FRAMING A COMPARATIVE ANALYSIS OF TROPICAL CIVILIZATIONS: SETS Project – Phase 1 (Volume 1)

Edited by

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Dedicated to Michael D. Coe, whose writings on the importance of the comparative analysis of tropical civilizations first inspired me as an undergraduate student, and more recently, whose kind words encouraged me when I subsequently started my own intellectual journey to contribute to this worthy endeavour.

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Cover Image:
Wat Mahathat, Sukhothai, Thailand.
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CHAPTER 1
FRAMING A COMPARATIVE ANALYSIS OF TROPICAL CIVILIZATIONS: AN INTRODUCTION TO THE SOCIO-ECOLOGICAL ENTANGLEMENT IN TROPICAL SOCIETIES (SETS) PROJECT

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Social Sciences and Humanities Research Council of Canada funding has been secured to facilitate the cross-cultural, comparative study of socio-ecological dynamics in tropical civilizations. The Insight Development Grant is being used to conduct a pilot study aimed at evaluating the quality of various data sets relevant to elucidating the reasons for the “collapse” of a number of tropical state formations throughout South and Southeast Asia in the latter part of the “Charter Era” (CE 800-1400). The proposed research activities will build 24 years of previous research focussed on the Maya of Central America, and a number of cursory, self-funded site visitations (2010-2014) and an extensive literature survey that have, in combination, provided the research team with a basic understanding of the ground plans and socio-ecological histories of the various Asian “Charter States” that form the sample for this study. The insights generated through the proposed investigations will ultimately be leveraged to craft a Partnership Grant to support an international, transdisciplinary research team whose primary objective will be to mobilize knowledge concerning socio-ecological issues in the world’s tropical zones, past and present.

BACKGROUND

In recent years there has been a growing concern with how climate change, population growth, declining resources, landscape modifications, food and water security, wealth disparities, pandemics, and the increasingly interconnected nature of the world economy might impact global society during the 21st century. This has fostered greater interest in the study of coupled socio-ecological systems (e.g., Berkes and Folke, eds. 1998; Berkes et al., eds. 2003; Gunderson and Holling, eds. 2002; Scheffer 2009; Walker and Salt 2006, 2012). Archaeologists are positioned to make a significant contribution to this important research endeavor given their unique database, which extends back millennia (Drennan et al. 2012:1). This comprehensive database is particularly relevant because: “...the present nature and complexity of socioecological systems are heavily contingent on the past; we cannot understand the present condition without going back centuries or even millennia” (Costanza et al. 2007:8). The ultimate goal of the proposed project is to use comparative archaeological data to build a more nuanced understanding of the roots of the various socio-ecological issues faced by contemporary tropical societies, including population growth, increasing disease rates (e.g., malaria and dengue), growing poverty, deforestation, expansion of agricultural production and monocropping, diminishing biodiversity, increasing water use and pollution, and the effects of climate change (Ewel and Bigelow 1996; Kricher 2011; Marcus 2009; McNeill 2003; McNeill 2003; Orians et al. 1996; Power and Flecker 1996).

Questioning the Potential of Tropical Ecosystems

When the antiquarians of the 19th century first started to explore the “ruins” of the Maya center of Palenque, and the Khmer capital of Angkor, these “lost cities in the jungle” both amazed and
perplexed scholars and the general public alike, because they challenged our preconceived notion of what “civilization” was, and how and where it should develop. The great semi-arid riverine regions of Egypt and Mesopotamia were considered the fountains of complex society, whereas the tropics were considered places of cultural and economic underdevelopment. Well into the 20th century tropical environments were still being characterized as limited in terms of agricultural potential – other than small-scale swidden farming (slash-and-burn) – and thus unlikely places for state formation to occur (Meggers 1954). Betty Meggers (1954:817) concluded that: “the environments lack the resources to maintain so high a level of culture…[they thus] represent a decline or deculturation” (Meggers 1954:817). Ester Boserup (1965, 1981) underscored the limitations that extensive swidden agriculture placed on the development of complex societies (see also Redman 1999:166-168; Winzeler 1976:624-626). Still others posited that because tropical environments are exceptionally homogenous, and thus unlikely to stimulate the growth of urban centers, the recognized civilizations must have originated elsewhere (Sanders and Price 1968; Winzeler 1976). Finally, although Michael Coe (1961) did not doubt the existence of indigenous tropical civilizations, he did argue that tropical societies, such as the Khmer and Maya, were comparatively decentralized, non-urban, emerged in homogenous environments with little resource diversity or variation in agricultural production, had limited trade, and major transportation issues.

We now know these assumptions are wrong. Tropical environments are quite heterogeneous (Scarborough and Burnside 2010:178), and they were often the settings for high populations, intensive agricultural regimes, complex water management systems, far-flung trade networks, and state formation. Tropical civilizations do, however, represent a distinct path to urban life and they appear to have shared a certain range of vulnerabilities that ultimately contributed to their “collapse” (Fletcher 2009:1). As defined by Young et al. (2007:450), a collapse is: “Any situation where the rate of change to a system:” 1) “has negative effects on human welfare, which, in the short or long term, are socially intolerable;” 2) “is more rapid and usually in the opposite direction to that preferred by at least some members of society,” 3) “will result in a fundamental downsizing, a loss of coherence, and/or significant restructuring of the constellation of arrangements that characterize the system;” and, 4) “cannot be stopped or controlled via an incremental change in behavior, resource allocation, or institutional values”

FRAMING THE ANALYSIS

The Initial Conditions Frame

To fully grasp the complexities associated with socio-ecological dynamics in the tropics we need to develop a broad, comparative understanding of the similarities and differences between different tropical civilizations. The necessary starting point for the kind of research proposed here is a consideration of the initial conditions that socio-cultural systems had to adapt to. Tropical ecosystems occur between the Tropic of Cancer (23°27’N) and the Tropic of Capricorn (23°27’S), with the “subtropics” occurring at the two extremes of this climatic zone (Kricher 2011:14-17), between roughly 23.5° – 40° North and South of the equator (Figure 1.1). Tropical ecosystems are characteristically warm and wet (Kricher 2011:27), and monsoonal, with distinct wet and dry seasons (Ewel and Bigelow 1996:195; Fletcher 2011, 2012; Kricher 2011:19). They also often witness short, but significant climatic-induced events, such as cyclones, and hurricanes (Ewel and Bigelow 1996:112). More prolonged shifts in climate may lead to droughts in some regions, at the
same time that others witness intense flooding (Kricher 2011:31).

Tropical soils are dominated by clay particles (Kricher 2011:26-27), and although there are local differences, for the most they are relatively homogenous, with yellow-orange soils dominating wetter, low-lying areas, and reddish soils predominating in drier, upland areas (Kricher 2011:26-27; Orians et al. 1996:197). Top soils are generally thin, or absent, and litter mats are also thin because plant and animal materials are rapidly decomposed and recycled (Kricher 2011:359, 373-374; Marcus 2009:28-29; Orians et al. 1996:196). Although the soils themselves are not necessarily thin, they are frequently susceptible to erosion, highly weathered, severely leached by heavy rains, phosphorous, calcium, and potassium deficient, acidic, often suffer from aluminum build-up – which is toxic for plants – and they are generally low in nutrients, and thus infertile (Kricher 2011:26-27, 362-363, 374; Marcus 2009:28-29; Orians et al. 1996:205). Nevertheless, tropical soils are quite diverse, and there are some very fertile soils adjacent to rivers, and in volcanic regions (Orians 1996:197).

![Köppen climate classification showing the world’s tropical zones and the locations of the SETS case studies](modified from wikipedia.org)

The tropics exhibit very high biodiversity in terms of plants and animals (Kricher 2011; Marcus 2009). Higher soil fertility and rainfall generally translate into higher biodiversity (Ewel and Bigelow 1996:109, 112; Kricher 2011:19; Orians et al. 1996:197). Unlike in temperate zones, where soil holds most of the nutrients, vegetation cover (both living and dead organic materials) contains more than 75% of the nutrients in tropical ecosystems. Dead organic matter is quickly recycled, and thus does not enrich the soil to a significant degree, although the litter and topsoil do support many tree species, generally those with shallow root systems. Tropical ecosystems therefore loose much of their nutrient content once the trees are removed. Although the cutting and burning of these trees does, initially, add nutrients to crops grown using swidden, this form of

Griffin et al. (2014) have recently demonstrated a link between tropical deforestation, local climate, and hydrology. Within this discussion three processes are considered particularly important: evapotranspiration, the albedo effect, and surface roughness (see also Shaw 2001). Under normal conditions, trees extract water from the soil via their root and leaf systems. When trees are removed the grasses, small shrubs, and agricultural plants that remain are far less efficient at extracting ground water. The water that is not extracted makes its way into groundwater aquifers, or is moved across the landscape as part of stream-flow. Significantly, tree evapotranspiration consumes considerable energy, which trees acquire from sunshine. However, when there are no trees, less solar energy is used up for evapotranspiration, and thus more of it goes into heating the ground surface, which raises the temperature of the earth’s surface. These increased temperatures, in turn, promote “rising air and higher pressures aloft,” which deters precipitation. This process is not unlike the contemporary issue of “urban heat islands,” which severely impact where precipitation tends to fall. Deforestation also impacts the local albedo, which refers to the ratio of the amount of solar radiation that is reflected by the earth’s surface to the amount that is absorbed by the ground. More tree cover means a lower albedo, which means more solar energy is absorbed by the earth’s surface. In contrast, cleared land has a higher albedo, meaning that more solar energy is reflected away from the earth’s surface. This higher albedo does lead to surface cooling, but this is overshadowed by the heating caused by reduced evapotranspiration, the net result being increased warming of the earth’s surface. Finally, surface roughness, which refers to the impact of ground cover on wind speeds, indicates that deforested areas, which are less “rough,” exhibit less wind resistance, and thus witness drier air, and greater evaporation of soil moisture. In the end, tropical deforestation clearly has the potential to exacerbate wide-spread drought conditions – especially in regions that are extensively cleared – and in other instances, where field systems are not contiguous, it can produce patchy drought conditions.

Two other initial conditions that must be taken into account when considering tropical resilience are: 1) the proliferation of vector-borne diseases that results from warm, stable temperatures (Miksic 1999:172-173); and, 2) the food storage disease issues that occur because of high humidity and temperatures (Scarborough and Burnside 2010:178-179).

In summary, the civilizations that emerged in the tropics had to contend with a unique set of initial conditions that both facilitated and inhibited their development.

The Geopolitical Frame

Geo-political criteria are also significant to the proposed research. Although comparative studies of tropical civilizations have been limited in number and scope, those that have been carried out to date do provide a range of potential candidates for incorporation in the current investigations (Bronson 1978; Coe 1957, 1961; Coningham et al. 2007; Dunning et al. 1999; Evans et al. 2007:14282; Fletcher 2009, 2012; Heitzman 1997:114-115; Scarborough and Burnside 2010; Scarborough and Lucero 2010). These studies have compared the Maya of Central America with various tropical civilizations in South and Southeast Asia (Figure 1.1), all of which fit the definition of a “Charter State,” which refers to “the earliest extensive indigenous polity in its area [that] provided a political and territorial charter for subsequent generations” (Lieberman 2011:937). The temporal focus of the study therefore becomes the “Charter Era” (CE 800-1400;
see Lieberman 2003, 2009, 2011). This period is significant for three reasons: 1) the period starting CE 750-800 was a time of significant political transformation in South and South East Asia (Lieberman 2003, 2009, 2011; Marr and Milner 1986; Rickefs et al. 2010; Stark 2006:411); 2) it coincides with the Medieval Climate Anomaly, a period of warming, and higher, more evenly distributed precipitation (i.e., over the course of an annual cycle) that likely provided ideal conditions for state expansion (Lieberman 2011:939); and, 3) most of the charter states in South and Southeast Asia “collapsed” between CE 1240 and 1479 (Lieberman 2003, 2009, 2011). The sample of charter states that are the focus of the study includes the following (prior self-funded visitations and SETS research trips are noted):

- The Khmer Empire (CE 802-1431), Cambodia, centered on the capital of Angkor – Angkor and its surrounding environs were visited for a combined total of 27 days on three separate trips between 2010-2013, and it will form the template for the additional research trips conducted as part of this research program;
- The Chola Empire (CE 849-1279), South India, centered on the capitals of Thanjavur (CE 848-1025), and Gangaikonda Cholapuram (CE 1025-1279) – to be visited in May-June 2015, following a brief reconnaissance of South India in September-October 2014;
- The Sinhalese Empire (377 BCE- CE 1310), Sri Lanka, centered on the capitals of Anuradhapura (377 BCE-CE 933 – visited for one day in 2011), and Polonnaruwa (CE 933-1310), visited for one day in 2011;
- The Burmese Empire (CE 950-1300), Myanmar/Burma, centered on the capital of Bagan – visited for three days in 2012 and six days in 2013;
- The Early Siamese Kingdom (CE 1238-1378), Thailand, centered on the capital of Sukhothai – visited for two days in 2011 and five days in 2013;
- The Dai Viet Kingdom (CE 1009-1400), Northern Vietnam, centered on the capital of Thang Long – visited for one day in 2010, and scheduled for re-visititation in December 2014;
- The Cham Kingdoms (CE 380-1471), Central Vietnam, centered on the capitals of Simhapura/Tra Kieu (CE 350-758) and the ritual center of My Son (visited for one day in 2010), Indrapura/Dong Duong (CE 758-986), and Vijaya/Cha Ban (CE 986-1471) – all to be visited in December 2014;
- The Mataram/Kediri/Singhasari/Majapahit Kingdoms (CE 716-1406), Central and East Java, centered on the capitals of Mataram/Medang (CE 716-930), Kadari/Kediri (CE 1100-1222), Janggala/Singhasari (CE 1222-1292), and Majapahit/Trowulan (1293-1406) – all visited in May-June 2014;
- The Classic Maya Kingdoms (CE 250-900), focussed on the Kingdom of Caracol, West Central Belize – based on fifteen field seasons working in the surrounding Vaca Plateau.

