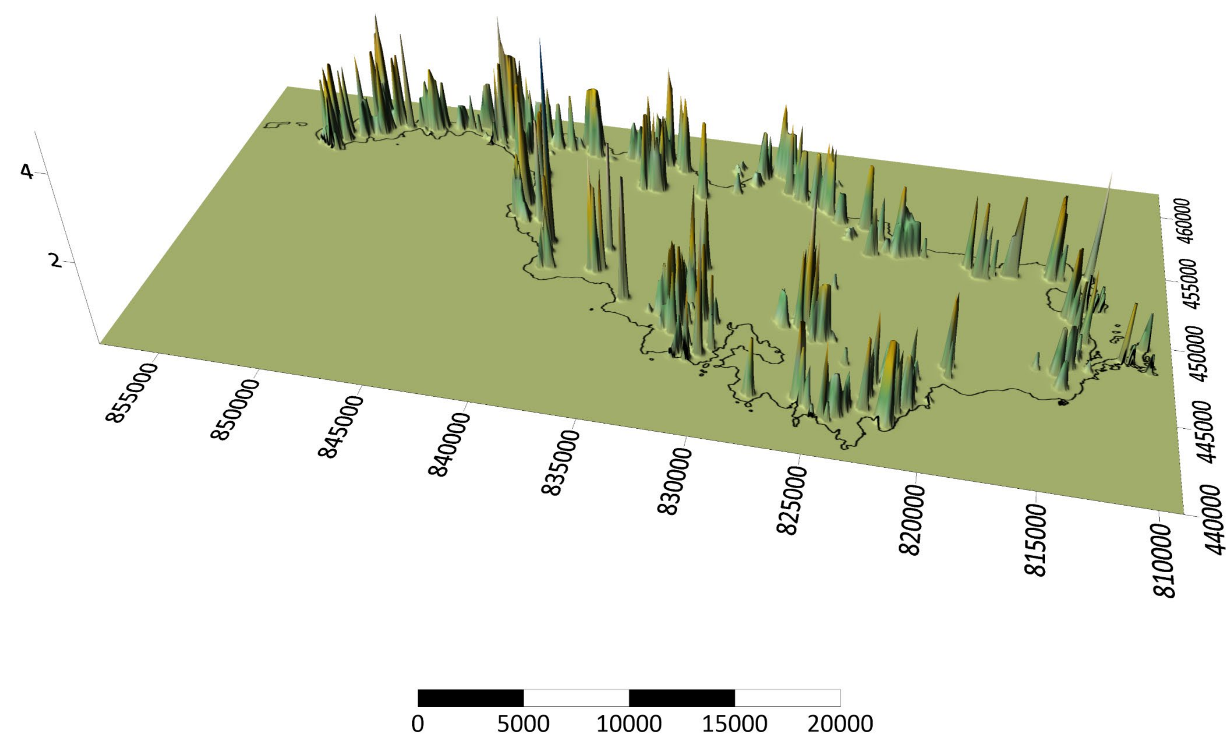

Figure 3.3.1 Unsmoothed Structure Density Surface Representing Stonework Era Occupation

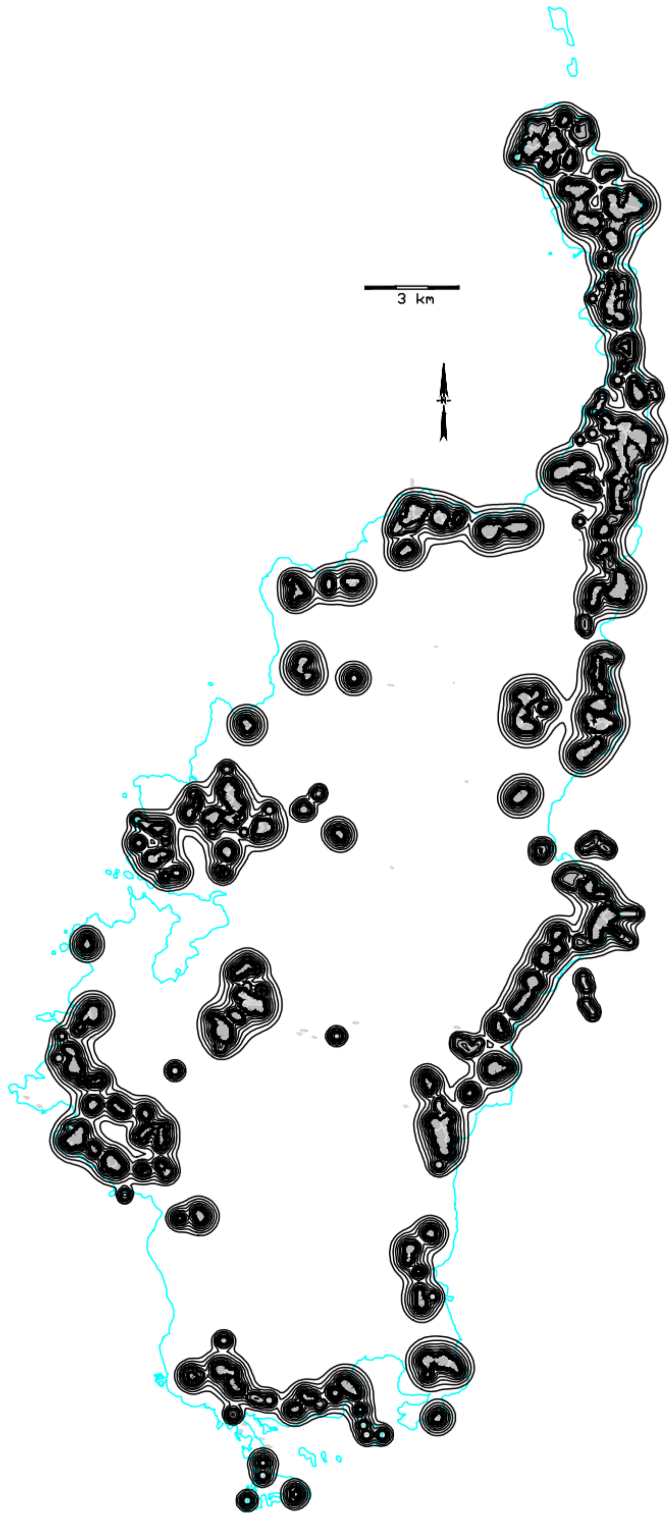

Figure 3.3.2 Contour Map of Structure Density Surface in the Stonework Era

3.4 Supra-local Communities in the Terrace Era

To evaluate whether or not supra-local communities emerge is the key to knowing whether or not a larger spatial scale of integration occurred in the region. Integration at this larger spatial scale can be political, as in regional polities and authority. It can also be economic, involving productive differentiation and economic interdependence at a larger scale. It can also be ritual integration that people attract people to a central place for ritual activities (Kantner and Vaughn 2012; Drennan et al. 2017). The emergence of supra-local communities means that people interact more frequently with others in the same regional community than with people in other regional communities. Interaction communities of this sort are produced by the centripetal forces that draw population towards either the more compact local communities, or at a larger scale, the regional communities separated by sparsely occupied territory from other regional communities. Archaeological evidence in the Valle de la Plata demonstrates that the supra-local communities can exist without the presence of local communities (Drennan 2006). In other words, even though the dispersed farmsteads are dominant at the local scale, a greater level of integration can still occur beyond the local level. Archaeologists have long recognized supra-local communities by labeling them “polities” or “districts”, and calling the empty space between them “buffer zones”. Without the existence of supra-local communities, it is likely that the degree of social complexity is very low since leadership of any kind is limited to a very small number of members. There is no need to create a complex social mechanism to manage the human relationships such as resolving conflicts, organizing communal affairs, or establishing public projects(Bandy 2004; Alberti 2014).

The density surface that was used to delineate local communities can be extended to delineate the regional clustering that is associated with supra-local communities. The density surfaces for delineating the supra-local communities were produced by inverse-distance-weighted averaging with distance raised to a lower power. High powers emphasize local detail; in contrast, low powers smooth the surface, so as to focus on larger scale patterns of settlement distribution. As the power distance is decreased, the inverse-distance-weighed averaging produces a smoother surface. Both sherd density surfaces and residential surfaces were produced to evaluate demographic distribution at the regional scale.

The structure density surfaces representing population distribution in the Terrace Era were produced by inverse weighting with distance raised to powers of 2,1, 0.5 (see Figures 3.4.1, 3.4.2, 3.4.3). Moving up from the local scale, the more smoothed surface shows clearly the presence of larger scale social units. Regional trends are clearest in the power 1 or power 0.5 surfaces, and which do not show a single heavy demographic concentration. Instead, there are multiple demographic clusters separated from each other by sparsely populated zones that can be used to draw the boundaries of these entities. These demographic clusters are the supra-local communities in which people interacted with each other more often than people who live outside. It is also important to recognize the variation in internal community structure between the supra-local communities. Some of them have one clear demographic peak; some of them have multiple demographic peaks in very close together.

The contour map of the power 1 smoothed surface enabled delineation of the approximate boundaries of these supra-local communities (see Figure 3.4.4). In the western part of Babeldaob Island, low cutoff contours were chosen to delineate the boundaries of four supra-local communities. In the eastern part high cutoff contours were chosen as the boundaries for the four supra-local communities.

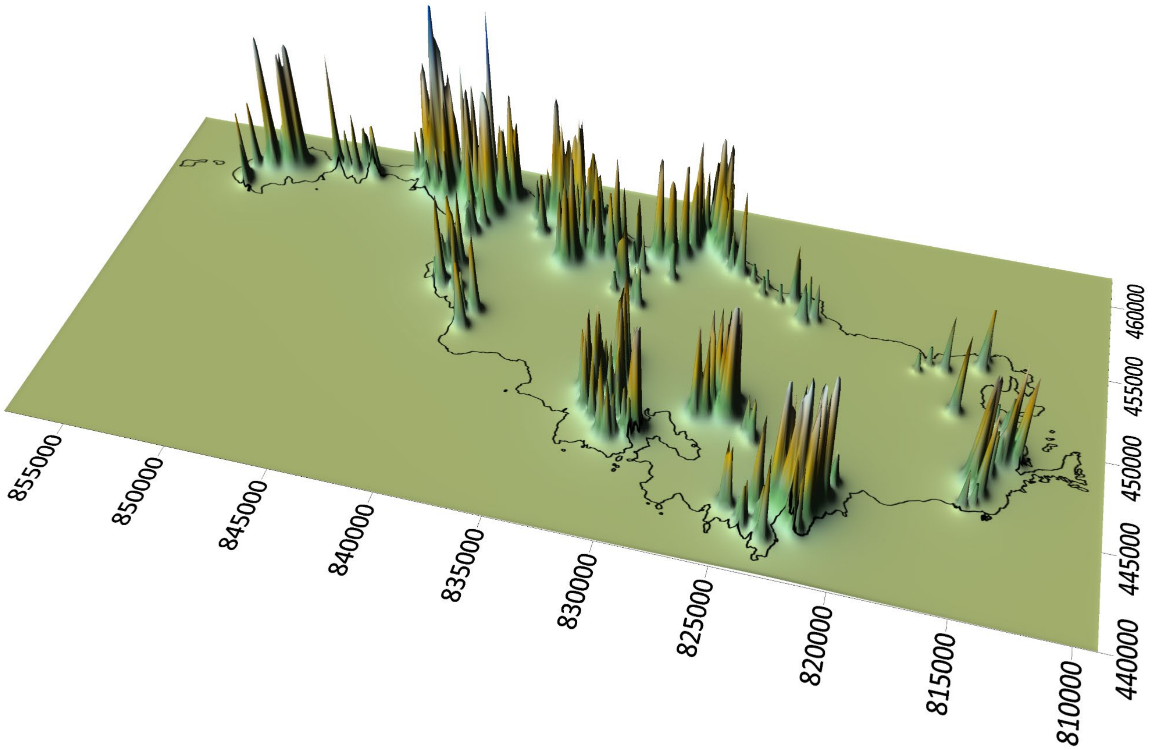

Figure 3.4.1 Power 2 Smoothed Density Surface Representing Population Distribution in the Terrace Era.

Inverse distance power used in the smoothing was 2.

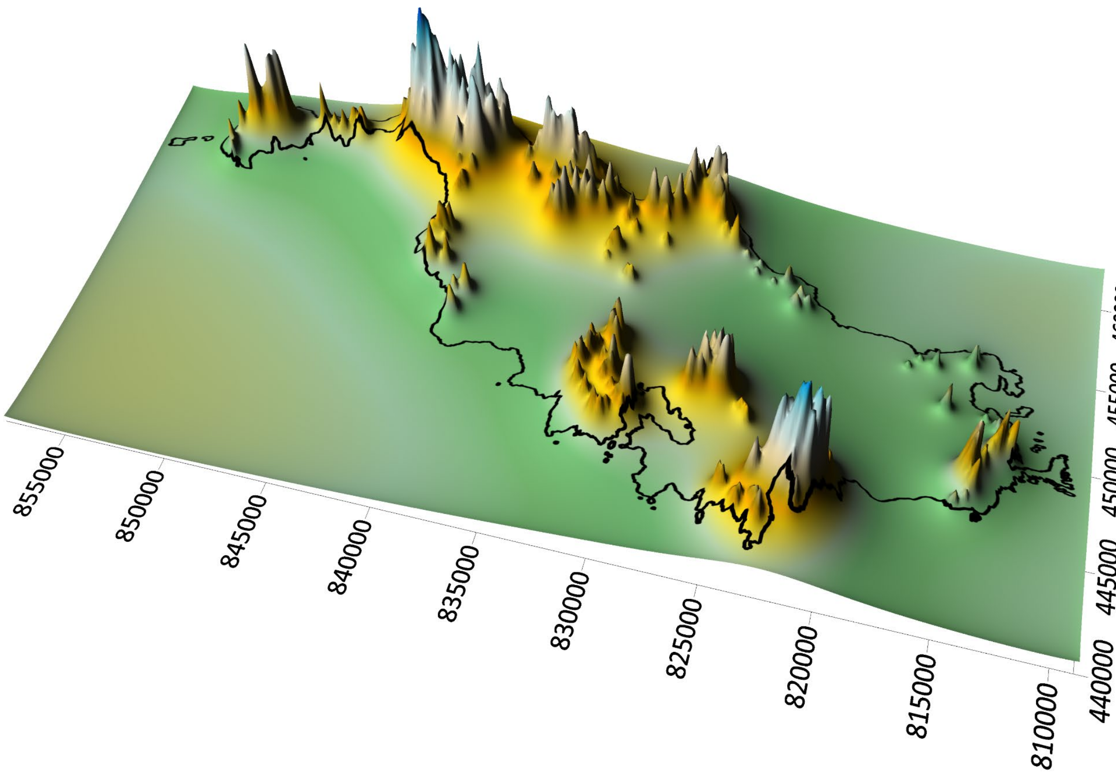

Figure 3.4.2 Power 1 Smoothed Density Surface Representing population Distribution in the Terrace Era.

Inverse distance power used in the smoothing was 1.

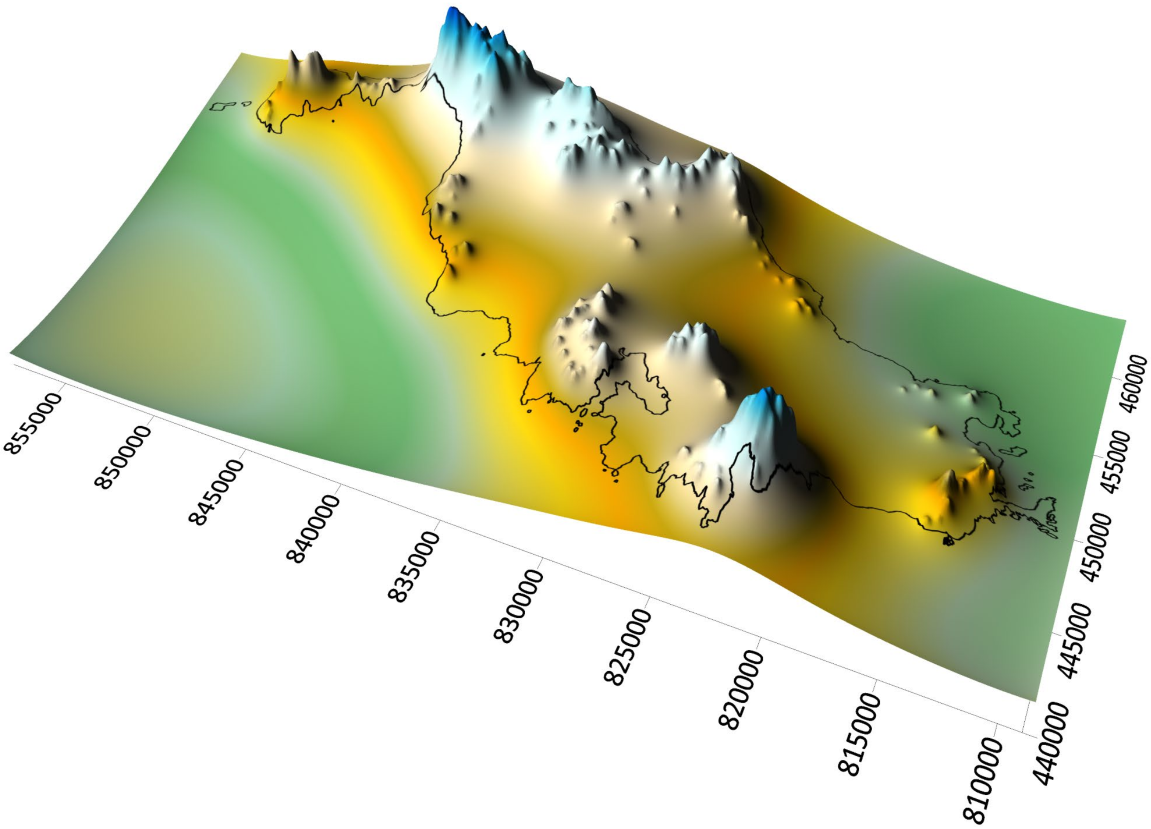

Figure 3.4.3 Power 0.5 Smoothed Density Surface Representing Population Distribution in the Terrace Era.

Inverse distance power used in the smoothing was 0.5.

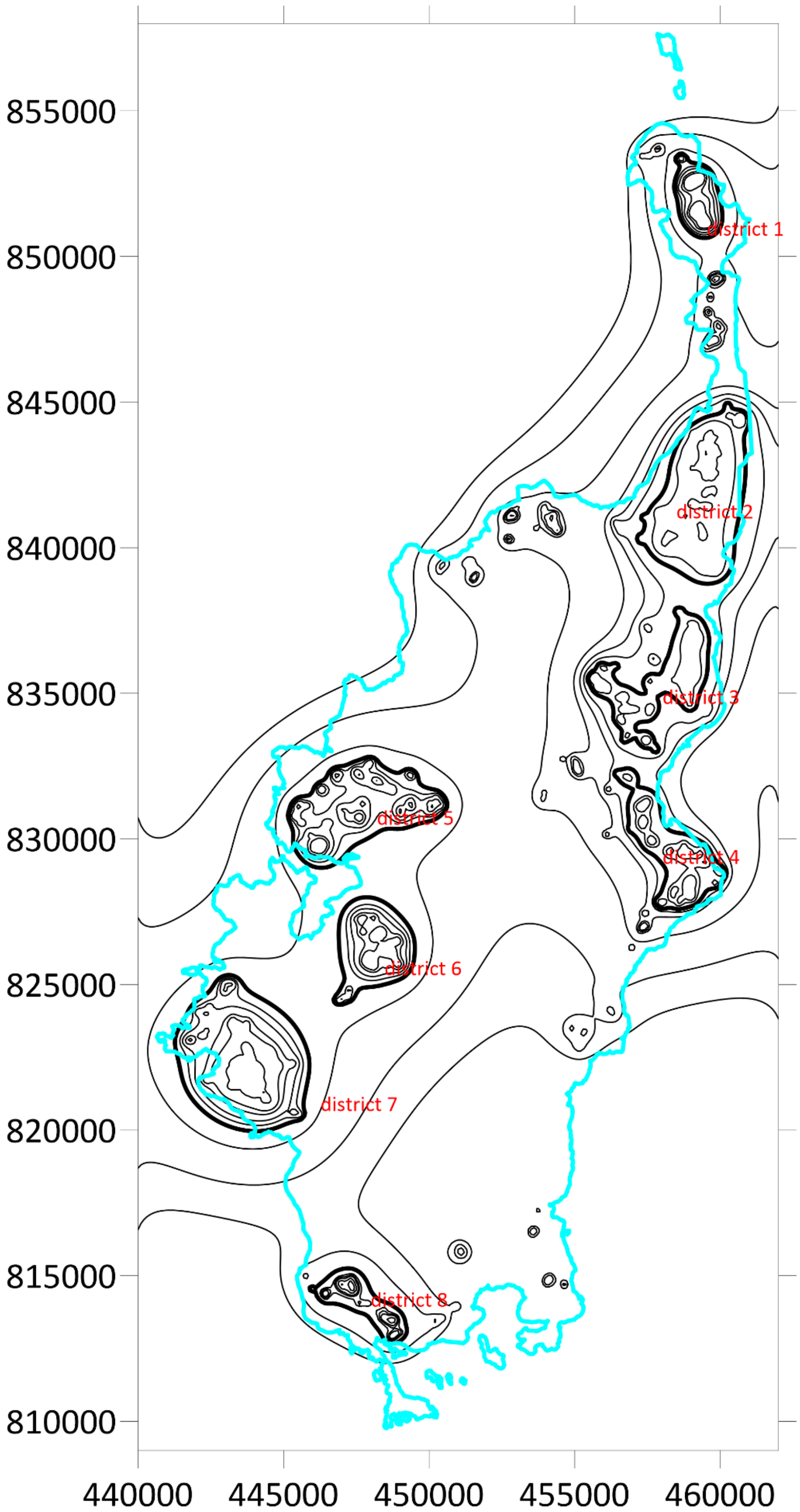

Figure 3.4.4 Contour Map of the Power 1 Smoothed Density Surface

District boundaries are indicated.

The overall demographic patterns reconstructed from the density surfaces suggest the political landscape on Babeldaob Island was divided into eight small polities, ranging from 3km² to 18km² in area (Table 3.4.1). In terms of absolute population size in each of supra-local communities, if all the occupation is contemporaneous, the populations of the supra-local communities ranged from 864 to 4000 people. It might be a 1-2 hour walk to the center of a supra-local community from its farthest periphery, allowing for the differences in elevation. 85% of the total population lived within the supra-local communities, whereas 15% lived outside their boundaries.

Table 3.4.1 Population of districts in the Terrace Era

District	Estimated number of structures	Population (18-21 people/house)	Area of districts (in km^2)
1	55	990-1155	3.42
2	189	3402-3969	14.97
3	115	2070-2415	7.69
4	92	1656-1932	6.98
5	112	2016-2352	12
6	73	1314-1533	6.97
7	160	2880-3360	17.94
8	48	864-1008	3.47
No District	148	2664-3108	Not applicable

In most of the supra-local communities, there is not a compact high density town in a central location. Instead, the center consists of farmsteads in closer proximity to other farmsteads than in the periphery, or in the spaces between the supra-local communities. The supra-local community showing a single demographic peak has a large terrace site in its center (beyond 10ha, the biggest one is 40ha). The central terrace site was surrounded by smaller terrace sites forming a big cluster. For the one with multiple demographic peaks, the central terrace site is small (6-7ha) and set apart from other terrace sites by about 100-500m.

3.5 Supra-local Communities in the Stonework Era

The same interpolation methods have been applied to delineate the boundaries of the supra-local communities in the Stonework Era. Structure density surfaces were produced with inverse distance weighting to powers of 2,1, and 0.5 (see Figure 3.5.1, Figure 3.5.2, Figure 3.5.3). Moving up from the local scale, surfaces that were produced by the two different population proxies become more and more similar. The regional trend is clearest in the power 1 and power 0.5 surfaces that were reconstructed from both population proxies. The approximate boundaries of ten supra-local communities were delineated by cut-off contour which were produced by contour map of power 1 structure density surface (Figure 3.5.4).

In the Stonework Era, the supra-local communities expand in size compared to the Terrace Era, mostly beyond 10km² (Table 3.5.1). The absolute population in each supra-local community is estimated based on an average number of people per structure of 18-21. The populations of the districts vary from 900 to 18,102 people.

The supra-local community (district 1) at the north end of Babeldaob Island stood out from all the other supra-local communities, with a population of 15,516-18,102 distributed on a narrow strip of land running over 16km long. The demographic pattern recovered from the density surfaces looks like several supra-local communities grew in density and merged into one interaction community in the north. There is no heavy concentration of occupation into a single central town. Instead, the demographic center is a dock surrounded by patches of occupation (around 130 households, or 2340-2730 people), distributed across an area of 63 ha, resulting in a residential density of about 40 people/ha. The dock is shared by people who lived in this supra-local community. Moreover, there are three demographic peaks in this supra-local community instead of one suggesting that people who lived in different demographic concentration interacted less often. The centripetal forces that produced this supra-local community were not very strong.

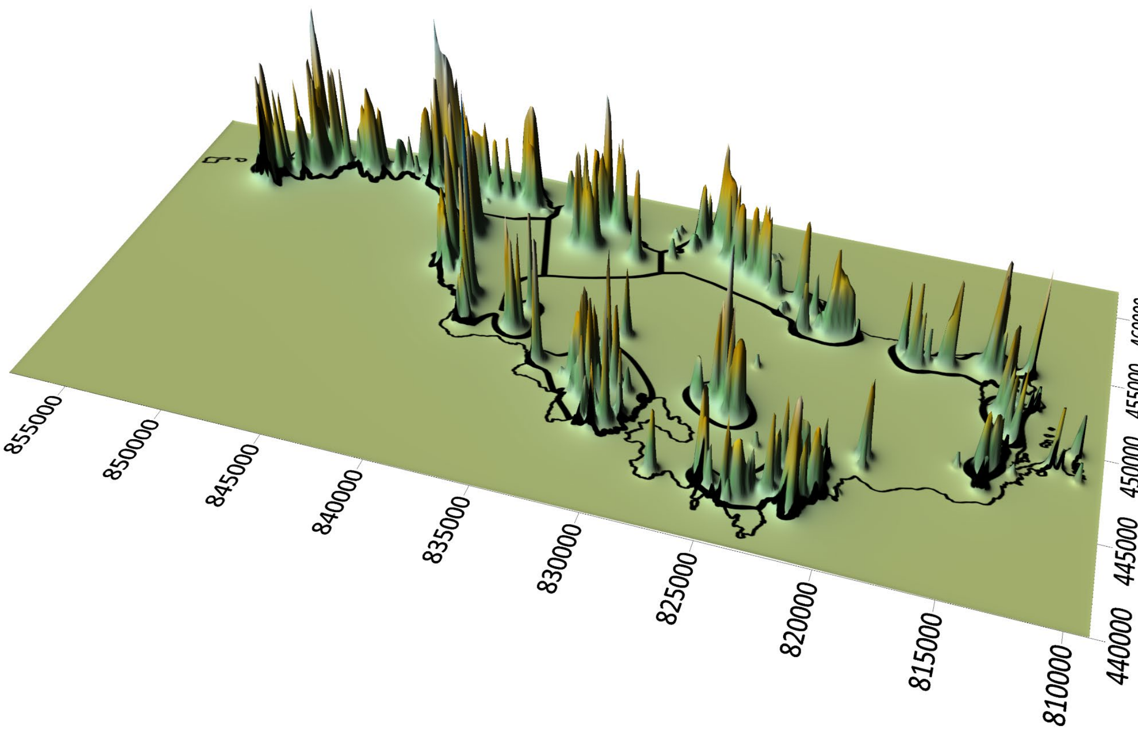

Figure 3.5.1 Power 2 Smoothed Density Surface Representing Population Distribution in the Stonework Era

Inverse distance power used in the smoothing was 2.

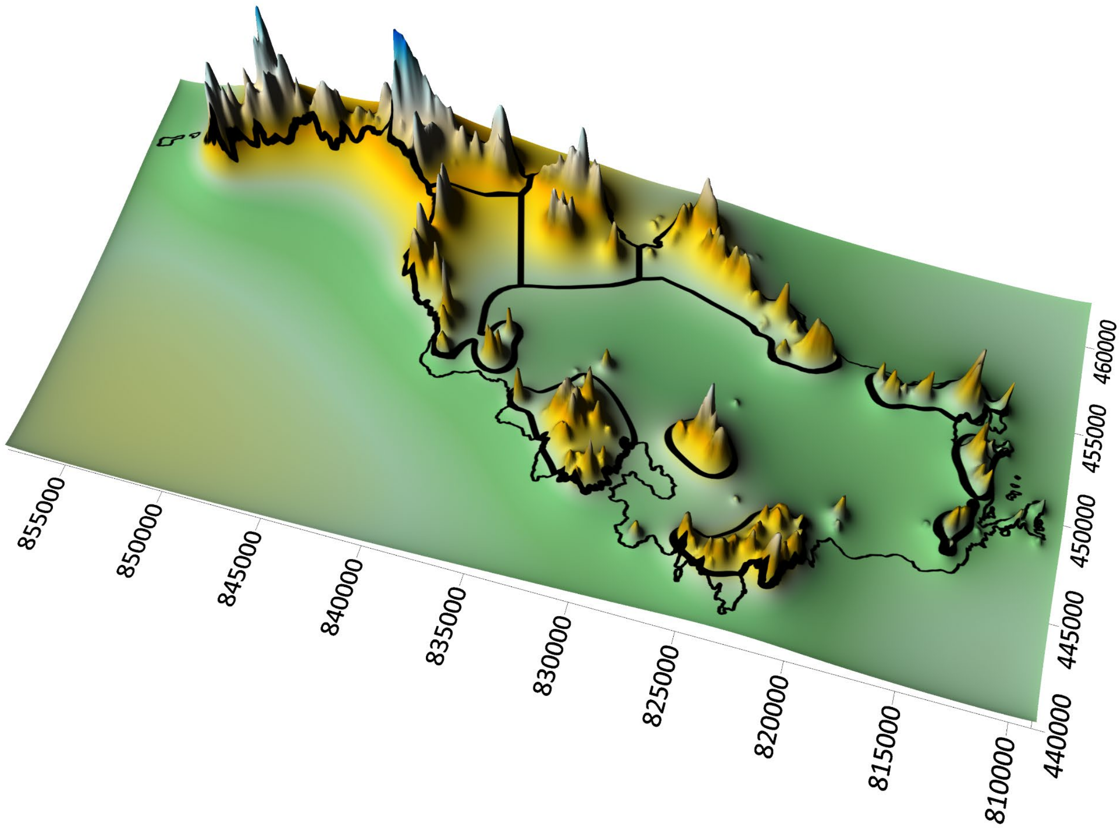

Figure 3.5.2 Power 1 Smoothed Density Surface Representing Population Distribution in the Stonework Era

Inverse distance power used in the smoothing was 1.

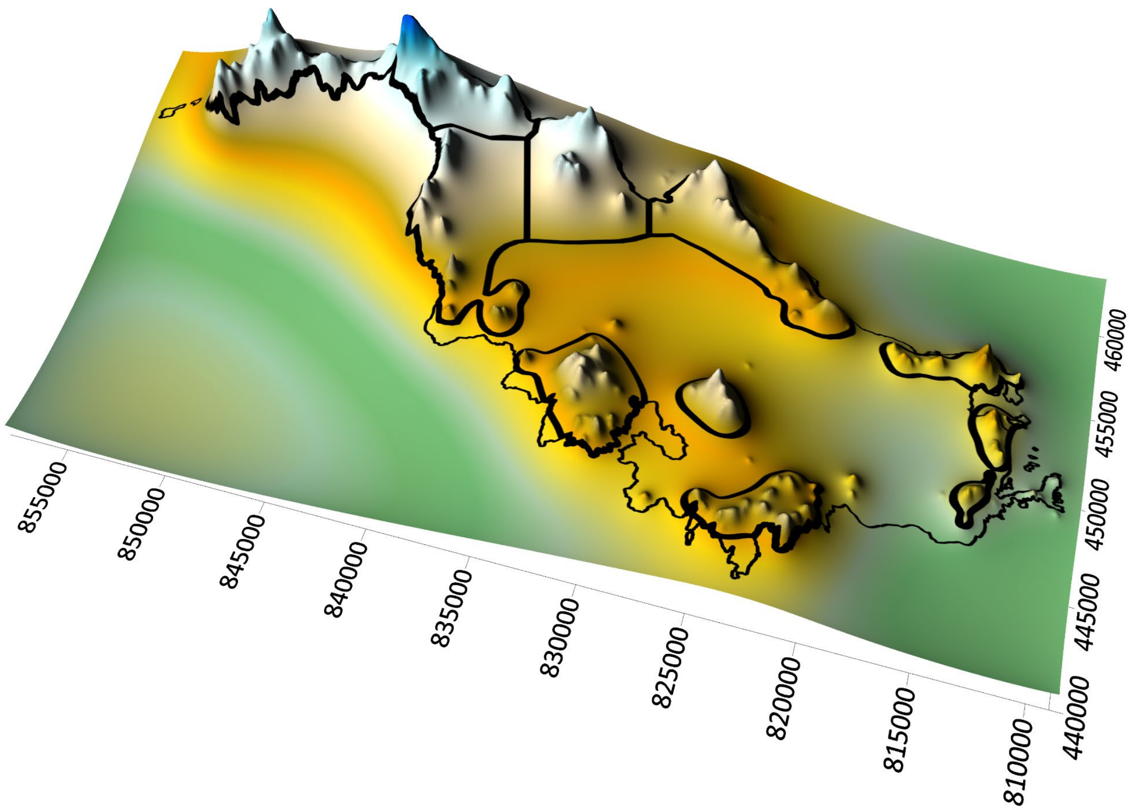

Figure 3.5.3 Power 0.5 Smoothed Density Surface Representing Population Distribution in the Stonework Era

Inverse distance power used in the smoothing was 0.5.