The Theoretical Frame

The theoretical approach that guides this pilot study is inherently comparative. According to Drennan et al. (2012:3): “Comparative methods are essential if archaeologists are to contribute to transdisciplinary research in the historical and social sciences and thereby broaden the scientific understanding of the past, the present, and the future of human societies.” It is important to stress, however, that: “Cross-cultural comparison is not about creating blanket generalizations that homogenize diverse cases. Rather, we need to construct operational models that can be tested against the varied scenarios of diverse human history across the planet” (Fletcher 2012:317).
<table>
<thead>
<tr>
<th><strong>Adaptive Cycle</strong></th>
<th><strong>Characteristics</strong></th>
<th><strong>Associated Concepts</strong></th>
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<tbody>
<tr>
<td>r-phase (growth and expansion)</td>
<td>rapid movement into uninhabited or sparsely populated landscapes, rapid population growth, new technologies and food acquisition strategies</td>
<td>niche construction refers to the process whereby “human beings initially adapt themselves to the dynamics of their environment, but over the long term societies’ needs are best served by modifications to the environmental dynamics” (Dearing et al. 2007:266; see also van der Leeuw 2007:215); colonized ecosystems, also known as artificial or cultural landscapes, result from “the deliberate and sustained alteration of natural processes that aim at 'improving' them according to society’s needs” (Weisz et al. 2001:123; see also Dearing et al. 2007:266; Fischer-Kowalski 2003; Haberl et al. 2011; Ponting 2007:67-69; Sieferle 2003; van der Leeuw 2007:214-215).</td>
</tr>
<tr>
<td>K-phase (accumulation and consolidation)</td>
<td>slow growth; conservation, accumulation, consolidation, and sequestration; intensification of production; increased management over, and investment in, a smaller number of key productive strategies; and, hypercoherence, which means there is a high level of integration</td>
<td>A risk spiral “is a dynamizing principle in the development of complex societies [wherein] the reduction of a particular risk leads to new types of uncertainty, which in turn require further (risky) innovations…[and a] permanent innovation pressure [that is] responsible for the restless transformations in complex societies” (Müller-Herold and Sieferle 1997:201-202); path dependency refers to a state in which people “cannot stop investing knowledge and effort into the system that they have modified, because any reduction in effort will allow natural dynamics to take over and transform the environment into one to which society is no longer adapted” (van der Leeuw 2007:215); sunk-costs or Concorde effects refers to a situation where agents “put more…effort into continuing with existing investments rather than exploring new ones,” which results in a tendency to undermine innovation (Cumming 2011:94; Janssen and Scheffer 2004; Walker and Salt 2006:87).</td>
</tr>
<tr>
<td>Ω-phase (release)</td>
<td>rapid, “creative destruction,” declining construction, abandonments, and the chaotic unraveling and release of resources</td>
<td>tipping points (Gladwell 2000), critical transitions (Scheffer 2009), or collapses (Diamond 2005; Tainter 1988); revolt refers to a situation where “a critical change in one cycle cascade[s] up to a vulnerable stage in a larger, slower one” (Holling et al. 2002:75).</td>
</tr>
<tr>
<td>α-phase (reorganization)</td>
<td>increased diversity, migrations (mobility), innovation, and rapid restructuring</td>
<td>reorganization can lead to a phase change, which might involve reorganization and return to a similar form of system, a system more akin to an earlier form of organization (i.e., as is inherent in the concept of remember [Nelson et al. 2006:246]), a reorganization into a “degraded state” – which is a process known as a poverty trap – or a more dramatic regime shift (also referred to as a system or state flip) into an entirely new form of system, with an entirely different identity (Holling and Gunderson 2002; Scheffer 2009:357; Walker and Salt 2006). Exit refers to a possible “leaking” away of potential, and/or options as part of the shift from the Ω to α Phases (Holling and Gunderson 2002; Gunderson and Holling, eds. 2002; Walker and Salt 2006:76-79).</td>
</tr>
</tbody>
</table>

Table 1.1. Characteristics of the four phases of the Adaptive Cycle and other key concepts relevant to the application of Resilience Theory (see Holling and Gunderson 2002; Gunderson and Holling, eds. 2002; Nelson et al. 2006:409-411; Walker and Salt 2006:76-79).
The comparative examination of tropical socio-ecological systems is facilitated by the application of a series of related concepts that fall under the rubric of resilience theory (Walker and Salt 2006, 2012). Some of the heuristic devices and processes that are most useful for modelling resilience are outlined in Table 1.1. Table 1.2 summarizes some of the key continua of variation that may be “bundled” together (e.g., Easton 1959), and assessed archaeologically, in efforts to capture the historically contingent aspects of resilience and vulnerability for particular cases studies. Further discussion of these continua can be found in some of the classic works on resilience theory (Holling and Gunderson 2002; Walker and Salt 2006, 2012).

<table>
<thead>
<tr>
<th>CONTINUA OF VARIATION</th>
<th>RESILIENCE IMPLICATIONS</th>
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<tbody>
<tr>
<td>Flexibility to Rigidity</td>
<td>Over time there is diminished ability to change direction, to carry out controlled transformations.</td>
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<tr>
<td>Diversity to Uniformity</td>
<td>Functional diversity refers to the different functional groups that comprise a system, with these groups exhibiting response diversity (different capability to respond to perturbances). Declining functional and response diversity over time leads to diminished resilience (c.f., Nelson et al. 2011).</td>
</tr>
<tr>
<td>Innovation to Conformity</td>
<td>Systems move from having a significant capacity to learn, adapt, experiment, and embrace change, to being exemplified by strong calls for subsidies and “business as usual” on the part of dominant individuals and institutions.</td>
</tr>
<tr>
<td>Openness</td>
<td>This refers to the ease with which ideas and people are able to move into and out of a system, with systems being too open or too closed being less resilient, because they are always in a state of transformation, or have a diminished capacity to receive innovations.</td>
</tr>
<tr>
<td>Significant Reserves to Diminishing Reserves</td>
<td>Over time, as a result of strategies of intensification, there tends to be fewer resources in play, and most resources tend to get “locked up,” meaning they are more tightly controlled, and more expensive.</td>
</tr>
<tr>
<td>Tight Feedbacks to Loose Feedbacks</td>
<td>Over time, systems start to see an increase in response times as a result of growing complexity, which makes the system as a whole less resilient.</td>
</tr>
<tr>
<td>Redundancy to Top-Down Control and Management</td>
<td>Redundancy and overlap in governance and institutional structures makes a system less specialized, with the various components being less reliant on each other, and hence more resilient during times of stress. Over time this flexibility gives way to a greater degree of conservatism, with incentives being provided to inhibit change, and there is ever-increasing command and control, and a growing emphasis on process, which manifest itself in more rules, regulations, and greater adherence to procedure.</td>
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<tr>
<td>Intermediate Levels of Modularity to Too Much, or Limited Modularity</td>
<td>Intermediate levels of connectivity, as in modular systems with various subcomponents that exhibit tight interactions, but are more loosely connected to each other, have higher levels of resilience “because the system is neither isolated from changes or perturbations nor overwhelmed by them” (Cumming 2011:138).</td>
</tr>
<tr>
<td>Significant to Diminished Social Capital</td>
<td>Over time there is a diminished capacity for systems to exhibit collective action in the face of perturbances, as exemplified by effective leadership, well-developed social networks, and overall trust.</td>
</tr>
<tr>
<td>Resilience-Positive to Resilience-Negative Efficiency</td>
<td>Some efficiency is useful, particularly if it conserves human or natural resources, but over time there is a tendency for systems to stop taking into account the secondary effects of efficiency, and because of the elimination of redundancies and emphasis on a specific range of values and interests (i.e., an “optimal” condition for a particular ecosystem or organization), there is a diminished capacity for response diversity, resulting in a dramatic decline in flexibility, and hence resilience.</td>
</tr>
</tbody>
</table>

Table 1.2. Continua of variation for assessing resilience in coupled socio-ecological systems (see Holling and Gunderson 2002; Walker and Salt 2006, 2012).
Finally, resilience concepts are merged with archaeological practice – and its emphasis on material culture – by adopting the tenets of “thing entanglement” theory, as recently discussed by Ian Hodder (2011a, 2011b, 2012). This “theory argues that human–thing entanglement comes about as a result of the dialectic between dependence (the reliance of humans and things on each other) and dependency (a constraining and limiting need of humans for things”; Hodder 2011a:175). In other words, we make things that enable us, and make us more productive, but these: “Things need maintenance and care, they run out and fall apart. Their physical materiality and chemical processes engage people in complex systems of relationships with other people and other things – that is, people and things get trapped in entanglements that themselves direct the way further change can occur” (Hodder 2011a:178, emphasis mine). In summary, entanglement theory not only complements resilience theory – it incorporates many of the same processes, such as niche construction, colonized ecosystems, risk spirals, path dependency, spatial resilience, and sunk cost effects (Hodder 2012:105, 166, 170) – but it also emphasizes material remains (Hodder 2012:222), and it therefore provides a means through which archaeologists can measure resilience cross-culturally, both qualitatively and quantitatively, using the continua of variation outlined in Table 1.2 (i.e., how flexible/robust or inflexible/brittle is a particular system at a given point in time?).

**METHODOLOGY**

Given that the sole purpose of this pilot study is to evaluate the quality of particular data sets relevant to the study of socio-ecological dynamics over the long term, the methods are not based on detailed archaeological excavations or survey. They are, however, grounded in the idea that “data proximity” is crucial to the comparative approach (Drennan and Peterson 2012). The project’s goals are thus being achieved through on-site visitations, detailed photographic documentation and note-taking, acquisition of rare or hard-to-find resources, essential background research, and meetings with local scholars. The efficacy of such an approach relates to the belief that, even though most cross-cultural comparisons are usually made using secondary and even tertiary sources, it is imperative that scholars engage with primary data and primary sources in order to develop a more nuanced understanding of where our case studies differ, and where they overlap. The resulting data will permit some cursory comparisons to be made between the collapse sequences of different charter states, as well as the ancient Maya, thus setting the stage for a more detailed, transdisciplinary study of resilience in the tropics, past and present.

To achieve the project’s goals four research trips are scheduled over the course of two years (2013-2015), during both the summer and winter breaks. The length of each field excursion varies from two to four weeks, based on the distances that need to be covered to enable the team to spend a minimum of five full research days in and around each charter state capital, and the combination of charter states that are being visited on each trip. The research team will consist of the applicant (Principal Investigator) and five student assistants. The actual make-up of each research team has been governed by the nature of student research projects. This reflects the desire that as many of the research findings as possible are written up as either Honour’s or Master’s theses, or Ph.D. dissertations. Individual student involvement is therefore dictated, at least in part, on the level of engagement required to obtain the necessary data for thesis/dissertation projects.

*The five student assistants will examine the quality, kind, and availability of specific data sets relevant to the examination of material entanglements.* What kind of archaeological data provides the best fit with resilience theory, and thing entanglement? To begin, it is useful to follow the lead
of Brian Walker and David Salt (2012:23), who stress that researchers should practice requisite simplicity when applying resilience theory to a specific case study. In other words, one should: “identify the minimum but sufficient information” required to explore the levels of resilience and vulnerability exhibited by a particular case study. Walker and Salt posit that, in general, between three and five key variables will play the most significant roles in determining resilience in most situations. In terms of examining entanglement and resilience within early tropical state formations, the most fruitful variables to examine appear to be:

- **Water Management**: All of the tropical states in the sample developed sophisticated water management systems to deal with the seasonal character of rainfall, such as reservoirs, canals, bridges, and irrigation networks (Figure 1.2). These water management systems, which were often very extensive, provided potable water, helped irrigate fields, channeled excess water so as to avoid flooding, and were manipulated to legitimize rulers and their associated governance apparatus (e.g., Scarborough 2003). The student assistants will visit various nodes in the water management system and record data concerning size, connectivity, spatial layout, and specialized features. The key guiding questions for this sub-project include:

![Figure 1.2. The Kamara Pokuna pool at Polonnaruwa, Sri Lanka.](image)

1. Why were water-management systems needed in the tropics?
   a. Did the need for water-management systems grow or diminish over time?
2. What components made up these water-management systems, and how did these components work together to store and/or move water across the landscape?
   a. How well-integrated were the various components?
3. How did these water-management systems develop overtime?
   a. Did smaller systems grow together, or was there a broader plan for development?
b. How reliant were support populations on state controlled water-management features?

4. What resources were needed to construct the various features associated with these systems, where did the building materials come from, who procured them, and who built the various components of the system?

5. Who funded, commissioned, managed, and maintained the water management system?
   a. Did the agents involved in these various aspects of water management change over time, and did investments in these various activities grow or diminish over time?

6. Who benefitted from the water management systems, and who was the most reliant on them?
   a. Did the beneficiaries change over time?
   b. Did some members of society become more or less reliant over time?

- **Agricultural Intensification**: All of the South East Asian charter states in the sample were agrarian based, and although other farming practices continued to be employed – such as dry rice production or swidden polyculture – there was heavy reliance on a single staple crop, rice, and thus a clear dependence on vast systems of rice paddies (Fletcher 2012:298; Figure 1.3). The student assistants will examine the agroecosystems that were created by the various charter states, and assess the character and extent of the field networks, and the distribution of associated features, such as granaries. Given the palimpsest quality of such field systems, students will have to consult available remote sensing data, and historic records, to build an understanding of the relic field systems. The key guiding questions for this sub-project include:

  ![Agricultural terracing near Candi Selogriyo, Central Java.](image)

  **Figure 1.3.** Agricultural terracing near Candi Selogriyo, Central Java.

  1. What environmental conditions are exhibited? (Topography, Hydrology, Temperature, Seasonality, Vegetation, Rainfall, Soils)
  2. What suites of crops were grown?
     a. What are the staple crops?
b. What are the supplementary crops?
c. What correlation is there between crops grown and environmental conditions?
d. To what degree is there a dependency on staple crop(s)?
   i. Does this change over time and when?
e. To what degree is crop production diversified?
   i. Does this change over time and when?

3. What production systems were used?
   a. How does this correlate with crops produced?
   b. How does this correlate with varying the geographical/environmental context?
   c. How does the system(s) develop, change, and diversify over time?
   d. Are there environmental characteristics that can be either beneficial or detrimental for agricultural production?
      i. How were these characteristics exploited or overcome?
      ii. Does this change over time?

4. Where are the agricultural systems located?
   a. Are their production enclaves?
   b. Did it follow the model of low-density urbanism?
      i. If not, what is different and why?
   c. Did exploited locations change or increase in both size and number of niches?
      i. When and why did these changes occur?

5. What is the agricultural strategy?
   a. How was the agricultural production organized?
      i. Who were the stakeholders and how does this change over time?
      ii. What institution(s) were involved in the organization and to what degree?
   b. How why did the agricultural strategy and its organization change?
      i. Are there periods of innovation, diversification, and change?
      ii. When did these changes occur?
      iii. What pressures were involved to initiate/forced these changes?

6. To what extent was the landscape utilized for production?
   a. How and why did this change over time?
   b. Was a maximum extent reached in terms of land use and production?
      i. If so when did it occur and for how long?
   c. Were there any significant agricultural failures/collapses?
• **Urban Epicentral Plan and Composition**: The charter states in question all exhibit low-density urbanism (Fletcher 2009, 2012), meaning the urban network is spread out across the landscape, rather than concentrated in a few densely inhabited cities (Figure 1.4). Nevertheless, all of the charter state capitals are characterized by a central precinct containing the most significant ritual, residential, and administrative features, most of which are surrounded by high walls and moats. The student assistants will examine the various architectural features associated with the epicenters, and assess construction methods and energy expenditures, building style and adornments, the possible functions and meanings behind specific buildings and building complexes, and overall spatial arrangements. The key guiding questions for this sub-project include:

![Low-density urbanism exemplified at Bagan, Myanmar.](image)

**Figure 1.4.** Low-density urbanism exemplified at Bagan, Myanmar.

**Questions (Study 1: Shirkey)**

1. What architectural features makeup the epicenters?
   a. Did the architectural inventory change over time, and if so, how and why?

2. How were the various architectural features organized vis-à-vis each other?
   a. Did this organization change over time, and if so, how and why?

3. What symbols, statuses, roles, and activities were situated in the epicenters?
   a. Did these change over time, and if so, how and why?

4. Who invested materially and ideologically in the epicenters?
   a. Did this change over time, and if so, how and why?

5. Who maintained and modified the epicenters?
   a. Did this change over time, and if so, how and why?
   b. Did construction practices change over time, and if so, how and why?

6. What role did city walls play in defining epicenters?
   a. Did the role of city walls change over time, and if so, how and why?
   b. Did the meaning of city walls change over time, and if so, how and why?
c. Were there significant differences between the symbols, statuses, roles, and activities found within and outside the city walls?

7. What was the overall significance of the epicenters?
   a. Did this change over time, and if so, how and why?

Questions (Study 2: Baron)
1. What kinds of buildings and spaces comprise epicenters in early tropical states?
   a. Did these change over time, and if so, how and why?
2. How were these buildings and spaces incorporated into the dominant ideology?
   a. Did the means of incorporation change over time, and if so, how and why?
3. How was elite legitimacy, wealth, and power entangled with epicenters?
   a. Did this change over time, and if so, how and why?
4. In what ways did these entanglements make political structures resilient or vulnerable to socio-ecological change?
   a. Did this change over time, and if so, how and why?

• Settlement Patterns: This component of the project will examine the low-density urbanism footprints of the various charter states by assessing how the support population was distributed across the landscape, and how this distribution reflects the location of water management, intensive agricultural, and other integrative features (see below; Figure 1.5). Given the perishable nature of most domestic architecture in the study area, and that little settlement archaeology has been conducted in South and Southeast Asia, it is expected that, beyond field reconnaissance of specific settlement nodes, the student assistants will need to consult historic documents, iconography, and unpublished field reports, in order to evaluate the settlement patterns in question. The key guiding questions for this sub-project include:

![Figure 1.5. Contemporary low-density settlement surrounding Sukhothai, Thailand.](image-url)
1. What types of settlement units (i.e., buildings and building clusters/complexes) were developed and constructed by each of the various Charter States?

2. For each of the Charter States, when and where on the landscape did the various types of settlement units first emerge?

3. Did any of the settlement units experience increased popularity through time?

4. When were the different types of settlement units ultimately abandoned?

5. What factors contributed to the emergence, increased popularity, and eventual decline of specific settlement units?

6. What types of statuses, roles, and activities were based in the various settlement units?
   a. Did these statuses, roles, and activities change over time, and if so, why?

7. Did the methods and materials used to construct and maintain specific settlement units change over time?
   a. Were there fluctuations in labour, material, construction, and building maintenance costs over time?
   b. Which settlement units were the most costly to construct and maintain, and if so, who was responsible for the construction and maintenance of these costly settlement units?

8. Did the various Charter States develop and situate particular types of settlement units in close proximity to water-management, agricultural, or integrative features?
   a. If so, did these patterns change with time, and under what circumstances did these changes occur?

9. In general, how were support populations patterned and distributed across the landscape within each Charter State?
   a. Did this settlement patterning change over time, and if so, why?
   b. If settlement unit patterns associated with construction, development, maintenance, organization, sponsorship, and distribution were dynamic, and changed over time, did these changes coincide with the greater state-level developments that were occurring among the various Charter States?
   c. In what ways do the changing settlement pattern relate to the degree of resilience exhibited by specific settlement units and the broader communities of which they were part?

10. Does the concept of specialized “settlement clusters,” as advocated by Isendahl and Smith (2013), McIntosh (1991), and Scarborough and Valdez (2009), have explanatory power with regard to explaining the relationship between different settlement units on the sub-regional scale?
• **Integrative Mechanisms**: All of the charter states in the sample developed a range of mechanisms that were aimed at increasing their level of economic, socio-political, and ideological integration. These mechanisms included things like roads, bridges, temples/monasteries, markets, administrative nodes, hospitals, rest houses, storage facilities, state controlled fields, and water management features (Figure 1.6). The latter two mechanisms are the specific focus of two of the sub-projects (see above). The student assistants for this component will therefore employ field reconnaissance and written records to assess the character, labor investment, function, and development of the remaining integrative features. The key guiding questions for this sub-project include:

![Figure 1.6. Spean Praptos Bridge, Cambodia.](image)

1. **What types of integrative mechanisms were employed by each charter state?**
2. **At what point during the development of each charter state were these integrative mechanisms introduced?**
   a. Were all of the mechanisms introduced at the same time, and if not, in what order do they appear?
3. **When did they show increased popularity and/or energy investment?**
   a. Does their popularity and highest energy investment coincide with particular periods of charter state development?
   b. Does their greatest popularity and highest energy investment coincide, or are there temporal differences?
4. **When were they abandoned?**
   a. Were they abandoned at the same time, or different times?
   b. What factors contributed to their abandonment?
5. **Who sponsored the construction and maintenance of each type of integrative mechanism for each charter state, and who physically carried out the construction and maintenance?**
   a. Does this change over time?
6. Who managed the integrative mechanisms?
   a. Does this change over time?

7. Can we assess the cost of labor, materials, and administration for each type of integrative mechanism?
   a. If so, which integrative mechanisms require the most amount of initial investment?
   b. Which integrative mechanisms require the most amount of maintenance?
   c. Which integrative mechanisms require the most amount of management?

8. Which segments of the society were using each type of integrative mechanism?

9. Which segment of the society was most reliant on each type of integrative mechanism?

CONCLUSIONS

The following chapters present the preliminary findings of the first two SETS field trips: Cambodia/Myanmar/Thailand (December 2013); East and Central Java (May-June 2014). The results of the ongoing data evaluation program (i.e., the assessment of data quality, kind, and availability) will eventually be used to address a set of even broader research questions, including:

1. Did all of the charter states share similar organizational principals? If not, what factors contributed to the differences (environmental conditions, cultural factors)? If so, what environmental and cultural factors fostered these shared characteristics (geographical, geological, biological, hydrological, climatological, trade, migrations, diffusion, or shared religious and/or ideological beliefs)?

2. Did these characteristics, in turn, lead to specific levels of resilience and/or vulnerability to shifting environmental and/or cultural circumstances?

3. Is the pattern of “thing entanglement” similar for all of the charter states? If not, what are the differences, and how did these come about?

4. Did the various charter states really reach a tipping point towards the end of the charter era, and thus “collapse,” or are their integrated socio-ecological histories better characterized by growth, punctuated by periods of less dramatic reorganization?

5. How similar and/or different are the organization properties and integrated socio-ecological histories of South and Southeast Asia from what we currently know about the ancient Maya?

6. Do contemporary nation states situated in tropical zones share certain qualities with the archaeological sample, and if so, do any of these characteristics suggest that these political formations are particularly vulnerable to environmental and/or cultural change?

7. Does the modern “megalopolis” – strings of interconnected metropolises encompassing rural and industrial spaces (Gottman 1961) – share any characteristics, structural or otherwise, with the tropical low-density urbanism of the charter states in question, and if so, are there any risks or vulnerabilities that contemporary planners and policy makers should be made aware of?
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My research focus evaluates the role of water-management systems and their effects on socio-ecological relationships in a particular sample of past tropical environments. Specifically, I am looking at the complexity of these systems, in terms of scale, quantity, and multipurpose functionality, to ascertain how important these systems were to the overall functioning of these particular tropical societies. I visited several water-management features throughout the duration of my first two trips to Cambodia, Thailand, and Myanmar, and East and Central Java, including reservoirs, canals, dams, moats, water temples, and wells. I focused on the general size, investment of labour, functionality, and purpose of these features. In looking at these elements, my initial interpretation of these systems is that the development and prolonged use of these water features played a fundamental role within these societies.

MY SAMPLE

My focus during the first trip was three specific Southeast Asia charter states dating to the Charter Era (CE 800-1400). As defined by Victor Lieberman (2003: 23), charter states were large political formations whose administrative and political achievements provided a charter for succeeding states. The three charter states of focus were the Khmer Empire in Cambodia (CE 802-1431), centered on the capital of Angkor, the Burmese Kingdom in Myanmar (CE 950-1300), centered on the capital of Bagan, and the Early Siamese Kingdom in Thailand (CE 1238-1378), centered on the capital of Sukhothai.

The focus of my second trip was four Charter States on the island of Java, in Indonesia. These are the Mataram (CE 716-930), Kediri (CE 1100-1222), Singhasari (CE 1222-1292), and Majapahit (CE 1293 – 1406). In Central Java, my focus centered on the capital of Mataram, which included areas such as the Prambanan Plain, the Dieng Plateau, and the Kedu Plain. While in East Java, I focused on the capitals of Kediri, Singhasari (known today as Malang), and Majapahit (modern Trowulan).

TIMEFRAME AND FIELDWORK

My first research trip took place in December, 2013. Spanning a total of 21 days, my research trip began on December 12, 2013. I arrived in Siem Reap, Cambodia on December 14. I was in Cambodia for a total of 6 days and departed in the early morning of December 19. While there I visited several important water management features. On December 15, I visited Angkor Wat, paying special attention to the moat, and Sras Srang, a large baray (reservoir), located within the Angkor region. On December 16, I visited Kbal Spean, located in the Kulen Hills, where much of the water of Angkor originates. On December 17, I visited the two largest barays in Angkor, the East and West Baray, and a water temple called Neak Pean.

I arrived in Bagan, Myanmar on December 19 and was there for a total of 7 days, departing on December 25. While the water features within this area were not as pronounced as those at
Angkor, I was able to visit some smaller reservoirs known as “lakes”, as well as the Irrawaddy River, which played a large role in regards to irrigation feeding canals and dams. On December 23, I visited four lakes, the Min Nam Thu Village Lake, the Dhamma Ya Zika Pagoda Lake, the Sulamani Lake, and the modern Law-ka-nanda Pagoda Lake, near the Irrawaddy River. On December 24, I took a trip out of the capital to the town of Mimbu. As sourced in many readings, the more sophisticated water management features were located outside the core Bagan capital, in rural towns such as Mimbu. While there I came across an old irrigation canal no longer in use in an agricultural field. Although modern modifications were visible, its presence indicates that these are the areas these features were originally functioning in.

I arrived in Sukhothai, Thailand on December 26 and was there for 6 days, departing on December 31. Seeing as there is very little written about Sukhothai, and even less about water management, this part of the trip was extremely important for me. Most of the temples I visited were surrounded by moats/reservoirs, and many had wells. On December 27, 2013, I visited the central zone of the Sukhothai Historical Park and was able to see the Traphang Trakuan Reservoir, the Traphang Ngoen Reservoir, and the Wat Traphang Ngoen Well. On December 28, I visited the Western zone of the Sukhothai Historical Park and visited the Traphan Thong Reservoir and the Wat Aranyik Well. On December 29, I took a day trip to Si Satchanalai and came across an abandoned canal in an agricultural field. I also visited the Saritphong Dam and Sao Ho canal on December 30, a very important water system for irrigation and water supply.