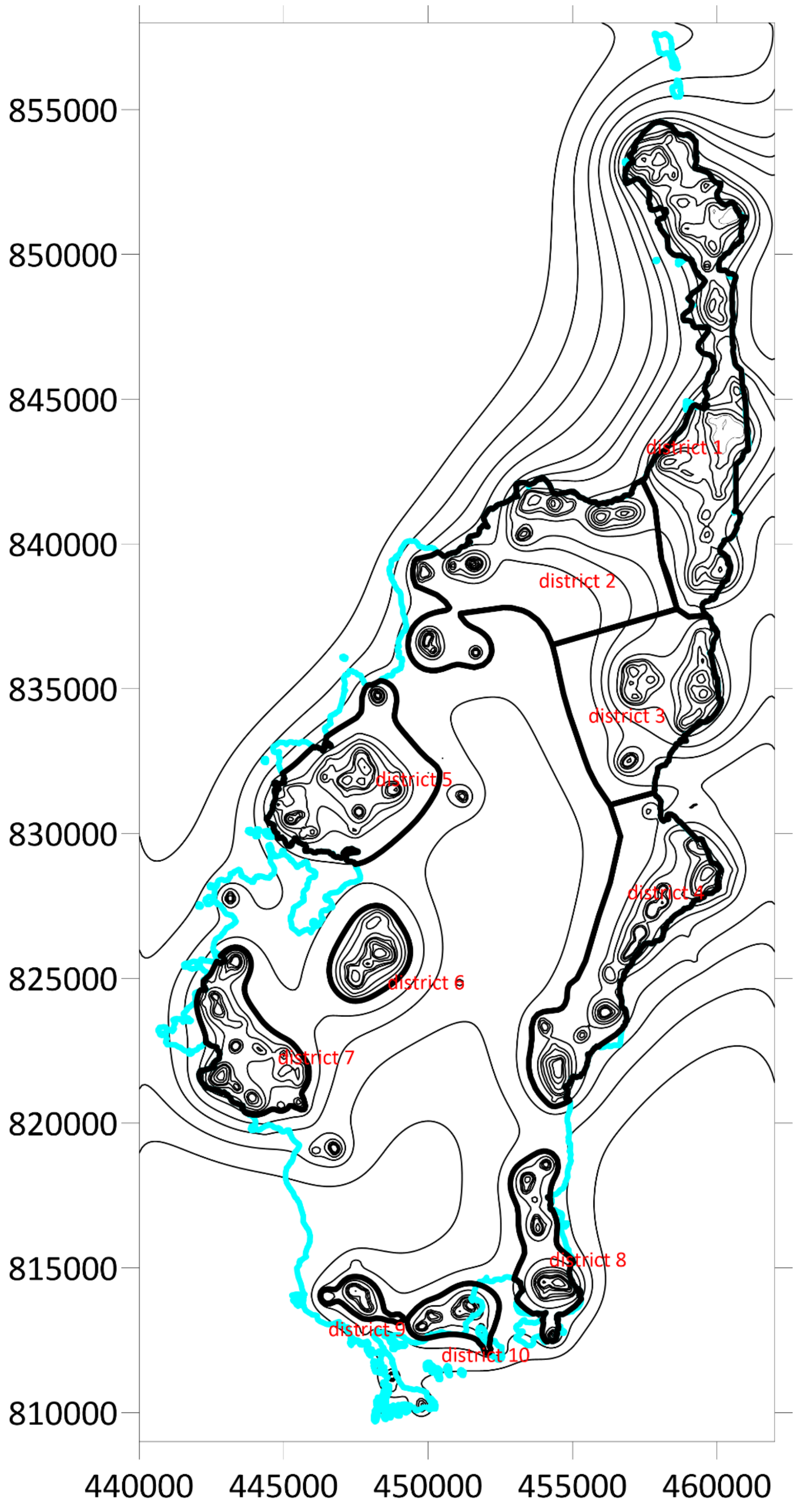

Figure 3.5.4 Contour Map of the Power 1 Smoothed Density Surface

District boundaries indicated.

Table 3.5.1 Population in the Stonework Era Districts

District	Estimated number of structures	Population (18 people/house)	Population (21 people/house)	Area of districts (in km²)
1	862	15,516	18,102	33.98
2	305	5490	6405	36.56
3	258	4644	5418	25.73
4	328	5904	6888	24.87
5	246	4428	5166	21.24
6	148	2664	3108	6.60
7	237	4266	4977	12.63
8	138	2484	2898	8.71
9	50	900	1050	2.16
10	68	1224	1428	4.62
No District	90	1620	1890	Not applicable

The rest of the supra-local communities are still small, ranging from 1000 to 7000 people. Like district 1, the demographic center is also not a town, instead it is located in the geographical center of the largest area of continuous occupation with a low and consistent population density (about 40 people/ha). The continuous occupation often has a population of 800-1400 people (around 40-70 households), spread across the area of 20-50ha. Moreover, there are multiple demographic peaks within most of the supra-local communities. It takes 2-3 hours on average, and for some 4-5 hours, to walk from local communities in the farthest periphery to the center. It suggests infrequent interaction with people in the center. But the occupation does tend to cluster into a circle of 1km diameter within the supra-local community suggesting centrally focused interaction beyond the local level.

The overall demographic patterns reconstructed from both density surfaces suggest a growing political centralization on Babeldaob Island compared to the previous period. About 30% of the total population lived in the north end of Babeldaob Island, which is less than 10% of the total land. Moreover, 97% of the population lived in a supra-local community, compared to 85% in the previous period. In district 1, although there is no central town, villages seem to connect to one another, forming an integrated community. A stone pathway connects households between these villages, and they share the same dock to the ocean.

However, the degree of integration is not very high in two respects. First, at the whole island scale, a fair number of small polities still exist. Some districts consist of populations below 3000 people across an area of $6km^2$. Second, the centripetal forces are still weak in all the supra-local communities, including district 1. Most of the supra-local communities have multiple demographic peaks, suggesting no single demographic center dominates all the other villages within the supra-local communities. Most people probably interacted with their neighbors more often than with people in the center of the supra-local community. In other words, most interactions were at local scale rather than a regional one.

3.6 Centralization and Integration in the Terrace Era

The demographic structure of the supra-local communities in the Terrace Era does not show a consistent degree of centralization in the supra-local communities. The degree of centralization was measured within each supra-local community by calculating proportions of the population of the polity in a series of equal-area concentric rings radiating from the demographic center. More centralized populations are characterized by the higher proportions of the population in the innermost rings (Drennan et al. 2015:74-77).

Centralization analysis for the Terrace Era was conducted for all the districts delineated in the structure density surface (see Figure 3.4.4). Table 3.6.1 shows the population of each ring for all districts in the Terrace Era in the calculation of a coefficient (*B*) to facilitate comparison of the degree of centralization. The *B* value ranges from 0 to 1, representing from no centralization to maximum centralization (Drennan et al. 2015:74-77). The variation of B value amongst the nine supra-local communities confirms the heterogeneity of the levels of spatial integration in the Terrace Era. Some supra-local communities show strong spatial centralization and others show very little. Ring graphs for the nine supra-local communities provides more detailed information about the differences between strong and weak spatial centralization (see Figure 3.6.1). The statistical significance of differences in the B values is based on the estimated number of households in each ring.

District 1,3, and7 shows some strength of spatial integration with *B* values ranging from 0.4 to 0.6. In all three cases, regional population is not concentrated in the first ring; instead, they are nucleated in the first 3-4 rings. This indicates that it was not the formation of compact central villages that caused regional demographic centralization. This indication is consistent with the dispersed nature of local communities, in which the population in the Terrace Era lived in widely scattered farmsteads, forming a continuous distribution across the landscape. However, population was still attracted to a central area that was larger than a single village, for reasons other than intensive everyday interaction which would have encouraged settlements in much closer proximity. In contrast, District 2,4, and 8 shows weak spatial centralization and District 5 and 6 show no centralization at all. Interestingly, the ring graphs of District 4,5,6, and 8 show a similar trait. Population drops rapidly in the second ring, then climbs up and reaches another lesser peak in the outer rings. This indicates the dispersed farmsteads cluster into several patches of relatively equal population instead of only one. Instead of being attracted to one large central area and interacting with more households there, households of these supra-local communities form several smaller centers with a smaller number of households in their supra-local community.

Table 3.6.1 Centralization Analysis in the Terrace Era

Terrace Era Centralization Analysis												
District 1												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	34	8	7	13	6	9	5	1	0	0	0	4
population (min)	612	144	131	230	115	164	82	16	0	0	0	66
population (max)	706	171	153	268	134	191	96	19	0	0	0	77
%	38.90%	9.44%	8.43%	14.76%	7.38%	10.54%	5.27%	1.05%	0.00%	0.00%	0.00%	4.22%
Cum %	38.90%	48.34%	56.78%	71.54%	78.92%	89.46%	94.73%	95.78%	95.78%	95.78%	95.78%	100.00%
B=	0.567		sum (households)		86							
District 2												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	38	19	15	15	4	8	19	17	25	14	9	0
population (min)	679	338	277	276	64	148	345	312	443	246	164	0
population (max)	792	395	323	322	75	172	402	364	517	287	191	0
%	20.63%	10.27%	8.42%	8.37%	1.95%	4.49%	10.47%	9.47%	13.46%	7.48%	4.99%	0.00%
Cum %	20.63%	30.90%	39.32%	47.70%	49.65%	54.13%	64.60%	74.08%	87.54%	95.01%	100.00%	100.00%
B=	0.206		sum (households)		183							
District 3												
Circle	1	2	3	4	5	6	7	8	9	10	11	12

Households	78	55	5	12	7	13	15	15	7	13	8	9
population (min)	1406	990	81	213	131	230	263	263	131	230	148	164
population (max)	1640	1155	95	249	153	268	306	306	153	268	172	191
%	33.08 %	23.31 %	1.91%	5.02%	3.09%	5.41%	6.18%	6.18%	3.09%	5.41%	3.48%	3.86%
Cum %	33.08 %	56.39 %	58.29%	63.32 %	66.40 %	71.81 %	77.99 %	84.17 %	87.26 %	92.66 %	96.14%	100.00 %
B=	0.432		sum (households)		236							
District 4												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	11	6	7	15	15	5	7	9	11	0	0	5
population (min)	202	115	131	263	263	82	131	164	197	0	0	98
population (max)	235	134	153	306	306	96	153	191	230	0	0	115
%	12.25 %	6.97%	7.98%	15.96 %	15.96 %	4.99%	7.98%	9.97%	11.97 %	0.00%	0.00%	5.98%
Cum %	12.25 %	19.22 %	27.20%	43.16 %	59.11 %	64.10 %	72.08 %	82.05 %	94.02 %	94.02 %	94.02%	100.00 %
B=	0.202		sum (households)		91							
District 5												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	22	1	4	11	10	8	3	7	16	10	5	15
population (min)	394	16	66	197	180	148	49	131	295	180	82	262
population (max)	459	19	76	230	211	172	57	153	345	211	96	306
%	19.67 %	0.82%	3.27%	9.83%	9.02%	7.37%	2.46%	6.56%	14.76 %	9.02%	4.10%	13.12%

Cum %	19.67 %	20.49 %	23.77%	33.60 %	42.62 %	49.99 %	52.45 %	59.01 %	73.77 %	82.78 %	86.88%	100.00 %
B=	-0.009		sum (households)		111							
District 6												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	9	1	2	5	5	8	7	4	2	2	5	7
population (min)	164	16	33	82	82	148	132	74	42	44	97	131
population (max)	191	19	38	96	96	172	154	86	49	51	113	153
%	15.70 %	1.57%	3.14%	7.85%	7.85%	14.13 %	12.63 %	7.08%	4.01%	4.22%	9.28%	12.56%
Cum %	15.70 %	17.27 %	20.41%	28.25 %	36.10 %	50.23 %	62.86 %	69.93 %	73.94 %	78.16 %	87.44%	100.00 %
B=	-0.018		sum (households)		58							
District 7												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	46	26	27	12	14	9	7	4	1	3	5	10
population (min)	821	459	492	213	246	164	131	66	16	49	98	181
population (max)	957	536	574	249	287	191	153	77	19	57	115	211
%	27.93 %	15.64 %	16.76%	7.26%	8.38%	5.59%	4.47%	2.23%	0.56%	1.68%	3.35%	6.15%
Cum %	27.93 %	43.58 %	60.34%	67.60 %	75.98 %	81.56 %	86.03 %	88.27 %	88.83 %	90.50 %	93.85%	100.00 %
B=	0.463		sum (households)		163							
District 8												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	18	3	6	0	0	2	2	4	5	6	4	5

population (min)	328	49	115	0	0	33	33	66	82	115	66	82
population (max)	383	57	134	0	0	38	38	77	96	134	77	96
%	33.90 %	5.08%	11.86%	0.00%	0.00%	3.39%	3.39%	6.78%	8.47%	11.86 %	6.78%	8.47%
Cum %	33.90 %	38.98 %	50.85%	50.85 %	50.85 %	54.24 %	57.63 %	64.41 %	72.88 %	84.75 %	91.53%	100.00 %
B=	0.183		sum (households)		54							
The entire island												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	137	118	89	85	66	41	94	67	38	53	144	58
population (min)	2466	2124	1602	1530	1188	738	1692	1206	684	954	2592	1050
population (max)	2877	2478	1869	1785	1386	861	1974	1407	798	1113	3024	1225
%	13.83 %	11.92 %	8.99%	8.58%	6.66%	4.14%	9.49%	6.77%	3.84%	5.35%	14.54%	5.89%
Cum %	13.83 %	25.75 %	34.74%	43.32 %	49.98 %	54.12 %	63.61 %	70.38 %	74.22 %	79.57 %	94.11%	100.00 %
B=	0.098		sum (households)		990							

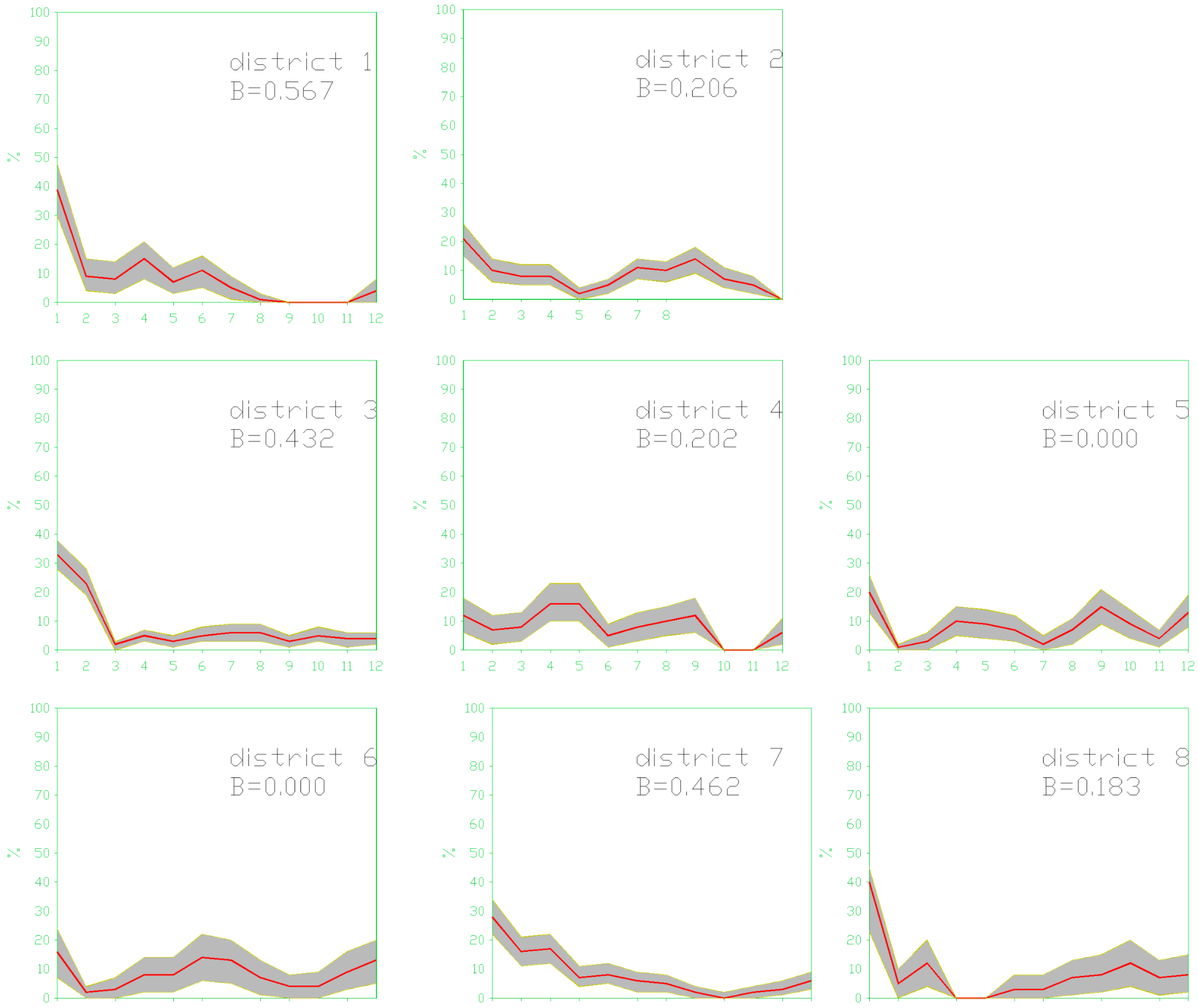

Figure 3.6.1 Centralization plot in Terrace Era

3.7 Centralization and Integration in the Stonework Era

Centralization analysis for all the districts in the Stonework Era (Table 3.7.1) shows the number of house structure of each ring for these ten supra-local communities (see Figure 3.5.4). The same ring graphs are produced for the ten supra-local communities, which provides more detail information for the demographic distribution (see Figure 3.7.1). The *B* value for the entire island in the Stonework Era is 0.263, increasing from 0.098 in the Terrace Era. Population becomes more centralized, even though this *B* value is not high. Half the total population on Babeldaob Island is concentrated in the three inner rings, which correspond to the north end of the Babeldaob Island.

Although 30% of the total population lived in district 1, the *B* value of district 1 shows no centralization at all. Although population is concentrated in the first three rings (nearly 40%), but there were two additional peaks of population in the outer rings. This trend is also clear in the ring graphs (Figure 3.7.1). The result of the centralization analysis aligns with the pattern of the density surface. Population in district 1 was attracted to one big center and two small centers. The population in the big center was only slightly larger than that in the small centers in the peripheral.

Another characteristic of the demographic structure for the Stonework Era is the weak centralization in most of the supra-local communities, except districts 3 and 6. Unlike the Terrace Era, more than one demographic peak occurs in all the supra-local communities, including those with stronger centralization (Figure 3.7.1). Similar to the pattern in district 1, the lesser demographic peaks are at the peripheries of the supra-local communities. The weak centralization of the supra-local community is not because people were distributed evenly across the landscape.

It is caused by the small centers at the peripheries of the supra-local communities. It is very interesting that the centralization is declining within the supra-local communities, although the centralization grows on the entire island.

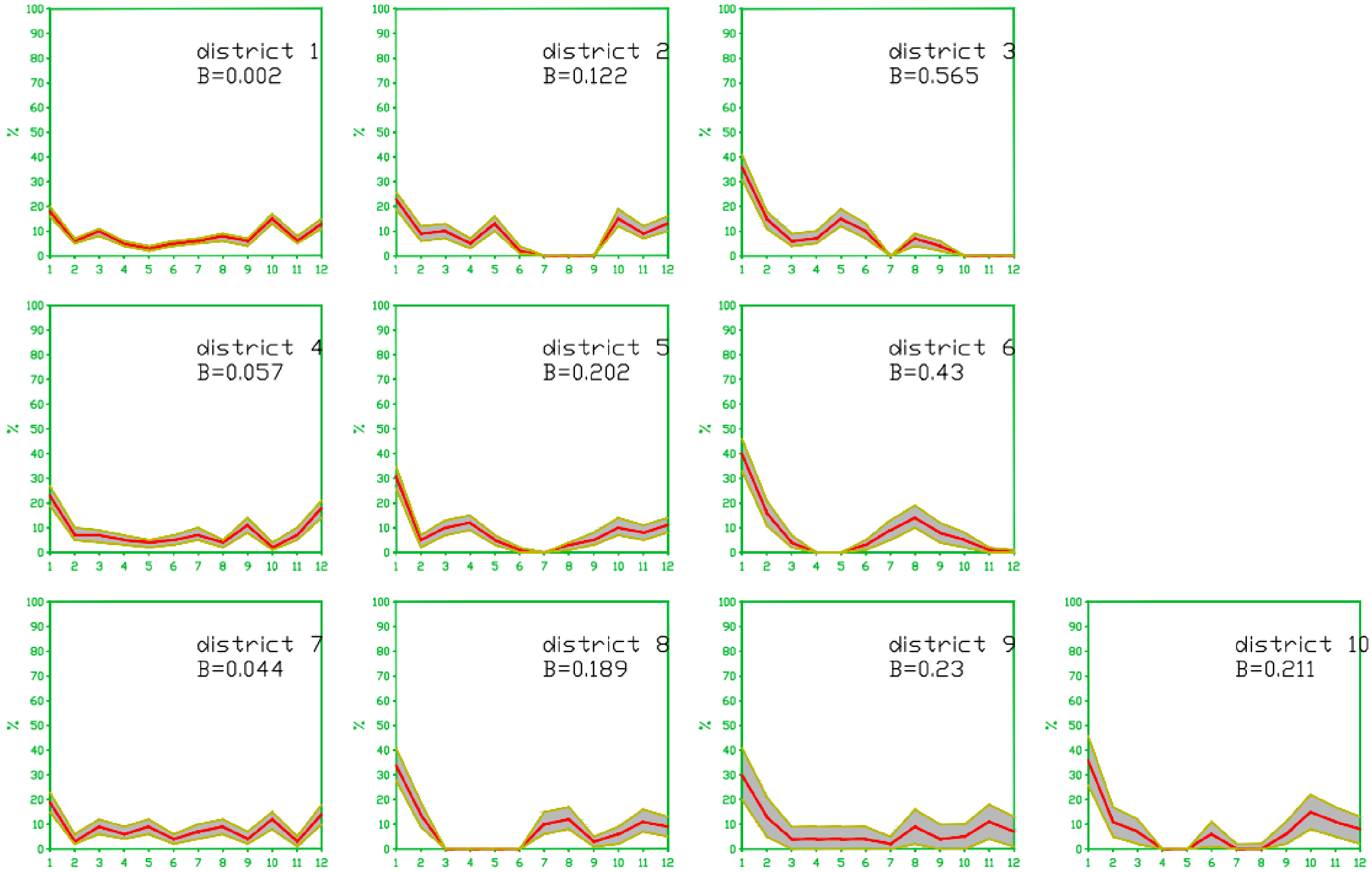

Figure 3.7.1 The Centralization Plots in the Stonework Era

Table 3.7.1 Centralization Analysis in the Stonework Era

Stonework Era Centralization Analysis												
District 1												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	155	53	83	44	23	44	52	67	48	129	55	109
population (min)	2790	954	1497	801	409	799	932	1200	872	2321	986	1956
population (max)	3255	1113	1746	934	477	932	1087	1400	1018	2708	1150	2282
%	17.98%	6.15%	9.65%	5.16%	2.64%	5.15%	6.00%	7.73%	5.62%	14.96%	6.35%	12.60%
Cum %	17.98%	24.13%	33.78%	38.94%	41.57%	46.72%	52.73%	60.46%	66.08%	81.04%	87.40%	100.00%
B=	0.002		sum(households)		862							
District 2												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	71	29	32	17	41	8	0	0	0	48	30	41
population (min)	1276	515	571	304	732	135	0	0	0	864	540	738
population (max)	1489	601	666	355	853	158	0	0	0	1008	630	861
%	22.49%	9.07%	10.06%	5.36%	12.89%	2.38%	0.00%	0.00%	0.00%	15.23%	9.52%	13.01%
Cum %	22.49%	31.56%	41.61%	46.98%	59.87%	62.25%	62.25%	62.25%	62.25%	77.48%	86.99%	100.00%
B=	0.120		sum(households)		315							
District 3												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	92	38	16	19	40	26	0	18	10	0	0	0
population (min)	1659	683	284	345	711	462	0	320	178	0	0	0
population (max)	1935	797	331	402	830	539	0	373	207	0	0	0
%	35.73%	14.72%	6.11%	7.43%	15.32%	9.96%	0.00%	6.90%	3.83%	0.00%	0.00%	0.00%
Cum %	35.73%	50.45%	56.56%	63.99%	79.31%	89.27%	89.27%	96.17%	100.00%	100.00%	100.00%	100.00%
B=	0.565		sum(households)		258							
District 4												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	75	24	22	17	12	17	24	12	36	7	24	57
population (min)	1358	437	391	305	220	309	440	209	652	129	424	1034

population (max)	1585	510	456	356	257	361	513	244	761	151	495	1206
%	22.99%	7.39%	6.62%	5.17%	3.72%	5.23%	7.44%	3.53%	11.04%	2.19%	7.18%	17.49%
Cum %	22.99%	30.38%	37.00%	42.17%	45.89%	51.12%	58.56%	62.10%	73.14%	75.33%	82.51%	100.00%
B=	0.057		sum(households)		328							
District 5												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	75	11	25	29	12	2	0	6	13	25	19	27
population (min)	1348	206	443	530	213	36	0	111	242	459	347	489
population (max)	1572	240	517	618	249	41	0	130	283	535	405	570
%	30.47%	4.65%	10.01%	11.98%	4.82%	0.80%	0.00%	2.51%	5.47%	10.37%	7.85%	11.05%
Cum %	30.47%	35.12%	45.13%	57.11%	61.93%	62.74%	62.74%	65.25%	70.72%	81.09%	88.95%	100.00%
B=	0.202		sum		246							
District 6												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	59	23	6	0	0	4	13	21	12	8	1	1
population (min)	1058	418	115	0	0	78	240	376	214	136	17	12
population (max)	1234	488	134	0	0	91	280	438	250	159	20	14
%	39.71%	15.70%	4.31%	0.00%	0.00%	2.93%	8.99%	14.11%	8.04%	5.11%	0.66%	0.44%
Cum %	39.71%	55.41%	59.72%	59.72%	59.72%	62.65%	71.65%	85.75%	93.80%	98.91%	99.56%	100.00%
B=	0.430		sum(households)		148							
District 7												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	44	10	20	15	21	10	16	22	10	28	8	33
population (min)	797	185	369	270	375	178	295	393	185	499	137	589
population (max)	929	216	430	315	438	207	344	458	216	582	160	688
%	18.65%	4.33%	8.63%	6.33%	8.78%	4.16%	6.90%	9.20%	4.34%	11.68%	3.20%	13.80%
Cum %	18.65%	22.98%	31.61%	37.94%	46.72%	50.87%	57.78%	66.97%	71.32%	83.00%	86.20%	100.00%
B=	0.044		sum(households)		237							
District 8												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	47	20	0	0	0	0	14	17	4	8	16	12

population (min)	854	356	0	0	0	0	257	301	75	142	285	213
population (max)	996	415	0	0	0	0	300	351	87	166	332	249
%	34.39%	14.33%	0.00%	0.00%	0.00%	0.00%	10.37%	12.12%	3.00%	5.73%	11.46%	8.60%
Cum %	34.39%	48.72%	48.72%	48.72%	48.72%	48.72%	59.08%	71.20%	74.21%	79.94%	91.40%	100.00%
B=	0.189		sum(households)		138							
District 9												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	15	7	2	2	2	2	1	4	2	3	6	3
population (min)	275	117	40	40	40	40	20	80	44	48	101	63
population (max)	321	137	47	47	47	47	23	93	51	56	118	73
%	30.28%	12.89%	4.41%	4.41%	4.41%	4.41%	2.21%	8.82%	4.84%	5.28%	11.15%	6.89%
Cum %	30.28%	43.17%	47.58%	51.99%	56.40%	60.81%	63.02%	71.84%	76.68%	81.96%	93.11%	100.00%
B=	0.231		sum(households)		50							
District 10												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	24	7	5	0	0	4	0	0	4	10	7	5
population (min)	441	132	86	0	0	74	5	5	76	178	131	95
population (max)	514	154	101	0	0	86	6	6	89	207	153	111
%	36.04%	10.77%	7.05%	0.00%	0.00%	6.05%	0.42%	0.42%	6.24%	14.54%	10.69%	7.78%
Cum %	36.04%	46.81%	53.86%	53.86%	53.86%	59.92%	60.33%	60.75%	66.99%	81.53%	92.22%	100.00%
B=	0.211		sum(households)		68							
The entire island												
Circle	1	2	3	4	5	6	7	8	9	10	11	12
Households	616	372	339	102	135	213	127	217	80	157	135	211
population (min)	11092	6691	6097	1834	2436	3828	2292	3904	1433	2821	2435	3797
population (max)	12940	7806	7113	2139	2842	4466	2674	4554	1671	3291	2841	4430
%	22.80%	13.75%	12.53%	3.77%	5.01%	7.87%	4.71%	8.02%	2.94%	5.80%	5.00%	7.80%
Cum %	22.80%	36.55%	49.08%	52.84%	57.85%	65.72%	70.43%	78.45%	81.39%	87.19%	92.20%	100.00%
B=	0.263		sum(households)		2703							

3.8 Summary

The demographic reconstruction for the Terrace Era and the Stonework Era reveals a very complicated relationship between population growth and social change on Babeldaob. Population levels increased by a factor of at least three and very likely seven from the Terrace Era to the Stonework Era, yet the degree of centralization declined in most of the supra-local communities in the Stonework Era. It looks like demographic growth did not drive regional integration, but instead led to the social fragmentation. Demographic growth is often seen as a major force behind the development of regional integration or at least an important part of the picture. However, the observed pattern seems to run counter-to this, so we need to evaluate how the population growth might have occurred at the community level both from archaeological evidence and ethnographic accounts to better unpack it.

3.8.1 **Population Growth and Settlement Dispersal**

One prominent characteristic of community structure in both the Terrace Era and the Stonework Era is the absence of compact towns with high residential densities in any of the supra-local communities, although demographic hills and valleys on the landscape. The nature of the centripetal forces in the Terrace Era involves socio-political alliances between the farmsteads. For the supra-local communities with stronger centralization, population was usually drawn toward one large terrace site with defensive structures, such as a large crown or a series of step terraces and ditches, usually situated on high elevation overlooking the landscape. A lot of smaller terrace sites were placed next to the large one, forming a big cluster of terrace system on the landscape of the supra-local community. Most of them are visible from each other. It is likely that they formed socio-political alliances and protected one another in time of war and helped each other to maintain the terrace fields in peace time. For the supra-local communities with weaker centralization, the nature of the center is the same, except the alliances were relatively weak and the sizes of their networks were small. Sometimes there were clear subdivisions within the supra-local communities.

In the Stonework Era, with a rapid population growth and the emergence of the big supra-local community the north end of the island, households were still very persistent in their dispersal, strongly resisting crowding into compact towns with fields around them. Households closer to the center of the supra-local community constructed more public facilities than households who lived far from the center. Public facilities include the stone pathways between households, docks, canoe houses, casual social places (iluid), meeting houses and taro patches. But the public facilities were not concentrated in the bounded area. They became the nodes that linked households. Some households surrounded the meeting house; some households surrounded one big household; some households encircled a plaza area on the built terrace. Moreover, some smaller centers appear at the periphery of the supra-local community, where the nature of the interaction is the same. In sum, the population growth from the Terrace Era to the Stonework Era did not result in the formation of a big town, but a blooming number of small social clubs in the big center and small centers within the supra-local communities.

3.8.2 **Imagined Community vs Interaction Community**

The community pattern reconstructed from the archaeological evidence contrast with ethnography by Kubary (1895) and Kramer (1919) in the late 19th century and early 20th century, as well as by Parmentier (1987) in the 1970s. Unlike the vagueness of local community boundaries based on archaeological evidence, ethnographic records emphasized clearly defined local communities. Kubary counted 70 villages in 1872; Kramer counted 253 villages, 84 of which were inhabited. Parmentier discussed fluidity in the concept of village in the ethnographic accounts. A village is not homogeneous spatial entity, but an entity of political jurisdiction or economic cooperation (Parmentier 1983:59). In fact the Palauan word for village is *beluu*, ranging in meaning from land, soil, earth to inhabited area, residential unit and political division. It has various spatial forms, which was built into the place names, such as "path"(rael), "cornerpost"(saus), "side"(bitang) and graded continuum of "large"/"small"(klou/kekere). It was not static, and its boundary was marked by roads and stones, which can be changed by events, negotiation and conflicts. To some degree the concept of village defined by the ethnographic accounts is an imagined community constructed in competing discourses--dynamic, contingent and contradictory (Anderson 1983). These communities might not have daily interaction, yet they share knowledge, goals and sentiments.

In contrast, the local communities delineated according to the density of archaeological remains follow the distance-interaction principle. People who belong to the same local communities were distributed close enough to have daily interaction. The interaction communities do not necessarily shared knowledge, goals and sentiments. The villages that are recognized by ethnographic accounts crosscut the interaction communities identified by the density of archaeological remains (Isbell 2000). According to ethnographic accounts in Palau, the village is their political affiliation, constructed by collective action. The center of a village is the meeting house (*bai*), which is the property of the men's club (*kaldebekel*). The men's club was made up of all the men in the village. The men's club made socio-political decisions for the village, such as building communal projects (stone pathways, bai, docks, walls, etc), waging wars and collecting Palauan money (Kramer 2017[1926]: 272). These activities that are central to the village do not require daily interaction. This is why we are not able to delineate the boundaries of "villages" according to the density of archaeological remains, because their interaction is relatively diffuse and infrequent.