The research for my second trip took place in May and June of 2014. I spent a total of 30 days in Java, from May 12 to June 12. The first portion of the trip was centered within East Java. The first place I visited was Malang (Singhasari), where I spent four days. Here, I visited many temples known as candis. On May 19, I visited Candi Songgoriti, which featured a hot spring, and the Coban Rondo Waterfall, a water source for the surrounding area. On May 20, on the way to Kediri, I passed through the city of Blitar and visited Candi Penataran, the largest temple complex in East Java, which featured the Petirtaan Pool. I also visited Candi Simping, which had a well on-site. I spent a total of four days in Kediri, but saw few major water management features. Of notable mention is Candi Dadi, which I visited on May 22.

The next area I visited was Trowulan (the Majapahit capital), in Mojokerto. This is where the bulk of my research took place, as the water management system at Majapahit Kingdom was vast. On May 24, I visited the Kolam Segaran (reservoir) and the Mojokreto Museum, which contained a large collection of water apparatuses such as water pipes, spouts, bowls, jugs, barrels, and vases. It also had on display a replica of an ancient well. On May 25, I visited Candi Tikus, a well-preserved bathing site. On May 26, I visited Candi Sumur, which had a well at the center of the temple, Candi Belahan, a water shrine, and Candi Jawi, which featured a large moat. This concluded the Eastern portion of my trip.

The areas within Central Java I visited were all part of the Mataram Kingdom. The first stop was in Prambanan. Of notable interest here was the Prambanan museum, which I visited on May 29. It featured many waterspouts, which could be seen on the Prambanan temples. On May 30, I visited the Candi Plaosan Canal and Ratu Boko, which featured a reservoir and many pools. The next stop was in Magelang. On June 3, I visited Borobudur, which featured many waterspouts. On June 6, I visited Candi Selogriyo, which was located at the top of a hill, the surrounding fields of which feature extensive agriculture and irrigation. The next stop was in the Dieng Plateau. On June 8, I visited Telega (Lake) Warno, Pengilon and Merdada. My last stop was in Surakarta, where on June 10, I visited Candi Kethek, which featured a spring.
RESEARCH GOALS

As the focus of my research is on water management systems, my overall goal is to look at the development and organization of water management systems in relation to the rise, florescence, collapse, and reorganization of these specific societies. Essentially, the question I am trying to answer is: how did water management systems make tropical societies more or less resilient over time? In regards to this sub-project’s goals, and my own thesis, my main objectives are to determine whether these systems were integral to the prosperity of the state, if too much dependence was placed upon them, and if the inability to maintain them indicates a lack of resilience within these states when faced with perturbations?

In order to achieve my goals, my in-field objectives focused on the complexity and location of the systems various components. When looking at a society, and trying to determine how vital water management truly was, certain criteria need to be assessed. First, the quantity of features would obviously help to determine whether water management systems were purposely commissioned by the state, and thus seen as important. Seeing as agriculture was the backbone of the economy for all of these societies, I would expect a great deal of investment in creating multiple systems, such as reservoirs, canals, dams, and so on. Size is also be an important factor to consider. Larger systems would be able to hold a greater amount of water while allowing a greater capacity of water to be redirected to others areas. This would in turn provide more available water to the people for general consumption, agricultural purposes, and/or religious rituals. Second, larger systems may be infused with ideological meaning. People typically associate large, grandiose pieces of architecture with power. So, larger systems would suggest greater power. Location is also something I took into consideration. All the societies had access to major river systems: the Mekong River near Angkor, the Irrawaddy River adjacent to Bagan, the Yom River in Thailand, and the Brantas and Solo Rivers in East and Central Java. With that said, all these societies also experienced wet and dry seasons, meaning even with river access, water storage during the wet season would be important for dry season living, construction, and agricultural pursuits.

The greatest amount of information on water management comes from Cambodia, as a lot of research has already been conducted there, so the quality and availability of that data is certainly robust. Bagan, Sukhothai, and Java more or less all fit into the same category, in that there is not a great deal of documented research on water management. A lot of the information I currently have come from a few selected scholars, and a great deal of my own data derives from signage at the sites, museum visits, and extensive photographic documentation. For most of the water features I visited I also took detailed notes, so by assessing quantity, size, and location in order to determine overall complexity, I will hopefully be able to determine the importance water management played within the society, and whether not having these systems anymore would impact the functioning of the state.

Some Theoretical Considerations

This sub-project focuses on two particular theories: Entanglement and Resilience theory. Entanglement, as discussed by Ian Hodder (2012: 88), describes the dialectic relationship between dependency and dependence. Humans and things, things and things, and things and humans depend on each other, rely on each other, and produce each other. Resilience theory ultimately seeks to understand the role of change in societies. At the core of resilience theory is
the adaptive cycle. Adaptive cycles look at the transformations of states and is marked by four phases: exploitation/rise (r phase), conservation/prosperity (K phase), release/collapse (Ω phase), and reorganization (α phase) (Holling 2001: 394; Redman 2005: 72-73). Movement though the cycle, from r phase to K phase shows an increase in connectedness or entanglement, and generally a decrease in resilience.

In determining how these water management systems developed through the adaptive cycle, and how entangled societies were with these systems, we can gain a better understanding as to how issues relating to maintaining water comes about and how problems such as organization, overdependence, maintenance, and climate change were dealt with in an attempt to better equip ourselves to deal with these issues as they arise within contemporary tropical societies. Thus, our ability to achieve greater sustainability for the future can be informed based on understanding how water management systems functioned within past societies.

**RESEARCH METHODS**

My research methods consisted of extensive photographic documentation, detailed note taking, meeting with local scholars, and museum visits. As mentioned, in Cambodia, I was able to visit many water management systems within and surrounding the capital of Angkor. I also met with archaeologist Damien Evans, whose current work using LiDAR, a remote sensing technology, has led to the discovery of many water management features not previously known. Although there were fewer water management features at Bagan, I did manage to visit several reservoirs (lakes), and a canal during a day trip to Minbu valley. In Sukhothai, I visited many temple moats and the Sanitphong Dam and Sao Ho Canal. In Java, the museum visits proved the most useful, especially the Mojokerto Museum, which had a great deal of information on water management. Of particular importance was my visit to Kolam Segaran, Candi Tikus, Candi Belahan, Ratu Boko, and the Dieng Plateau.

**BACKGROUND**

**Water Management in Antiquity**

Water, in both past and present societies, is perhaps the most important resource (Scarborough 2003: 1). As a result, water availability remains tightly entwined in every facet of everyday life. From drinking water, religious purification uses of water, to water as a tool for subsistence purposes. It is an all-encompassing, indispensable part of how people lived. It is not surprising then, that the need to control water would bring forward changes to the built environment, how water was used, and power relations between who controlled water and who did not. Water management systems, in a lot of ways, represented an economic and political force within these tropical societies (Scarborough 2003: 4).

The study of water management within anthropology has been an important issue discussed by many scholars, but it has also fueled several competing theories on the use of water management in regards to how societies organized themselves. The most noted scholar to study water management was Karl Wittfogel (1957:3), who in *Oriental Despotism*, proposed the term “hydraulic civilization” be used to describe Oriental society. His hydraulic hypothesis stated that Asian states used large-scale irrigation as an organizing principle to maintain despotic rule. The building of these systems would require planning and resources through the means of
bureaucracy, and a great deal of forced labour (Mithen 2010: 5251; Wittfogel 1957: 47). Anthropologist Julian Steward made similar claims in 1955, stating that irrigation was the organizing principle for state formation (Mithen 2010: 5251).

Robert McC. Adams (Scarborough 2003: 18) was the first to test Wittfogel’s hypothesis, and he concluded that irrigation was only one component that contributed to how states formed. Adams did not view irrigation as a centralizing and controlling force in society, and he believed it very rarely led to social complexity. Williams Sanders (Scarborough 2003: 18) argued against Adams theory, stating that irrigation was a very important component in Mesoamerica. Nevertheless, the affirmation by both Adams and Sanders that water management systems came after the emergence of states, and not before, as Wittfogel hypothesized, led to the abandonment of his theory (Mithen 2010: 5251). The debate on whether water management plays a centralizing role in societies is, however, still ongoing.

A lot of contemporary water management theories focus on a broader spectrum of features, not irrigation alone (Mithen 2010: 5251). Understanding the complex relationship between how people interact with each other and also how they interact with their environment has led to greater breadth for water management studies. Not only does the degree of water manipulation depend on climate and geomorphology, but also, in many cases, water management will often propel people who are usually in conflict to cooperate in order to coordinate labor tasks (Scarborough 2003: 11). This is because people who are able to work together and use their resources and land most effectively will create much more resilient systems (Scarborough 2003: 4).

Climate and Water Management in Southeast Asia

Within Southeast Asia, and among my sample of past tropical societies, development of more sophisticated water management systems was influenced by a warming trend that started in the 9th or 10th century. The years between 900/1000 and 1250/1300 CE are known as the Medieval Climate Anomaly (Lieberman 2003: 102). The Medieval Climate Anomaly exhibited unusually warmer conditions with increased rainfall, which greatly “enhanced monsoon flows in Southeast Asia” (Lieberman 2011: 933; Lieberman and Buckley 2012: 1074). Longer monsoon seasons and shorter dry season droughts were “ideal conditions for agricultural and political expansion” (Lieberman and Buckley 2012: 1074).

In order to handle water shortage in the dry season reservoirs still needed to be built in order to store water accumulated during the wet season. Reservoirs are basins that hold water through the use of canals or channels (Scarborough 2003: 47). Storage dams and diversion dams, also known as weirs, are usually associated with reservoirs. Dams can help slow the flow of water when there is an overabundance and can help to raise water levels in reservoirs by slowing outflow to other canals. Canals are “artificial waterways” intended for agriculture (Scarborough 2003: 65; 70). Canals are used to channel water from rivers and reservoirs to agricultural fields and to areas in need of water. Wells are vertical shafts dug into the ground to retrieve water (Scarborough 2003: 43). An aquifer, a layer of rock water passes though, is typically how groundwater is extracted from wells.

As the main form of subsistence within these societies, agriculture played a large role in water management expansion. Wet rice irrigation required water management by means of rain-fed and irrigated systems (O’ Connor 1995: 970). In rain-fed systems, seasonal rains watered fields either directly or indirectly through run off. These systems used bunds (to hold or spread
water), tanks, ponds, canals, and various flood management features. Irrigated systems used weirs to tap into rivers to divert water into canals. Many of these systems also had symbolic, spiritual, and political dimensions. Monumentality in size and the ability to provide access to water demonstrated the power of kings, while religious statues and small temples associated with these systems reinforced their spiritual and symbolic importance.

**Water Management amongst the Charter States**

The Khmer Empire developed a large water management network, which consisted of reservoirs, water channels, moats, and water temples. This large system covered an area of 1,000 km², and Angkor has often been referred to as a “hydraulic city” (Fletcher et al. 2008: 658-659). This “hydraulic city” of channels and embankments was made from “masonry and huge quantities of clayey sand,” which was what most structures in Angkor were made of (Mithen 2010: 5252). While water temples and tanks were present within the urban area, the center of the network was home to large reservoirs (barays). This network survived for over three centuries, although it was subject to major remodeling throughout the years. To this day some of the features are still in use.

The area comprising the Burmese Empire included an interconnected system of canals, dams, and reservoirs. Since the dating of pre-Burman irrigation systems is uncertain, there is some debate within the discipline as to its origin (Lieberman 2003: 100). Richard O’Connor (1995: 975) claims that irrigation networks belonging to the predecessors of the Burmese employed a flood-managing type of farming which relied on natural flooding, canals, tanks, and run-off. When the Burmese took control over the area, they refined and elaborated these systems, adding weirs to open up areas to Kyaukse and Minbu (Lieberman 2003: 100; 2011: 942; O’ Connor 1995: 975). In contrast to this scenario is the argument by Janice Stargardt, who claims that the Burmese merely extended the already sophisticated water systems of the Pyu, the first protostate of Burma, which consisted of dams, sluices, diversionary barricades and weirs (Lieberman 2003: 101).

The Early Siamese Kingdom modified their landscape with water control features such as reservoirs, moats, and wells. Although the Khao Lunag mountain range served as a source of water for ancient Sukhothai, its location between Khao Luang and the Yom River was problematic as it suffered from a lack of water during the dry season, and river run-off in the wet season. As a result, an irrigation system was developed. Dykes and canals helped control floodwater and divert water into town ponds (Thai World Heritage Information Centre). The rectangular town of Sukhothai was surrounded by a triple moat, with the Sariphong reservoir situated nearby.

The Kingdoms in East and Central Java featured an extensive network of water management including reservoirs, irrigation canals, waterspouts, pools, and wells. Very little information is available on water management in the Mataram Kingdom (ca. 716-930) as no surviving text makes mention of it. This lack of information may have been due to the eruption of Mount Merapi in the tenth century, which made the area uninhabitable, possibly forcing the shift from Central Java to East Java (Christie 2007: 246; Hall 2011: 135, 138). There is mention, however, of officials who were involved with particular water duties, such as the water official, the water “marriage official”, the dike/balk official, and the royal water official (Christie 2007: 245). Aside from the dam (dauuhan) that may have been located on the Opak River, no other mention is made of water management in Central Java. Despite the lack of documented sources on water
management in Central Java, the fact that the island’s main source of economic subsistence was wet-rice cultivation suggests there would have been great importance placed on irrigation systems.