The two concepts of community based on archaeological reconstruction and ethnographic records can also help explain the differences in centralization of the regional polities in the history of Palau. The ethnographic accounts emphasize the dominance of capital villages (center) in the regional polities and the emergence of paramount chiefs in these polities (Parmentier 1987:59-61). Ideally all the member villages in the regional polities submitted their political decisions to the capital village, and under the leadership of the paramount chief. Ethnographic accounts reflect a process of group-identity formation rather than internal structure of regional polities. Oral history itself also shows the fluidity of power dynamics inside these regional polities. In some accounts, member villages allied with another capital village to fight against the capital village of their own districts. There was competition between the capital village and its member villages. It is possible that ethnographic accounts may overstate the level of political integration because oral tradition is also a means to establish political control and authority. More importantly, the ethnographic accounts reflect the promotion of regional polities (a form of group identity) through political negotiation, warfare between groups and construction of public goods. The archaeological evidence also suggests the clear existence of supra-local communities and increased size of supra-local communities, although the degree of centralization is relatively weak within supra-local communities.

3.8.3 **Compare Community Structure with Other Early Complex Societies**

The persistent settlement dispersal and yet growing regional population in the Palau trajectory sounds like the intensified agrarian mode of settlement in many semitropical and tropical regions, such as the Classic Maya (Drennan 1988), the Rio Tonosi valley of Pacific Panama (Berrey 2015), and other contexts of low-density urbanism (Flether 2012, Scarborough and Lucero 2010). They all create settlements of highly varied size and forms, characterized by low density occupation spread over vast areas. There is no centralized town or city that dominates the entire region like other complex societies. Intensive cultivation is a response to the growing population.

However, household spacing varies considerably in these low density complex societies. For instance, In the Rio Tonosi valley, households have relatively similar areas of land (about 0.5-1 ha) surrounding their residences. Comparatively, Maya farmers had a wider range of agricultural plots, ranging from 0.25 ha to 4.5 ha (Lemonnier and Vanneire 2013). The reasons behind this may involve the different modes of intensification, that is responding to the specific regional environment. In the Rio Tonosi valley, the agricultural soil is very productive, and annual rainfall is abundant and stable. Agricultural intensification does not involve intensively transforming the landscape, building irrigation systems and water management. In this case, households do not require cooperation from one another (Berrey 2015). In contrast, Maya farmers were located in a landscape of poor drainage, which requires intensive water management for farming. Diverse strategies depending on the local environment, required some level of cooperative activities between households (Scarborough and Lucero 2010). The organizational differences can also be responses to other inter-household dynamics, such as kinship systems or unequal relationships between households. For instance, for the Classic Maya, the area of agricultural land corresponds to other architectural signals such as the status of the households (Lemonnier and Vanneire 2013); in the Rio Tonosi, there is little evidence to show prestige differentiation according to the mortuary evidence (Berrey 2015).

Household spacing also has a wide range in the Stonework Era villages of Palau, which make it more similar to the Maya than the Rio Tonosi. Some households are relatively isolated with more than 100 m to their nearest neighbor, whereas some households form small clusters at closer distances (less than 20m). Moreover, most households were connected by stone pathways and shared other public facilities even though they were set apart from each other. Like the Maya, agricultural productivity in Palau is also limited by the narrow river valleys and poor drainage, which potentially requires more interhousehold economic cooperation. The ethnographic accounts also suggest the existence of matrilineal interhousehold economic networks. The high-ranking households (called blai) also organized socio-economic events through the matrilineal network (called kebliil). The affiliated households contributed food, labor and money to the high-ranking households, where the gathering and exchange often happened (Kramer 2017[1926]:123). Compared to the men's club at the regional level, the matrilineal network is more localized and responsible for coordinating the subsistence economy on a daily basis. This hints at the possibility of local-scale productive differentiation and economic which will be evaluated in the following chapters.

3.8.4 **Expected Organizational Patterns**

Our working hypothesis comes from the comparison of four societies in Remote Oceania. It involves a dynamic relationship between the *agricultural productivity*, *community structure* and *productive differentiation*. These three elements are social forces that shape the forms and degrees of unequal relationships and eventually produce different social trajectories. In this chapter, we reconstructed both regional and local community structure from the archaeological remains. According to the working hypothesis, this revealed puzzle implemented expectations of two other elements in the prehistoric societies of Palau.

In the trajectory of Palau, population witnessed a rapid growth, in terms of both the entire island population and the populations of supra-local communities, yet the centers of the supra-local communities still appeared to be a collection of villages with significant areas of agricultural fields. This means farming was a very important part of people's lives rather than interaction with one another. The increase in agricultural activities was also supported by the zooarchaeological research. The faunal evidence on Orrak island (1km southeast of Babeldaob Island) suggests that fishing have declined significantly from the Terrace Era to the Stonework Era. Yet it was not due to overfishing, which is often marked by diet-breadth expansion, increased taxonomic richness, a switch to offshore fishing or decreasing prey body size. The archaeological evidences caused by the anthropogenic depression of marine resources was not detected in the Stonework Era (Fitzpatrick and Kataoka 2005; Fitzpatrick et al. 2011; Giovas et al.2010; Giovas et al. 2015). The decline in fishing activities is likely caused by the growing investment in taro cultivation, which was facilitated by the construction of pondfield irrigation in the Stonework Era. According to our hypothesis, we will expect to see denser population on or adjacent to the more productive land. Or people will be close by the places where they can transform the landscape and create the productive land for farming. The places that are ideal for farmland transformation are distributed beside the mangrove swamp, because mangroves have positive effects on trapping sediments from the upland erosion and provide ongoing nutrition for the soil (Fitzpatrick and Giovas 2021).

On the other hand, the narrow river valleys on Babeldaob Island limits the capable resources for farming. Most of population is distributed along the coast and few people live in the inland river valley. People in the Terrace Era were distributed more inland compared to the Stonework Era, yet most of settlements were less than 1km away from the coastline. In the Stonework Era, most of settlements were less than 500m away from coastline. For both periods, no substantial occupation occurred in the central mountainous area. Moreover, faunal evidence on Orrak Island and Ulong Island and ethnographic records suggest that the marine economy has always been an important component of Palauan subsistence. The faunal record, for example, is composed of assemblages dominated by mollusks and inshore fish. Although the decline in fishing happened in the Stonework Era, the growing reliance on collecting shellfish made up the protein shortfall. (Clark 2004; Clark et al. 2006; Fitzpatrick et al. 2011; Fitzpatrick and Giovas 2021; Johannes 1981; Ono and Clark 2012). Limited farming resources also restricted pig husbandry and eventually caused the extirpation of pigs (Clark et al.2013; Giovas 2006), which were a very important protein source and a symbol for social prestige in Polynesia (Dye 2014; Kirch and O'day 2013).

The mixed subsistence economy would have promoted productive differentiation in the subsistence arena because of the varieties of different subsistence pursuits especially in the Stonework Era, when household spacing was reduced between some households. We might expect to see households produced different kinds of utilitarian goods and tools so that they can be more specialized in their subsistence pursuits and thus create economies of scale. The construction of pondfield irrigation in the Stonework Era is also likely to create more opportunities for economic collaboration, which might potentially reduce economic self-surfficiency of households even in dispersed communities.

On the regional scale, we will also expect to see social factors other than the environmental factors attract population to concentrate and form supra-local communities because of the limited farmland. There will be other centripetal forces than the productive farmland to attract population to move into the regional polities. We can see a growing size of supra-local communities from the Terrace Era to the Stonework Era, but at the same time, the internal structure of these supra-local communities is loose. We can look more closely at district 1, the largest supra-local community in the Stonework Era and four times larger than the other supra-local communities. What centripetal forces create supra-local communities? From the architectural evidence, there are no unusual monuments, palaces or other costly signals in the center of district 1 besides the same meeting houses, stone pathways, docks and resting places that are elsewhere on the Babeldaob island. I suspect the centripetal force is the ability to organize the cooperative labor and exchange networks through building public works, rituals, feasting, etc (Stanish 2004; Stanish 2009). Like other low-density urban neighborhoods, district 1 may have been created through the bottom-up processes of social interaction between neighbors. Social gatherings often occur at a small scale in different sectors of a supra-local community (Smith 2011). Therefore, it is harder for archaeologists to notice their existence at first glance without spectacular architecture. We need to study domestic activities in order to understand their nature. We will evaluate the nature of interhousehold labor organization through household artifact assemblages in chapter 5.

4.0 The Relationship Between Demographic Structure and Resource Distribution

4.1 Rank Order Correlation between Occupation and Agricultural Resources

This chapter investigates the relationship between the *demographic distribution* and *agricultural productivity* on Babeldaob Island. Babeldaob Island is a volcanic island of 330km². It is the largest island of Palau, and accounts for 80% of the land area in the Palau archipelago. According to the regional demographic reconstruction (chapter 3), the population on the Babeldaob Island in the Stonework Era was around 60,000 people. This is much higher than the today's population on Babeldaob, which is around 6000 people. This situation is a product of colonial influence on the socio-political dynamics of the Palau archipelago, since Koror Island (the small volcanic island south of Babeldaob Island) became the center of administration and economic activities. Yet in prehistory, Babeldaob Island was the hub of community development.

Agricultural productivity is of course closely associated with the agricultural practices. For the two periods we focus on in this dissertation, a shift in the agricultural practices is indicated by pollen study. The pollen diagram of 15 wetland cores shows a pattern of savanna/grassland formation and retreat. Athens (2005) suggested that this corresponds to subsistence practices in the Terrace Era and the Stonework Era. Swidden agriculture dominated in the Terrace Era, resulting in the expansion of savanna in the uplands; whereas agroforestry and pondfield agriculture dominated in the Stonework Era, resulting in the regeneration of forest in the uplands. This doesn't imply that people in the Stonework Era abandoned swidden. The hypothesis is that swidden caused the erosion of upland sediment and formed the hydromorphic soil in the lowlands, which was suitable for swamp taro cultivation. On the other hand the loss of nutrients in the uplands reduced the swiddens and promoted pondfields.

The clearest settlement pattern feature in the Terrace Era and Stonework Era is its dispersed nature, in which households have chosen to locate their residences near or directly on the land that they farm. Such a close spatial association between residence patterns and farming patterns makes us expect to see denser population on the more productive land, especially for the Stonework Era. When the population grows, the societies become even more fragmented with a very low degree of centralization in most of the regional polities. This suggests that agricultural intensification and the control of land might be the most important in the Stonework Era, a hypothesis that will be tested in the data analysis of this chapter. This chapter specifically focused on answering the question: to what extent did the natural distribution of agricultural land influenced the evolution of the regional demographic distribution?

To assess the role of agricultural productivity in settlement location decisions, it is important to see how it influenced occupation patterns at various scales. At the archipelago scale, environmental conditions were clearly a factor in determining settlement pattern before the colonial period. Most of population lived on Babeldaob Island before colonial contact, where the terrestrial resources are much more diverse than the other islands in the Palau archipelago. However, the role of agricultural productivity becomes much less clear as we decrease the scale of analysis to the Babeldaob Island, the supra-local communities, or the daily catchment zone of a household.

The first analysis examines the correlation between population density and agricultural productivity of the soil on the scale of Babeldaob Island. This approach is based on the delineation of soilscapes, conducted by the USDA (United States Department of Agriculture) and NRCS

(Natural Resources Conservation Service) in 2009 (USDA and NRCS, 2009). Babeldaob Island contains 55 soilscapes based on characteristics of the soils and landscape. I focused on six variables related to agricultural productivity from the attributes in these studies. These six variables are water availability, nutrients, oxygen availability, effective depth, resistance to erosion, and shrink-swell potential. Each variable is rated in the original dataset according to the interpretation of the researchers. To give overall rankings of the agricultural productivity for all the soilscapes, I assigned numeric values to each variable according to this interpretive rating system in table 4.1.1.

Table 4.1.1 Agricultural Productivity of Soilscapes

Soilscape	Water Availability	Nutrient Availability	Oxygen Availability	Effective Depth	Resistance to erosion	Shrink-swell potential	Productivity including wetland agriculture	Dryland agricultural productivity
600	9	3	5	4	11	3	3	3
601	9	3	5	4	11	3	3	3
602	9	3	5	4	10	3	2.5	2.5
603	9	3	5	4	9	3	2.5	2.5
604	9	1	5	4	9	3	1.5	1.5
605	9	3	5	4	9	3	2.5	2.5
606	9	1	5	4	10	3	1.5	1.5
607	9	3	5	4	7	3	2	2
608	9	3	5	4	9	3	2.5	2
609	9	3	5	4	9	3	2	2
610	9	3	5	4	6	3	1.5	1.5
611	9	3	5	4	9	3	2	2
612	9	2	5	4	11	3	1.5	1.5
613	9	2	5	4	10	3	1.5	1.5
614	6	2	5	4	7	3	1	1
615	8	5	1	5	8	4	2	1
616	10	5	1	5	12	4	3	1
617	8	5	1	5	8	4	2	1
618	10	5	1	5	12	4	3	1
619	6	4	5	3	7	3	1.5	1.5
620	9	1	5	5	6	3	1	1
621	9	1	5	5	5	3	1	1
622	2	1	4	5	4	1	0.5	0.5
623	2	1	4	5	2	1	0.5	0.5
624	3	1	4	5	4	1	0.5	0.5
625	3	1	4	5	4	1	0.5	0.5
626	3	1	4	5	3	1	0.5	0.5
627	3	1	5	5	2	1	0.5	0.5

628	1	5	3	5	12	4	1.5	1.5
630	10	4	2	5	12	4	3	1
631	7	5	1	5	11	4	2	1
632	5	4	5	1	1	4	1	1
633	1	4	5	1	1	4	1	1
634	5	4	5	1	1	4	1	1
635	6	2	5	5	11	3	1	1
636	6	2	5	5	10	3	1	1
637	6	2	5	5	7	2	1	1
638	6	1	5	5	6	2	1	1
639	6	2	5	5	5	3	1	1
640	6	2	5	5	11	3	1	1
641	6	2	5	5	10	3	1	1
642	6	1	5	5	7	3	1	1
643	6	2	5	5	6	2	1	1
644	6	1	5	5	5	3	1	1
647	1	5	5	2	1	4	1	1
648	3	1	2	5	4	1	0	0
649	3	1	2	4	4	1	0	0
650	4	1	2	5	4	1	0	0
651	3	1	2	4	3	1	0	0
652	4	1	2	5	3	1	0	0
653	9	1	5	5	5	3	1	1
654	9	1	5	5	9	3	1.5	1.5
659	6	2	5	3	7	3	1	1
660	5	2	5	1	1	4	0.5	0.5
661	1	2	5	1	1	4	0.5	0.5
	1-very high/high permeability low/very low water holding	1-very high/high aluminum saturation top soil and subsoil, low sum of base (below 25 meq)	1-well poorly drained, frequent/very frequent flooding, none/frequent ponding	1-very shallow depth class	1-very high/medium run-off class, very shallow depth class, 12-75, 30-50, >80degree slope	1-very high shrink-swell potential		

	2-very low permeability very high water holding	2-moderate aluminum topsoil very high/moderate subsoil, low sum of base (below 25 meq)	2-somewhat poorly drained, frequent/none flooding, none/occasional ponding	2-shallow depth class	2-very high run-off class, very deep depth class, 12-50 slope	2-high shrink-swell potential		
	3-low permeability very high water holding	3-low aluminum topsoil very high subsoil, low sum of base (below 25meq)	3-some what excessively drained, none ponding, occasional flooding	3-moderate deep depth class	3-very high run-off class, very deep depth class, 12-30 degree slope	3-moderate shrink-swell potential		
	4-low permeability high water holding	4-low aluminum topsoil low/moderate subsoil and high sum of base	4-moderately well drained, none ponding and flooding	4- very deep but has certain distance to the restrictive layer	4-very high run-off class, very deep depth class, lower than 20 degree	4-low shrink-swell potential		
	5-moderate high permeability very low water holding	5-0% aluminum topsoil and high sum of base	5-well drained	5-very deep	5-high run-off class, very deep, 30-75 degree slope			
	6-moderate high permeability low water holding				6-high run-off class, very deep, 20-50 degree slope			
	7-high permeability moderate water holding				7-high run-off class, very deep/moderate deep, 12-30 degree			

	8-high permeability high/very high water holding				8-high run-off class, very deep, 0-1 degree slope			
	9-moderate high permeability moderate water holding				9-medium run-off class, >30 degree slope			
	10-moderate high permeability very high water holding				10-medium run-off class, <30 degree slope			
					11-very low/low run-off class			
					12-neglegeble run-off class, <10 degree slope			

- Water availability and management

Water availability depends on precipitation, soil permeability and available water capacity. Since the precipitation is the same across all the soilscapes in Palau (about 3300-4650mm per year), we mainly consider soil permeability and available water capacity. Soil permeability is the ability of the soil to transmit water and air. Soil permeability was rated as very high(more than 36cm/hr), high (3.6-36cm/hr), moderately high (0.36-3.6cm/hr), low (0.0036-0.036 cm/hr) and very low (less than 0.0036 cm/hr). Available water capacity is an indicator of a soil's ability to retain water and make it available for plant use. Available water capacity was rated as very high (more than 30cm), high (25-30cm), moderate (15-20cm), low (5-15cm), and very low (0-5cm). If the soil has high permeability yet low water holding capacity, supplemental irrigation is needed during the dry season (December to April in Palau). If both values are high, the soil is productive in all seasons. If permeability is low and water capacity is high, even though the water is sufficient, the clay soil will hinder root penetration and nutrient flow. A value for water availability is assigned to all soilscapes according to the combinations of these two values, on a scale from 1 to 10. A rating of 7 or better means the soil does not need irrigation in the dry season. A rating below 6 means it needs irrigation in the dry season or to mix organic materials with the original clay soil.

- Nutrient availability

Nutrient availability depends on the acidity of the soil and its content of organic carbon, aluminum, potassium, phosphorus and bases generally. The sum of bases (the total amount of calcium, magnesium, sodium and potassium per 100 grams of soil) and the percentage of aluminum saturation are the indexes I chose for rating the extent to which it is suitable for growing crops. A rating of 1-2 means the soil has high aluminum and low pH (less than 5), as well as the sum of bases is below 25 meq/100g. These soils make the cultivation of crops very difficult unless farmers invest time to improve the soil quality. A rating of 3 and above means the soil is not acidic and has lower amounts of aluminum and sum of bases above 65 meq/100g. This soil is productive for a long term of cultivation.

- Oxygen availability

Soil oxygen availability has impacts on the root development in general. The factors that determine the oxygen availability are the hydraulic properties of the soils, including ponding, flooding, and drainage class. Well drained and moderately drained soil has no ponding or flooding effects. In comparison, the poor-drained soil has various effects of ponding and flooding. This variable is rated on a scale of 1 to 5, with 2 and below corresponding to poorly drained swampy soil, and 4 and above corresponding to well drained soil. The poorly drained soils only support wetland taro patches. The well-drained soil supports agroforestry and cultivation of other subsistence crops.

- Effective Depth

The effective depth of soil is the depth to which roots can grow without physical or chemical impediments, such as the water table, hardened soil layers, loose sand, or impermeable clays. This variable is rated on a scale of 1 to 5, with 2 and below corresponding to shallow soils, and 4 and above corresponding to deep soils. Shallow soils can still produce crops, but only deep soils can provide long term fertility.

- Resistance to Erosion

Soil erosion is the loss of soil along a slope or unsheltered space caused by the action of water and wind. Resistance to erosion depends on the effective depth of the soil, the slope and the hydraulic effect (mainly runoff class). This variable is rated on a scale of 1-12, with 1 representing extremely steep slopes, very shallow soil, and high runoff, where erosion and landslides are almost impossible to prevent, and 12 representing extremely gentle or no slope and very deep soil. Erosion has little immediate impact on agriculture on Babeldaob, but a rating of 6 and below means major limitation for long-term use.

- Shrink-swell potentials

Shrink-swell potential is the relative change in volume to be expected with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. A rating of 2 and below means soil has a high shrink-swell capacity, which can cause structural damage of soil and pull roots apart.

- Agricultural productivity

Agricultural productivity was assigned to each soilscape according to the numeric rating of each variable discussed above. The judgment focused especially on low scores for single variables instead of averaging ratings for all variables. Low scores (yellow cells in Table 4.1.1) for any variable except oxygen availability will create obstacles for long term use. Wetland taro can be cultivated in swamps, however, where the oxygen level is low. The soilscapes that are productive for pondfield agriculture are not suitable for dryland plants. Thus there are productivity rankings for exclusive swidden agriculture separate from the overall productivity for both swidden and pondfield on a scale from 0 to 3.

Soils rated 0-0.5 are not suitable for agriculture, because 4-5 out of 6 variables have low scores. The soilscapes that belong to this rank are the fluviomarine terraces on volcanic islands, which are extremely infertile for growing crops. Those rated 1-2 have major limitations for long term use primarily involving nutrient and water availability. They suffer from drought or flooding in the dry season and the wet season. They are also less resistant to the erosion because of the soil texture and steep slopes. Those rated 2.5 are suitable for producing crops on a long term basis, mostly on forested uplands with gentle slopes. Those rated 3 are the most productive soils both in uplands and bottom lands. Although the bottom land soils have low score of oxygen availability, they are productive for wetland taro cultivation if the pondfield irrigation system is practiced (Kirch 1994). The fertile upland soils are those under forest vegetation, which both provides the organic patterns for the crop, and protection from erosion.

- The distribution of good farmland

Swidden and pondfield agriculture involve different staples. Swidden agriculture produces a wide range of staples, including taros, yams, bananas, tapioca, and coconuts. Pondfield agriculture is limited to two kinds of swamp taros (*Cyrtosperma chamissonis* and *Colocasia esculenta*).

For swidden agriculture, the most productive soils (3) are located in narrow valley floors along the streams on the Babeldaob Island (soilscapes 600 and 601). These soilscapes are most fertile because they are covered by the dense forest vegetation, which helps regenerate nutrients and keeps water from evaporating quickly. They are also resistant to erosion because of the hydraulic effect and flat slopes. The second most productive soils (2.5) are in the central and southern uplands. These soilscapes are also very productive for dryland crops because they have higher levels of nutrients and better ability to retain the water. They are suitable for plant growth in both and dry seasons. But compared to soilscapes 600 and 601, they are less resistant to the erosion. Swidden agriculture will cause the loss of nutrients after in several years. (see Figure 4.1.1 for their distribution on the map).

For pondfield agriculture, the most productive soils are the swamps and flood plains on the valley floors (soilscapes 616, 618 and 630). They were formed of alluvial sediments or organic material over alluvial sediments derived from volcanic rocks. The sedimentary records suggest the formation of hydromorphic soils largely resulted from upland erosion around 2000-2500BP as some wetland core records provide clear illustration of a sudden influx of upland sediment on the top of wetland sediments (Athens and Ward 2005). Thus these soilscapes probably did not exist in the Terrace Era and they were formed by anthropogenic processes. The second most productive soils are mangrove swamps adjacent to the coast. They are less fertile because they suffer frequent sea water intrusion in the wet season. Sea water in taro patches is detrimental to the growth of taro, resulting in crop losses as high as 75-100 percent. It is necessary to build dikes to protect the taro patches (Rosario et al. 2015:74).

- The rank order correlation analysis

The rank-order correlation coefficients (Spearman's *r*) are measured to see the correlation between agricultural productivity and population density. If households choose their residence mainly according to the distribution of good farming resources, then the densest occupation should occur on or near the most productive soilscape and sparser occupation should occur on or near the less productive soilscapes.

For the Terrace Era, the soil ranks were on the basis of their potential for swidden agriculture. As we learned from the geological history, the hydromorphic soils had not yet been formed and people had not transformed the poorly drained area into productive soils. Therefore, all the poorly drained soils were ranked as low productivity. The measurement of population density includes both those living on the productive land and living adjacent to the productive land. The population density of those living on a soilscape is calculated as the estimated number of structures on each soilscape divided by the total area of that soilscape. The population density of those living near the soilscape is calculated as the area of a 100m buffer zone, a 200m buffer zone, a 500m buffer zone in each soilscape divided by the total area of that soilscape (see Table 4.1.2).

For the Stonework Era, the ranking systems incorporates the anthropogenic transformation of wetlands. The soil ranks were based on both their potential for swidden and pondfield agriculture. The population density was measured in the same way as the Terrace Era (see table 4.1.3). Since some of the productive soilscapes for pondfield agriculture were made artificially, the rating of productivity does not reflect the natural distribution of environmental resources but reflects the newly adopted pondfield agricultural activities. Thus the following correlation analysis for the wetlands reflects to what degree the new adopted pondfield agriculture determined population distribution.

All the indexes were converted into rank orders for the 55 soilscapes for each period. Then the rank order correlation coefficient between agricultural productivity and the four indexes of population density are calculated respectively for both periods in table 4.1.2 and table 4.1.3.

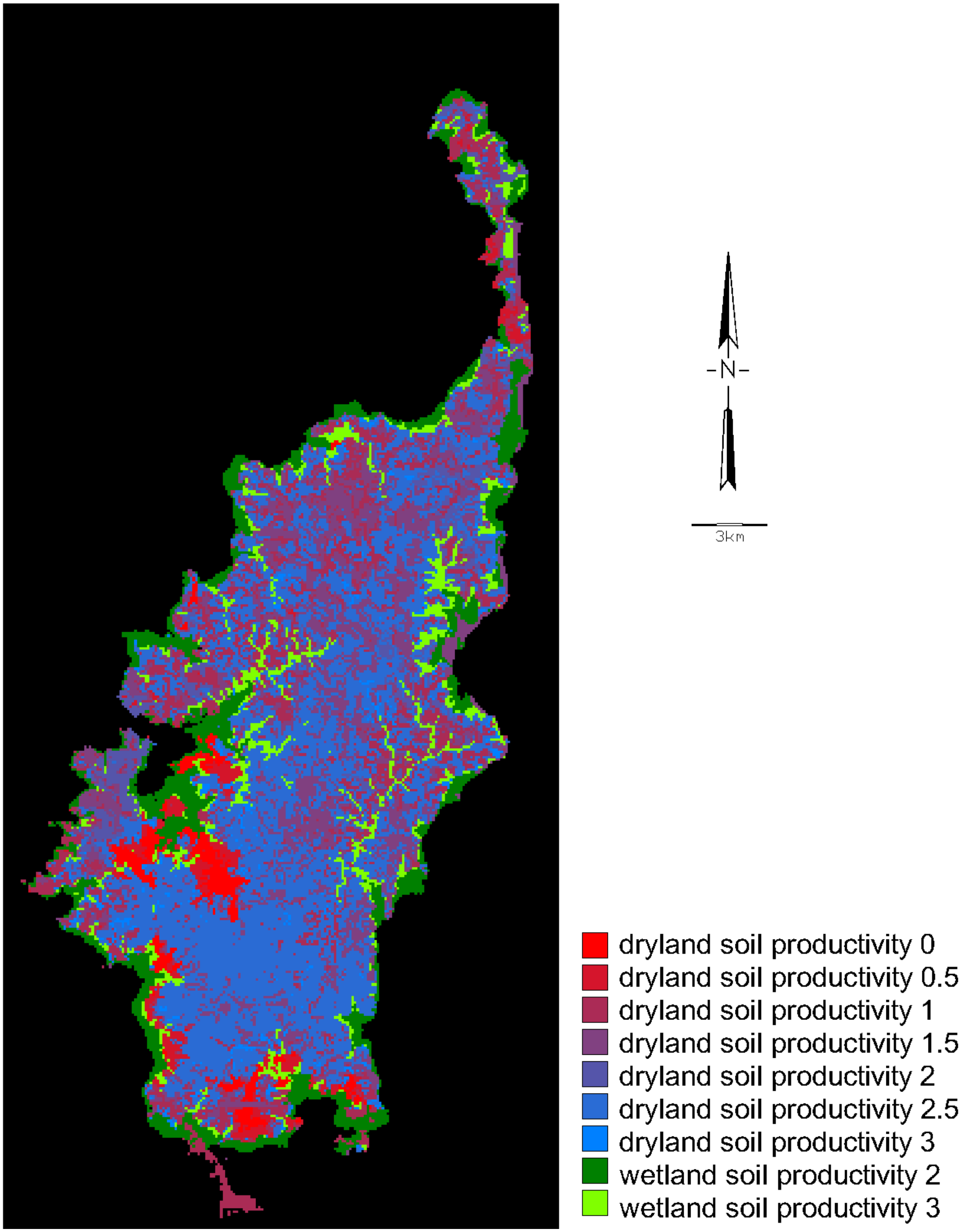

Figure 4.1.1 Distribution of Soils of Different Agricultural Productivity Ranks on Babeldaob Island

Table 4.1.2 Rank Order Correlation between Population Density and Agricultural Productivity in Terrace Era

Soilscape	Dryland productivity	Rank order	Area (km²)	Terrace structures per km²	Rank order	Terrace Era 100m buffer occupied ratio	Rank order	Terrace Era 200m buffer occupied ratio	Rank order	Terrace Era 500m buffer occupied ratio	Rank order
600	3	54.5	1	9	45	22.00%	45	36.00%	46	62.00%	43
601	3	54.5	5.51	3	30	11.98%	37	20.51%	36	41.38%	29
602	2.5	52	37.96	2	24	5.74%	21	10.19%	19	21.94%	12
603	2.5	52	83.47	2	23	4.96%	16	8.64%	14.5	19.30%	9
604	1.5	42.5	52.62	2	26	7.37%	27	11.95%	23.5	25.31%	16
605	2.5	52	0.07	0	4.5	0.00%	3.5	0.00%	2.5	28.57%	19
606	1.5	42.5	2.03	0	13	5.42%	19	9.36%	14.5	57.64%	40
607	2	48.5	7.78	3	34	14.65%	41	24.68%	41	55.01%	37
608	2	48.5	11.62	3	33	13.17%	39	23.67%	39	50.52%	33
609	2	48.5	4.81	8	43	21.83%	44	33.68%	45	64.03%	44
610	1.5	42.5	1.83	1	18	3.28%	13	9.29%	14.5	39.34%	28
611	2	48.5	5.45	1	19	5.14%	17	8.81%	14.5	23.12%	14
612	1.5	42.5	0.96	4	36	9.38%	34	12.50%	27	37.50%	26
613	1.5	42.5	5.43	3	35	9.02%	33	12.89%	27	22.10%	13
614	1	26	13.2	3	29	6.29%	25	9.77%	19	24.24%	15
615	1	26	0.19	0	4.5	0.00%	3.5	0.00%	2.5	0.00%	1
616	1	26	3.22	1	15	5.90%	23	18.32%	33	51.55%	36
617	1	26	39.27	0	9	2.39%	11	6.82%	12	35.60%	24
618	1	26	13.58	1	21	8.84%	32	20.03%	34.5	56.92%	39
619	1.5	42.5	1.19	1	17	2.52%	12	2.52%	9	16.81%	6
620	1	26	11.23	3	32	6.14%	24	10.33%	19	30.72%	21
621	1	26	1.94	3	31	10.31%	35	15.98%	32	29.90%	20
622	0.5	9.5	1.37	1	16	0.73%	9	1.46%	5.5	20.44%	10
623	0.5	9.5	0.64	5	37	7.81%	28	12.50%	27	18.75%	8
624	0.5	9.5	1.44	0	4.5	0.69%	8	3.47%	9	20.83%	11
625	0.5	9.5	1.52	1	20	5.26%	18	11.84%	23.5	27.63%	18
626	0.5	9.5	2.18	1	22	5.50%	20	12.39%	23.5	17.43%	7
627	0.5	9.5	1.01	2	27	7.92%	30	9.90%	19	44.55%	31
628	1.5	42.5	2.33	0	11	4.72%	15	12.02%	23.5	50.64%	34

630	1	26	6.39	0	12	6.42%	26	14.71%	30.5	45.38%	32
631	1	26	1.76	1	14	4.55%	14	19.89%	34.5	86.93%	53
632	1	26	1.76	6	40	12.50%	38	23.86%	39	51.14%	35
633	1	26	3.46	2	28	8.67%	31	15.32%	30.5	33.24%	23
634	1	26	1.7	8	44	18.82%	43	23.53%	39	58.24%	41
635	1	26	0.92	22	49	35.87%	49	45.65%	48.5	71.74%	48
636	1	26	2.88	24	50	45.14%	51	59.38%	51	81.94%	52
637	1	26	3.51	25	51	44.73%	50	54.99%	50	71.51%	47
638	1	26	2.16	29	54	65.28%	55	77.78%	55	93.06%	54
639	1	26	0.9	28	52	56.67%	53	68.89%	53	80.00%	50
640	1	26	0.18	11	47	22.22%	46	33.33%	44	61.11%	42
641	1	26	0.96	10	46	28.13%	47	39.58%	47	67.71%	46
642	1	26	2.38	13	48	35.29%	48	45.80%	48.5	64.29%	45
643	1	26	1.48	28	53	52.03%	52	63.51%	52	80.41%	51
644	1	26	0.23	43	55	65.22%	54	73.91%	54	100.00%	55
647	1	26	2.81	0	4.5	0.36%	7	1.07%	5.5	7.47%	3
648	0	3	2.41	0	10	2.07%	10	5.39%	11	31.12%	22
649	0	3	1.48	0	4.5	0.00%	3.5	2.70%	9	27.03%	17
650	0	3	2.36	0	4.5	0.00%	3.5	0.00%	2.5	14.83%	4
651	0	3	2.47	0	4.5	0.00%	3.5	0.00%	2.5	3.24%	2
652	0	3	0.65	0	4.5	0.00%	3.5	1.54%	7	15.38%	5
653	1	26	0.51	6	41	7.84%	29	13.73%	29	37.25%	25
654	1.5	42.5	1.55	2	25	5.81%	22	10.32%	19	43.87%	30
659	1	26	0.73	5	39	10.96%	36	21.92%	37	38.36%	27
660	0.5	9.5	1.11	5	38	18.02%	42	28.83%	42.5	73.87%	49
661	0.5	9.5	0.49	6	42	14.29%	40	28.57%	42.5	55.10%	38
				Spearman's *r*	0.17		0.198		0.154		0.159
				p	0.11		0.07		0.13		0.12

*This table calculates the Terrace Era population density for each soilscape and percentage of occupied area in the 100 m buffer zone, 200m buffer zone and 500m buffer zone. It also calculates the corresponding ranks. Then those number are used in the rank order correlation calculation.

Table 4.1.3 Rank Order Correlation between Population Density and Agricultural Productivity in Stonework Era

Soilscape	Productivity including wetland	Rank order	Area (km^2)	Stonework Era structures per km^2	Rank order	Stonework Era 100m buffer occupied ratio	Rank order	Stonework Era 200m buffer occupied ratio	Rank order	Stonework Era 500m buffer occupied ratio	Rank order
631	2	44.5	1.76	48	55	88.64%	55	96.02%	55	100.00%	55
628	1.5	37	2.33	30	52	55.36%	54	73.82%	54	95.71%	54
600	3	53	1	38	53	44.00%	53	48.00%	51	69.00%	42
641	1	23	0.96	27	50	32.29%	52	48.96%	52	81.25%	48
618	3	53	13.58	23	48	30.85%	51	40.21%	46	62.67%	38
635	1	23	0.92	14	39	29.35%	50	50.00%	53	88.04%	52
605	2.5	49	0.07	43	54	28.57%	49	28.57%	36	28.57%	18
616	3	53	3.22	18	46	27.95%	48	35.71%	43	53.11%	34
607	2	44.5	7.78	27	49	27.63%	47	33.68%	40	46.92%	31
606	1.5	37	2.03	29	51	26.60%	46	31.03%	37	39.90%	26
636	1	23	2.88	15	43	25.69%	45	44.44%	50	80.56%	46
609	2	44.5	4.81	17	45	23.91%	44	31.60%	38	45.32%	30
640	1	23	0.18	22	47	22.22%	43	33.33%	39	77.78%	45
643	1	23	1.48	15	42	21.62%	42	41.89%	47	85.81%	50
637	1	23	3.51	11	36	21.08%	41	36.75%	45	67.52%	41
642	1	23	2.38	7	26	19.75%	40	36.55%	44	63.45%	39
647	1	23	2.81	10	35	19.22%	39	34.88%	42	81.14%	47
601	3	53	5.51	17	44	18.69%	38	23.96%	33	41.56%	28
633	1	23	3.46	13	38	17.63%	37	28.32%	35	50.58%	32
638	1	23	2.16	8	29.5	17.59%	36	42.59%	48	82.87%	49
619	1.5	37	1.19	14	41	15.97%	35	19.33%	26	35.29%	24
630	3	53	6.39	12	37	15.02%	34	20.97%	29	40.06%	27
608	2.5	37	11.62	9	32	13.68%	33	19.79%	27	41.91%	29
660	0.5	9.5	1.11	5	21	12.61%	32	34.23%	41	90.09%	53
634	1	23	1.7	4	18	12.35%	31	27.06%	34	65.88%	40
661	0.5	9.5	0.49	8	28	12.24%	30	22.45%	30	73.47%	44
649	0	3	1.48	14	40	12.16%	29	15.54%	24	29.73%	21
625	0.5	9.5	1.52	10	34	11.18%	28	17.11%	25	38.16%	25
632	1	23	1.76	3	16	10.80%	27	23.86%	32	55.11%	36
654	1.5	37	1.55	6	23	10.32%	26	13.55%	21	24.52%	11
624	0.5	9.5	1.44	8	29.5	9.72%	25	10.42%	17	16.67%	4

617	2	44.5	39.27	2	13	9.65%	24	20.04%	28	55.05%	35
602	2.5	49	37.96	8	27	9.56%	23	13.70%	22	25.66%	14
648	0	3	2.41	10	33	8.71%	22	13.28%	20	31.95%	23
644	1	23	0.23	0	5.5	8.70%	21	43.48%	49	86.96%	51
612	1.5	37	0.96	9	31	7.29%	20	8.33%	13	29.17%	19
610	1.5	37	1.83	5	22	6.56%	19	10.93%	19	27.32%	17
604	1.5	37	52.62	4	19	6.23%	18	9.79%	16	24.57%	12
627	0.5	9.5	1.01	7	25	5.94%	17	10.89%	18	26.73%	16
603	2.5	49	83.47	4	20	5.76%	16	8.71%	14	20.22%	7
639	1	23	0.9	0	5.5	5.56%	15	23.33%	31	60.00%	37
613	1.5	37	5.43	3	17	5.16%	14	8.10%	12	24.31%	10
611	2	44.5	5.45	6	24	4.95%	13	9.72%	15	29.91%	22
653	1	23	0.51	0	5.5	3.92%	12	13.73%	23	25.49%	13
614	1	23	13.2	2	14	3.79%	11	6.29%	10	20.53%	8
626	0.5	9.5	2.18	3	15	3.67%	10	6.88%	11	16.06%	3
620	1	23	11.23	1	11	2.32%	9	5.34%	9	26.27%	15
650	0	3	2.36	0	5.5	0.85%	8	2.97%	6	22.03%	9
621	1	23	1.94	0	5.5	0.52%	7	3.09%	7	29.38%	20
651	0	3	2.47	0	5.5	0.40%	6	0.40%	3	7.69%	1.5
615	2	44.5	0.19	0	5.5	0.00%	3	5.26%	8	52.63%	33
622	0.5	9.5	1.37	0	5.5	0.00%	3	1.46%	4	19.71%	6
623	0.5	9.5	0.64	0	5.5	0.00%	3	0.00%	1.5	18.75%	5
652	0	3	0.65	0	5.5	0.00%	3	1.54%	5	7.69%	1.5
659	1	23	0.73	1	12	0.00%	3	0.00%	1.5	72.60%	43
				spearman's *r*	0.439		0.419		0.31		0.179
				p	0.001		0.001		0.002		0.096

* This table calculates the Stonework Era population density for each soilscape and percentage of occupied area in the 100 m buffer zone, 200m buffer zone and 500m buffer zone. It also calculates the corresponding ranks. Then those number are used in the rank order correlation calculation.

- Results of the rank-order correlation analysis

The results show that in the Terrace Era, the correlation between agricultural productivity and population density is weakly positive with moderate significance *(r_s=0.17, p=0.11)*. The correlation coefficient is slightly higher for the 100m buffer zone and the agricultural productivity (r_s=0.198, p=0.07) and lower for the 200m buffer zone (r_s=0.154, p=0.13) and the 500m buffer zone (r_s=0.159, p=0.12).

The pattern suggests that people distributed themselves across the landscape weakly according to dryland agricultural productivity. Much of this is attributable to the fact that ten soilscapes with the highest occupation densities are of low agricultural productivity (soilscapes 635-644, productivity of 1). These soilscapes on the infertile hillslopes have high acidity and aluminum, as well as low water capacity. In the modern times, these soilscapes are under a grassland-pandanus forest plant community (or savanna landscape). But surprisingly, a lot of terrace settlements were on or near these soilscapes. Many people choose to live on or near places where farming conditions were not good, even though most people farmed the land surrounding their residences. Why? Apparently not because of overpopulation on good land, since vacant fertile farmland for swidden agriculture on the Babeldaob Island. Likely human relationships played a more important role in the occupation patterns than resource distribution did. I elaborate the reasons in the next analysis.

In contrast, there is a stronger positive and highly significant rank-order correlation between agricultural productivity and population density in the Stonework Era (r_s=0.439, p=0.001). The correlation coefficient is almost the same between the 100m buffer zone and agricultural productivity (r_s=0.419, p=.001) and lower for the 200m buffer zone (r_s=0.31, p=0.002) and the 500m buffer zone (r_s=0.179, p=0.096).

The distribution of agricultural resources explains the occupational distribution of the Stonework Era much better than of the Terrace Era. The most productive soilscapes (600, 616, 618) have now become the soilscapes of higher occupation densities consistently for the residential locations and various buffer zones. The increase in correlation coefficient results from the adoption of pondfield irrigation. An increasing population lived on the soilscapes exclusive for the pondfield agriculture from nearly 0 to 20-40 structures/km^2 (see Table 4.1.2 for soilscape 616, 618, 631). The occupational rankings of these soilscapes are even higher in the 100m buffer zone (see Table 4.1.2 for soilscapes 616, 618, 631). People moved from the uplands where their farming suffered from soil depletion and erosion to the coast where the run-off sediments were trapped behind the mangrove forest. They built taro ponds from the run-off sediments, thus protecting the coral reef zone as well (Fitzpatrick and Giovas 2021). The newly adopted agricultural technology and intensification explains the low degree of centralization in all the supra-local communities. The construction of pondfields and agricultural innovation led people to interact more with the land and less with other people, thus creating a force of decentralization.

At the same time, the correlation coefficient is not super high in the Stonework Era. This also suggests even the weak centralizing forces of the supra-local communities prevent even stronger correlations between population and productivity. It is likely that the pondfield construction and the mixed economy of subsistence promoted economic collaboration and the emergence of local labor organizations. Farming is not the sole factor that determined people's settlement choice. I will evaluate other factors in the following analyses.

4.2 Land Distribution in the Supra-local Communities

The next analysis involves the same variables, analyzed by districts. I calculated the rank-order correlation coefficient (Spearman's *r*) between agricultural productivity and occupation density district by district (each case in the analysis was a district). If more people were attracted to the districts with more good farmland, we will see a high rank-order correlation; if not, we will see a low rank-order correlation.

In the Terrace Era, the rank-order correlation between agricultural productivity and occupation density of supra-local communities is negligible (r_s for good farmland ratio=0.1, p>0.5; r_s for good dry farmland ratio=0.067, p>0.5). This suggests supra-local communities that have dense populations did not usually encompass large amounts of good farmland. If we read the numbers in detail, on the one hand, district 1 and 2 are the districts with the 2nd and 3rd densest populations, but the index of the agricultural productivity ranks 8th and 9th out of nine districts; on the other hand district 7 with the densest population has the highest amount of good farmland compared to other districts. The centralization analysis (see chapter 3.6) helps explain this complicated result. Districts 1 and 2 have high centralization indexes (B=0.567), whereas district 7 has a low centralization index (B=-0.018). This suggests that supra-local communities with powerful centers attract population to landscapes with relatively poor farming conditions, and supra-local communities with weak centers attract people because of their fertile farmland. This divided principle makes the correlation between agricultural productivity and the population distribution weak.

I use district 2 and district 7 as our examples to illustrate the two principles. Figure 4.2.1, it shows that the occupation of district 2 settled on the soils of low productivity and next to small patches of the good dry farmland (soilscapes 607-608). The center of the district 2 includes a series of terrace complexes. It is on the high point of the ridge and overlooks the nearby landscape. The terrace complexes have the morphology of a defensive structure, including a steep sided crown, which is encircled by a deep ditch with other normal terraces placed next to the crown (Liston et al. 2007c: 171-175). In Figure 4.2.2, it seems like some people live directly on the good dry farmland, but there is a good proportion of people who live on unproductive land and next to good dry farmland (soilscapes 600-604). In both cases, both strong center and weak center of the supra-local communities sacrifice living directly on the fertile land for security and yet they still have access to the good dry farmland.

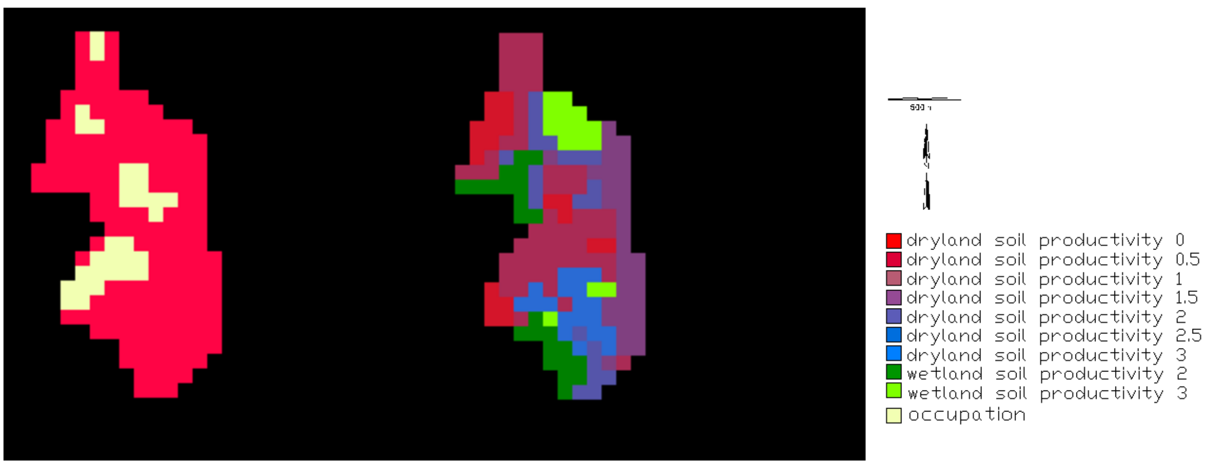

Figure 4.2.1 Occupational Distribution and Agricultural Productivity Distribution in District 2

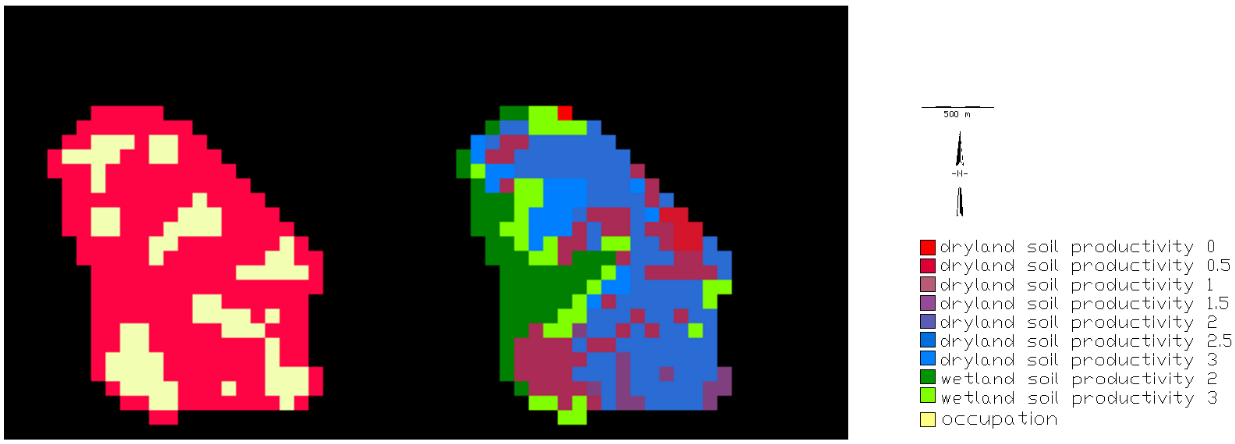

Figure 4.2.2 Occupational Distribution and Agricultural Productivity Distribution in District 7

In the Stonework Era, the rank-order correlation between agricultural productivity and occupation density of supra-local communities is also nearly neglected (r_s for good farmland ratio=-0.2, p=0.02; r_s for good wetland ratio=-0.042, p>0.5). This means that the supra-local communities that have dense populations do not have large amounts of good farmland. I singled out the wetland ratio here and do not see high population densities in wetland either. This result seems contradictory to the first analysis. Although individual households choose to settle on productive farmland, the strong regional polities does not own more productive farmland compared to other regional polities.

District 1 is the best example to explain this dynamic. According to the study of regional demography, district 1 is more than two times larger than the other districts in the Stonework Era, and almost of 30% of the total population on Babeldaob Island lived in that district. In contrast to the high occupation density, the total agricultural productivity ranks 8th out of 10 supra-local communities; the wetland productivity ranks 5th out of 10. This suggests that forces other than the agricultural productivity attract people to settle in the north end of the island. District 1 does not encompass the most productive farmland (for either wetland or dryland) compared to other districts on Babeldaob.

4.3 The Defensive Landscape

The pattern from prior analysis suggests that economic rationality did not explain the population distribution well in the Terrace Era. This was supported by the weak correlation between agricultural productivity and occupational density in the entire island analysis, as well as the supra-local community analysis. Therefore, we would like to explore what are the other factors that influence settlement choices in the Terrace Era. Consideration of other factors brings us to revisit the function of the terrace sites, which has been debated between scholars over the years. Some argued they are built for cultivating plants (Lucking 1984), some argued they are defensive structures (Liston and Tuggle 2006), some argued they are ritual facilities (Phear 2007). Each interpretation is based on detail from sites their opponents specifically worked on. In this chapter, instead of focusing single sites, we will look at the general pattern of landscape in the Terrace Era and the Stonework Era to evaluate the extent to which the conflicts between households impacted where people choose to live in the Terrace Era and the Stonework Era.

In societies where centralized authorities exist, fortifications will only appear in the capital of the region and at the border, because security is controlled by the center. On the contrary, in societies where the center is weak, fortifications are common for the majority of the settlements. When the integration is weak, wars are often the way that people solve problems (Arkush 2011:59-69). Wars often involve small numbers of people and occur at relatively high frequencies unless some other local mechanism helps them mitigate conflicts. Due to the frequency and the scale of warfare, the most common form of fortification is to utilize the landscape as part of the defensive system (Lau 2010, Roscoe 2008). Settling on hilltops is a very practical strategy, which can help warn of surprised attack and slow down the enemies' advance. To be able to recognize the hilltops of the landscape, we need to analyze the terrain based on the DEM (digital elevation model) map. The DEM map is a raster product assembled by the US geological survey with a resolution of 10m by 10m. I calculated Topographic Prominence Index (TPI) in the 500m×500m grid and the degree of slope based on the DEM map. The goal is to compare the characteristics of the terrain in which settlements of the Terrace Era and the Stonework Era are located.

Topographic Prominence Index was calculated by the following procedures. I made a 500m×500m DEM map from the original DEM (10m by 10m). Each new cell value was the mean of the previous values (250 previous cells in total for each new cell). I subtract this mean from the elevation value for the cell. Then I classify the relative elevation map into five categories. Category 1 is >30m below the mean elevation; Category 2 is 5-30m below the mean elevation; Category 3 ranges from 5m below to 5m above the mean elevation; Category 4 is 5-30m above the mean elevation; and Category 5 is >30m above the mean elevation.

Then a chi-square test evaluated how likely the Terrace Era sample and the Stonework Era sample (population proxy is the estimated number of structures) came from a population in which there was no preference for locating settlement in any particular environmental setting (see table 4.3.1). The difference between the observed population distribution and expected population distribution is very highly significant for both the Terrace Era (χ^2=100.65, p<0.001, *Cramer's V*=0.32) and the Stonework Era (χ^2=23.89, p<0.001, *Cramer's V*=0.09), although the difference was stronger for the Terrace Era than the Stonework Era. Specifically, the observed proportion of Category 2 (5-30 m lower than the mean elevation) on the basis of the Terrace Era sample was much less than we would expect (t=-6.36, p<0.001); whereas the proportion of Category 4(5-30m higher than the mean elevation) was much greater than we would expect (t=7.83, p<0.001). The results show clearly that the population in the Terrace Era favored the higher positions on the local landscape. In contrast, the population in the Stonework Era favored flat parts of the local landscape. The observed proportion of Category 5 (30m above the mean elevation) was much less than we would expect (t=-5.65, p<0.01) and the observed proportion of Category 3 (mean elevation) was greater than expected (t=1.87, 0.05<p<0.1).

Table 4.3.1 Terrace Era TPI and Hypothetical Test

	Topographic Prominence Index					
	30 m below the mean	30-5m below the mean	between -5 and 5 m	5m above the mean	30m above the mean	Totals
Expected population	2.92%	33.08%	30.19%	29.51%	4.30%	100.00 %
Terrace Era Exp.	29	327	298	292	42	988
Terrace Era Obs.	19	241	247	413	68	988
t test	-2.28	-6.36	-3.77	7.83	3.21	
p-level	0.05<*p*<0.02	*p*<0.001	*p*<0.001	*p*<0.001	0.001<*p*< 0.002	
Chi-square=100.65, df=5, P-level<0.001, Cramer's V=0.32						
Stonework Era Exp.	78	889	811	793	115	2686
Stonework Era Obs.	65	908	856	788	69	2686
t test	-1.68	0.79	1.87	-0.2	-5.65	
p-level	0.05<*p*<0.1	0.2<*p*<0.5	0.05<*p*<0.1	*p*>0.5	*P*<0.001	
Chi-square=23.89, df=5, p<0.001, Cramer's V=0.09						

Slope analysis is complementary approach for analyzing the terrain. I reduced the resolution of the DEM to 100 by 100m in order to create a meaningful slope image. Settlements that are located on steep slopes are more defensible than those located on the flat areas. I classified the slope into seven categories. Category 1 is 0-5 degrees, Category 2 is 5-10 degrees, Category 3 is 10-15 degrees, Category 4 is 15-20 degrees, Category 5 is 20-25 degrees, Category 6 is 25-30 degrees, Category 7 is above 30 degrees （see Figure 4.3.1). Then I calculated the proportion of the total population (population proxy is the estimated number of structures) in each of the categories.

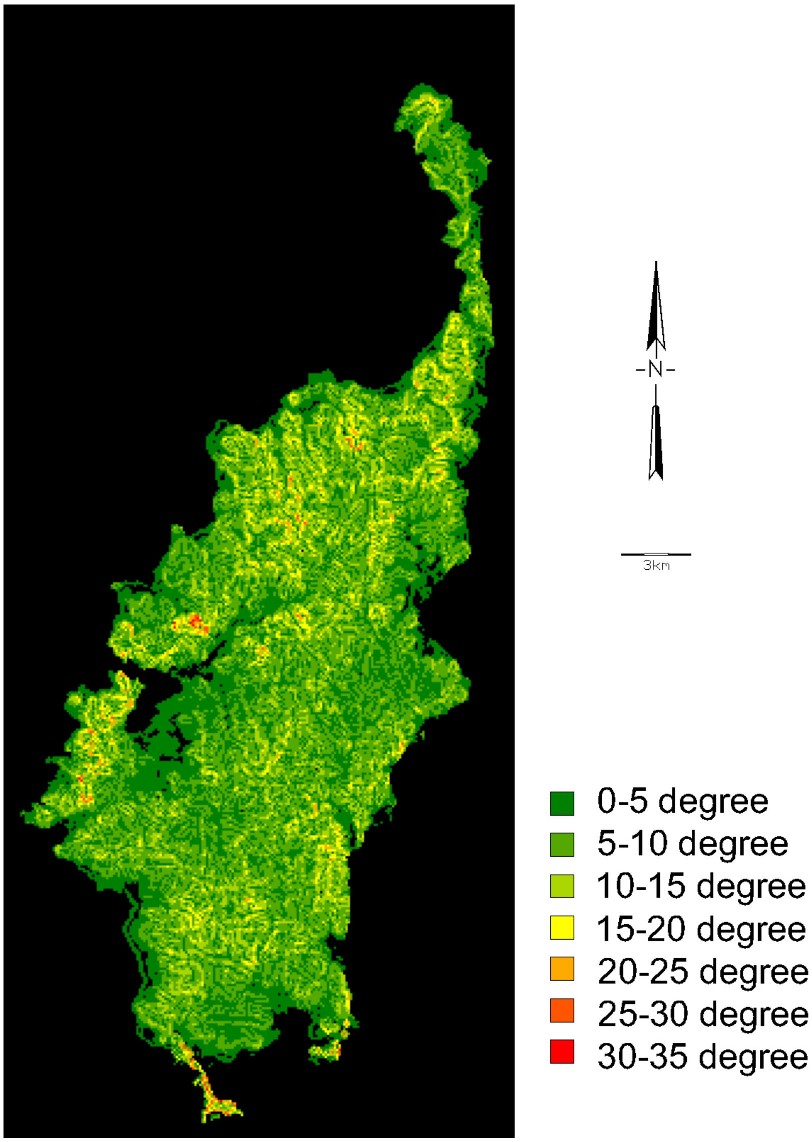

Figure 4.3.1 Slopes

Then I used the same Chi-Square test to see how likely the samples from the Terrace Era and the Stonework Era came from populations in which settlement was evenly distributed across slopes of different steepness (Table 4.3.2). The difference between the observed population distribution and the expected population distribution was very highly significant for both the

Terrace Era (χ^2=80.8, p<0.001, *Cramer's V*=0.29) and the Stonework Era (χ^2=28.14, p<0.001, *Cramer's V*=0.1), although the difference was stronger for the Terrace Era than the Stonework Era. Specifically, the observed population of flat land was much less than we would expect (t=-9.83, p<0.001); whereas the observed population of slopes of 5-10 degrees and 10-15 degrees was greater than expected. This result shows clearly that people in the Terrace Era preferred to settle on slopes of 5-15 degrees rather than on flat land. In contrast, the population in the Stonework Era favored the low slope of 5-10 degrees rather than steep slopes beyond 10 degrees.

Table 4.3.2 Hypothetical Test for Terrace Era Population Distribution on Slopes

	Slope							
	0-5 degrees	5-10 degrees	10-15 degrees	15-20 degrees	20-25 degrees	25-30 degrees	>30 degrees	total
Expected	37.48%	40.25%	16.92%	4.04%	0.93%	0.27%	0.11%	100.00%
Terrace Era Exp.	370	398	167	40	9	3	1	988
Terrace Era Obs.	239	485	212	44	7	1	0	988
t test (95% confidence)	-9.83	5.59	3.48	0.64	-0.83	-1.72	0	
p-level	*p*<0.001	*p*<0.001	*p*<0.001	*p*>0.5	0.5<*p*<0.2	0.05<*p*<0.1	Not applicable	
Chi-square=80.8, df=7, P-level<0.001, Cramer's V=0.29								
Stonework Era Exp.	1007	1081	454	108	25	7	3	2686
Stonework Era Obs.	1011	1147	422	78	19	3	6	2686
t test (95% confidence)	0.23	2.48	-1.74	-3.58	-1.46	-2.71	1.93	
p-level	*p*>0.5	0.01<*p*<0.02	0.02<*p*<0.05	*p*<0.001	0.05<*p*<0.1	0.002<*p*<0.005	0.02<*p*<0.05	
Chi-square=28.14, df=7, p-level<0.001, Cramer's V=0.1								

The results of both analyses show that households of the Terrace Era preferred to locate in areas of high elevation and slopes, which provides better defensibility. One may argue that the land on the relative high elevations and steep slopes is likely the good dry farmland. However, from the entire island analysis (chapter 4.1), we know the favored soilscapes (635-644) are not the best dryland fields; in the supra-local community analysis, we know the supra-local communities with the denser populations did not control the most productive dryland. This means a substantial proportion of people who lived on higher and steeper slopes did not live on or close to the productive farmland. Besides that, I also conducted an additional one sample t test to see the difference between the observed population and the expected population according to the percentage of good dry farmland in each category of topographic types (table 4.3.3). It is extremely unlikely that the observed preference for living on relatively high elevation is due to the distribution of good dry farmland, and it is not very likely that the observed preference to live on steep slopes (15-25 degrees) is due to the distribution of good dry farmland. The regional settlement pattern on the topographic types complements the detailed description of the Terrace Sites, painting the growing tension between neighbors in the Terrace Era. Liston and Tuggle (2006) argued that crowns (one type of terrace site) functioned as lookouts for the surrounding areas. There is also evidence of palisades surrounding the crowns, indicating that some of them were fortified. This means conflicts arose between households who lived in the same supra-local communities. The frequency of wars is high, so that people sacrificed their convenience for farming in order to defend their properties and lives.

In comparison, households of the Stonework Era preferred to settle on flat land which has obvious weakness in terms of defensibility. Conflicts between households are apparently less intensive, so that people could live on the flat land without worrying about the surprised attack. Liston and Tuggle (2006) suggest that the supra-local communities built their defensive system collectively. They cite the center of district 1 as an example. I made a map to show the arrangement of the defensive structures (see Figure 4.3.2). A 500 m causeway extending from north to south along the west coast and a 300m causeway extending from the shoreline to the reef at the east coast. In addition a stone wall was constructed along the coast as well as a 200 m stone pathway connecting the dock to the village. Most of the public defensive systems were distributed along the coast, which means enemies were not their neighbors within the supra-local communities, but from the different supra-local communities, who would attack them from the sea. It is also likely that the frequency of inter-polity war is low. Otherwise, we would see households living closer together instead of the dispersed patterns seen in the settlement analysis.

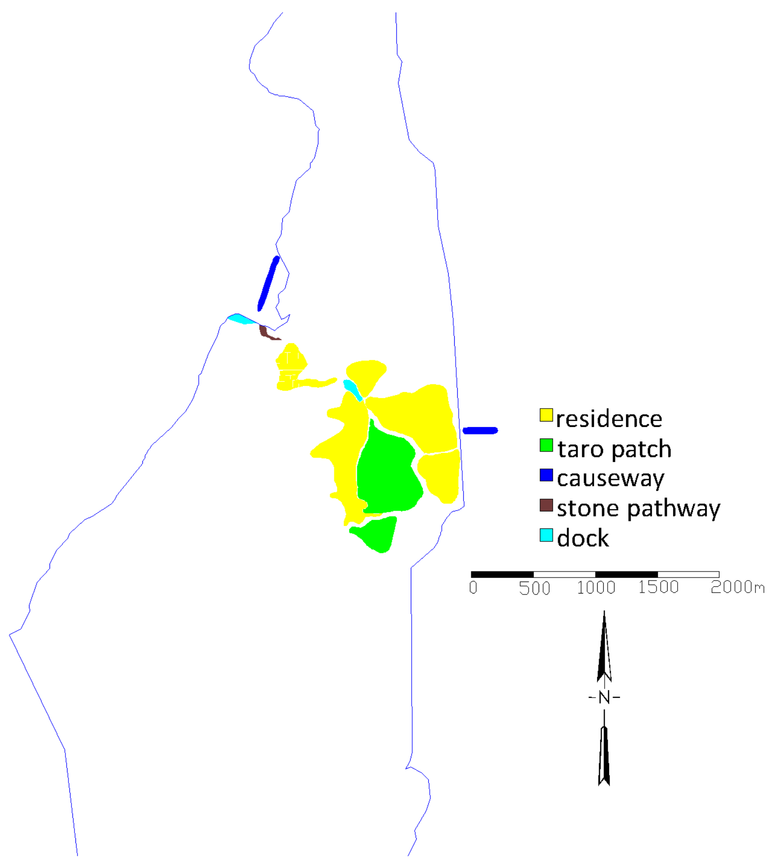

Figure 4.3.2 Defensive Structures in the Center of District 1

Table 4.3.3 Hypothetical Test for Topography Preference in the Stonework Era

Topographic Prominence Index								
	30 m below the mean	30-5m below the mean	between -5 and 5 m	5-30m above the mean	30m above the mean	Totals		
Expected population proportion	3.45%	35.96%	23.64%	33.00%	3.96%	100%		
Terrace Era Exp.	34	355	234	326	39	988		
Terrace Era Obs.	19	241	247	413	68	988		
t test (95% confidence)	-3.47	-8.44	1.01	5.63	3.64			
p-level	*p*<0.001	*p*<0.001	0.2<*p*<0.5	*p*<0.001	*p*<0.001			
Slope								
	"0"-"5" degree	"5"-"10" degree	"10"-"15" degree	"15"-"20" degree	"20"-"25" degree	"25"-"30" degree	>"30" degree	total
Expected population proportion	24.96%	50.45%	20.84%	3.42%	0.31%	0.02%	0.00%	100%
Terrace Era Exp.	247	498	206	34	3	0	0	988
Terrace Era Obs.	239	485	212.00	44	7	1	0	988
t test (95% confidence)	-0.62	-0.82	0.49	1.58	1.49	0.78	not applicable	
p-level	*p*>0.5	0.2<*p*<0.5	*p*>0.5	0.1<*p*<0.2	0.1<*p*<0.2	0.2<*p*<0.5	not applicable	

4.4 General Environmental Basis of Settlement Concentration

The previous analyses were based on assumptions about agricultural productivity. One of the questions that arise in this kind of analysis is how applicable the modern criteria of agricultural productivity are for prehistoric Palauan agricultural systems. Therefore, we conducted another analysis to see if we could identify any direct environmental basis for the concentration of occupation without any assumption about what environmental characteristics would lead to high agricultural productivity.

The analysis was based on a grid of 1665 quadrats, each 500 by 500 m, covering the entire Babeldaob Island. First the total number of structures was counted for each of the 1665 quadrats. The mean and standard deviation of this measurement were calculated for each period. The quadrats that have structures 2 to 3 standard deviations above the mean are marked as grey solid squares and the quadrats that have structures more than 3 standard deviations above the mean are marked as black solid squares (see Figure 4.4.1 and Figure 4.4.2). This will show where the concentrations of occupation are for both periods.