The situation is somewhat different in East Java, in that water management is much better documented. As a result of the importance wet-rice farming had on the economic and political development of East Java, irrigation systems such as canals and pipes were built (Hall 2011: 138). In the tenth-century, major water management systems were built, resulting in a regional hydraulic system of dams, dykes, and canals. The village of Trowulan, in the heart of the Majapahit Kingdom, was especially skilled in water management (Miksic 2009: 144). Its hydraulic systems consisted of several dams, large and small reservoirs, canals, pools, channeling pipes, and wells (Miksic 2012). Unfortunately, the eruption of Mount Anjasmo in 1451 destroyed most of these water features, but inscriptions have helped to uncover the elaborate water management system that once existed (Miksic 2012; The Jakarta Post).

**FINDINGS**

Unless otherwise cited, all the information within this section was obtained from signage at sites, displays at museums, maps and brochures, and speaking to local people.

**Water Management in Angkor**

The hydraulic network at Angkor was made up of “elaborate configurations of channels and embankments” which allowed water to be stored, dispersed and redirected across the landscape (Fletcher et al. 2008: 660). Angkor is located between the Kulen Hills and the Tonle Sap Lake. It was the world’s “largest pre-industrial city,” covering more than 3000km² with an estimated population of over one million (Mithen 2010:5252). This location illustrates how large this “hydraulic city” was, as water originating from rivers in the Kulen Hills flowed through water channels to the core of Angkor, and drained out into the Tonle Sap Lake.

As mentioned, a major source of water for Angkor originated from rivers in the Kulen Hills. Within the Kulen Hills area is Kbal Spean, a ritual feature associated with the Stung Kbal Spean River, also known as the river of a thousand lingas (see Figure 2.1). Kbal Spean consists of a series of religious carvings in the stone substrate of the river bed (see Figure 2.2). Water from Kbal Spean and other rivers in the Kulen Hills was fed through channels, such as the Great North Channel or the former Siem Reap Channel, and collected mainly in large reservoirs known as barays (Kummu 2009: 1417).

The West Baray (see Figure 2.3) was the largest of all of the barays in Angkor. Spanning a length of 8 km, a width of 2.1 km, and able to hold up to 50 million m³ of water, the West Baray resembles a large lake (Fletcher et al. 2008: 662). The East Baray (see Figure 2.4) was 7.12 km long and 1.7 km wide (Moore 1989: 210). The latter and no longer holds water. Channels connected to these barays served multiple purposes, and crisscrossed the entire landscape (Fletcher et al. 2008: 662; Kummu 2009: 1416). Although barays were the main means of storage, water was also accumulated in smaller reservoirs, such as Sras Srang (see Figure 2.5) and temple moats (Kummu 2009: 1418). Angkor Wat’s temple moat (see Figure 2.6) is 200 m wide and able to hold a large amount of water (Moore 1989: 210).
Figure 2.1. Kbal Spean, Angkor, Cambodia, December 16, 2013.

Figure 2.2. Religious carvings at Kbal Spean Angkor, Cambodia, December 16, 2013.

Figure 2.3. West Baray, Angkor, Cambodia, December 17, 2013.
Figure 2.4. East Baray (Dry), Angkor, Cambodia, December 17, 2013.

Figure 2.5. Sras Srang, Angkor, Cambodia, December 17, 2013.

Figure 2.6. Angkor Wat Moat, Angkor, Cambodia, December 17, 2013.
I also visited the water temple of Neak Pean (see Figure 2.7), a “small single-spired temple” that “symbolizes comic synergy” (Meister 2000: 264). A long wooden boardwalk over the Preah Khan Baray (see Figure 2.8) leads to the temple. The temple is a symbol of a legendary lake in the Himalayas that could cure illness. The water at Neak Pean was redistributed through canals that flowed into rivers, transforming the waters of Angkor into “magic streams.” Similar to the East and West Baray, which both had a “water-court temple,” called the East and West Mebon respectively, Neak Pean served as the water temple for the Preah Khan Baray.

Figure 2.7. Neak Pean, Angkor, Cambodia, December 17, 2013.

Figure 2.8. Preah Khan Baray Angkor, Cambodia, December 17, 2013.

Water Management in Bagan

The capital of Bagan functioned more as a political and spiritual center. The archaeological zone contains myriad temples and pagodas, and a few substantial water control features are also present. Most of the water control features within Bagan consist of small reservoirs, referred to as lakes. Inscriptions identity two reservoirs dug or dammed by a king. One is called “Emerald
Lake” and the other one is near Minnanthu. The date of the inscription is said to be around 1102 (Luce and Ba Shun 1969: 56-57). This information corresponds with data I collected on my on-site visit, at which time I visited several of these lakes. The first one I visited was an average sized lake built in the 13th century in the Minnanthu village (see Figure 2.9). At the time it was used as a source of drinking water, but now it is only used for animals. The second lake I visited was near the Dhama Ya Zi Ka Pagoda (see Figure 2.10). It was built in the 11th century. The use of this lake is unknown, but it was not a source of drinking water. Currently, it has fishes in it, which might symbolize protection of the nat spirits (spirits worshipped through Buddhism). A modern lake I visited, the Law-Ka-Nan-Da Lake (see Figure 2.11), roughly 100 years old, was also filled with fishes to protect the nat spirit. The close vicinity of these lakes to pagodas aligns with this theory.

Figure 2.9. Lake in the Minnanthu village, Bagan, Myanmar, December 23, 2013.

Figure 2.10. Dhama Ya Zi Ka Lake, Bagan, Myanmar, December 23, 2013.
The next lake I visited was the Sulamani Lake (see Figure 2.12), near the Sulamani Pahto. Unlike the previous ones, which were constructed with bricks and stones, this 12th century reservoir was dug out.

The more sophisticated water control features are situated outside the capital, in small towns such as Kyaukse and Minbu. During a day trip to Minbu I came across a canal in the middle of an agricultural field (see Figure 2.13). Although this canal was not functioning at the time of my visit, and may have been modern – or least it exhibited modern modifications – it was most likely used for irrigation. In conjunction with this examples, inscriptions identify a canal north of Sagu, in Minbu (Luce and Ba Shun 1969: 31). Moreover, Kyaukse’s irrigated rice-field fed Bagan through a system of canals via the Zawgy and Panlaung rivers. Seven dams were built, four feeding off the Panlaung (Kinda, Nga Naingthin, Pyaungbya and Kume) and three feeding of the Zawgy (Nwadet, Kunhse, and Gutaw) (Luce and Ba Shun 1969: 31).
Figure 2.13. Canal in Minbu (Possibly modern; exhibits modern modifications), Bagan, Myanmar, December 24, 2013.
Water Management in Sukhothai

Sukhothai was the political and administrative capital of the Early Siamese Kingdom. Known for its agriculture and ceramics, Sukhothai attracted many migrants, extending its influence and power from the late 1200s to the mid-1300s (Lieberman 2003: 244). Accomplished in hydraulic engineering, landscape modification was done via the construction of dams, reservoirs, ponds, and canals (UNESCO). Water was used for agriculture, ritual functions, and protection in the form of city moats.

Most of the water control features I visited in Sukhothai were temple and city moats. The Sukhothai Historical Park covers the area where the capital of the Sukhothai Kingdom used to be. The central zone of the park is inside the city walls, and is protected by three walls and moats. The area is rectangular in shape and has a gate in each quadrant – North, South, East, and West. Namo Gate is the southern gate of Sukhothai. To defend Sukhothai against enemy attack, two outer earthen ramparts and an inner earthen structure covered with laterite and brick were built, with three moats in between (see Figure 2.14). The moats also functioned as channels to carry away water for flood prevention.

Inside the central zone there are numerous temples and temple moats. The Wat Sa Si monument is located in the middle of a large reservoir known as Traphang Trakuan (see Figure 2.15). The monument includes a circular stupa known as a chedi and an ordination hall. The ordination hall in the middle of the reservoir points to a Buddhist concept of demarcating an area where monks perform religious functions by enclosing the holy precincts with water as a symbol of purity. Similarly, Wat Traphrang Ngeon is an ancient temple without a boundary wall. It has a main chedi, an assembly hall, and an ordination hall in the middle of a reservoir named Traphang Ngoen (see Figure 2.16). There was also a well near the temple (see Figure 2.17). As well, Wat Traphan Thong is an ancient monument constructed on an island in the middle of a reservoir named Traphan Thong (see Figure 2.18). This Buddhist building was rebuilt in 2005 and continues to be used by monks. Fishes in the reservoir may also indicate protection of the nat spirit. This monument also featured a well. Wells were consistently present at many of these temple sites. The Wat Aranyik temple, situated outside the city wall to the west, featured is a rectangular well made of laterite, which had a supply of water year-round (see Figure 2.19). Wat Suan Kaeo Uttayan Yai and Wat Nang Praya are two Buddhist monasteries located in Si Satchanalai that also had wells. On the trip to Si Satchanalai, I also came across a canal in the middle of an agricultural field (see Figure 2.20).

Finally, I also visited the dam/reservoir and the Sao Ho canal (see Figure 2.21 and 2.22). Situated to the west of Sukhothai, the dam is adjacent to a range of hills known as the Prathak range. This range is abundant in vegetation of all kinds, including herbs, and serves as a receptacle for rainwater. The large Saritphong dam was constructed between two hills, Kaho Kieo Ai Ma and Khao Phra Bat Bat Yai, in order to carry water into canals for irrigation and water supply for Sukhothai. Water from Saritphong was brought along the Sao Ho canal into the southwestern part of the town.
Figure 2.14. 1 of the 3 moats at Namo Gate, Sukhothai, Thailand, December 30, 2013.

Figure 2.15. Traphang Trakuan Reservoir, Sukhothai, Thailand, December 27, 2013.
Figure 2.16. Traphang Ngoen Reservoir, Sukhothai, Thailand, December 27, 2013.

Figure 2.17. Wat Traphang Ngoen Well, Sukhothai, Thailand, December 27, 2013.

Figure 2.18. Traphan Thong Reservoir, Sukhothai, Thailand, December 28, 2013.
Figure 2.19. Wat Aranyik Well, Sukhothai, Thailand, December 28, 2013.

Figure 2.20. Canal in Si Satchanalai, Sukhothai, Thailand, December 29, 2013.
Figure 2.21. Saritphong Dam, Sukhothai, Thailand, December 30, 2013.

Figure 2.22. Sao Ho canal, Sukhothai, Thailand, December 30, 2013.
Water Management in Central and East Java

Central and East Java saw the rise and fall of many kingdoms between (CE 716-1406), such as Maratam, Kediri, Singhasari, and Majapahit. What allowed these kingdoms to flourish was the hospitable environment the island of Java had to offer. Economic growth and prosperity had a great deal to do with agriculture, specifically wet-rice cultivation. As a result, irrigation systems were be a fundamental component within these societies. Despite the fact that it is known that wet-rice cultivation was practiced extensively in Central Java, most of the records we have on hydraulic systems only reference East Java. Inscriptions for Central Java mostly refer mainly to officials responsible for maintaining irrigation systems and land use for farming (Hall 2011:138).

Despite the lack of published material, I was able to collect a significant amount of data illustrating the importance and presence of water management within Central Java. The Mataram Kingdom in Central Java was home to some impressive architectural constructions, such as Borobudur and Prambanan. Most temples in Central Java have waterspouts jaladwara on their outer walls. Waterspouts typically vary in design from temple to temple but are usually carved in the form of a creature, and sometimes as an amalgamation of different animals (See Figure 2.23, 2.24 and 2.25). The importance of waterspouts on temples allowed for rainwater to drain from the temples to prevent flooding and damage. The Kendi Spout, made of gold, was an elaborate spout in the form of a Makara, a mythical beast with an elephant trunk, a lion’s mane, a parrot’s beak, and the tail of a fish (see Figure 2.26). It can be seen on temples in Central Java from the 8th to 10th centuries.

I also visited Ratu Boko, a royal palace from the Mataram Kingdom. Water features at this site included holy wells and pools. The holy well can be found at the back of Pembakaran Temple. It measures 2.3 m x 1.8 m, and has a depth of water of about 2 m in the dry season (see Figure 2.27). In the past, water from this well was used in religious ceremonies. It was believed that its water would bring luck to anyone who used it. Next to the well is a small reservoir (see Figure 2.28). The pool complex is divided into two parts, north and south. The north complex is rectangular and consists of seven pools, five large ones and two small ones (see Figure 2.29), while the south complex consist of 28 pools, 14 large round pools, 13 small round ones, and one small square one (see Figure 2.30).

One temple complex I visited in the Prambanan district was Candi Plaosan, which was surrounded by a canal measuring 440 m x 270 m (see Figure 2.31). In the past, the canal was used as a drainage system for the temple complex. Two other sites I visited that reinforced the importance of agriculture within Java were Candi Selogriyo and the Dieng Plateau. Candi Selogriyo is located on top of a mountain. The mountain features an incredible array of agricultural terracing (see Figure 2.32). The irrigation to support such expansive cultivation was also quite elaborate, as water from a stream at the top of the mountain is channeled down, redirected, and tapped into to irrigate the fields (see Figure 2.33, 2.34, and 2.35). The Dieng Plateau is located at an elevation of 2,008 meters above sea level. In close proximity to volcanoes, its landscape features fields, craters and lakes. Three lakes (telegas) within the Dieng Plateau are Telaga Warna, Telaga Pengilon, and Telaga Merdada. While, Telega Warna (Sulfur Lake) and Telaga Pengilon are adjoining lakes, Telaga Merdada is the largest lake in the Dieng
Figure 2.23. Waterspouts on Prambanan Temple, Central Java, May 29, 2014.