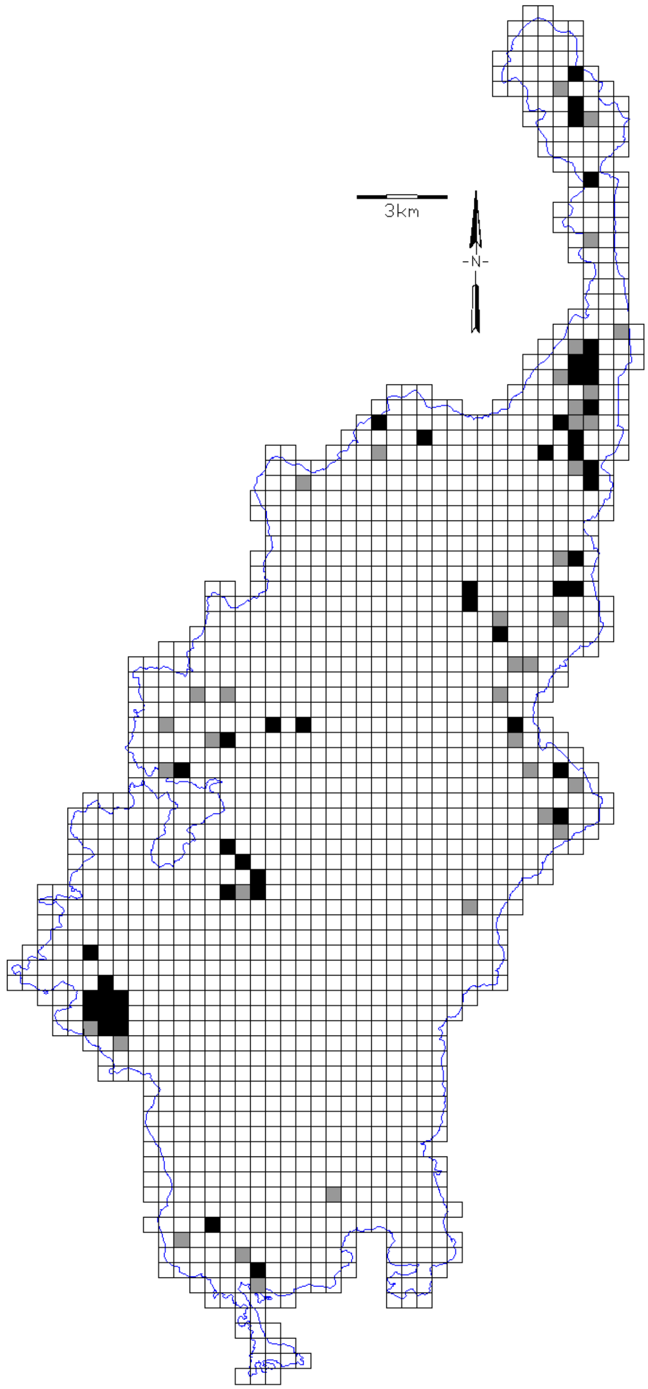

Figure 4.4.1 Quadrats (500m by 500m) with Unusually High Observed Number of Structures in the Terrace Era

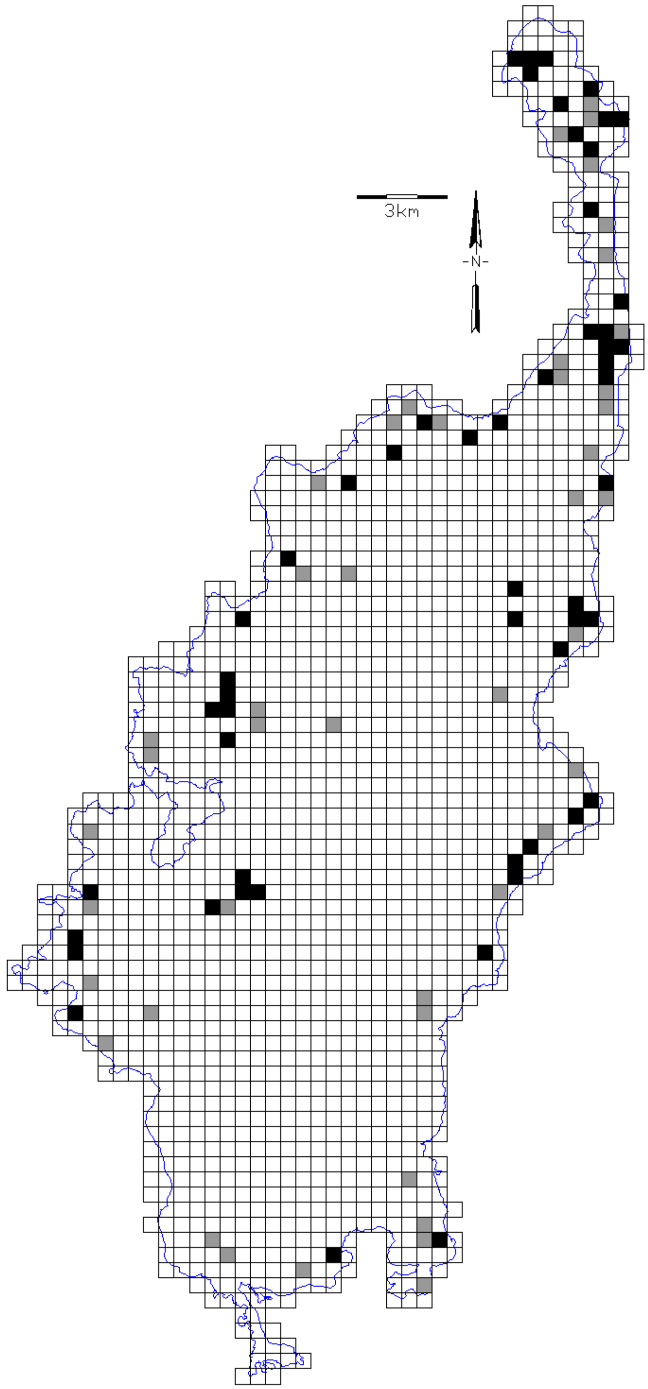

Figure 4.4.2 Quadrats (500m by 500m) with Unusually High Observed Number of Structures in the Stonework Era

Then we can compare these observed densities of occupation with the expected densities of occupation from the environmental variables. The expected densities were measured by calculating the number of structures per ha within each of the soilscapes during the Terrace Era and the Stonework Era. For example, soilscape 600 has a total area of 100 ha on Babeldaob Island, and there was a total of 9 structures of the Terrace Era and 38 structures of the Stonework Era. The overall density occupation for soilscape 600 is thus 0.09 structures/ha for the Terrace Era and 0.38 structures/ha for the Stonework Era. This density of occupation is the expected density for each soilscape in that period. From these expectations an expected number of structures in each quadrat was calculated, based on the area of each soilscape found in that quadrat. For example, a quadrat whose territory includes 10 ha of soilscape 600 will be expected to have 0.9 structure for the Terrace Era and 3.8 structures for the Stonework Era in that 10ha. The expected number of structures will be added together with other expected numbers of structures from any other soilscapes within that quadrat to arrive at a total expected number of structures for that quadrat. This same process was repeated for each of the 1665 quadrats for the two periods.

Finally, the expected number of structures for each period in each quadrat was subtracted from the observed number of structures for that period in each quadrat. The resulting numbers are negative for a quadrat if the observed occupation was less than the expected, positive if the observed occupation was greater than the expected. If the environmental variables explained perfectively the amount of occupation found there, the resulting numbers would be 0. The mean and the standard deviation of this measurement were also calculated for each period. The quadrats that have structures 2 to 3 standard deviations above the mean are marked as grey solid squares and the quadrats that have structures more than 3 standard deviations above the mean are marked as black solid squares (see Figure 4.4.3 and Figure 4.4.4). This shows where the unexpectedly high settlement concentrations are located.

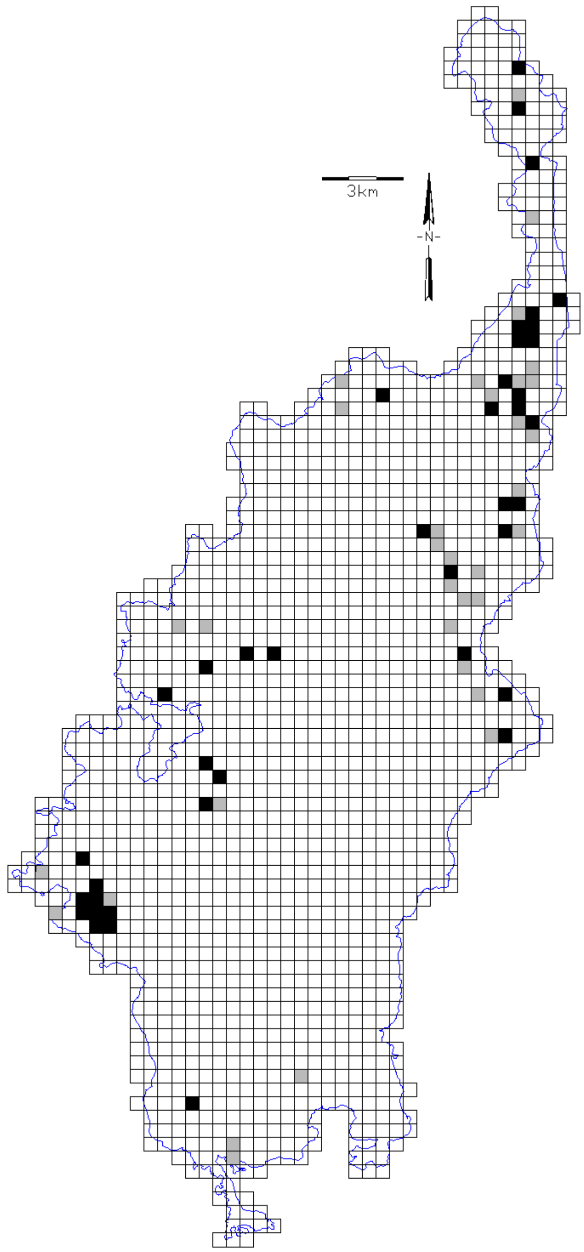

Figure 4.4.3 Quadrats (500m by 500m) with Unusually High Observed-minus-expected Number of Structures in the Terrace Era

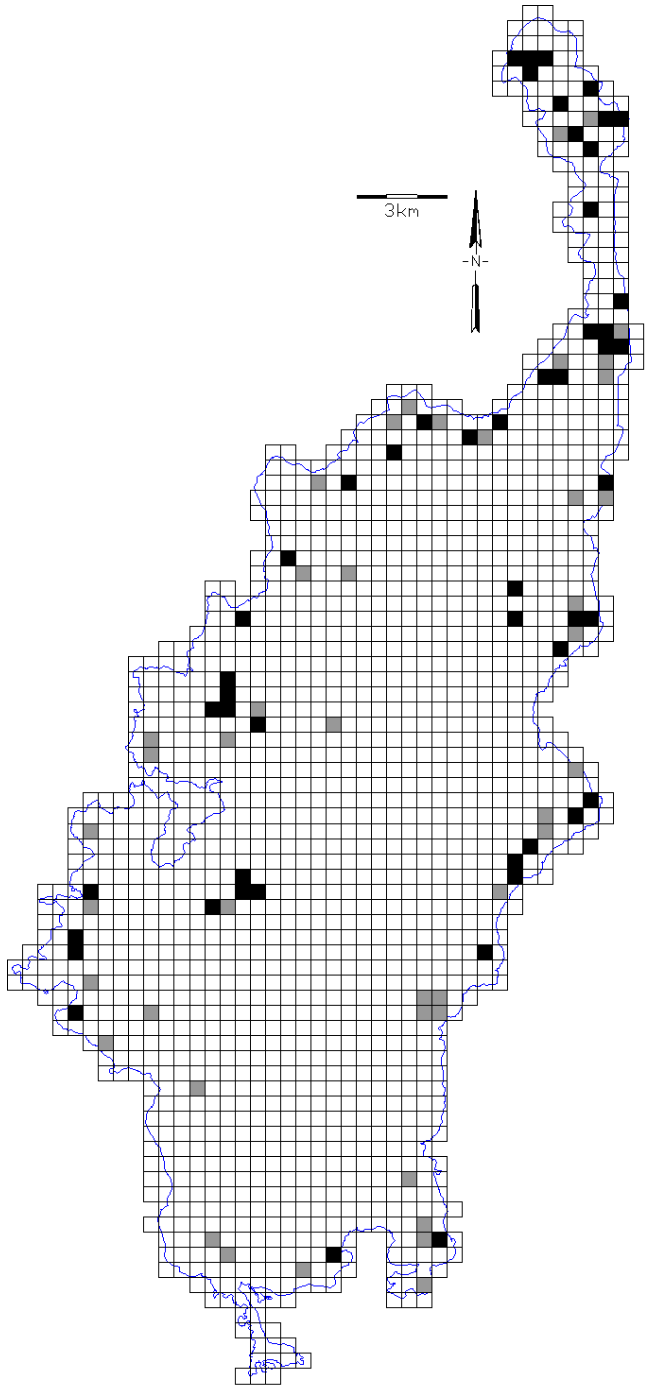

Figure 4.4.4 Quadrats (500m by 500m) with Unusually High Observed-minus-expected Number of Structures in the Stonework Era

A regression analysis was conducted between the expected and observed number of structures in each quadrat. The correlation is positive and highly significant for both the Terrace Era and the Stonework Era. The r^2 values in Table 4.4.1 indicate that the environmental conditions account for about half of the variability in observed number of structures by quadrat in the Terrace Era. This declines to about 40 percent in the Stonework Era. The results tell us the environmental conditions do explain the settlement concentrations to some extent for both periods.

Table 4.4.1 The Regression Analysis between the Expected and Observed Number of Structures by 500m Grid Unit

	Observed mean (number of structures)	Observed standard deviation	Expected mean (number of structures)	Observed minus expected standard deviation	Correlation coefficient (r^2)
Terrace Era	0.595	1.806	0.546	1.555	0.548
Stonework Era	1.627	4.527	1.567	4.175	0.419

On the other hand, the maps of locations of quadrats with unusually large excesses of observed occupation over expected occupation (Figure 4.4.3 and 4.4.4) are like the original maps of observed occupation (Figure 4.4.1 and 4.4.2). After eliminating the factors of environmental attraction, the concentrations seen initially still remain. The locations of the concentrations are the centers of the supra-local communities that are discussed intensively in the chapter 3. For the Terrace Era, the centers are the clusters of terraces complexes; for the Stonework Era, the centers are where the public facilities concentrate. In both cases, the centers are not compact towns with clear boundaries. But the centers create centripetal social forces for the community. The analysis gives us confidence that concentrations are not the simple product of environmental conditions.

4.5 Summary

4.5.1 **Evaluating the Working Hypothesis**

The analysis of land use on Babeldaob gives us a different picture from our prediction. The intensified agrarian mode of settlement predicts that household locational choice should follow economic rationality. However, this is not what we see in the Terrace Era. Instead, the denser population did not choose their residence locations mainly according to agricultural productivity; the supra-local community with denser population did not control more productive land, surprisingly. Instead, denser populations preferred to concentrate on defensive parts of the landscape rather than on productive soils. In other words, the role of agricultural productivity is not so important as expected for the Terrace Era. This result seems to be counterintuitive because the dispersed settlement arrangement reduced household security by spreading out neighbors who could have protected each other. At the same time, although most households farmed immediately adjacent to their residences, the agricultural productivity is not the primary concern for the locational decision either. It seems that people in the Terrace Era balanced their concerns between security and farming.

The observed pattern aligns better to our prediction in the Stonework Era. As the population increased at least four times in the Stonework Era, preference for settling near good land became more important, as denser population located directly on the more fertile flat land and gave up settlement defensibility. According to the working hypothesis, controlling productive land can’t be the sole force that drives the regional integration because of the environmental limitations in Babeldaob Island. This prediction also finds support in our analysis. The supra-local community with the denser population did not control more fertile land. The concentration of the population is not the simple product of occupying more productive farmland. Social forces helped form the supra-local communities, while some households made their locational decisions according to their individual economic rationality, which hindered the process of strong integration (especially economic integration) within the supra-local communities.

4.5.2 **Modes of Intensification and Its Implications for Community Organization**

The two different modes of intensification, landesque capital intensification and cropping cycle intensification, discussed by Kirch (2006) in Polynesian chiefdoms, shed light on the different patterns that we see between the Terrace Era and the Stonework Era. An important shift in the mode of intensification occurred in the Stonework Era: application of pondfield irrigation. This is reflected not only in the pollen record of the wetland cores across the island, but also in the growing population density on the soilscapes useful only for wetland crop cultivation. It is likely that pondfield agriculture sustained the dramatic increase of population (at least four times) in the Stonework Era that could not be supported by dryland agriculture. This change in the mode of intensification impacted the dynamics of interaction with neighbors for subsistence activities and thus changed community structure.

Kirch (1994: 163-186) documented how the two different modes of intensification impacted human-environment relationships in the wetland Sigave chiefdom and the dryland Alo chiefdom. Swidden agriculture required households in Alo to deal with extensive areas of farmland. Fourteen households worked on one or more swidden gardens during the three-year period of the survey; some worked as many as six or eight. The mean area of the swidden gardens was 456m² (*n*=53), ranging from 70-929m². In contrast, households of Sigave normally managed one unit of pondfield, at least in initial allocation. Ownership of pondfields became more and more complicated through time after the initial allocation because of matrilineal inheritance. The mean pondfield area was 250mm² (*n*=348), ranging from 10-299m². It is clear that pondfield agriculture indudes people to interact with the same plot intensively over a long period of time; whereas swidden agriculture induces people to interact with extensive areas of land.

Cropping cycle intensification then, means cultivating more land and/or shortening the fallow season. Individual households make decisions about where to farm and where to fallow each year, and these decisions might interfere with their neighbor's plans. For example, a household might decide to leave a plot fallow so that their descendants could return to farm that plot in the future, but a neighbor might intrude to farm the plot in the meantime. Although according to our analysis, population pressure is not an issue in the Terrace Era, the process of cropping cycle intensification still creates tension and conflict between neighbors. This could be why in the Terrace Era, people sacrificed living directly on productive farmland in order to live in the defensive locations. Conflict also emerged in other chiefly societies characterized by cropping cycle intensification (Kirch 2006). Conspicuous leaders appeared and fought to one another. But unlike Maui and Hawai'i, none of the chiefdoms in the Terrace Era succeeded in integrating the whole island politically. All the regional polities had proportions of similar sizes. No terrace site is conspicuously different from others in terms of size or technical complexity. This implies other differences in social processes between the Terrace Era and the Stonework Era, which can be explored in household relationships at the local community scale.

Landesque capital intensification is through the construction and maintenance of irrigation systems, which requires the cooperation between neighbors. In the study of the Anahulu Valley of Hawai'i, Kirch and Sahlins (1992:154-164) examined the social production of pondfield irrigation. To initiate pondfield irrigation, people organized collective labor to dig ditches, level terraces, build banks that prevent flooding from the sea. After construction, the canal system needs constant collective maintenance of stream flow, especially in the dry season. Conflicts are likely to arise between neighbors over water control. Individual pondfields get water in two main ways: direct supply from the main canal and field-to-field flow. Obviously the second type is less privileged. In the dry season, the field directly connected to the main canal suffers less risk than the one dependent on field-to-field flow. Although digging the main canal requires collective action, the benefits derived vary from household to household. The division of returned from collective labor are thus unfair. This raises an evolutionary question: how do neighbors develop norms of cooperation and sustain them over time, particularly in social contexts in which political coercion is absent? The key to social cooperation is dealing with the "free-rider" problems inherent in groups of self-centered people. This requires the creation of mechanisms to sustain the inherent inequality arising from water control and to ensure stability in the community.

The analysis in this chapter shows that more people lived directly on the productive land over time and became less concerned about the defense. Clearly people found solutions to the free-rider problem so as to collaborate in collective pondfield management. They created social mechanisms to compensate for the "unfairness". At the same time, agricultural intensification promotes individual economic rationality and creates decentralizing forces in the community. This hinders the process of socio-economic integration at a large scale. Our question is how did people creates the stable and complex cooperative mechanisms with relatively loose organization, so that individual households could still pursue their self-interest (economically or socially)? We will explore this question through the examination of household relationships at the local scale.

5.0 Productive Differentiation and Economic Interdependence in the Local Community

5.1 Determining Household Units

As the population of Palau increased, the multiple supra-local communities grew as well, especially one chiefdom in the north of Babeldaob which became 2-3 times bigger than other supra-local communities with an estimated population of 15,000-18,000. At the same time, no local community became a central town in this process of organizational change more fragmented than in the previous period. This demographic process is similar to the intensified agrarian mode of settlement in many other tropical societies. Agricultural intensification in the Stonework Era is indicated by the relationship between population distribution and environmental resources. And the other important factor that led to a more decentralized structure within the supra-local communities was the changing mode of agricultural intensification. The nature of pondfield irrigation requires a more stable mechanism of cooperation than swidden agriculture does at the local scale, but at the same time hinders large scale socio-economic integration. In this chapter, I will examine how people established and maintained collaboration in the context of fragmented and decentralized social organization?

To answer this question, I will study the relationships between households that make up the local communities with a focus on the differentiation of human activities undertaken in different household space. Differentiations of several kinds shapes the matrix of interaction between households. If households do not interact with one another very much, they are likely to have similar sets of activities. If households do interact with one another, they may specialize in different activities and exchange products with one another. Therefore, reconstructing differentiation in activities sheds light on household relationships. This matrix of interaction is the arena where collaboration occurs in everyday life; it is also the arena where the asymmetrical relations or inequalities of several kinds start to form (Drennan et al 2010, Drennan and Peterson 2012).

Reconstructing differentiation in activities is the core analysis in this chapter, which is based on comparison of artifact assemblages recovered from different household units. The key is to measure the degree of differentiation between household units both from the Terrace Era and the Stonework Era in aspects of production, prestige, wealth, and ritual. Inter-household differentiation tells us to what extent people of the Terrace Era and the Stonework Era had specialized domestic economies and broke down economic self-sufficiency (research question 3). In addition, we assess to what extent other kinds of differentiation (i.e. wealth, prestige and ritual) existed in the Terrace Era and the Stonework Era and investigate any connections between them (research question 4). The degree of differentiation in all these dimensions and how they changed between the in two chronological periods help us understand how collaborative mechanisms were established in the context of fragmented and decentralized social organization.

5.1.1 **Household Units in the Terrace Era**

Archaeologists who study the Terrace Era seldom use the concept of household because features that they can be associated with house structures are not often found. However, the development of household archeology in recent decades (Wilk and Rathje 1982) called for looking beyond house structures to the larger spaces across which domestic activities were spread. Terraces can be seen as the space where domestic activities took place. According to size and the spacing of terraces, each one represents fewer than three households and most of them probably held single households. In this analysis, each household unit is the people who lived on the same terrace. The collective action of building terraces suggests that it is a sociologically meaningful unit.

The compact road project placed trenches and test pits on these terraces. The excavations recovered material remains that indicate different kinds of domestic activities, allowing us to compare the activities carried out by different households and reconstruct relationships between them. Domestic activities were not limited to productive activities, but included ritual activities and farming activities (Lucking 1984:136-147, Phear 2007:91-92). The aim here is not to decide which is the principal activity of each terrace but to assess the degree of differentiation in the activities of different terraces.

The samples of household units come from five supra-local communities, district 2, district 3, district 4, district 6, and district 7. Artifact assemblages of test pits on the same terrace within a radius of 50 m are lumped into a single household unit. Terrace sites have only one household unit except for two sites (NI-1:2, NI-1:4) because test pits were usually placed less than 100 m. For instance, NA-4:12 is a terrace site with three crown-shaped earthworks across 6ha, but the test pits were all placed on one crown-shaped earthwork within 1ha. The sample of household units totaled 24 spread through different districts all over Babeldaob, including 1 household unit from district 2, 10 from district 3, 8 from district 4, 1 from district 6, 3 from district 7, 1 not within any districts (see Figure 5.1.1).

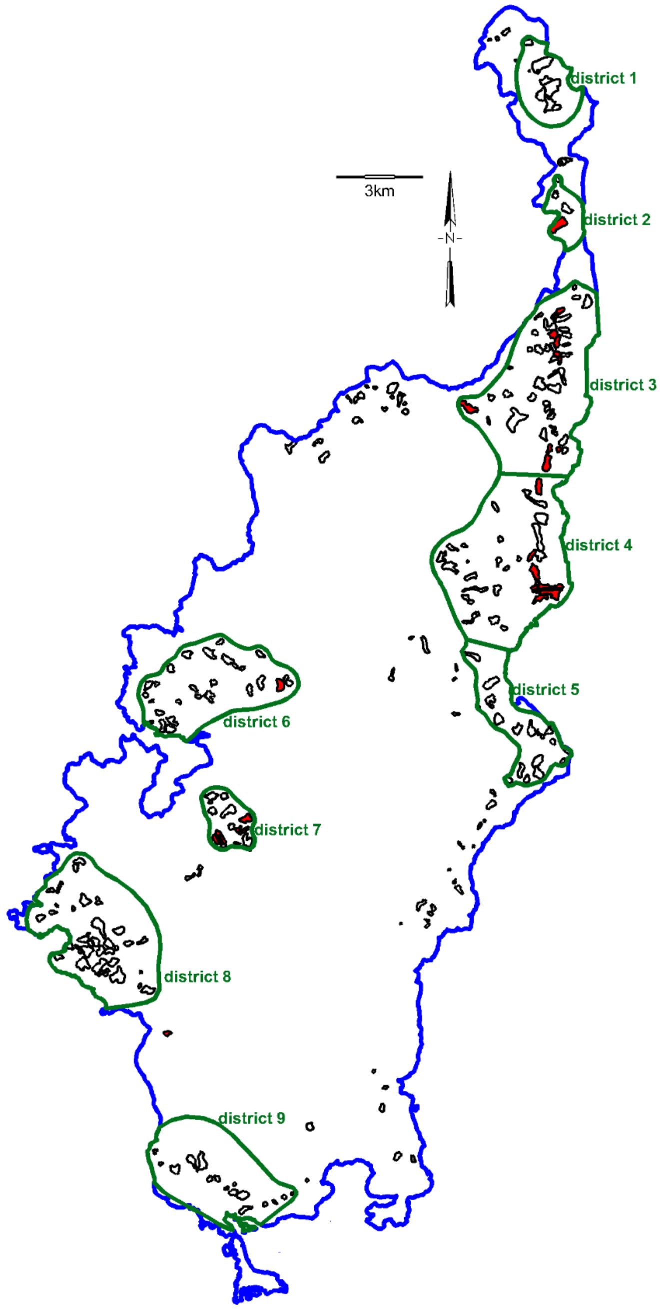

Figure 5.1.1 The sample household units in the Terrace Era

5.1.2 **Household Units in the Stonework Era**

Household units are easier to identify in the Stonework Era because of the preservation of house structures. A typical household unit includes a stone platform made of rounded and angular basalt cobbles and boulders as a structural foundation, and a vegetable garden of coconut trees, taros and fruit trees surrounds the residential structure. Most households are connected to other households via stone pathways. Household activities took place inside the residential structure and in garden area outside the structures. In this analysis, artifact assemblages from test pits in close proximity to the same stone platform are lumped into the same household unit.

The sample of household units falls within four sites NA-4:4 (Ngetcherong traditional village), NT-3:9 (Ngerdubech traditional village), NT-2:1(Ngimis traditional village), NT-2:5 (Ngerumlol traditional village) (Figure 5.1.2), because these were only four sites with recovered midden deposits. Although they were identified as four stonework villages by archaeologists in the Palau Compact Road Survey, they are not village communities with clear buffer zone a separating them from other village communities (see Figure 5.1.2).

NA-4:4 is a very dispersed community with 34 structures across 8 ha (Liston et al. 2007: 215-291). It is at the demographic center of district 1. This demographic center is a continuous occupation covering 1km² (2.8km from north to south, 0.5-1km from east to west). Archaeologists divided this big cluster of occupation into 12 sites with boundaries contiguous to one another and NA-4:4 is one of them. In the phase I and phase II data recovery of the Palau Compact Road Project, 6 shovel tests, 12 stratigraphic trenches, and 11 controlled test units were placed inside or next to 11 out of the 34 residential structures.

NT-3:9 and NT-2:5 are located at the demographic center of district 6. These two sites are next to one another. There is no physical gap between them except a stone pathway. The boundary was set in this way because of accounts from oral history. Ngerumlol was once a hamlet of Ngerdubech and became independent after Ngerdubech was abandoned. Both NT-3:9 and NT-2:5 are very dispersed communities. Specifically, there are 56 households organized in 5-6 small groups across 28 ha in NT-3:9 (Liston et al.2011a:161-216); there are 13 households across 2 ha in NT-2:5 (Wickler et al.2005b:277-288). Households arrange themselves into small clusters. Some households cluster around an open plaza, some households cluster around the public meeting house (bai), some households cluster around the earth mound. In the phase I and phase II data recovery of the Palau Compact Road Project,14 stratigraphic trenches, 8 shovel tests and 3 controlled test units were placed inside or next to the 10 residential structures in NT-3:9; 2 stratigraphic trenches were placed in the garden area of 2 residential structures in NT-2:5.

NT-2:1 is about 200 m southwest of NT-3:9 in district 6. It is also a dispersed village community with 16 households in 6 ha. In the phase I and phase II data recovery of the Palau Compact Road Project, 5 controlled test units, 16 stratigraphic trenches were placed inside or next to the 5 residential structures (Liston et al. 2007b:131-156).

Finally, the sample of household units totaled 22 (9 from Ngetcherong, 6 from Ngerdubech, 2 from Ngerumlol, 5 from Ngimis). These samples don't represent all the households in any of the local communities. They are just the ones where artifact collections were made.

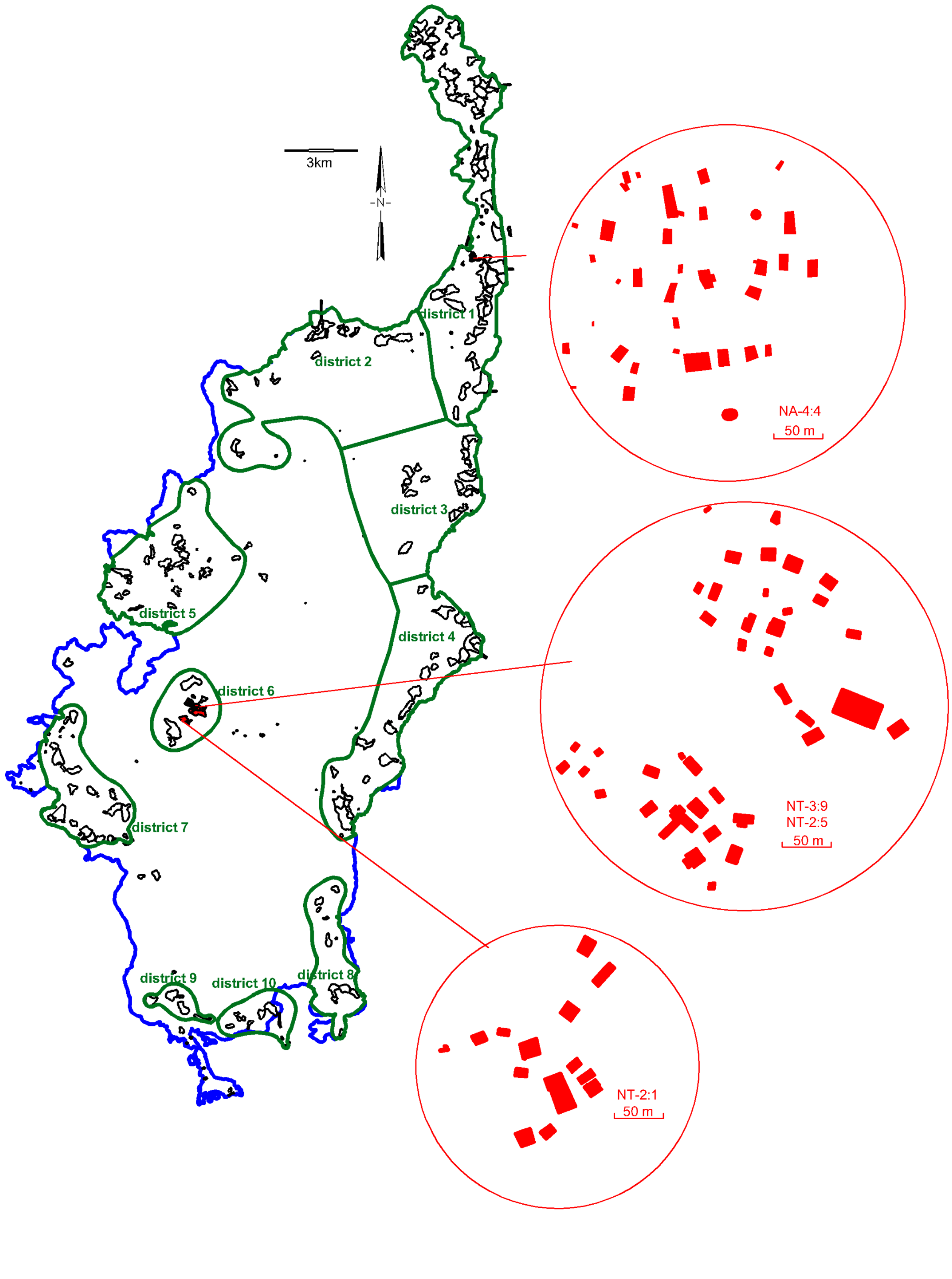

Figure 5.1.2 Sample household units in the Stonework Era

5.2 Multidimensional Scaling of Household Lithic Assemblages

Each of the household units was represented by an artifact assemblage consisting primarily of pottery sherds and lithic artifacts (including both tools and debitage). Any household unit that did not yield a sample of at least 24 lithic artifacts was eliminated from the analysis of lithic assemblages. Table 5.2.1 and Table 5.2.2 are the counts recorded for various types of lithic artifacts for the Terrace Era and the Stonework Era respectively.

The variables recorded are as follows:

Site name: the site where the household unit is located.

Household code: the code number for household unit. In the Terrace Era, the household code starting with A belong to district 2; the household codes starting with B belong to district 3; the household codes starting with C belong to district 4; the household codes starting with D belong to 6; the household codes starting with E belong to district 7 and the household codes starting with F belong to district 8. In the Stonework Era, the household codes starting with A belong to NA-4:4; the household codes starting with B belong to NT-3:9; the household codes starting with C belong to NT-2:5; the household codes starting with D belongs to NT-2:1.

Total lithic artifacts: the total number of lithic artifacts from the households.

<u>Raw material of lithics:</u>

Shell: the number of shell artifacts(analyzed together with lithics)

Aragonite: the number of aragonite artifacts

Basalt: the number of basalt artifacts

CCS: the number of CCS artifacts

Quartz: the number of quartz artifacts

Limestone: the number of limestone artifacts

Siltstone: the number of siltstone artifacts

Tool:

Grinding stone: the number of grinding stones

Flake tool: the number of flake tools

Hammerstone: the number of hammerstones

Bead: the number of stone beads

Core:

Unidirectional: the number of unidirectional flake cores

Bipolar: the number of bipolar flake cores

Debitage:

The debitage categories include complete flakes, broken flakes, flake fragments and shatter according to the Sullivan and Rozen (1985) typology. Bipolar debitage is an additional debitage category, which was identified by lithic analysts in the Palau Compact Road Project.

Complete flakes: the number of complete unfinished flakes

Broken flakes: the number of broken unfinished flakes

Flake fragments: the number of flake fragments

Bipolar flakes: the number of bipolar unretouched flakes

Shatter: the number of pieces shatter

Table 5.2.1 Raw Counts of Lithic Artifact Types for 14 Household in the Terrace Era

Site code	Household code	Total lithic artifacts	raw material							tool					core		debitage					
			shell	aragonite	basalt	ccs	quartz	limestone	siltstone	adze	grinding stone	flake tool	hammerstone	total	unidirectional core	bipolar core	complete flakes	broken flakes	flake fragment	bipolar debitage	shatter	total
NA-1:10	BF1	38	2	0	0	36	0	2	0	0	1	0	1	2	0	1	2	1	10	8	9	30
NA-4:12	BF2	54	0	0	2	51	0	1	0	1	0	2	1	4	1		1	5	12	3	28	49
NA-4:6	BF3	48	0	0	2	43	1	1	1	0	1	1	0	2	0	1	2	5	12	3	17	39
NA-4:15	BF4	128	0	0	2	125	0	1	0	2	0	2	0	4	3	2	5	0	53	24	36	118
NI-1:3	CF1	71	0	0	0	69	0	2	0	0	0	1	0	1	0	1	0	5	25	10	13	53
NI-1:3	CF2	55	0	0	0	55	0	0	0	0	0	0	0	0	0	8	0	2	20	16	9	47
NI-1:4	CF5	177	0	0	3	174	0	0	0	2	0	1	0	3	0	3	3	0	55	69	54	181
NI-1:4	CF6	436	0	0	0	436	0	0	1	0	1	0	1	2	0	4	17	0	216	122	80	435
NI-1:4	CF7,8	458	0	0	0	458	1	0	0	0	0	2	0	2	0	16	38	0	182	130	90	440
NI2:36	CF9	293	1	0	4	288	0	0	0	4	0	1	1	6	0	6	20	0	125	81	55	281
NI-2:14	CF10	49	0	0	0	49	0	0	0	0	0	0	0	0	0	3	5	0	17	19	5	46
NM4:7	DF1	174	0	0	3	171	0	0	0	1	1	0	2	4	1	7	41	0	71	50	31	193
NT-3:10	EF1	262	0	0	3	259	0	0	0	1	0	2	0	3	6	13	25	0	72	82	61	240
IM-5:5	FF1	29	0	2	2	15	2	8	0	0	0	0	1	1	0	0	13	0	0	0	15	28

Table 5.2.2 Raw counts of Lithic Artifact Types for 14 Household in the Stonework Era

Household unit	House hold code	Total lithic artifacts	raw material						Tool						core		debitage						
			shell	basalt	ccs	quartz	limestone	siltstone	adze	bead	grinding stone	flake tool	hammer stone	total	unidirectional core	bipolar core	complete flakes	broken flakes	flake fragment	bipolar debitage	shatter	cortex	total
feature 57, 61 (bai)	AF57,61	26	0	1	24	1	0	0	0	0	1	1	0	2	1	0	0	0	0	0	7	10	7
feature 12	AF12	47	1	11	7	0	26	3	0	0	0	0	0	0	2	0	29	0	0	0	15	no data	44
feature 38	BF38	126	1	6	34	0	84	2	1	1	0	0	0	2	0	0	82	0	4	0	30	1	116
feature 39	BF39	142	0	2	134	2	1	0	1	0	0	3	0	4	0	20	1	7	73	7	36	24	124
feature 13	BF13	375	0	21	63	1	288	2	0	0	0	1	0	1	0	0	97	3	7	0	235	4	342
feature 9	BF9	145	0	4	130	9	2	0	0	0	0	0	2	2	0	6	0	15	30	12	59	42	116
feature 12	BF12	209	0	0	41	0	167	1	0	0	0	0	0	0	0	1	66	0	8	0	133	no data	207
feature 13(NT-2:5)	CF13	73	0	8	23	0	42	0	0	0	0	0	0	0	0	0	30	0	2	0	41	no data	73
feature 10 (NT-2:5)	CF10	57	0	1	20	0	16	0	0	0	0	0	0	0	0	0	13	0	0	0	23	no data	36
feature 17	DF17	28	0	1	12	5	1	0	0	0	1	1	0	2	0	1	0	2	5	1	9	10	17
feature 12/13	DF12/13	205	1	0	128	26	49	2	1	0	1	2	0	4	2	4	55	13	34	2	58	22	162
feature 8	DF8	104	0	1	20	0	83	0	0	0	0	1	0	1	1	0	50	0	0	0	54	no data	104
feautre 1 (bai)	DF1	160	0	1	25	0	134	0	0	1	0	0	0	1	0	0	39	0	1	0	118	no data	158
feature 4	DF4	24	0	0	9	0	15	0	0	1	0	0	0	1	0	0	15	0	0	0	9	no data	24

These counts were transformed into the proportions for each households and became the variations in the nonmetric multidimensional scaling analyses. The final analyses presented here were based on these variables. Table 5.2.3 and Table 5.2.4 are proportions for household units in the Terrace Era and the Stonework Era respectively.

Lithic artifact variables

% shell: the number of shell artifacts/total lithic artifacts

% basalt: the number of basalt artifacts/total lithic artifacts

% CCS: the number of CCS artifacts/total lithic artifacts

% quartz: the number of quartz artifacts/total lithic artifacts

% limestone: the number of limestone artifacts/total lithic artifacts

% siltstone: the number of siltstone artifacts/total lithic artifacts

% aragonite: the number of aragonite artifacts/total lithic artifacts

% adze: the number of adze/total lithic artifacts

% grinding stone: the number of grinding stone/total lithic artifacts

% flake tool: the number of flake tool/total lithic artifacts

% hammerstone: the number of hammerstone/total lithic artifacts

% core: the number of flake cores/total lithic artifacts

% complete flakes: the number of complete unretouched flakes/total lithic artifacts

% broken flakes: the number of broken unretouched flakes/total lithic artifacts

% flake fragment: the number of flake fragments/total lithic artifacts

% bipolar flakes: the number of bipolar unretouched/total lithic artifacts

% shatter: the number of lithic shatter/total lithic artifacts

Table 5.2.3 Percentages of Lihtic Artifacts Types for 14 Households of Terrace Era

household code	total lithics	shell	basalt	ccs	quartz	limestone	aragonite	siltstone	adze	grinding stone	flake tool	hammerstone	core	complete flake	broken flakes	flake fragment	bipolar debitage	shatter
BF1	38	5.26%	0.00%	94.74%	0.00%	5.26%	0.00%	0.00%	0.00%	2.63%	0.00%	2.63%	2.63%	5.26%	2.63%	26.32%	21.05%	23.68%
BF2	54	0.00%	3.70%	94.44%	0.00%	1.85%	0.00%	0.00%	1.85%	0.00%	3.70%	1.85%	1.85%	1.85%	9.26%	22.22%	5.56%	51.85%
BF3	48	0.00%	4.17%	89.58%	2.08%	2.08%	0.00%	2.08%	0.00%	2.08%	2.08%	0.00%	2.08%	4.17%	10.42%	25.00%	6.25%	35.42%
BF4	128	0.00%	1.56%	97.66%	0.00%	0.78%	0.00%	0.00%	1.56%	0.00%	1.56%	0.00%	3.91%	3.91%	0.00%	41.41%	18.75%	28.13%
CF1	71	0.00%	0.00%	97.18%	0.00%	2.82%	0.00%	0.00%	0.00%	0.00%	1.41%	0.00%	1.41%	0.00%	7.04%	35.21%	14.08%	18.31%
CF2	55	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.55%	0.00%	3.64%	36.36%	29.09%	16.36%
CF5	177	0.00%	1.69%	98.31%	0.00%	0.00%	0.00%	0.00%	1.13%	0.00%	0.56%	0.00%	1.69%	1.69%	0.00%	31.07%	38.98%	30.51%
CF6	436	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.23%	0.00%	0.23%	0.00%	0.23%	0.92%	3.90%	0.00%	49.54%	27.98%	18.35%
CF7,8	458	0.00%	0.00%	100.00%	0.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.44%	0.00%	3.49%	8.30%	0.00%	39.74%	28.38%	19.65%
CF9	293	0.34%	1.37%	98.29%	0.00%	0.00%	0.00%	0.00%	1.37%	0.00%	0.34%	0.34%	2.05%	6.83%	0.00%	42.66%	27.65%	18.77%
CF10	49	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.12%	10.20%	0.00%	34.69%	38.78%	10.20%
DF1	174	0.00%	1.72%	98.28%	0.00%	0.00%	0.00%	0.00%	0.57%	0.57%	0.00%	1.15%	4.60%	23.56%	0.00%	40.80%	28.74%	17.82%
EF1	262	0.00%	1.15%	98.85%	0.00%	0.00%	0.00%	0.00%	0.38%	0.00%	0.76%	0.00%	7.25%	9.54%	0.00%	27.48%	31.30%	23.28%
FF1	29	0.00%	6.90%	51.72%	6.90%	27.59%	6.90%	0.00%	0.00%	0.00%	0.00%	3.45%	0.00%	44.83%	0.00%	0.00%	0.00%	51.72%

Table 5.2.4 Percentages of Lihtic Artifacts Types for 14 Households of Stonework Era

household code	total lithics	shell	basalt	ccs	quartz	limestone	siltstone	adze	bead	grinding stone	flake tool	hammerstone	core	complete flake	broken flakes	flake fragment	bipolar debitage	shatter
AF57,61	26	0.00%	3.85%	92.31%	3.85%	0.00%	0.00%	0.00%	0.00%	3.85%	3.85%	0.00%	3.85%	0.00%	0.00%	0.00%	0.00%	26.92%
AF12	47	2.13%	23.40%	14.89%	0.00%	55.32%	6.38%	0.00%	0.00%	0.00%	0.00%	0.00%	4.26%	61.70%	0.00%	0.00%	0.00%	31.91%
BF38	126	0.79%	4.76%	26.98%	0.00%	66.67%	1.59%	0.79%	0.79%	0.00%	0.00%	0.00%	0.00%	65.08%	0.00%	3.17%	0.00%	23.81%
BF39	142	0.00%	1.41%	94.37%	1.41%	0.70%	0.00%	0.70%	0.00%	0.00%	2.11%	0.00%	14.08%	0.70%	4.93%	51.41%	4.93%	25.35%
BF13	375	0.00%	5.60%	16.80%	0.27%	76.80%	0.53%	0.00%	0.00%	0.00%	0.27%	0.00%	0.00%	25.87%	0.80%	1.87%	0.00%	62.67%
BF9	145	0.00%	2.76%	89.66%	6.21%	1.38%	0.00%	0.00%	0.00%	0.00%	0.00%	1.38%	4.14%	0.00%	10.34%	20.69%	8.28%	40.69%
BF12	209	0.00%	0.00%	19.62%	0.00%	79.90%	0.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	31.58%	0.00%	3.83%	0.00%	63.64%
CF13	73	0.00%	10.96%	31.51%	0.00%	57.53%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	41.10%	0.00%	2.74%	0.00%	56.16%
CF10	57	0.00%	1.75%	35.09%	0.00%	28.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	22.81%	0.00%	0.00%	0.00%	40.35%
DF17	28	0.00%	3.57%	42.86%	17.86%	3.57%	0.00%	0.00%	0.00%	3.57%	3.57%	0.00%	3.57%	0.00%	7.14%	17.86%	3.57%	32.14%
DF12/13	205	0.49%	0.00%	62.44%	12.68%	23.90%	0.98%	0.49%	0.00%	0.49%	0.98%	0.00%	2.93%	26.83%	6.34%	16.59%	0.98%	28.29%
DF8	104	0.00%	0.96%	19.23%	0.00%	79.81%	0.00%	0.00%	0.00%	0.00%	0.96%	0.00%	0.96%	48.08%	0.00%	0.00%	0.00%	51.92%
DF1	160	0.00%	0.63%	15.63%	0.00%	83.75%	0.00%	0.00%	0.63%	0.00%	0.00%	0.00%	0.00%	24.38%	0.00%	0.63%	0.00%	73.75%
DF4	24	0.00%	0.00%	37.50%	0.00%	62.50%	0.00%	0.00%	4.17%	0.00%	0.00%	0.00%	0.00%	62.50%	0.00%	0.00%	0.00%	37.50%

Nonmetric multidimensional scaling analysis is a multivariate technique to visualize graphically individual cases in the dataset. This method is the most intuitive and simplest of the various approaches to multivariate analysis (Drennan 2009:285-307). It creates a configuration of points, each representing one household unit in the dataset. The aim of the configuration is to put the two most similar households at the shortest distance from each other, and the two most dissimilar households at the farthest distance from each other. Dissimilarities were measured by Euclidean distance on standardized variables. The variables are all proportions of artifact categories within household units. Ceramic and lithic assemblages were analyzed separately because the two classes of artifacts relate to different aspects of relationships between households.

Lithic assemblages in the Terrace Era

A selected set of 17 lithic variables produced the patterning of variation in lithic assemblages between households (Table 5.2.3). The multidimensional scaling result (Figure 5.2.1) was produced from standardized Euclidean distances between all pairs of the 14 household units in the Terrace Era. The Two dimensional configuration was chosen because its final stress value was 0.03. (There is a rule of thumb that stress values of about 0.15 or less are often associated with interpretable configurations.)

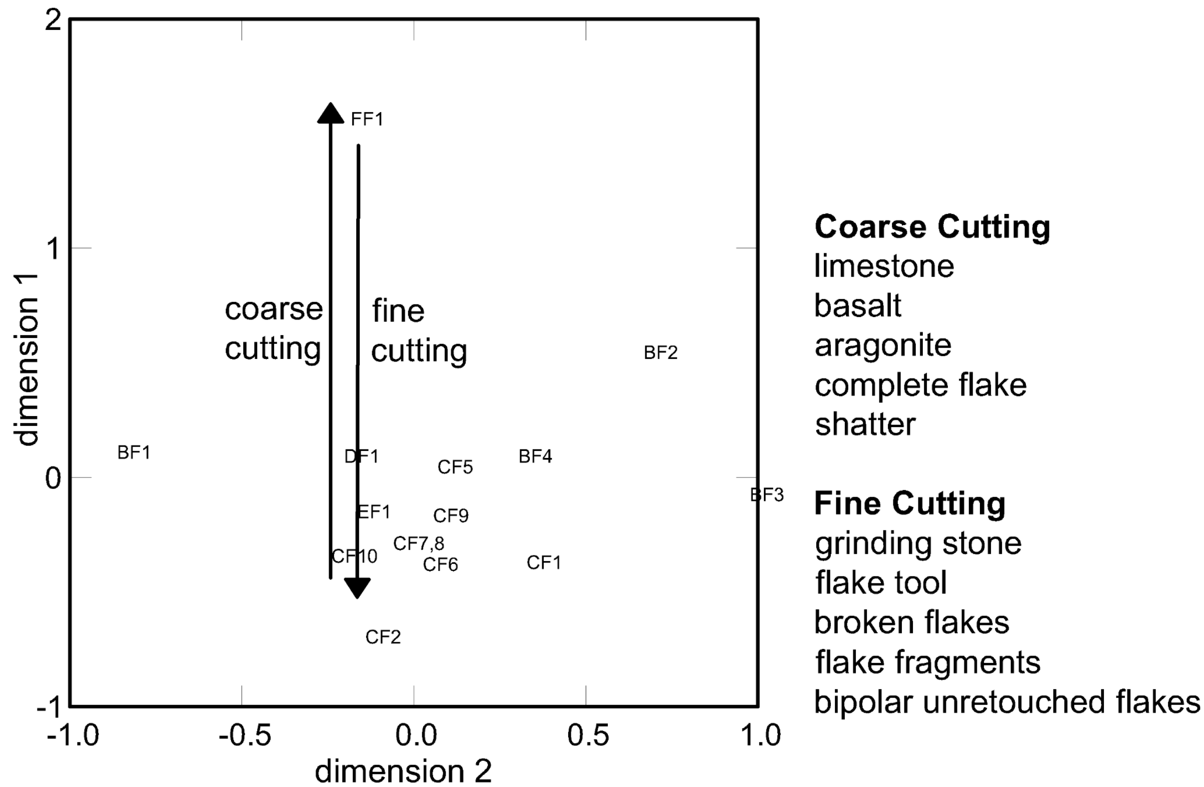

Figure 5.2.1 MDS Plot for a Two Dimensional Solution of Lithic Artifacts from 14 households in the Terrace Era

A very high value on dimension 1 pulls FF1 away from the rest. It has much higher proportions of limestone, basalt, quartz and aragonite lithic artifacts and much lower proportions of CCS. The raw materials of the lithic artifacts from the rest of households were dominated by CCS. This difference in the use of raw material indicates that FF1 involved more coarse cutting work, whereas the rest of the households were involved in more fine cutting work. Besides the raw material, FF1 also has higher proportions of complete unretouched flakes, hammerstones and shatter. In contrast, the rest of the households have higher proportions of flake cores, flake fragments, and bipolar unretouched flakes. These assemblages indicate a pattern of finer cutting work, especially the high proportions of bipolar unretouched flakes which relate to production of sharp flakes and drills. FF1 participated in more heavy-duty production and coarser cutting work; the rest of the households were characterized by generalized light duty production and finer cutting work, which represents a normal range of ordinary basic household activities.

The Terrace Era lithic assemblage analysis thus indicates that most household units conducted similar kinds of economic activities (light duty and fine cutting), but household FF1 was different. Since FF1 belongs to district 8 and is far away from the rest of the households, its unusualness might be related to its own local environment. It is unlikely that very much economic interdependence existed between households in the Terrace Era. The mean Euclidean distance between pairs of Terrace Era household lithic assemblage is 4.8±0.41 (for 95% confidence).

Lithic assemblages in the Stonework Era

The most interpretable multidimensional scaling result for the Stonework Era lithic assemblages (Figure 5.2.2) was produced from standardized Euclidean distances between pairs of 14 household units with the same selected set of 17 variables (Table 5.2.4). Two dimensions were selected with a final stress value of 0.036.

The household units toward the top of the plot have higher proportions of limestone, basalt and siltstone lithic artifacts. Household units toward the bottom of the plot have higher proportions of CCS and quartz, and this same part of the scaling configuration is where the rarer limestone, basalt and siltstone are. This indicates coarser cutting work was more dominant amongst households with high values on dimension 1 and finer work among households with low values on dimension 1.

The group of households with low values on dimension 1 also includes higher proportions of lithic cores, grinding stones and flake tools. In terms of lithic debitage, they have higher proportions of broken flakes, flake fragments, and bipolar unretouched flakes. All of this continues to be consistent with the finer cutting work for the same group of household units. Interestingly, the two groups of household units in the dataset crosscut the four different sites.

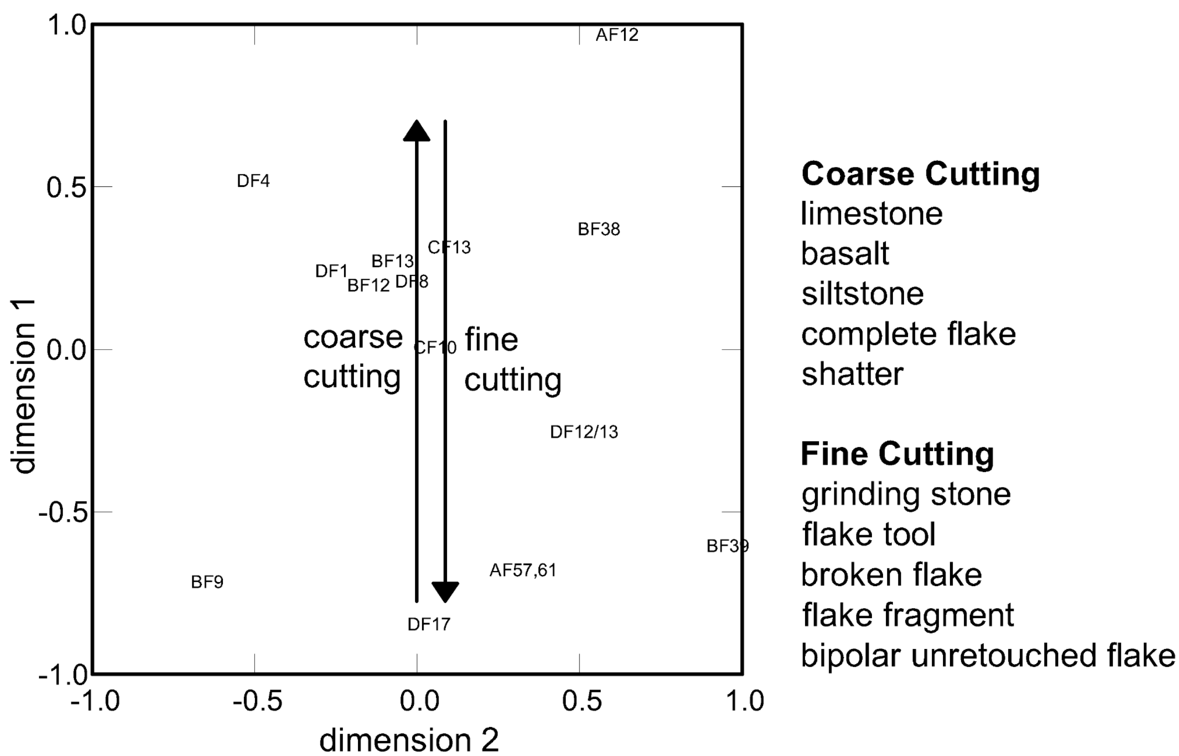

Figure 5.2.2 MDS Plot for a Two Dimensional Solution of Lithic Artifacts from 14 households in the Stonework Era

The patterns in the Stonework Era lithic assemblage analysis were different from those in the Terrace Era, reflecting a growing differentiation of productive activities between households in the four dispersed village communities. Some household units specialized in heavy-duty work, whereas other household units nearby specialized in light duty work. Thus some degree of economic interdependence emerged between households in the Stonework Era. The mean

Euclidean distance between pairs of Stonework Era household lithic assemblages is 5.062±0.344 (for 95% confidence level). Although the statistical significance of this difference between the two periods is small, the number for the Terrace Era is inflated because of FF1 which is strongly separated from the rest. In contrast, the number for the Stonework Era is a product of the differentiation between households who live in the same neighborhood in the Stonework Era. Therefore, the pattern suggests households in the Stonework Era specialized in different subsistence or non-subsistence productive tasks and likely depended on one another in the realm of everyday life.

5.3 Multidimensional Scaling of Household Ceramic Assemblages

Each of the household units was also represented by ceramic assemblages. Any household unit that did not yield a sample of at least 24 ceramic artifacts was eliminated from the analysis of ceramic assemblages. Table 5.3.1 and Table 5.3.2 present the ceramic assemblages from the Terrace Era and the Stonework Era respectively.

The ceramic variables are as follows:

Total ceramics: the total number of ceramic sherds from the households.

<u>Special items:</u>

Game piece: the number of game pieces

Kiln waster: the number of kiln wasters

Oil lamp: the number of lamp sherds

<u>Surface treatment:</u>

Slip: the number of slipped sherds

Burnish: the number of burnished sherds

Decorated: the number of decorated sherds. The decoration techniques include painting, incising, banding, fingernail impressions, punctations, perforations, knobs, ridges, and coiled feet.

<u>Color:</u>

Dull black: the number of dull black sherds

Oxidized: the number of red or orange oxidized sherds

Vibrant black: the number of vibrant black sherds

White: the number of white sherds

<u>Rim form</u>

Direct: the number of sherds that have direct rim form.

Everted: the number of sherds that have everted rim form.

Inverted: the number of sherds that have inverted rim form.

<u>Diameter</u>

the number of sherds with rim diameters of 41-50cm, 31-40cm, 21-30cm, and 10-20cm. It is not possible to measure the diameter of all sherds.

Table 5.3.1 Raw Counts of Ceramic Attributes for 14 Household in the Terrace Era

			surface treatment			color				rim form			diameter				
site code	Household code	diagnose ceramics	slip	burnish	decorated (paint, incised, banding etc.)	dull back	oxidized	vibrant black	white	direct	everted	inverted	41-50cm	31-40cm	21-30cm	10-20cm	0-10cm
NA-3:1	AF1	39	1	6	3	32	1	6	0	13	1	18	5	0	5	3	0
NA-1:10	BF1	186	11	19	0	155	27	4	0	35	6	100	5	2	2	15	0
NA-4:12	BF2	125	80	0	11	78	4	1	41	62	18	50	no data	no data	no data	no data	no data
NA-4:6	BF3	175	2	16	0	166	6	3	0	44	11	58	21	1	9	12	0
NA-1:8	BF5	123	0	5	0	111	11	0	0	8	1	76	8	0	3	11	2
NA-1:9	BF6	24	0	2	0	21	2	1	0	4	0	14	1	0	1	4	0
NA-1:28	BF7	80	0	0	3	63	5	2	5	30	19	31	no data	no data	no data	no data	no data
NA-1:35	BF8	61	18	18	12	44	14	0	8	12	1	47	no data	no data	no data	no data	no data
NA-2:5	BF9	67	10	0	8	30	18	3	3	17	1	38	no data	no data	no data	no data	no data
NA-2:22	BF10	32	8	0	1	13	14	1	3	3	0	21	no data	no data	no data	no data	
NI-1:2 (NI:T6)	CF2	76	1	2	0	71	2	3	0	13	8	24	5	2	6	7	0
NI-1:2 (NI:T7,8,9)	CF3	55	0	0	0	51	3	1	0	3	2	37	6	1	7	6	0
NI-1:2 (NI:T10)	CF4	338	0	25	0	314	22	2	0	12	1	310	22	1	17	19	0
NI-1:4 (feature 7)	CF5	68	0	0	15	10	6	46	6	8	1	52	no data	no data	no data	no data	no data
NI-1:4 (feature 6,12)	CF6	265	2	0	5	181	13	12	59	5	1	235	no data	no data	no data	no data	no data
NI-1:4 (feature 5)	CF7	125	36	0	4	74	19	7	24	14	27	30	no data	no data	no data	no data	no data
NI-1:4 (feature 9)	CF8	70	0	0	5	54	1	8	7	9		17	no data	no data	no data	no data	no data
NI-2:36 (NI-2a)	CF9	242	96	0	35	211	1	26	2	98	1	135	no data	no data	no data	no data	no data
NM-4:7	DF1	39	15	0	4	25	2	1	11	13	1	23	no data	no data	no data	no data	no data
NT-3:10	EF1	155	42	4	17	103	21	0	14	56	8	75	4	1	2	6	0
NT-2:2	EF2	34	0	5	0	29	5	0	0	4	2	21	6	0	3	9	0
NT-3:13	EF3	44	27	1	3	25	16	0	3	4	0	39	no data	no data	no data	no data	no data

Table 5.3.2 Raw Counts of Ceramic Attributes for 14 Household in the Stonework Era

Household unit	Household code	total ceramics	special items			surface treatment			color				rim form			diameter			
			game piece	kiln waster	oil lamp	slip	burnish	decorated (paint, incised, banding etc.)	dull back	oxidized	vibrant black	white	direct	everted	inverted	41-50cm	31-40cm	21-30cm	10-20cm
feature 57, 61 (bai)	AF57,61	235	0	1	0	54	42	2	160	65	3	5	38	19	131	6	5	2	0
feature 62	AF62	40	0	0	0	1	3	2	14	4	3	0	2	1	11	1	2	1	0
feature 42	AF42	34	0	0	0	4	6	0	24	9	2	0	8	1	16	5	3	1	0
feature 43	AF43	49	0	0	0	1	2	0	43	5	1	0	5	0	31	3	4	3	0
feature 64	AF64	119	0	0	0	10	7	1	100	15	3	0	15	1	80	15	16	8	3
feature 68	AF68	86	0	0	0	5	3	1	64	12	6	0	17	0	43	0	2	1	0
feature 67	AF67	136	0	0	0	5	16	2	114	21	1	0	10	3	89	13	13	9	8
feature 29	AF29	188	14	0	0	144	19	68	97	11	0	56	49	7	20	no data	no data	no data	no data
feature 12	AF12	327	0	0	0	7	0	0	309	18	0	0	1	0	0	no data	no data	no data	no data
feature 38	BF38	151	0	0	0	7	2	0	133	7	11	0	14	7	11	4	1	3	0
feature 5 (bai)	BF5	47	0	0	0	0	12	0	35	11	2	0	5	0	33	2	2	7	0
feature 39	BF39	70	0	0	0	2	1	3	55	13	2	0	6	0	43	2	2	6	0
feature 13	BF13	153	0	0	0	9	1	1	140	4	9	0	7	0	3	0	1	0	0
feature 9	BF9	74	0	0	0	3	10	3	63	10	1	0	11	2	42	2	2	1	0
feature 12	BF12	43	0	0	0	1	0	0	39	4	0	0	0	0	0	no data	no data	no data	no data
feature 13(NT-2:5)	CF13	173	0	0	0	44	2	1	118	22	33	0	13	0	9	no data	no data	no data	no data
feature 10 (NT-2:5)	CF10	104	0	0	0	0	0	0	99	5	1	0	4	0	2	no data	no data	no data	no data
feature 17	DF17	66	0	0	0	1	12	1	36	7	1	0	8	1	31	7	9	1	2
feature 12/13	DF12/13	382	0	0	0	6	32	1	131	36	40	0	11	0	85	6	11	10	0
feature 8	DF8	197	0	0	0	5	5	0	135	50	9	3	11	0	0	no data	no data	no data	no data
feature 1 (bai)	DF1	187	0	0	0	0	1	0	117	35	33	1	12	0	1	no data	no data	no data	no data
feature 4	DF4	24	0	0	0	0	1	0	21	0	3	0	1	0	0	no data	no data	no data	no data

These counts were transformed into the proportions of the total ceramic sherds for each household unit and became the variables in the nonmetric multidimensional scaling analyses. Table 5.3.3 and Table 5.3.4 are the proportions for household units in the Terrace Era and the Stonework Era.

Ceramic artifact variables

%slip: the number of slipped sherds/total ceramics

%burnish: the number of burnished sherds/total ceramics

%decoration: the number of decorated sherds /total ceramics

%dull black: the number of dull black sherds/total ceramics

%oxidize: the number oxidized sherds/total ceramics

%vibrant black: the number of vibrant black sherds/total ceramics

%white: the number of white sherds/total ceramics

%direct: the number of sherds with direct rims/total ceramics

%everted: the number of sherds with everted rims/total ceramics

%inverted: the number of sherds with inverted rims/total ceramics.

%large vessel: the number of sherds with diameters of 41-50cm/total ceramics.