Figure 2.24. Waterspout on Mendut Temple, Central Java, June 3, 2014.

Figure 2.25. Waterspout on Borobudur Temple, Central Java, June 3, 2014.
Figure 2.26. Kendi Spout displayed at the Prambanan Museum, Central Java, May 29, 2014.

Figure 2.27. Holy Well at Ratu Boko, Central Java, May 30, 2014.

Figure 2.28. Reservoir at Ratu Boko, Central Java, May 30, 2014.
Figure 2.29. North Pool Complex at Ratu Boko, Central Java, May 30, 2014.

Figure 2.30. South Pool Complex at Ratu Boko, Central Java, May 30, 2014.

Figure 2.31. Candi Plaosan Canal, Central Java, May 30, 2014.
Figure 2.32. Agricultural terracing at Candi Selogriyo, Central Java, June 5, 2014.

Figure 2.33. Stream at the top of the mountain, Candi Selogriyo, Central Java, June 5, 2014.

Figure 2.34. Water being channeled down the mountain, Candi Selogriyo, Central Java, June 5, 2014.
Figure 2.35. Irrigation of the rice fields on the mountain, Candi Selogriyo, Central Java, June 5, 2014.

Plateau and is surrounded by hills of terracing (see Figures 2.36 and 2.37). Water from the lake is used for irrigation for the surrounding fields. The last temple I visited in Central Java was Candi Kethek, which featured a spring.

Shifting over to Malang in East Java, formally Singhasari (CE 1222-1292), I visited Candi Songgoriti, a hot water temple. It has three springs, all located in a square pit (see Figure 2.38). The hot water from these springs is drained outside through “spouts into a bathing place on the south side” of the temple (Soekmono 1995:27). These hot water springs are believed by many to have spiritual properties. While in Malang, I also visited Coban Rondo, a waterfall located in the forest of Pujon (see Figure 2.39). Along with other waterfalls in the area, Coban Rondo would have been a source of water used by the people of Singhasari.

On the way to Kediri (CE 1100-1222), I visited the Penataran Temple Complex, located in Blitar. On the south side of the third section of the temple complex is a footpath, which leads to the Petirtaan Pool, a sacred bathing pool (see Figure 2.40). The pool is made of brick, measures 6 m x 3 m in size, and has a depth of 2.5 m. While in Blitar, I also visited Candi Simping, which featured a well. I, unfortunately, was unable to visit any major water systems in Kediri. While Candi Dadi did have a well on site, due to a volcanic eruption that occurred in February 2014, I was unable to visit Waduk Siman, a large reservoir from the 9th century (Indonesia News and Archives).

Trowulan, formally the capital of the Majapahit Kingdom (CE 1293-1406), had much more to offer in regards to water management. I visited the Kolam Segaran, a large reservoir made of brick, measuring 375 m x 175 m (see Figure 2.41). Although evidence supports the use of the Segaran as a water reservoir, and being part of a water system connected to ancient dams such as Baureno, Kumitir, Domas, Kraton, Kedungwulan and Temon (most of them now destroyed) and ancient canals, local folklore also suggests it was used as a place for entertaining foreign guests (The Jakarta Post). It is believed that the Segeran was located close to the capital of Majapahit, as wells have been found throughout the site (Miksic 2009: 143). I also visited Candi Tikus, a bathing site located underground (see Figure 2.42). It is made from brick and measures 22.5 m x 22.5 m and has a depth of 3.5 m. Aerial photographs indicate what may have been canals used for water circulation (Miksic 2009: 143).
Figure 2.36. Telega Warna & Telega Pengilon, Dieng Plateau, Central Java, June 8, 2014.

Figure 2.37. Telega Merdada, Dieng Plateau, Central Java, June 8, 2014.

Figure 2.38. Candi Songgoriti Hot Spring, East Java, May 19, 2014.
The Mojokerto museum also featured a very extensive display of water management items dating to the Majapahit era. Water pipes with multiple joints indicated sophisticated water supply facilities (see Figure 2.43), while various forms of waterspouts were used to channel water at temples or sacred bathing places. Water vases were used as water containers (see Figure 2.44), while stone water barrels connected with the holy water basins (see Figure 2.45). Cisterns were rectangular water basins made of clay and were decorated with reliefs on the outside (see Figure
2.46). These items had many functions, among which were related to religious ceremonies, as a water container for rich families, and as a form of communication to convey moral messages.

The type of wells found in Trowulan were made of bricks and clay. Brick wells were square or round in shape and were often made with different types of brick materials. Square wells used square bricks, while round wells used curved bricks (see Figure 2.47). The clay wells were called “jobong”. Square-shaped wells were mostly used for religious purposes and are often located near sacred places. Round-shaped wells and jobong were used by households and for agriculture.

While in Trowulan, I also visited Candi Sumur, which had a well at the center of the temple, Candi Belahan, a water shrine, and Candi Jawi, which featured a large moat (see Figures 2.48 and 2.49).

Figure 2.41. Kolam Segaran, East Java, May 24, 2014.

Figure 2.42. Candi Tikus, East Java, May 25, 2014.
Figure 2.43. Majapahit water pipes at the Mojokerto Museum, East Java, May 24, 2014.

Figure 2.44. Majapahit water vase displayed at the Mojokerto Museum, East Java, May 24, 2014.

Figure 2.45. Majapahit stone water barrel at the Mojokerto Museum, East Java, May 24, 2014.
Figure 2.46. Majapahit cistern displayed at the Mojokerto Museum, East Java, May 24, 2014.

Figure 2.47. Majapahit ancient well at the Mojokerto Museum, East Java, May 24, 2014.

Figure 2.48. Candi Belahan “water shrine”, East Java, May 26, 2014.
DISCUSSION

Quality of Data

The strengths and weaknesses of the specific data sets relating to my topic of study are two-fold. On the one hand, there is a great deal of published data on Angkor, specifically focused on water management, and that in itself is beneficial. However, I have found that because there is so much information available, I have to be extremely selective in what I decide to use. For Angkor, most of the data I will be using will consist of scholarly sources and published data sets, while the data I collected will act as more of a corroborating source.

With Bagan, it may be slightly more equal. I only have a handful of sources for Bagan focused on water management, so working with those sources, combined with my own data, should be more straightforward. One of the drawbacks with my data for Bagan is that most of the more sophisticated water features were located in small towns some distance from the Bagan capital. I was only able to visit one of those towns, so I will need to locate more substantial information regarding those features.

The Sukhothai study will concentrate more on the data I collected, simply because there is very little published material on Sukhothai, especially concerning water management. Luckily, I was able to collect a lot of valuable information on water management on my trip, which will certainly benefit me. However, it would be helpful to get a more definitive picture of how the hydraulic network at Sukhothai worked.

Java will consist of a fair amount of both scholarly sources and my own collected data. In regards to Central Java, more of my own data on water management will need to be used, as very few inscriptions make reference to them, but the fact that there were officials whose job was specifically devoted to dealing with issues pertaining to water suggests water management was of great importance. Luckily, I was able to collect a good amount of information on water management in Central Java.

East Java will probably be more equal with respect to my use of scholarly sources and my own data. There are a handful of really good sources on water management in East Java. A drawback with own data was I was unable to visit a still existing reservoir in Kediri due to a recent volcanic eruption, and most of the dams, reservoirs, and canals in Majapahit were
destroyed during a previous volcanic eruption. Luckily, there are several sources on the Trowulan capital, and the elaborate water management network that once existed there. Despite some of these setbacks, my visits to many of the still existing sites, and the information I obtained from the Mojokerto museum, proved to be invaluable.

Entanglement, Resilience and Vulnerability

With the level of investment in constructing water management features, we see that all four of these societies were extremely entangled with these. A significant level of entanglement with these systems is via agriculture. Agriculture was important for the prosperity of the economy and the kingdoms as a whole. Improved weather conditions during the Medieval Climate Anomaly promoted agricultural expansion, which required more sophisticated water management techniques. The complex, interconnected networks of reservoirs, water channels, canals, and dams that resulted not only helped to secure economic success, but also provided a consistent water supply throughout the year, and acted as a flood prevention measure as excess water was redirected to surrounding areas. Water management also had symbolic, spiritual, and political dimensions. Many of the moats, reservoirs, and wells were situated close to temples, and they thus reinforced the spiritual aspects of these systems by designating the water as holy. As well, the sheer size, connectivity, and quantity of these systems clearly demonstrated the immense power kings yielded.

The complexity of these systems suggests that water management was an important component to the overall organization of these societies. The image presented of these societies is not one of a few small-scale, independent water management systems scattered across the landscape, but rather one of a major network of large reservoirs, canals, dams, wells, pools, and shrines, in addition to a myriad of smaller components, such as waterspouts and water pipes. The interconnectivity and sophistication of these features suggest an elaborate and complex design. The people of these societies would have come to depend on these systems for continued agricultural prosperity, general water consumption, flood prevention, as well as for religious purposes.

In looking at all these features, we see the continued use of water management systems into the K-phrase of the adaptive cycle likely caused these societies to become tightly bound and dependent on them. Greater dependence resulted in less resilience, indicating that the state relied too heavily on these systems and would not be able to undergo controlled change when faced with triggering events. Possible triggering events could result from climate change. The period after the Medieval Climate Anomaly (ca. 1300 CE) exhibited much drier conditions, with less water being available for the water management system to store and redistribute. As well, lack of maintenance could have led to the inability of these systems to store water, while poorly maintained water channels could also result in water not reaching agricultural fields. There are also many instances where states that undergo attacks, and who on the verge of decline lose the ability to exert power over the people. Rules and regulations normally followed become less adhered to, possibly resulting in lack of maintenance, cessation of construction, and simply a disregard for continue work projects. A final possibility would be the destruction of the systems through continued attacks on the state, or as a result of volcanic eruptions (particularly within Java).

Any of these triggering events, resulting in the inability of these societies to use these systems, would leave them in a vulnerable state. Consequently, once these systems were no
longer operational, the society would not be able to function to the same extent as before. Seeing as all of these societies were heavily populated, and the people were dependent on an available water supply, not having one would have caused severe problems. This ultimately leads the society into the Omega phase, described as a release or collapse, and then onto the Alpha phase, reorganization, which is marked by a higher level of resilience.

**CONCLUSIONS**

**Importance of On-Site Visits**

Overall, the data I collected during my visit to these places was imperative for my topic of study, especially when looking at Bagan, Sukhothai and Java. The published data available on water management systems for these places is just not sufficient for the purposes of this project. In evaluating how dependence on these systems affected these societies, extensive research needs to be done on size, connectivity, spatial layout, and specialized features. Seeing as the majority of water management systems I visited in Bagan, Sukhothai and Central Java have not been recorded or written about in any scholarly format, traveling to these places has provided me with the ability to make much more informed statements and conclusions on what it means to be dependent on these systems, how these societies functioned with them, and how they adapted without them.

For Angkor, the situation is slightly different because the Khmer Empire has been such a focal point for archaeological research. Thus, the information available on water management systems is plentiful. As such, my data will act more as a supplementary source. Regardless, the trip to Cambodia was just as important to my study. Almost everything I have read on water management in Angkor refers to it as an extensive, sophisticated, “hydraulic city” of sorts, but I do not think I fully understood just how far-reaching this hydraulic network really was until I saw it for myself. Looking upon the West Baray was an unbelievable experience, because although I had read about how massive it was, seeing something that was so large, and reminiscent of a lake, truly put into perspective the significant amount of investment, time, and labour that would have gone into creating it, which was something I did not wholly comprehend until then.

Likewise, I knew that Java was in many ways renowned for its terracing, but to actually see the magnitude of agriculture that occurs within the country was incredible. Every last piece of available land is used for agriculture. Fields upon fields of terracing can be seen at every angle, from every point, in every village. As a result, irrigation systems are also seen everywhere one looks. Seeing the importance present-day Java places on agriculture absolutely helped me to understand how important it also would have been in the past.

Based on my research thus far, and the data I collected during these trips, it is evident that these states were extremely entangled with their water management systems. Not only did the Khmer, Burmese, Siamese, and Javanese people depend heavily on them for prosperity, but they also acted as reinforcing spiritual and political devices. This level of entanglement is not at all surprising given the fact that water is so essential within all facets of life. Consequently, greater dependence on these systems led to less resilience over time, which resulted in these societies being vulnerable to unexpected perturbations. It is clear that these systems were essential for the purposes of agriculture, water storage, flood control, religious rituals, and protection. As such, when triggering events occurred, leading to the inability to use these systems, societies that
depended on water management for any of these things would not be able to function to the same extent as before. As my ultimate goal is to determine how the use of water management systems, and consequently the loss of them, impacted past tropical societies, it is my hope that this research will help to contextualize the full extent of water management within the broader tropical experience.

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CHAPTER 3
AGRICULTURAL INTENSIFICATION AMONGST THE CHARTER STATES OF SOUTHEAST ASIA: A STUDY OF RESILIENCE, VULNERABILITY, AND ENTANGLEMENT

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My research is focused on the agricultural intensification exhibited by Southeast Asian charter states. The goal is to address the role of agricultural strategies in the socio-ecological dynamics of these charter states. The focus is on entanglement and resiliency, on both the individual and collective scales. This study therefore involves identifying the specifics of the each agricultural strategy and exploring its adaptability, vulnerability, and resilience. To assess the changing relationship between these states and their agricultural strategies over time, the methodological approach of the adaptive cycle will be utilized. Research has taken place across several charter states. First, the Khmer Empire (CE 802-1431) focused on the capital Angkor and its surrounding archaeological sites and features. Second, the Burmese Empire (CE 950-1300) centered on the capital of Bagan, with a supplementary visit to the peripheral “rice-bowl” of Minbu. Third, the Early Siamese Kingdom (CE 1238-1378) focused on the capital of Sukhothai and the peripheral site of Si Satchanalai. Finally, a series of kingdoms found across Central and East Java were also investigated, including: Mataram; Kediri; Singhasari; and Majapahit (CE 716-1406). While these capitals were the primary focus, the agricultural study expanded its scope as much as possible, exploring key granaries, as well as the surrounding and intermediate areas. Fieldwork took place over two field trips, over a total of 43 days. During this time each charter state capital was subjected to four or five days of research.

METHODOLOGY AND OBJECTIVES

Two methodological approaches were utilized; Discourse and Research Assessment as well as Contextualization and Reassessment. The former is achieved through extensive literature review, evaluation of relevant datasets, and the assessment of current theoretical paradigms. The latter involves visiting past and present agricultural capitals and field systems to assess practices. The goal is to not only contextualize the research but to reassess the literature from a comparative perspective using an understanding of socio-ecological systems. The adaptive cycle is particularly beneficial for its ability to model multiple variables temporally in order to extrapolate the resilience, entanglement, and vulnerabilities of these systems (see below).

The objective of this study is to understand the agricultural strategy as a whole, which necessitates an understanding of all of variables involved, beyond that of simply the agricultural techniques or methods. These variables include an understanding of the geology, climate, ecology, rainfall regimes, crops, as well as past social, political, and economic organization. This demands an interdisciplinary approach that incorporates several disciplines to gain a holistic understand of the agricultural strategy (Tress et al. 2006:17; Klein 2011:286). The inclusion of ethnographic work and contemporary assessments to compare the past with the present is a step towards achieving these transdisciplinary goals. To truly conduct transdisciplinary research would require the involvement of non-academic participant’s necessary for a participatory approach (Tress et al.
2006:17; Klein 2011:286). At this point, research is aimed at building the structural foundations for future phases to take this unique and informative step towards becoming truly transdisciplinary.

The nature of this interdisciplinary method, with the inclusion of multiple variables, is crucial for understanding the entanglement of agricultural strategies and past societies. Hodder (2012) expresses the interconnectedness of humans and things, things which are in constant state of fluidity and change, experienced at a variety of spatial and temporal scales. This makes it essential to take a holistic and multiscale approach to understanding the dynamics and intimate nature of past agricultural strategies. It is important to understand this entanglement not only on the scale of the past society, but also the much longer temporal scale of that links the past to the present. In many cases, especially within the tropics, both past and present societies encounter the same variables, limitations, and advantages. Thus, by exploring the past, we as a whole can better understand ourselves and our present surroundings. Further, it is vital to understand that past societies did not develop in isolation from either their neighbors, or their own pasts. This is also true for current societies, as we are intrinsically entangled with our past, which shapes and directs society and the choices we make. In terms of past and present agricultural strategies, we can identify these connections, and nowhere is this more apparent than in tropical societies as a whole, especially within Southeast Asia. By exploring the past we can learn about the processes that shaped these societies and directed their future. Further, we can understand the similarities and differences that are encountered today, as well as our entanglement with the past.

BACKGROUND

As an agricultural study within Southeast Asia it is important to highlight two important crops; rice and millet. Rice has received a significant amount of research that has provided important temporal, genetic, and management considerations. Millet, although undoubtedly important, lacks this breadth of investigation.

Rice (Oriza sativa) was domesticated several times and in several areas. Our interests lie in the Yangzi river basin (4400- 3300 BCE) and the subsequent spread of rice, rice farmers, and labor-intensive systems South into Southeast Asia (3000-2000 BCE. Bellwood 2007; Fuller and Qin 2009; Fuller et al. 2007:42; 2009:103,105; Highman et al. 2011:249). Historically there are two types of rice, japonica and indica; the former is used in intensive forms of wet cultivation, while the latter is used in dry-land practices. Indica is a hydrid of japonica and other wild varieties, although its development is unknown (Mudar 1995:184; Weber et al. 2010:82). These varieties facilitate the ability to produce rice in a variety of environments that range from high to low rainfall levels, permsonsoon or monsoon, and from mountain sides to plains.

Millet played an important role despite the lack of archaeological discourse. The coarse small millet grains, come in a variety of genera. Setaria, foxtail millet, has a long history of use, starting along the Yellow River (5500 BCE; Lee et al. 2007; Liu et al. 2009; Lu et al. 2009) the loci for its movement into Southeast Asia (2000 BCE; Kealofer 2002; Weber et al. 2010:79, 81). Millet is a fast maturing drought resistant crop that requires low levels of rainfall (400-700 mm) and can grow in a wide range of temperatures, soils, and elevations (Mudar 1995:183; Weber et al. 2010:80). These are important characteristic in Southeast Asia, with its large dry areas of semi-tropical forests and savannahs (Kealhofer 2002). Millet is less demanding on the soils than rice, and can be grown in the same fields for longer periods of time (Mudar 1995:183).

The production of dry crops, Indica and Setaria, is accomplished through rain-fed, dry-land cultivation, planted by broadcast or individually (Weber et al. 2010:82). Crops are planted near the
end of the dry season and are dependent on wet season rains (Figure 3.1). These dry crops can both be grown in the same conditions and act as a security measure. Specifically, modern farmers state it “ensured a good yield… if there was little rain, then foxtail millet would thrive; if there was a lot of rain, then they would get a good harvest of rice” (Weber et al. 2010:82).

The production of wet rice, typically *japonica*, is accomplished in several fashions; floodplain agriculture and formal bunded (padi) fields. Floodplain agriculture occurs along the sides of large rivers bounded by floodplains that can extend ten to twenty kilometers away (Figure 3.2). During the rainy season the river expands and floods the surrounding plains until the dry season, when waters recede and the area returns to drought conditions (Wolters 2007:216, 227). Traditionally, these are difficult areas to manage due to the seasonally vast and fast moving water (van Liere 1980:265). There are two methods to farm these areas. First is to use a floating, long-stem variety of rice which grows fast to avoid submersion, and still produces after the water recedes. This rice is planted by broadcast with no landscape modification (Davivongs 2003:3; Wolter 2007:216; van Liere 1980:269). The second method, ‘receding flood’ agriculture, involves the construction of features such as dikes, bunds, reservoirs, or the use of natural depressions, that function to retard, spread, or capture the flood waters (van Liere 1980:271; Wolter 2007:216). Farmers transplant seedlings or broadcast immediately after the flood water recedes, and use the captured water to inundate the fields.
The production of wet rice using a formal bunded (padi) system uses less land than dry-land cultivation, but it does require more water and a higher degree of labor investment and overall management (Figure 3.3; Mudar 1999:6; van Liere 1980:272). Typically, seeds are started a few weeks before the wet season in a small nursery with bunded walls in order to allow seedlings to develop. During this time padi fields are prepared, which involves creating and repairing large bunds as well as ploughing and weeding. Seedling bundles are transplanted and individually planted by hand. The water depth is maintained as they grow, and they are harvested in a hundred days. Close to harvest time, the standing water is drained and sickles are used to reap, after which time the kernels are dried in the sun, threshed, stems and husks removed, and dried again (Shepard 1973).

The final production system is intensive household gardens, producing a variety of crops that can include tubers, vegetables, fruits, and arboriculture (Figure 3.4; O’Connor 1995:970). This mode of production can make up as much as half of a household’s consumption, with surplus used to trade and sell (Davivongs 2003:2; Dove 1990). It has been argued that such production represents an early form of tropical cultivation (Hutterer 1983:187). There have been a number of studies of past household gardens, but these are often overshadowed by larger investigations into major techniques, such as wet or dry land cultivation (Dove 1990:150).
Thailand

Environment. Thailand is naturally bounded by mountains in the west and north, the Mekong River along the east, while the Gulf of Thailand and the Andaman Sea boarder the south (Sponsel 1998:380). The climate is broken into three seasons; rainy (May-October) with the warm wet air of the southwest monsoon; dry (November-February) with the cool dry air of the northeast monsoon; and a cool season between. Across the Central Plain the average annual rainfall is 1400 mm, although it decreases in the west, making it the driest area in Southeast Asia (Highman and Thosarat 1998:16, 19; Rooney 2008:15; Mudar 1995:164; Sponsel 1998:381). The natural environment is best categorized into five ecologically distinct regions, North, Northeast, Central, South, and Southeast (Donner 1982). The central region is focus of this report, with the Siamese Kingdom being based along the Yom River (Rooney 2008:15). The region is centered on the Chao Phraya River Basin, a broad river valley with fertile soils that create the most productive “rice-
bowl” in the country (Sponel 1998:380). The region is now a large alluvial plain with numerous natural and artificial waterways (Highman and Thosarat 1998:13).

Primary Crops. Northern Thailand was possibly the earliest loci for rice domestication in Southeast Asia, an idea supported by paleobotanical data, artifact analysis of grinding and farming implements, as well as rice chaff within temple brick tempe (Kealhofer 2002; Kealhofer and Grave 2008; Kealhofer and Piperno 1994; Lertcharnit 2005:65; Weber et al. 2010:81; White et al. 1995:123). During the 13th century CE an inscription lists the maintenance of padi fields as the accomplishments of King Ramkhamhaeng (Wyatt 2003:54). Further, in 1687 a French envoy to the Kingdom of Siam states that: “rice is the principal harvest of the Siamese and their best nourishment” (Mudar 1995:157). Millet would have also played an important role in the development and maintenance of the Early Siames Kingdom which controlled large stretches of dry land throughout the Khorat Plateau. There is little to no archaeological evidence for rice production at the site of Sukhothai itself. In close proximity, and part of the kingdom by 1279 CE, is Kamphaeng Phet. Paleoenvironmental studies here present a slow transition from dry land crops to wet rice by the 2nd millennium CE (Kealhofer and Grave 2008:210; Wyatt 2003:42).

Supplemental Crops. The primary loci for supplemental crop production in the Early Siamese Kingdom was within household gardens. Contemporary households grow vegetables and fruits, and reports suggest corn, chili, sugar cane, cassava, and peanuts are also cultivated (Lertcharnit 2005:56, 62). Outside of the household, in the flood plains, orchards are planted in raised beds separated by ditches (Davivongs 2003:2). Archaeological excavations have revealed a large number of grinding stones potentially used to render tubers and cereal crops into edible form (Lertcharnit 2005:65). Further evidence comes from Wyatt’s 1994 interpretation of the first Sukhothai inscription (Ramkhamhaeng Inscription), which documents the use of areca, betel, coconuts, jackfruit, mango, and tamarind: “They plant areca groves and betel groves all over this muang; coconut groves and jackfruit groves are planted in abundance in this muang, mango groves and tamarind groves are planted in abundance in this muang. Anyone who plants them gets them for himself and keeps them,” Inscription #1 (I/19-35; II/1-8); “There are groves of areca and betel, upland and lowland farms, homesteads, large and small villages, groves of mango and tamarind,” Inscription #1 [III/1-3]

Cambodia

Environment. The Khmer civilization occupies the Cambodian lowlands around the lower Mekong River. The Mekong River is a great fluvial system that annually covers a large part of the lower Mekong River Plains with rich silts. It begins as a deep-valley torrent, gradually becoming a gentle flow into the lower plains (Coe 1961:76). The Tonle Sap is a 2300 km square lake, that expands to 10,000 and 15,000 sq. km in the rainy season due to the backed up of flood water at its outlet into the Mekong (Kummu 2009:1415). Three perennial rivers, the Roluos, Siem Reap, and Puok Rivers, feeds the Tonle Sap from the Kulen Hills. Angkor was established in the catchments of these three rivers, and the Khmer constructing extensive systems of reservoirs or barays and irrigation canals (see Chapter 2). The annual runoff for these three catchments is around 500 mm (Kummu 2009:1415). Moving down from the Kulen Hills is a series of coalescing alluvial fans that form an extensive alluvial apron of more permeable sandy soils (Engelhardt 1996:153). Further south is a deposit of clayey soils with high moisture content which is flooded annually by the Tonle Sap, making this soil fertile (Engelhardt 1996:153). Marked seasonal changes are controlled by monsoons with a dry and wet season (1000 -1500 mm; Coe 1961:77). This area
develops a monsoon forest instead of true tropical rain forest (Coe 1961:77). The Cambodian lowlands also consists of large, scattered savannahs. The flooding of the Lower Mekong River and the Tonle Sap Lake deposits rich silts and nutrients on to the adjacent plains, replenishing or recharging the alluvium soil, and allowing for intensive agriculture.

Primary Crops. Rice is the most important cereal of the Khmer (Li 1970:12). During the Angkorian period, the Angkorian plains normally yield one annual harvest (Coe 1961:77). Chou Ta-Kuan, a 13th century Chinese emissary to Angkor, observed, however, three to four crops per year, likely referring to different systems of rice farming: receding rice or dry season irrigated rice, deepwater or floating rice, and different varieties of rice grown in ecological micro-niches along the Tonle Sap (Engelhardt 1996:153; Moore 1989:212). Contemporary rice cultivators plant several rice varieties in the different parts of the same field to reduce risk (FAO 2002:49). Rice can be planted throughout the year, but there are two main cropping seasons: the wet and dry season.