Table 5.3.3 Percentages of Ceramic Attributes for 14 households of Terrace Era

house code	All ceramics	slip	burnish	decoration	dull back	oxidize	vibrant black	white	direct	everted	inverted	large vessel
AF1	39	2.56%	15.38%	7.69%	82.05%	2.56%	15.38%	0.00%	33.33%	2.56%	46.15%	12.82%
BF1	186	5.91%	10.22%	0.00%	83.33%	14.52%	2.15%	0.00%	18.82%	3.23%	53.76%	2.69%
BF2	125	64.00%	0.00%	8.80%	62.40%	3.20%	0.80%	32.80%	49.60%	14.40%	40.00%	-100.00%
BF3	175	1.14%	9.14%	0.00%	94.86%	3.43%	1.71%	0.00%	25.14%	6.29%	33.14%	12.00%
BF5	123	0.00%	4.07%	0.00%	90.24%	8.94%	0.00%	0.00%	6.50%	0.81%	61.79%	6.50%
BF6	24	0.00%	8.33%	0.00%	87.50%	8.33%	4.17%	0.00%	16.67%	0.00%	58.33%	4.17%
BF7	80	0.00%	0.00%	3.75%	78.75%	6.25%	2.50%	6.25%	37.50%	23.75%	38.75%	-100.00%
BF8	61	29.51%	29.51%	19.67%	72.13%	22.95%	0.00%	13.11%	19.67%	1.64%	77.05%	-100.00%
BF9	67	14.93%	0.00%	11.94%	44.78%	26.87%	4.48%	4.48%	25.37%	1.49%	56.72%	-100.00%
BF10	32	25.00%	0.00%	3.13%	40.63%	43.75%	3.13%	9.38%	9.38%	0.00%	65.63%	-100.00%
CF2	76	1.32%	2.63%	0.00%	93.42%	2.63%	3.95%	0.00%	17.11%	10.53%	31.58%	6.58%
CF3	55	0.00%	0.00%	0.00%	92.73%	5.45%	1.82%	0.00%	5.45%	3.64%	67.27%	10.91%
CF4	338	0.00%	7.40%	0.00%	92.90%	6.51%	0.59%	0.00%	3.55%	0.30%	91.72%	6.51%
CF5	68	0.00%	0.00%	22.06%	14.71%	8.82%	67.65%	8.82%	11.76%	1.47%	76.47%	-100.00%
CF6	265	0.75%	0.00%	1.89%	68.30%	4.91%	4.53%	22.26%	1.89%	0.38%	88.68%	-100.00%
CF7	125	28.80%	0.00%	3.20%	59.20%	15.20%	5.60%	19.20%	11.20%	21.60%	24.00%	-100.00%
CF8	70	0.00%	0.00%	7.14%	77.14%	1.43%	11.43%	10.00%	12.86%	0.00%	24.29%	-100.00%
CF9	242	39.67%	0.00%	14.46%	87.19%	0.41%	10.74%	0.83%	40.50%	0.41%	55.79%	-100.00%
DF1	39	38.46%	0.00%	10.26%	64.10%	5.13%	2.56%	28.21%	33.33%	2.56%	58.97%	-100.00%
EF1	155	27.10%	2.58%	10.97%	66.45%	13.55%	0.00%	9.03%	36.13%	5.16%	48.39%	2.58%
EF2	34	0.00%	14.71%	0.00%	85.29%	14.71%	0.00%	0.00%	11.76%	5.88%	61.76%	17.65%
EF3	44	61.36%	2.27%	6.82%	56.82%	36.36%	0.00%	6.82%	9.09%	0.00%	88.64%	-100.00%

Table 5.3.4 Percentages of Ceramic Attributes for 14 households of Stonework Era

house code	diagnose ceramics	game piece	kiln waster	slip	burnish	decoration	dull back	oxidize	vibrant black	white	direct	everted	inverted	large vessel
AF57,61	235	0.00%	0.43%	22.98%	17.87%	0.85%	68.09%	27.66%	1.28%	2.13%	16.17%	8.09%	55.74%	2.55%
AF62	40	0.00%	0.00%	2.50%	7.50%	5.00%	35.00%	10.00%	7.50%	0.00%	5.00%	2.50%	27.50%	2.50%
AF42	34	0.00%	0.00%	11.76%	17.65%	0.00%	70.59%	26.47%	5.88%	0.00%	23.53%	2.94%	47.06%	14.71%
AF43	49	0.00%	0.00%	2.04%	4.08%	0.00%	87.76%	10.20%	2.04%	0.00%	10.20%	0.00%	63.27%	6.12%
AF64	119	0.00%	0.00%	8.40%	5.88%	0.84%	84.03%	12.61%	2.52%	0.00%	12.61%	0.84%	67.23%	12.61%
AF68	86	0.00%	0.00%	5.81%	3.49%	1.16%	74.42%	13.95%	6.98%	0.00%	19.77%	0.00%	50.00%	0.00%
AF67	136	0.00%	0.00%	3.68%	11.76%	1.47%	83.82%	15.44%	0.74%	0.00%	7.35%	2.21%	65.44%	9.56%
AF29	188	7.45%	0.00%	76.60%	10.11%	36.17%	51.60%	5.85%	0.00%	29.79%	26.06%	3.72%	10.64%	-100.00%
AF12	327	0.00%	0.00%	2.14%	0.00%	0.00%	94.50%	5.50%	0.00%	0.00%	0.31%	0.00%	0.00%	-100.00%
BF38	151	0.00%	0.00%	4.64%	1.32%	0.00%	88.08%	4.64%	7.28%	0.00%	9.27%	4.64%	7.28%	2.65%
BF5	47	0.00%	0.00%	0.00%	25.53%	0.00%	74.47%	23.40%	4.26%	0.00%	10.64%	0.00%	70.21%	4.26%
BF39	70	0.00%	0.00%	2.86%	1.43%	4.29%	78.57%	18.57%	2.86%	0.00%	8.57%	0.00%	61.43%	2.86%
BF13	153	0.00%	0.00%	5.88%	0.65%	0.65%	91.50%	2.61%	5.88%	0.00%	4.58%	0.00%	1.96%	0.00%
BF9	74	0.00%	0.00%	4.05%	13.51%	4.05%	85.14%	13.51%	1.35%	0.00%	14.86%	2.70%	56.76%	2.70%
BF12	43	0.00%	0.00%	2.33%	0.00%	0.00%	90.70%	9.30%	0.00%	0.00%	0.00%	0.00%	0.00%	-100.00%
CF13	173	0.00%	0.00%	25.43%	1.16%	0.58%	68.21%	12.72%	19.08%	0.00%	7.51%	0.00%	5.20%	-100.00%
CF10	104	0.00%	0.00%	0.00%	0.00%	0.00%	95.19%	4.81%	0.96%	0.00%	3.85%	0.00%	1.92%	-100.00%
DF17	66	0.00%	0.00%	1.52%	18.18%	1.52%	54.55%	10.61%	1.52%	0.00%	12.12%	1.52%	46.97%	10.61%
DF12/13	382	0.00%	0.00%	1.57%	8.38%	0.26%	34.29%	9.42%	10.47%	0.00%	2.88%	0.00%	22.25%	1.57%
DF8	197	0.00%	0.00%	2.54%	2.54%	0.00%	68.53%	25.38%	4.57%	1.52%	5.58%	0.00%	0.00%	-100.00%
DF1	187	0.00%	0.00%	0.00%	0.53%	0.00%	62.57%	18.72%	17.65%	0.53%	6.42%	0.00%	0.53%	-100.00%
DF4	24	0.00%	0.00%	0.00%	4.17%	0.00%	87.50%	0.00%	12.50%	0.00%	4.17%	0.00%	0.00%	-100.00%

Ceramic assemblage in the Terrace Era

A selected set of 11 ceramic variables was used in the multidimensional scaling (Table 5.3.3). The multidimensional scaling (Figure 5.3.1) for the ceramic assemblages was produced in the same way as that for the lithic assemblages: from Euclidean distances on standardized variables between all pairs of 22 household units. The final stress for this two dimensional configuration was 0.07.

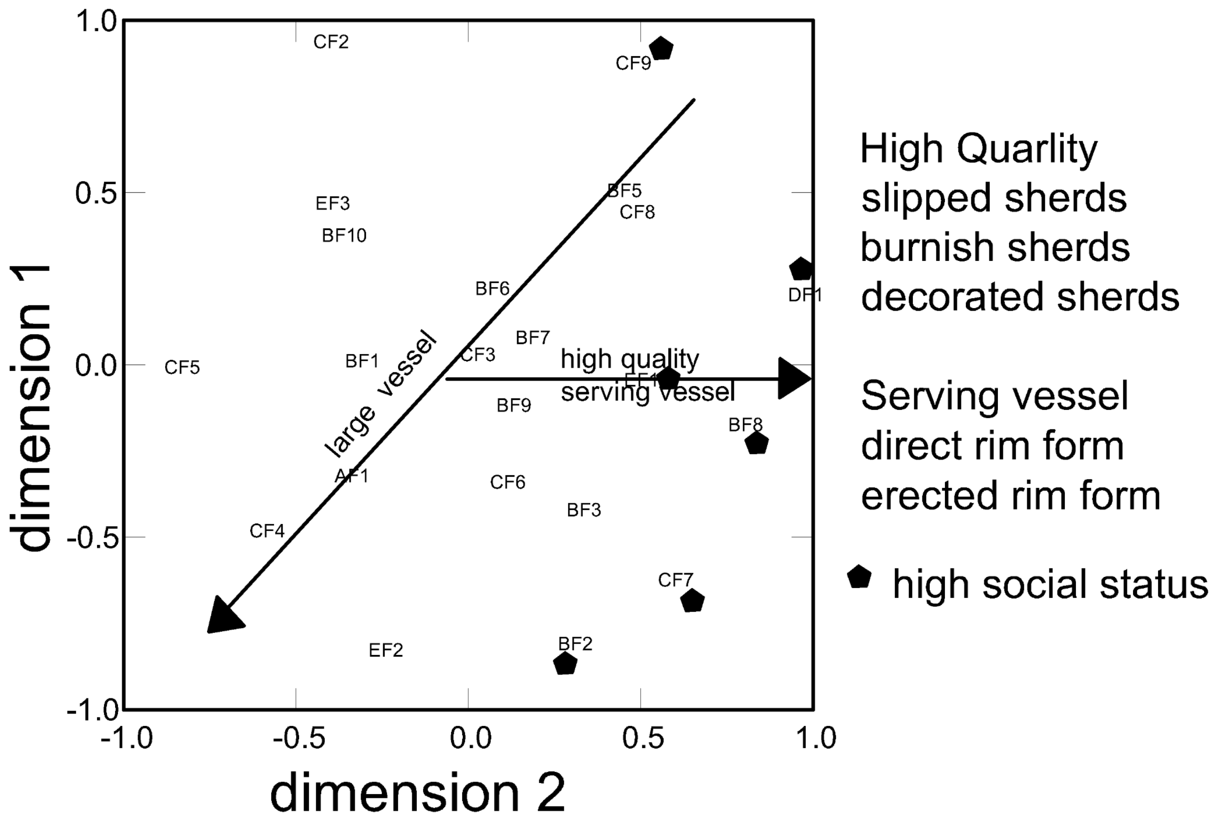

Figure 5.3.1 MDS Plot for a Two Dimensional Solution of Ceramic Attributes from 14 households in the Terrace Era

The principle that dominates the relationships between household units seen in the ceramic variables is the social ranking. The six ceramic variables relating to quality and function of the ceramic vessels are slipped sherds, burnished sherds, decorated sherds, direct rim forms, everted rim forms and large vessels. Household units that have high proportions of good quality ceramics and of serving vessels are in the center right of the configuration. For instance, BF2 has more than 60% slipped sheds and more than 50% serving vessels. BF8 has 30% burnished sherds, 20% decorated sherds and 20% serving vessels. CF9 has 40% slipped sherds, 15% decorated sherds and 40% serving vessels. These household units (CF9, DF1, EF1, BF8, CF7, BF2) have relatively high proportions of good quality ceramic assemblages and serving vessels compared to other household units. This suggest they would have been in better positions than others to enjoy using good quality utensils for serving more elegant food. These characteristics have often been argued to relate to prestige differentiation seen in households that have greater capacity for hosting feasts and public events for other households. They do not necessarily accumulate greater material wealth, but they have greater impacts in the social realm.

At the same time, most household units are scattered along dimensions 1 and 2. Some households have high proportions of serving vessels, but lower proportions of high quality ceramics (eg.CF5); others have high proportions of high quality ceramics, yet not have high proportions of serving vessels (eg.BF7). The mean Euclidean distance between pairs of Terrace Era household ceramic assemblages is 4.112±0.113 (for 95% confidence). These asymmetrical relationships between households are very weak and not well established between in the Terrace Era.

Ceramic assemblage in the Stonework Era

The multidimensional scaling for the Stonework ceramic assemblages (Figure 5.3.2) was produced from Euclidean distances on standardized variables between all pairs of the 22 household units. 13 ceramic variables and the two dimensional solution were selected with a final stress value 0.039.

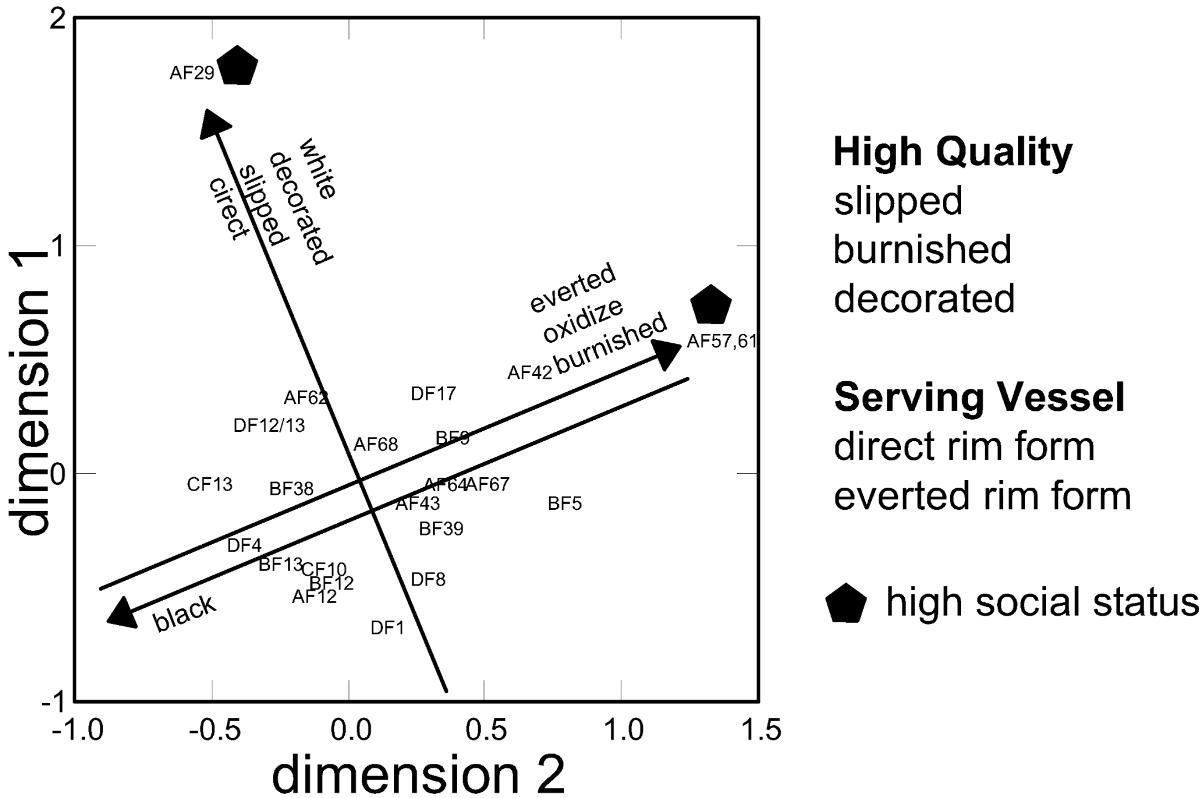

Figure 5.3.2 MDS Plot for a Two Dimensional Solution of Ceramic Attributes from 14 households in the Stonework Era

Compared to the Terrace Era, asymmetrical relationships between households are a clear dominant principle in the Stonework Era. The ceramic variables that produced the patterning associate with the quality and function of ceramic vessels, including slipped sherds, burnished sherds, decorated sherds, direct rim forms and everted rim forms. Amongst the household units in the Stonework Era, AF29 is distinguished from the rest of the household units by extremely high proportions of slipped sherds (76%), decorated sherds (36%), and white color sherds (30%). It is also the only household with a set of game pieces in their midden debris. AF29 is unique because it is the only household with such high values for these variables. AF29 also has relatively high proportions of serving vessels. AF57,61 pulled out toward the right edge of the plot, with relatively high proportions of burnished sherds and oxidized sherds. It also has relatively high proportions of serving vessels. More of the variables form a gradient roughly parallel to dimension 2, making AF57, 61 not entirely unique.

The principle that dominates the relationships between household units seen in ceramic assemblages is still social prestige, but the force that set apart households in the Stonework Era becomes stronger. One household has extremely high proportions of elaborate decorated vessels and special items. It indicates that some households attempted to monopolize access to high quality goods and special materials. Not only did they achieve social prestige by hosting events, but also controlled possession of high-quality goods.

Neither Terrace Era nor the Stonework Era communities present a sharp division between high-ranking and low-ranking household units. The mean Euclidean distance between pairs of Stonework Era household ceramic assemblages is 4.235±0.214 (for 95% confidence); it is slightly higher than the Terrace Era, which is 4.112±0.113. Although the difference in Euclidean distance is modest between these two periods, the number for the Stonework Era is due largely to the unusualness of AF29. It is likely that prestige differentiation became much stronger in the Stonework Era, when lithic and ceramic assemblages suggest both productive and prestige differentiation that are more prominent than the Terrace Era.

5.4 Spatial Patterning in the Neighborhood

Ceramic and lithic assemblages indicate only very slight productive differentiation and economic interdependence in the Terrace Era. Firstly, the independent productive activity pattern is reflected by the household lithic assemblages. *The light duty tool set* identified in the multidimensional scaling analysis is strongly represented in almost all the household units widely scattered across Babeldaob Island. This tool set reflects common daily household activities in the Terrace Era. Moreover, household units in close proximity show a higher degree of similarity than widely separated households. Households interact with the surrounding environment in a similar fashion and maintain self-sufficiency within the neighborhood. The best example is in district 4 (household number starting with C), which is the only district where the recovered household units are quite to each other. CF1 is 200 m away from CF2. CF5,6,7,8 are the earth platforms from NI-1:4, and they are all located on the same terrace within a radius of 200m., These households cluster in the lower central part of the multidimensional scaling plot of lithic assemblages. Thus these household units in close proximity perform a similar array of productive activities and do not rely on one another for the material used in everyday life.

The economic independence of the households in the neighborhood further supports the hostile community dynamic suggested by the defensive landscape in the Terrace Era. Household units maintained a high level economic self-sufficiency living in the fortified settlement and protecting the harvest of the swidden gardens. However, this does not mean that there was no interaction in the neighborhood. Some households display greater social prestige by hosting more public events indicated by high proportions of high quality serving vessels. These households of high social status are not concentrated in one supra-local community but are scattered across different supra-local communities. Although these households are more independent in terms of the subsistence economy, they might well share social events at the local scale. Some households established slightly better social position and wider social influence by hosting these local social gatherings. Yet this influence did not extend beyond their supra-local community and probably was based on kinship.

In contrast with Terrace Era, the productive differentiation and economic interdependence is evident in the Stonework Era. The activity sets represented by household lithic assemblages at NA-4:4 (Ngetcherong), NT-3:9 (Ngerdubech), NT-2:5 (Ngerumlol) and NT-2:1(Ngimis) appeared patchily in the neighborhood(Figure 5.4.1-5.4.3). The *coarse cutting* tool set (or heavy duty tool set) identified in the multidimensional scaling analysis is strongly represented in only one household in Ngetcherong (AF12), three households (BF38, BF12, BF13) in the eastern part of Ngerdubech, two adjacent households (CF10, CF13) in Ngerumlol, and three households (DF1, DF4, DF8) in the eastern part of Ngimis. The *fine cutting* tool set (or light duty tool set) is strongly represented by one household in Ngetcherong (AF57,61), two adjacent households (BF9, BF39) in the western part of Ngerdubech, and two adjacent households (DF12-13, DF17) in the western part of Ngimis.

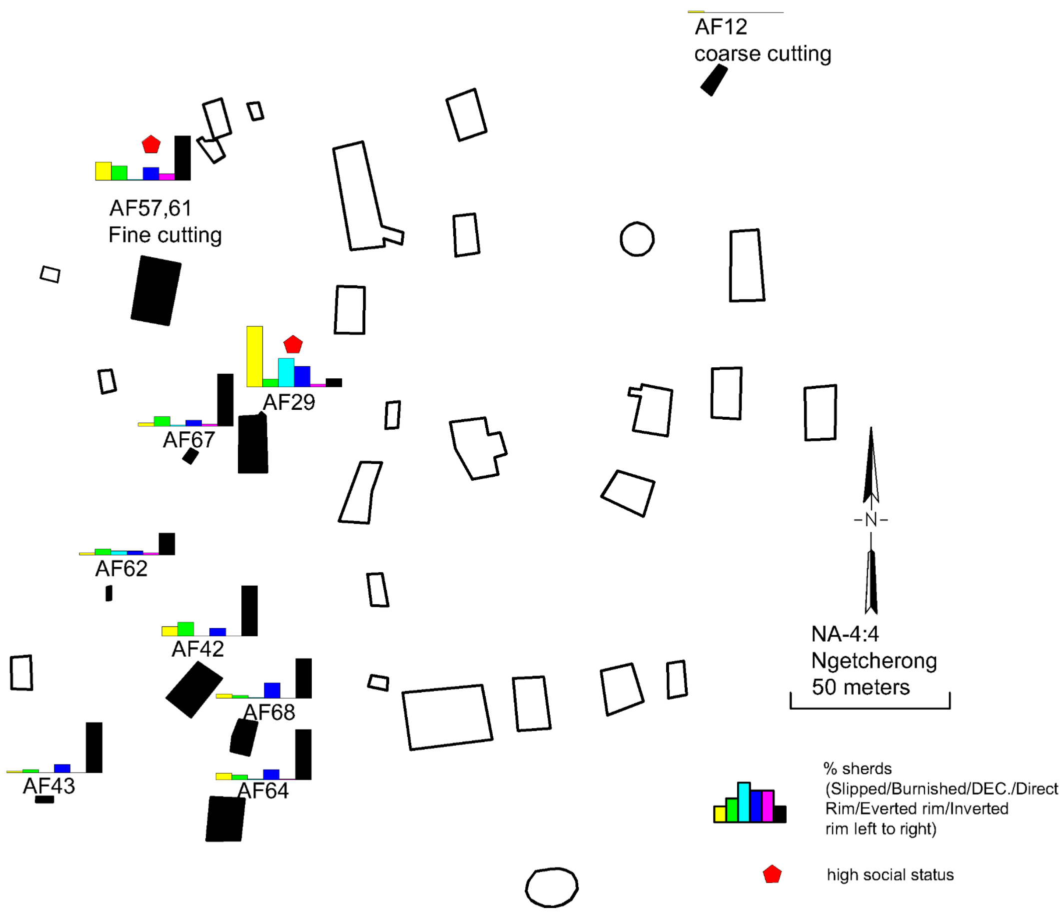

Figure 5.4.1 Distributions of Productive Activities and High-ranking Households at Ngetcherong (NA-4:4)

The distribution of lithic assemblages suggests that close neighbors at Ngerdubech, Ngerumlol and Ngimis shared similar lithic tool sets because they performed similar kinds of productive activities. These connections are likely to reflect kinship links or other kinds of social bonds. Economic interdependence between household units emerged between these neighboring groups (possibly kin groups). The two or three adjacent household units focused on certain services or products that were provided to the residents of other neighborhoods where those tool sets were under-represented. Although these household units did not form a compact town which have facilitated frequent economic exchange of subsistence goods, they nonetheless specialized in different arrays of productive activities from their neighbors. The labor organization is by no means concentrated workshop, but certainly formed small-scale working groups in the close distance.

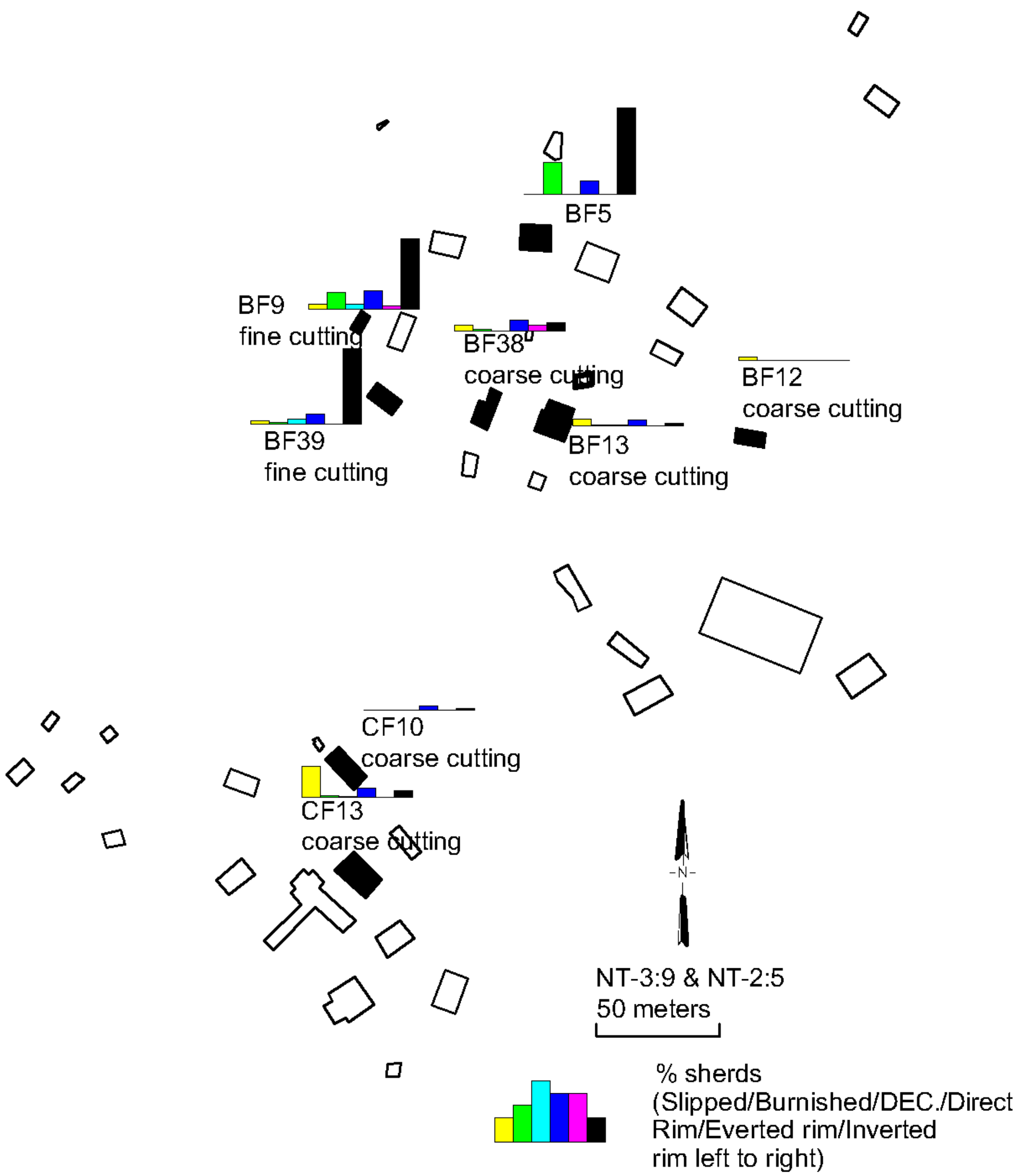

Figure 5.4.2 Distributions of Productive Activities and High-ranking households at Ngerdubech (NT-3:9) and Ngerumlol (NT-2:15)

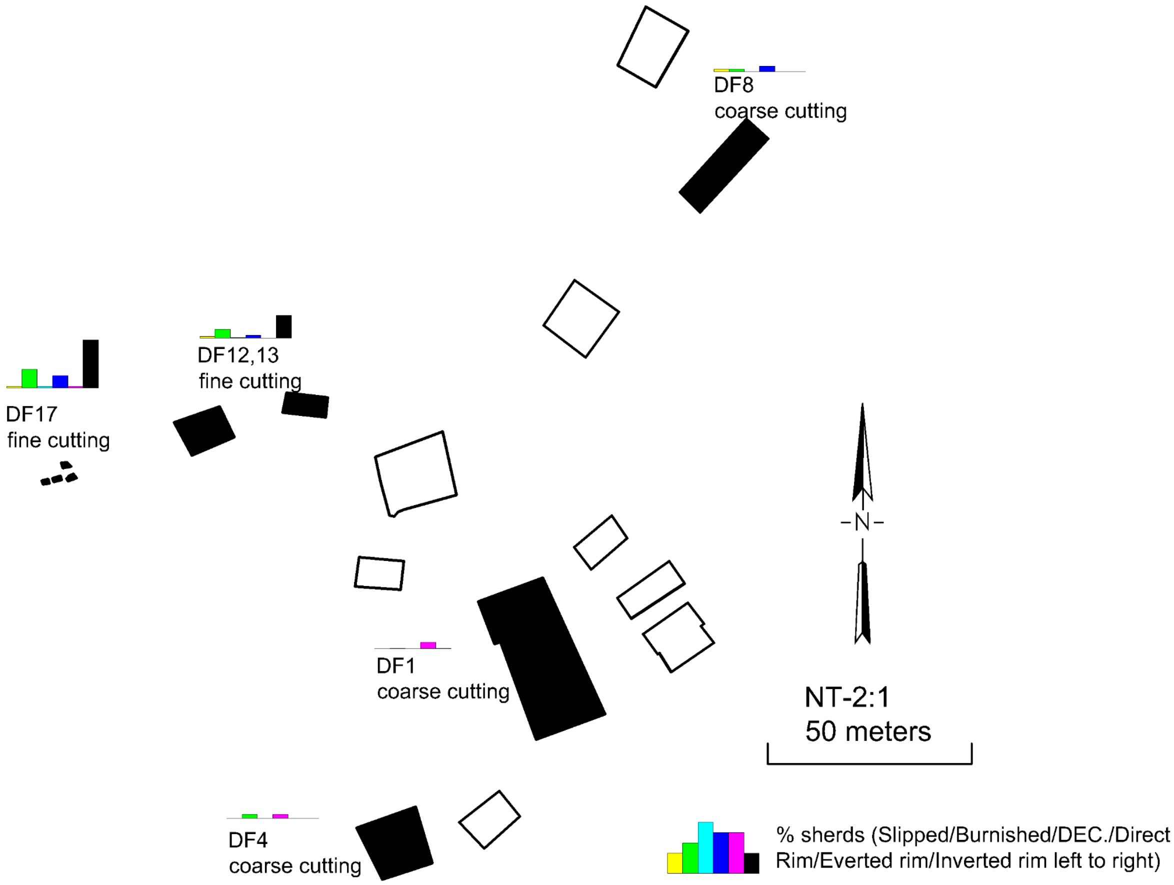

Figure 5.4.3 Distributions of Productive Activities and High-ranking Households at Ngimis (NT-2:1)

Special attention was paid to Ngetcherong. Only two households yield a sufficient number of lithic artifacts (beyond 24) for analysis, this is not because of a small sample of artifacts in general but largely because of relatively low percentage of lithic artifacts (Figure 5.4.4.). It is clear that all the household units in Ngetcherong (household numbers starting with A) have much lower proportions of lithic artifacts than those in Ngerdubech, Ngerumlol and Ngimis (household numbers starting with B\C\D). Our confidence in this statement is very high since the estimated proportions for all fall outside the 99% confidence error ranges for the other households. This pattern suggests that households in Ngetcherong did not engage in a wide range of productive activities like other households in the Stonework Era.

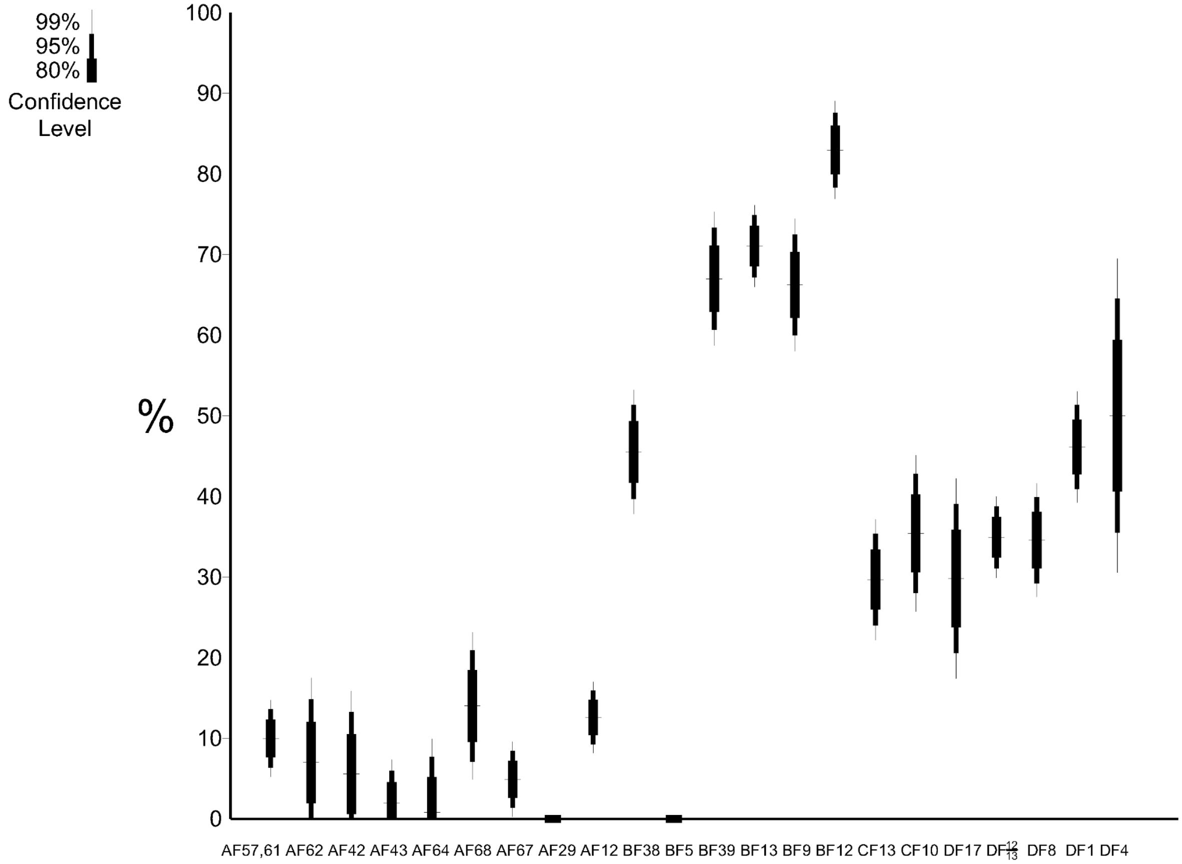

Figure 5.4.4 Bullet Graph of Proportions of Lithic Artifacts per Household in the Stonework Era

The spatial proximity of households also links the productive activities with social prestige. All the households in Ngetcherong have relatively higher social prestige indicated by higher proportions of good quality and serving vessels. Although households of Ngetcherong engaged less in coarse cutting and fine cutting work, they showed higher social prestige. AF29 stands out strongly for high prestige in terms of good quality vessels and special items, but it does not participate in productive activities that are common in other household units (no lithics were found in the midden). Spatially it is located at the center of the community. Social prestige and productive activities were thus negatively correlated in terms of spatial distribution. The only household (AF12) engaged in the *coarse cutting work* in this community was in a location peripheral to the main group. This heavy cutting work did not respond to high social prestige.

Prestige differentiation also has some relationship to productive differentiation at Ngerdubech, Ngerumlol and Ngimis. Households with more fine cutting work seem to have had slightly better social position than the households with more coarse cutting work (BF9, CF13 and DF17). Their social prestige is modestly higher than the other households in the neighborhood, and might represent material wealth from their productive activities.

5.5 Summary

5.5.1 **Evaluating the working hypothesis**

The observed patterns of household relationships in the Terrace Era aligns with the predicted patterns. According to the working hypothesis, long distances between households discourages frequent interaction between neighbors and promotes economic independence. This expectation is demonstrated by the household activities reconstructed from the artifact assemblages. Most households utilized the light duty tool set most prominently and performed similar kinds of domestic activities adapted to their local environment.

According to the working hypothesis, the lack of productive alluvial soil made the accumulation of material wealth through agricultural intensification difficult. The observed pattern corresponds to this prediction in that the household assemblages did not show much wealth differentiation. No households appeared to have a higher standard of living, such as possessing high quality goods that require much labor. This is also consistent with the idea that no household controlled more productive land and marginalized some other households on less land.

On the other hand, prestige differentiation between households is indicated by the ceramic assemblages. Some households held higher social positions than their neighbors from hosting competitive feasting events. But this prestige differentiation is modest and not supported by wealth differentiation. For instance, the households with higher percentages of elegant serving vessels did not construct larger platforms for living or own more farmland. Some households with more farmland and larger platforms do not show evidence of hosting feasts. This suggest social ranking was not static but rather subject to change through wars and competitive feasts.

The observed patterns of household relationships in the Stonework Era also correspond to the predicted patterns. According to the hypothesis, productive differentiation and economic interdependence will occur at a local scale between households in closer proximity. This is exactly what we have seen in this chapter. Adjacent household units specialized in particular productive activities and provided services and products to other households where production of these things was under-represented; At the same time they likely received services and products from the other households. The degree of productive differentiation entails a similar degree of economic interdependence amongst the scattered households.

Like the Terrace Era, the lack of productive alluvial soil also limited the accumulation of material wealth for people in the Stonework Era. Although households with high proportions of fine cutting works seems to have had higher standards of living, the degree is modest. Generally, members of local communities provided mutual benefits for one another without making clear wealth ranks amongst them. On the other hand, prestige differentiation developed clearly in the Stonework Era, but prestige did not come from their productive activities. The prestigious households in Ngetcherong largely escaped from daily productive activities. The most prestigious household AF29 seems to be a household that organized special feasts and gatherings rather than a household with a luxurious lifestyle.

5.5.2 **Modes of Intensification and Their Implications for Productive Differentiation and Economic Interdependence**

Living in scattered households did not produce the same degree of the productive differentiation and economic interdependence in both periods. As indicated in the household assemblages, productive differentiation was unmistakably stronger in the Stonework Era than in the Terrace Era. This pattern was associated with different modes of agricultural intensification.

According to ethnological accounts of Futuna, the swidden cycle involves much labor all year round (Kirch 1994:105-123). The cycle includes not only intensive garden preparation (survey and clearing) but also frequent planting and harvesting of different crops, plus constant weeding and mulching to regenerate the soil. In contrast the pondfield cycle involves more labor in the beginning for building the agricultural landscape, but much less labor for planting and harvesting. As a consequence, cropping cycle intensification requires individual household to spend their time and energy on the swidden gardens all year round. This demanding interaction between people and land discouraged household units specialized daily economic tasks and grow interdependence between one another. The artifact assemblages suggest that households economic activities were similar to one another and adapt to the local environment.

For landesque capital intensification, construction of irrigation systems requires intensive labor in the initial phase, and the allocation of water flow is not equal in the dry season. The nature of irrigation requires much more collaborative work compared to swidden agriculture. Although building canal networks does not require centralized management at the regional scale (Kirch 1994:159), the system operated at a local scale that involved households in close proximity (the local word kaiga, meaning a group of kin resident on the same land of which they have common use). From the previous chapter, we know that village living was absent, and the household units in the Stonework Era was widely scattered. How was collaboration between households established in this dispersed settlement distribution? The analysis in this chapter reveals the mechanism. The artifact assemblages show that some households in the neighborhood were involved in more heavy duty work, which was likely associated with the construction of pond fields. These households tended to locate adjacent to each other, making collaboration convenient. The activity pattern suggests that some people in the neighborhood were more focused on constructing and maintaining the irrigation system than others. Their role in the community may have involved seasonal labor to clear the ditches, level the terraces and build the banks. This freed some households from heavy duty labor. In exchange some other households were more involved in light duty work, such as coconut fiber making, basketry and wood carving. The nature of pond field agriculture requires periodic collaboration, which encourages productive differentiation amongst the households, thus reducing economic independence even in the dispersal settlement distributions.

5.5.3 **The Role of Productive Differentiation in the Development of Social Complexity**

We can approach the role of productive differentiation in the development of social complexity by evaluating the connections (if any) between productive differentiation and wealth/prestige/ritual differentiation amongst the households in both periods. Productive differentiation reflects horizontal relationships between household units, but wealth differentiation, prestige differentiation and ritual differentiation reflect vertical relationships between household units. Chronological comparison of the household relationships (horizontal and vertical and their connections) provides a robust way to examine the role of productive differentiation in shaping social organization in Palau.

The major difference between these two periods in terms of household relationships is the emergence of productive differentiation and economic interdependence in the subsistence realm. There is some indication of correlation between productive differentiation and wealth differentiation. It seems that people involved in irrigation construction and maintenance had less access to good quality materials and occupied a lower social position than people who were free from this labor. However the degree of difference is modest. To a large extent, productive differentiation and economic interdependence create benefits for all through economies of scale. All households in the neighborhood enjoyed the benefits of the irrigation system, stone pathways, and other public facilities. These systems developed in bottom-up fashion without conspicuous leaders who controlled the production and distribution of economic necessities. Cooperation stayed at the local scale and did not contribute to the process of social integration. Localized water management systems make societies more fragmented as the population grows.

The potential challenge in this system is to keep people cooperating over time without political coercion. The prominent dimension that characterized household relations was prestige differentiation and social prestige was negatively correlated with the productive differentiation. The prestigious households in Ngetcherong engaged less in productive activities compared to other households. According to the MDS results, social prestige came from secular social gatherings (AF57,61) and religious ceremonies (AF29). The households in the center of the supra-local community emerged to bring people together for seasonal markets and ceremonies or other social activities that served to integrate the dispersed households. The systems allowed some people be free from daily productive activities, and they devoted their time to social activities that helped to resolve conflict between people in community building events and rituals.

6.0 Conclusion

6.1 Responses to Research Questions

The dissertation research is designed to evaluate whether the patterns observed in a comparison between four Pacific Island societies hold true for Palau as well. The four research questions concern social change in Palau at various scales (including regional settlement demography, relationships with the environmental resources, and relationships between households) so as to make a possible comparison with other early complex societies in the Pacific. The variation across these societies is not viewed simply as a consequence of historical contingency, but of divergent evolution sparked by specific forces of social change. Answering the four research questions seeks to identify the forces that led to divergence within the context of Pacific island societies.

6.1.1 **Demographic Structure**

The first research question concerns pre-contact demographic structure in Palau. How large was the population? How large and how compact were local communities? How large demographically and spatially, were supra-local communities? How strongly centralized were they? How did demographic structure change over time? Finally, how did demographic distributions compare with those of the other four Pacific Island societies in the comparison?

The demographic analysis in chapter three reconstructed the total population size and its change in Palau; the size and centralization of supra-local communities; and the size and compactness of local communities. The fundamental assumption underlying demographic analysis is that when more people live for longer times in a particular place, they leave more traces (artifacts and architectures) on the landscape. Because of sample was small, population was estimated based on the number of house structures rather than the area and density of artifact scatters. The total population of the Terrace Era is estimated at 17,910-20,895 and that of the Stonework Era at 53,712-62,664. Stonework Era population was almost three times than that in Terrace Era.

Local community structure was very dispersed for both the Terrace Era and the Stonework Era. The interpolated density surface did not suggest satisfactory boundaries for local communities because of this scattered distribution, although the average residential density increased from 18-21 people/ha in the Terrace Era to 36-42 people/ha in the Stonework Era. The increase in residential density did not, however, form compact villages; instead Babeldaob Island was covered by a fairly continuous occupation, especially along the coast and at the north end. The pattern represents the intensified agrarian mode of settlement seen in many semitropical and tropical regions, characterized by low density occupation spread over a vast area. One other important difference in the local community structure between the Terrace Era and the Stonework Era is that there is a wider range of household spacing for the latter period. When compared to other low density complex societies, we argued the range of household spacing in the Stonework Era was triggered by the development of irrigation systems and water management, which is more similar to the Maya region than the Rio Tonosi Valley of Pacific Panama. And that difference emerged because of different modes of agricultural intensification in response to the local environment.

In the Palau trajectory, there were always 8-10 supra-local communities on the island of Babeldaob, but no single supra-local community ever successfully dominated the entire political landscape. In the Terrace Era, all the supra-local communities were small, ranging from 3km^2 to

18km^2, and containing populations of 900-4000 people. In the Stonework Era, most supra-local communities increased both spatially and demographically, and their average population was about 6000 people. District 1 stood out from the rest with a population of over 15,000 along a narrow strip of land of 16km long. That largest supra-local community represented 30% of the total population, but still did not seem to integrate the entire Babeldaob Island.

Although the size of supra-local communities increased in the Stonework Era, the degree of centralization declined from the Terrace Era, with an average B value of 0.28, to the Stonework Era with an average B value of 0.20. The population surge in the Stonework Era did not increase regional integration, but instead increased social fragmentation. Although households clustered at greater densities in district 1 (the north end of the island), suggesting there may have been some integrative force at work there which did not exist in other parts of the Babeldaob, the force seemed to be relatively weak because it did not create very strong centralization. Settlement decisions in the Stonework Era seem to have been motivated by individual households' economic concerns, such as productive agricultural land and water sources. The demographic centers of the supra-local communities were more closely packed household units living in corporate economic and social relationships. They shared labors in the construction of pond field irrigation, stone pathways, public meeting houses, docks, and defensive systems. Such labor organization was not centrally controlled and managed, instead organization was at the household level. It is very likely that public works were organized seasonally by some household units in voluntary fashion. This kind of interaction did not promote compact village living or social integration at larger scales

Palauan settlement patterns in the Terrace Era and the Stonework Era were like Hawaiian and Society Island settlement patterns, which were also dominated by dispersed households; and less like Yap and Mailu, which were more compact in nature. East Polynesian was settled 1000-

1200AD, 2000 years after the colonization of the Palauan archipelago, which was around the same time as the Stonework Era. Although the length of settlement development was different, these island groups ended up with similar settlement patterns as population increased. Urban centers were absent, and the nature of settlement patterns varied considerably depending on topography and other environmental factors. However, the average East Polynesian homesteads were larger in size and more complex in structure than the average Palauan homestead. Most households occupied a space between 1 ha and 4 ha (Kahn and Kirch 2013; Field et al. 2010; Kirch and Sahlin 1992); whereas most households in Palau occupied 0.25-1ha. Most of the homesteads in East Polynesia consisted of multiple functionally differentiated structures and activity areas (Weisler and Kirch 1985; Field et al. 2010; Kahn 2005); whereas most Palauan households had a single primary residential structure and shared functional facilities with other households. Generally speaking, in East Polynesia, the development of social complexity reflects in the increased differentiation between the elite households and the commoners'; this can be seen in residential size and functional complexity (Field et al. 2010). This trend did not appear in Palau trajectory.

6.1.2 **The Relationship between Demographic Structures and Resource Distribution**

The second question focused on the centralizing forces that drew populations closer together. Was it control of the most productive agricultural land? To what extent, did the natural distribution of agricultural land influenced the regional demographic distribution? How did the relationship between environment and demography change over time? And how did the force at work compare with those of other Pacific islands?

Systematic analysis of the distribution of Terrace Era settlement with respect to environmental variables (chapter 4.1 and 4.2) revealed a counter-intuitive pattern. The agricultural intensification did not cause people to live on and farm the very most productive land. The weak rank-order correlation between population density and agricultural productivity at different scales showed that the role of agricultural productivity in settlement location was not as important as we expected; instead the infertile hilltops and uplands were favored when people made their settlement choices. What were the reasons for people to live in these locations since it does not maximize agricultural productivity? The analysis of topography in chapter 4.3 suggested that neighborhood security was a significant factor in determining their settlement locations. The spatial analysis demonstrated that Terrace Era settlements were in more defensible locations than those of the Stonework Era because of their preference for high elevations and steep slopes. Some terrace sites suggested they have fortification functions, such as the presence of deep ditches and palisades (Liston and Tuggle 2006).

Cropping cycle intensification promoted warfare for seizing land seizing in order to control farming resources. Compared to pondfield agriculture, swidden agriculture had a much larger catchment area for daily transportation because of its extensive farming style (Kirch 1994). Both reasons encouraged people to increase their defensive abilities and trade off convenience in access to farmland. Moreover, given forest clearance for swidden agriculture (Athens 2005), hilltops were probably more productive than they are today, especially compared to farming lowland fields more subject to flooding and with poorer drainage if without the construction of pond fields. Overall, the settlement preference for the Terrace Era was a compromise decision between neighborhood security and control of farmland.

By contrast, systematic analysis of the distribution of Stonework Era settlement with respect to environmental variables showed that agricultural activities played a more important role in the settlement distribution although the correlation was not very strong. The erosion of upland soils created an accumulation of fertile soil on the coast but probably harmed the lagoon and coral reef zones. To better manage the changing landscape, people innovated pondfield irrigation and cultivated productive wetland taros (*Colocasia esculenta*), which helped trap the sediment before it reached the sea, and protected the coastal margins (Victor et al. 2004; Fitzpatrick and Giovas 2021). At the same time, pondfield irrigation increased the efficiency of food production because the calories yield per unit of land is higher for wetland taros than the dryland food crops (Kirch 1994). Therefore warfare shifted its emphasis from seizing land to unpredictable raiding for materials and women (Liston and Tuggle 2006). Under these circumstances, valley floor and coastal land behind the mangrove forest were favored because of the great yield from pondfield agriculture.

On the other hand, a significant proportion of occupation can't be explained well according to the distribution of farmland, even though the correlation is higher for the Stonework Era. This is especially true at the scale of the supra-local community. The districts with denser population do not contain higher proportions of productive farmland. Clearly other factors had great impact on how people organized themselves. Two potential factors are likely involved: the distribution of marine resources and the capability of organizing local collaborative networks. Lack of data on marine resources make it impossible to evaluate their productivity along the coast of Babeldaob at present. Thus, we turn to the social factors that produced different household spacing as in Palau. Specifically, we evaluated the degree of productive differentiation and economic interdependence, as well as the degree of wealth, prestige and ritual differentiation between households at the local level via comparing their household assemblages in chapter 5.

Settlement dispersal in Palau produced two different kinds of relationship between environment and population. This distinction was attributable to the changing mode of agricultural intensification. Cropping cycle intensification encouraged conflict over control of land. The principal centripetal force that formed supra-local communities was alliance for warfare. Hilltop settlement locations helped allied households see each other and protect each other from frequent warfare for territorial acquisition. Even without impressive fortifications, hilltop locations provided considerable dwelling protection in many tribal societies, such as highland New Guinea, Central Arizona and highland Peru (Roscoe 2008; Lau 2010; Solometo 2006). The intensity of warfare was higher in the Terrace Era than in the Stonework Era. Thus, people sacrificed convenient access to productive land and moved to hilltops.

In contrast, the landesque capital intensification increased the efficiency of food production by landscape modification. The labor organization that constructed and maintained pondfield irrigation required neighborhood collaboration and constant investment in the land. Community dynamics reduced the drive for territorial acquisition and encouraged household units to choose location based on economic concerns. Although warfare continued in the Stonework Era, emphasis shifted to the unpredictable and probably less frequent raiding for goods and women. Some household units cooperated and built defensive stone walls and causeways at important entry points in order to protect people from unexpected raiding especially from the sea (Liston and Tuggle 2006). Both labor organization and the nature of conflicts promoted a more positive relationship between environment and population in the Stonework Era. At the same time, other social factors played an equally important role in population distribution.

Two contrasting kinds of agro-ecosystem were first proposed by Kirch (1994) in the Hawaiian archipelago. Landesque capital intensification dominated the windward sides of geologically older islands, such as Oahu and Moloka'i; whereas cropping cycle intensification dominated in the leeward sides of geologically younger islands, such as Hawai'i and Maui

(Landefoged et al. 2009). Kirch (1994, 2006) argued that the two different modes in Hawai'i had a significant impact on the evolution of political economy. Cropping cycle intensification required more labor inputs and likely created resource pressure. According to Carneiro's theory, that produced larger scale political integration on the island dominated by swidden agriculture than the islands dominated by pondfield agriculture. However, this did not happen in Palau. We did not see a larger scale political integration in the Terrace Era when cropping cycle intensification dominated. Cropping cycle intensification may have created much stronger socio-political integration in Hawai'i because of the strong positive relationship between demographic distribution and environmental resources. In both agro-ecosystems in Hawai'i, household units chose their locations according to the distribution of environmental resources. As the population increased, people expanded their territory into the vacant productive land and households also expanded their territory by building more residential structures in the immediate area (Field et al. 2010, 2011). During the process founder families accumulated material wealth. Wealth differentiation was supported by elite ideology in Hawai'i which made commoners believe in their own inferiority and that their lands belonged to the chiefs, fostering payment of tribute in agricultural products to elite households or regional temples. A comparison between Hawaiian and others shows that those in Hawai'i did not use fortification hilltop or ridgetop fortification or other labor intensive defensive structures; instead there were more war temples and refuges to mitigate the conflicts (Kolb and Dixon 2002). In return, less conflict between neighborhoods made it easier secured the possibilities to accumulate material wealth from agricultural production. Elites filled more ritual roles that maintained social cohesion and legitimized wealth differentiation (Kahn 2015). As a result, socio-political integration reached a larger scale in the Hawaiian islands than in Palau, where frequent conflicts and lack of financial bases limited the scale of integration.

6.1.3 **Productive Differentiation in the Local Community**

The third research question focused on the extent of productive differentiation between households in the local community. What kinds of goods (if any) were produced by specialists? How did the degree of productive differentiation change over time? How did it compare to other Pacific island societies?

Productive differentiation in Palau never approached full-time specialization or centralized labor organization (in workshop-like conditions). It occurred only to a modest degree, in which certain households engaged in certain activities more than others, with some small amount of economic interdependence between households on a daily basis. Nonmetric multidimensional scaling analysis was conducted to visualize the dissimilarities of domestic activities between household units in the Terrace Era and the Stonework Era respectively. The MDS plots identified the presence of two activity emphases: heavy duty/coarse cutting activities and light duty/fine cutting activities. In the Terrace Era, most of household units conducted light duty/fine cutting activities which are associated with general household activities, suggesting that they maintained a high level of self-sufficiency. By contrast, modest differences in economic activities were identified between households in the neighborhoods of the Stonework Era. Nine out of fourteen household units emphasized heavy duty activities, which are probably associated with construction and maintenance of irrigation facilities. The rest of the households emphasized light duty activities, which are probably associated with ordinary basic household activities. Households with similar economic activities were spatially close together, suggesting that they coordinated with one another. A probable scenario for the Stonework Era is that some households in close proximity carried out the periodical construction and maintenance of the irrigation system for other households whose pond fields were in the same local hydraulic system, and they would have received some craft items in return.

Under similar circumstances of pondfield irrigation in windward Hawai'i, the construction and maintenance of public works did not create economic interdependence between households in everyday life. However, differential production focused on prestige goods and ritual paraphernalia; and this production was often for long distance exchange instead of close neighbors. For instance, comparison of the faunal assemblages between inland and coastal locations in leeward Kohala showed distinctive assemblages adapted to their immediate environmental resources, but some traded between the two areas inlarger carnivorous fish, pigs and dogs (Field et al. 2016). Why did public works in Hawai'i not encourage economic interdependence in the subsistence realm? Both Allen (1991) and Kirch and Sahlins (1992) argued that the irrigation systems in Hawai'i show a high level of surplus production, which is different from Palauan pond field systems because of the larger areas of fields each household cultivated in Hawai'i. The wider valleys of Hawai'i enabled household units to produce more material wealth, and that provided the financial basis for social hierarchies. In return the same process encouraged aggrandizers to expand their surplus production for competition and hindered the tendency to form small groups for mutual aid.

6.1.4 **Wealth, Prestige and Ritual Differentiation in the Local Community**

The fourth research question focused on the extent of wealth, prestige, and ritual differentiation in the relationships between households in local communities. What connections were there between these kinds of differentiation and productive differentiation? What was the role of productive differentiation in the development of social complexity? How did these relationships change over time? How did they compare to those of other Pacific societies?

In both the Terrace Era and the Stonework Era, vertical relationships between households mainly existed in the realm of social prestige and ritual roles rather than in the realm of material wealth, based on household artifact assemblage and architectural evidence. For the Terrace Era, the high-ranking households had higher proportions of good quality and serving vessels, suggesting a capability to host ritual and communal feasts. For the Stonework Era, social prestige came from the capability to organize social gatherings and rituals. Households of high rank did not display a higher standard of living by owning high quality tools or utilitarian vessels. The architectural evidence does not suggest that high prestige households occupied larger farm plots; nor were they of better quality construction than other households.

Mortuary practices in Palau suggested a modest degree of prestige and ritual differentiation throughout the trajectory. Between 3000-2000, the residents of Palau buried their deceased collectively in limestone caves. Chelechol ra Orrak, a cemetery used for 1000 years, contained more than 55 individuals (most of them represented by fragments). A modest degree of prestige differentiation was observed in this site because most of individuals in the cemetery are females and buried with pearl shell scrapers, whereas only one male was found with a mollusk shell and a pearl shell scraper (Fitzpatrick and Boyle 2002; Fitzpatrick and Nelson 2008; Nelson and Fitzpatrick 2006). However, the differentiation in grave goods was not a reflection of diet. The skeletal population did not show any dietary distinctions based on sex or age (Stone et al. 2019). Thus females likely had higher social prestige but the difference is more symbolic than economic.

In the late Stonework Era, people buried their deceased under abandoned stone platforms. In Ngerdubech (NT-3:9), 15 human burial pits were found in feature 38 and 4 burial pits were found in feature 80. Four of the fifteen human burials under the feature 38; one of the four burials under the feature 80. Most of the grave goods were bracelets of Indo-Pacific glass beads (Liston

2011a: 173-188). The glass beads were of Chinese origin, but they might have been imported from Yap or the Philippines rather than directly from China (Liston 2011b :374-385). Clearly some people had access to exotic glass beads and some did not. According to ethnographic accounts, glass beads were considered as money in Palau; they were exchanged in important life rituals, such as weddings and funerals. Palauan money also carried supernatural power in terms of origin stories (Rietzenthaler 1954). This also reflects some degree of prestige and ritual differentiation in the society.

Compared to Palau, prestige and ritual differentiation in East Polynesia is intertwined with wealth differentiation. The social prestige of chiefs was financially supported by the accumulation of material wealth through ownership of productive farmland. Household research in Kohala, Hawai'i, suggests that wealth differentiation emerged around 1650AD and is shown in the expansion of territories and the construction of new more elaborate residential architecture, as well as in an abundance of high quality artifacts and food for elite residential complexes (Field et al. 2010). The degree of prestige and ritual differentiation is even stronger in East Polynesia than that in Palau. Elite household compounds include ritual shrines, and are also spatially closer to the temples, more secluded from ordinary households (Field et al. 2010; Kahn 2015). In comparison, Palauan elites' compounds did not show difference in ritual functions, and public ritual facilities were less impressive than those in East Polynesia. Strong ritual authority also legitimized elites in monopolizing the access to prestige goods, as well as in consuming high proportions of prestige foods (Bayman and Nakamura 2001; Kirch et al. 2012). The comparison of the degree of wealth, prestige and ritual differentiation between Palau and East Polynesia suggests that the intersection and entanglement of these vertical relationships enhanced the degree of differentiation between elites and commoners in East Polynesia.

Productive differentiation played very different roles in building social hierarchy in Palau and East Polynesia. As discussed under question 3, differential production in Palau focused on productive activities in the subsistence realm and exchange at the local scale, whereas differential production in East Polynesia focused on prestige goods and ritual paraphernalia and exchange at the regional scale. These two emphases directed change in social organization along different paths. In Palau, productive differentiation created economic efficiencies and collective benefits for all, instead of producing capitals for social divisions. Those involved in special productive activities in Palau did not enjoy a better social position or have a higher standard of living; to the contrary, those less involved in specialized activities had higher social prestige from organizing social and ritual events for dispersed community members. Economic cooperation was organized locally and in bottom-up fashion; the elites' role was the social glue for the loosely connected communities so that potential conflicts (for example over water allocation) between neighbors could be resolved in seasonal gatherings. Social prestige came from elites' service in integrating the community rather than from control of the productive system. The lack of control of productive systems might also have made elites in Palau less influential in other dimensions of inequality.

By contrast, in East Polynesia, specialized production of prestige goods and ritual items contributed to materialize the intangible power of elites in the society. Elite households (often priestly households) were in charge of producing ritual items made of prestigious materials. The best example is the Mauna Kea adze quarry on Hawai'i Island, where 265 workshops and 45 religious shrines were concentrated. These raw materials were traded to different parts of Hawai'i and other islands. Kirch et al. (2012) found that a higher percentage of Mauna Kea artifacts were found in the elite residences and heiau (temples) in Maui. Additional evidence from priests' household artifact assemblages in the 'Opunuhu Valley of the Society Islands and in the Kanikinui district of Maui Island shows that these households engaged intensively in the production of ritual items and in performing ritual activities (Kahn 2015). In summary, elites in both Hawai'i and Palau did not control the production of subsistence goods, but Hawaiian elites controlled the production of prestige goods, which contributed to the role of elite ideology in the development of social complexity.

6.2 Evaluation of Working Hypothesis

The working hypothesis in this research involves the complicated relationships between *agricultural productivity* and *intensification*, *local community structure* and *local-scale productive differentiation* and *economic interdependence* and how these shape social hierarchy in different ways. Where agricultural productivity is high, people tend to intensify agricultural production in response to population growth. Intensive agriculture encourages people to disperse across the land rather than to gather in compact villages. The lack of village living discourages productive differentiation and economic interdependence between households. In this case, the power and authority of elites tend to rely on resource control without relation to productive differentiation and economic interdependence. Periodic warfare is likely to occur because of the desire for territorial expansion for farming resources. Where agricultural productivity is low, although agricultural intensification might still happen, the vulnerability of the environment will eventually limit the long-term agricultural intensification and require a mixed subsistence economy based on fishing, collecting shellfish, hunting and agriculture. This situation encourages productive differentiation in different subsistence arenas and thus creates a pattern of village living to facilitate economic interaction. And such productive differentiation might provide a pathway to social changes through wealth differentiation. Warfare in this kind of society usually focuses on rapid and unpredictable raiding for portable goods.

If this working hypothesis held true for Palau, then productive differentiation and economic interdependence in the utilitarian goods of daily life would be limited because of the dispersed settlement pattern. However, the limited agricultural productivity of Palau would require a mixed subsistence economy including a big marine component, which will require substantial populations near the coast. As population increases, household spacing will be shortened and potentially undermine economic independence between some households at short distance. The degree of productive differentiation in Palau was somewhere between that of East Polynesia and that of Mailu/Yap. At the same time, limited agricultural productivity will limit the growth of wealth differentiation between households. The power and the authority of elites will mainly come from prestige or ritual differentiation.

Generally speaking, the observed pattern in both periods aligns well with the expected patterns according to the working hypothesis. In the Terrace Era, productive differentiation in economic necessities was underdeveloped, and household units conducted similar domestic activities adapted to the local environment. The narrow river valleys and the severe soil erosion caused by swidden and earth construction limited the productivity of farmland. No wealth differentiation was observed between household units, but some households held higher social prestige from hosting local social gatherings. The centripetal force that formed supra-local communities was political alliance to defend land because the expansion of swidden agriculture promoted warfare over land control. Leaders who had higher social prestige organized social gatherings and rituals to strengthen alliances. Intensive conflicts further restricted the accumulation of material wealth grounded in the agricultural economy.

As a result of soil erosion and population increase, the innovation of pondfield agriculture became a solution and motivated people to transform the landscape for farming in the Stonework Era (Fitzpatrick and Giovas 2021). At the same time, limited agricultural productivity required multiple subsistence pursuits, especially to make up for a shortfall of animal protein from declining fishing and from pig extirpation (Fitzpatrick et al. 2011; Giovas 2006). Both the construction of pondfields and the mixed subsistence economy promoted productive differentiation and economic interdependence between households in the close proximity, even though intensive farming tends to create a dispersed settlement pattern. The capability of organizing local networks of economic cooperation became a centripetal force forming supra-local communities. The nature of the centripetal force also changed the nature of wars, from territorial expansion (more frequent and intensive) to unpredictable raiding for portable objects (less frequent). The study of household relationships in Chapter Five painted a picture of local organization. Two or three adjacent household units (probably a kin group) focused on constructing and maintaining pondfield irrigation. Their labor served other kin groups who engaged in light duty work, such as collecting shellfish, basket making, pottery making and wood carving. Productive differentiation was modest but able to provide mutual benefit to participating households. Leaders in the community did not control production or access to material wealth; instead their roles were to host social gatherings and rituals in different sectors (probably based on kin groups) within supra-local communities in order to facilitate corporate decision-making, resolve conflicts, and carry out public works. Economic cooperation necessarily create or need a strong central government or a very powerful leader. The process of integration is bottom-up, but it still allows people to create economies of scale (Erickson 2006).

The consistency of Palauan social trajectories with the hypothesis helped us understand better the differences between the trajectories of early complex society in the Pacific islands. Palauan trajectories shared much with East Polynesia and less with Mailu and Yap. Settlements in both regions persistently took the form of scattered farmsteads from the early colonization period to the proto-historic period. Both regions witnessed a substantial increase of population density in their cultural sequences, and they both responded to the problem by intensifying agricultural production. Both regions had two modes of agricultural intensification and these two modes produced distinctive social relationships.

However, agricultural productivity is not equivalent for the two regions because of the much wider valley floors and much larger coastal plains of East Polynesian islands compared to Palau. This creates different patterns of social organization under the two modes of agricultural intensification in Palau compared to East Polynesian. For the swidden agriculture in Palau, the lack of agricultural productivity limited the capacity to accumulate material wealth. Social prestige without a financial basis was subject to competition, thus promoting conflict and insecurity. People sacrifice living near productive land in favor of more defensive locations and this further limits surplus production; in East Polynesia, the intertwined wealth, prestige and ritual differentiation promotes hierarchical order and neighborhood stability, which permits settlement close to the alluvial flats regardless of defensive concerns, further enhancing surplus production. For pondfield agriculture, productive differentiation and economic interdependence is more developed in Palau than in East Polynesian chiefdoms. The limited areas of pondfield and the importance of the marine economy in Palau causes more compact household spacing along the coast under circumstances of population increase in Palau compared to East Polynesian chiefdoms. Closer proximity allowed for household units to collaborate more in the subsistence realm. At the same time, wealth differentiation was underdeveloped in Palau because of the limited farming resources compared to East Polynesian chiefdoms.

6.3 Future Research

The relationships hypothesized in this research have helped us understand better the differences between trajectories of early complex society development in Pacific Island societies. The differences between social trajectories are not simply the consequence of historical contingency but have been generated by interactions between environmental characteristics and organizational characteristics. We are interested in discovering these inter-linked webs of mutual causality rather than just identifying a single prime cause. The hypothetical relationships that have been tested in Palau held true in many aspects. These hypothetical relationships are consistent with a good amount of existing archaeological data and environmental observation in the Pacific. They are worth further empirical evaluation against more systematic data that can be collected in several disciplines.

First, the analysis of environmental characteristics for Palau was based on the soilscapes characterized by USDA. Although these soilscapes are very useful for ranking relative agricultural productivity, they are not precise enough to make absolute estimates of carrying capacity (in terms of both sustainability and surplus production). Higher-resolution data from agronomy on agricultural yields and risks (especially in El Niño years) would make it possible to estimate carrying capacity for the swidden agriculture and the pondfield agriculture. Estimated agricultural yields can be compared to estimated populations from archaeological remains, so that the sustainability and capacity of surplus production can be evaluated. Likewise, systematically collected ethnographic data would show how contemporary farmers cooperate in managing their pondfield irrigation systems in the dispersed neighborhoods on Babeldaob and see whether it aligns with the patterns we have described. Kirch and Sahlins (1992) have suggested that mapping the internal hydraulic features of irrigation systems is very important to learn the social relations of production. Mapping out the internal structure reveals canal system sharing and who occupies more advantageous positions.

Second, analysis suggested that the distribution of marine resources is likely to have significant impacts on settlement distribution. Pursuing this idea requires systematic evaluation of the productivity of marine resources. Faunal assemblages from archaeological contexts reveal three main means of marine resource exploitation: offshore fishing, inshore fishing and shellfish collection (Giovas 2011; Ono and Clark 2012). The different fishing strategies create relative criteria for ranking resource productivity. NCCOS (National Centers for Coastal Ocean Science) mapped 1500km^2 of shallow water habitats in Palau. This map was produced with high resolution multispectral satellite imagery and might help evaluate marine resource productivity and provide a basis for investigating how the distribution of marine resources impacted the demographic distribution.

Third, population estimates for the Terrace Era could be improved by a complete systematic regional settlement pattern survey. The preservation of house structure is not as good as that in the Stonework Era. Only 17 out of 248 settlements have been mapped in detail, which makes the density index less accurate. Another density index comes from the surface sherd density which could be recorded in future systematic settlement pattern survey as of now only 11 out of 248 settlements have recorded surface sherd densities.

Finally, the current samples of household assemblages allow only initial study of inter-household relationship. Sample size would be increased in several ways. The current database provides a relatively small sample of lithic artifacts. A sample of 150 lithic artifacts per household unit would make it possible to estimate the proportion of different items in the lithic assemblages with error ranges no larger than 6.7% at the 90% confidence. Only 6 out of 16 households in the Terrace Era and 4 out of 15 households have samples this large. An increase in sample size for each household could reveal clearer patterns of productive activities. The current database also lack systematic collection of faunal remains. The recovery of faunal assemblages would reveal the subsistence strategies for each household and further reveal to what extent productive differentiation in the subsistence realm occurred. Moreover, the faunal assemblages provide another line of evidence to reveal patterns of wealth and prestige differentiation between household units. And finally it would be useful to excavate more household units in district 1 of the Stonework Era. The regional demographic survey shows that the population of district 1 is three to four times larger than that of other districts, suggesting some unique characteristics for this district. At the same time, the household assemblages shows that households in the center of district 1 (Ngetcherong) have fewer lithic artifacts than other households in district 1. Households in district 1 thus may display a higher degree of productive differentiation than other districts. The current sample of households in district 1 is all concentrated in the western part of Ngetcherong. Excavation of more households and spread across district 1 might reveal a stronger pattern of productive differentiation and economic interdependence than we see right now.

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