Supplemental Crops. As soon as the wet season rice crop is harvested other crops are planted (FAO 2002:49). These includes millet, tubers, taro, ape, yams, and water chestnut. Vegetables and spices include amaranths, eggplant, multiple bean varieties, black pepper, cardamom, clove, cassia, ginger root, nutmeg, turmeric, and betel. Trees and fruits include balsam pear, white gourd, serpent gourd, luffa, breadfruit, multiple species of citrus, coconut palm, durian, jackfruit, mango, and rambutan (Li 1970:13; Hutterer 1983:183). These supplementary crops do not require large amounts of water, and they can therefore be grown year round in gardens and orchard plots. These provide both additional nutrition and income to the Khmer populations past, and present.

Myanmar

Environment. Myanmar’s topography influenced both its agricultural strategy and social developments throughout its history. The dry zone in Upper Myanmar plays an important role, beings strategically located in association with three major and seven perennial rivers, as well as two large mountain chains that run north-south. The Irrawaddy, Sittaung, and Salween are major rivers that run parallel to these mountain chains creating large, long plains. In Upper Myanmar, major rivers lie in low elevations facilitating large catchment areas and providing access to water in the dry season (Aung-Thwin 1990:2; Higham 2001:129). In the upper elevations, perennial rivers receive a higher level of annual precipitation (1000-2541 mm) due to annual monsoons (Aung-Thwin 1990:6). As a result of the perennial nature of these rivers, they are constantly recharged with dissolved and suspended nutrients that are transferred significant distances, reducing the need for fertilization, crop rotation, and creating reliable yields (Aung-Thwin 1990:6). On average Upper Myanmar receives, 518-800 mm of rain per year while the dry zone only receives 200 mm (Aung-Thwin 1990:5). Low rainfall levels create a marginal area for rain-fed dry-crops without the use of irrigation systems (Aung-Thwin 1990:5). Using irrigation systems, the prolonged sunshine and high temperature made Upper Myanmar conducive to padi fields that could weather droughts and hold water emanating from the perennial rivers (Aung-Thwin 1990:12, 33).

Primary Crops. Myanmar is known as one of the “rice-bowls” of Southeast Asia. There are four contemporary varieties of rice (locally referred to as kaukyin, kauklat, kaukkyi, mayin) cultivated in the dry zone of Upper Myanmar, facilitating a nearly year round harvest (Aung-Thwin 1990:9). Historically, there were two primary types, Indica and Japnica, although their origins are still unknown. Both were used in the 1st century CE. Although Japonica dominated until the 10th
century CE, by the 14th-16th centuries they saw equal use (Aung-Thwin 1990:8, 33). The preference for Indica developed amongst the farmers of the river valleys, in areas of major irrigation works (Aung-Thwin 1990:33). Evidence of rice husks is often embedded in temple bricks across Myanmar, giving insight into their varieties and frequencies (Aung-Thwin 1990:8).

Supplemental Crops. The greatest varieties of crops are found in the dry zone (Aung-Thwin 1990:11). Supplemental crops are grown in small areas and gardens dependent on rainfall, with no irrigation (Aung-Thwin 1990:6, 40-41, 50, 53). Areas without irrigation systems are able to grow one dry weather crop, followed by a single padi crop planted along major rivers utilizing floodwaters. Techniques included rotating crops such as millet and sesame within padi fields during times of water scarcity, and preference for fast maturation rates, and nutritional effect on soils (Aung-Thwin 1990:6, 32, 40-41). Supplemental crops played a role within local and regional consumption, although would not have altered the Empire’s history (Aung-Thwin 1990:3).

Java

Environment. The volcanic island of Java is approximately 130,000 sq. km in size, being 1,000 km long and 81 km wide. In the north stretches alluvial plains are found. Further south runs a mountain chain, the North Serayu Ridge. South again is the central depression zone, interspersed with several volcanos. A chain of volcanic mountains stretches across the southeast portion of Java, interspaced with valleys and basins. In the east, mountains create flat and well-drained areas, while in the southwest they give way to gently sloping plains (Degroot 2009:37; Donner 1987:7; Whitten et al. 1996). The volcanic nature of the region is often viewed as destructive, but eruptions also provide large quantities of neutral-to-basic, mineral rich volcanic mud and ash. Eruptions not only fall on the surrounding lands, but materials also enter the river systems to renew the soils in distant areas, creating fertile alluvial belts (Christie 2007:238; Donner 1987:9). Major rivers and drainage basins include the Solo, Brantas, Citarum, Manuk, and Serayu (Degroot 2009:38). TwotHIRDS of the rivers in Java develop from streams flowing from the mountains, ultimately forming large rivers that divide at the coast, creating deltas. These rivers and subsequent streams play an important role in the irrigation of the terraced fields that line the valleys and basins, and over time these have been modified to the extent that there are no free flowing major rivers (Christie 2007:238; Donner 1987:9; Whitten et al. 1996; Wolters 2007:215). These rivers change drastically in the wet monsoon season (Hoekstra et al. 1989:502). There is seasonal monsoon wet and dry seasons with moderate rainfall between 1,200-2,000 mm (Christie 2007:237; Wolters 2007:214, 220; Worsley 2012).

Primary Crops. Java is the most productive rice-producing island in Indonesia, both past and present (Xiao et al. 2005:108). Evidence suggests the swidden cultivation of grains in western Indonesia between 5000-3000 years ago, and rice on Bali by the 1st millennium CE (Bellwood 1997:110, 233; Christie 2007:235-236). Rice become a permanent staple in the later Neolithic (Chang 1976; Christie 2007:235-236). Historical sources and inscribed tax charters provide the strongest evidence for rice production. The earliest dates for systematic irrigation, and both wet and dry rice as the most important subsistence item, market commodity, and tax payment, date to the 9th century CE (Christie 2007:237; Hill 2010:221-222). According to Chinese reports in the 11th and 12th century, Java was a major producer and distributor of rice (Christie 2007:243). A 14th century inscription from the poem Arjunawijaya describes the kings’ journey “through the rice-fields and settlements” (Robson 2012). These inscriptions describe the prevalence of both dry and
wet rice production. Millet would have also played an important role, and was likely introduced from Summatra, but the dates of introduction remain unknown (Blench 2012).

**Supplemental Crops.** Contemporary studies identify 64 different plant species and 12 tree species producing nuts, flowers, seeds, leaves, sap, and fruits within Central Java household gardens (Dove 1990:156). Studies of the Dieng Plateau, too high to produce rice, demonstrates historical production of European vegetable such as cabbage, potatoes, onions, beans, and maize, as well as non-European crops such as taro, millet, cotton, native fruit trees, and various palms (Christie 2007:235, 243; Pudjoarinto and Cushing 2001:331, 338; Worsley 2012). Trees such as bamboo would also have been important for both timber and firewood, although the amount of land dedicated to their production is unknown (Pudjoarinto and Cushing 2001:338).

**FINDINGS**

**Thailand**

Very little research has been done on the history of the early kingdoms prior to the fourteenth century CE (Wyatt 1994:3). For this reason, there are two avenues towards understanding the agricultural strategy of Sukhothai. The first is to examine the pre-existing strategies prior to the Kingdom. The second derives from ethnographic studies of contemporary practices.

The Early Siamese Kingdom did not develop in isolation nor in an area devoid of settlement. There were long-standing communities of Mon and Khmer in the region (Wyatt 2003:46). Sukhothai developed its own cultural and religious characteristics in a period of localism, when the Khmer and other empires in the region were in decline and unable to exert pressure on central Thailand, giving rise to a rapid succession of independent centers during the first half of the 2nd millennium CE (Graves 1995:247-248; Wyatt 1994:35). The historical sequence preceding Sukhothai’s specific agricultural strategy suggests either a continued use of dry-rice in uplands as the lowlands were increasingly exploited for wet-rice, or a slow conversion of dry-rice uplands into wet-rice production (Davivongs 2003:3; McNeely and Sochaczewski 1995:38; O’Connor 1995; Sponsel 1998:386). It does appear that there was a pre-existing dependence on wet rice agriculture prior to the emergence of the Early Siamese Kingdom at Sulhothai (Mudar 1999:6). Between the 5th and 10th century CE bunded fields and rice husks appeared in bricks (Takaya 1987:262-263; Watabe 1976). Further, early settlements shift from environments distinctly suited for dry rice production to those better suited for wet rice, a move accompanied by the conversion of dry uplands into productive wet rice areas (Kealhofer and Grave 2008; Mudar 1995, 1999). This shift was supported by the demand for upland resources and the involvement of upland groups as the pace of commerce and transportation technologies increased in the 2nd millennium CE (Graves 1995:245). Thus, production during the Early Siamese Kingdom involved the use of both dry and wet rice, with a large investment in wet rice production (Kealhofer and Grave 2008). By the 13th century CE Sukhothai inscriptions describes the expansion of wet rice production (Wyatt 1984:54).

Contemporary analysis of agricultural production in Thailand provides important insight into techniques, crops, and reliance on specific practices (Mudar 1995:157). Wet rice production is currently practiced using both broadcast and padi production, supported through the retention of rainwater, similar to past practices (Hanks 1972; Mudar 1999:6). Dry rice is found in smallholdings throughout the mountainous zones in the upper northeast and south, and is cultivated through broadcast (FAO 2002). Padi wet rice is practiced in the lower northern areas and the Central Plains. This diversity of production and exploitation of different niches plays an important
role historically and contemporarily (Figure 3.5). In the rain fed lowlands multi-cropping is commonly employed, with series of rice varieties being grown along with mungbeans, maize, and nuts.

![Figure 3.5. Dry-Land Field and Irrigated Field (Left, Sukothai; Right Si, Satchanalai, Thailand)](image)

**Cambodia**

Ancient Khmer adopted different systems of rice farming: flood recession rice or dry season irrigated rice, long-stem rice, and different varieties of rice that were grown in ecological micro-niches along the Tonle Sap (Engelhardt 1996:153). These different systems reduced risk if one failed. Another strategy farmers used to reduce risk is dividing each field into small plots for different varieties of rice, that way at least a percentage, if not all, of the planted rice will be harvestable (FAO 2002:49). Having supplementary crops growing throughout the landscape also guaranteed food if the rice crop fails. A brief visit to the local markets throughout Cambodia exemplifies the importance of household gardens and supplemental crops (Figure 3.6). The produce for sale in these markets is an excellent example of both productivity and diversity. While the enormous quantity of local crops sold in markets and along the sides of the streets demonstrates the importance of these crops within the diet. The Khmer almost never plant rice back to back. As soon as the wet season rice crop is harvested, another crop is planted in its place to take advantage of water still in the fields (FAO 2002:49). The ancient Khmer built extensive systems of reservoirs (barays) and canals to both draw water from perennial rivers and supplement dry season rice crop via irrigation. It has been suggested that water in these reservoirs are used to flood the fields during crucial periods of the growing cycle and also for early watering of the fields (Moore 1989:212; Groslier 1979). These extensive systems of reservoirs and canals allowed the ancient Khmer to have at least two crops of rice annually. The archaeological remains of these canals and reservoirs indicate the possibility of a dry season crop yields in the past, depending on the annual precipitation, which varied from year to year (Moore 1989:213). At the end of the dry season these reservoir will have a small amount of water left at the bottom and the bottom of these reservoir are utilized to nurture nursery rice that will eventually be transplanted into fields (Moore 1989:212; Groslier 1967). Rice seedbeds are also commonly found adjacent to house plots in the contemporary Khmer villages surrounding Angkor, as was probably the case in the past.

It is hard to detect ancient production zones but it is possible that today’s production zones mirrored that of the past. Contemporary production zones are located in the flood plains of the
Tonle Sap, Lower Mekong River, and Mekong Delta. These are traditional areas of low plains which flooded annually, resulting in the deposition of rich silts and nutrients. With mechanized farming and modern irrigation the production areas may not have increased much, as rice crop yields have increased per hectare, providing enough for domestic consumption and export.

Figure 3.6. Locally grown produce in market (Siem Reap, Cambodia).

Myanmar

Agriculture, especially padi production, and the environment have had a strong influence on Myanmar history and culture. “The principles that underlay the political, religious, administrative, and social institutions of pre-colonial Burma are testimony to this special relationship between man and his environment” (Aung-Thwin 1990:7).

During the Bagan period there were six distinct production enclaves supported by perennial rivers and irrigation systems (Aung-Thwin 1990:2). Granary construction began during the Pyu period (1st-9th century CE) with a significant expansion in the 9th century and constant modification until the end of the Bagan period (Aung-Thwin 1990:2, 13-14; Higham 2001:132; Lieberman 1987:167; Moore 2003:36). These areas were fundamental for the control of Myanmar, as is evident from the original shift from the Kyaukse granary area to the capital at Bagan in the 9th century, and the growing concern for efficient rice production during the 11th and 13th centuries (Aung-Thwin 1985:184; 1990:2; Hudson and Lustig 2008:277). As a result, the six important “granary” sub-regions of approximately 663,360 acres of padi fields were developed; Kyaukse, Minbu, Mu Valley, Tonplon, Meiktila, and Yamethin (Aung-Thwin 1990:13, 32).

The Bagan Empire supported a large population, with almost half of the inhabitants living within river valleys (Aung-Thwin 1990:54). Although a demographic equilibrium from the middle Bagan Dynasty onward has been argued, it is evident that populations of forced laborers were systematically relocated to serve as cultivators amongst the production enclaves, where they cleared and cultivate new lands, and generally expanded areas of cultivation and increased total productive capacity (Aung-Thwin 1990:35, 55). This would have had a significant impact on production levels, strategies, and organization. However, the degree of population growth and declines associated with such movements has not been quantified (Aung-Thwin 1990:35).
Bagan dynasty, it has been argued, was able to reach a maximum level of production (Aung-Thwin 1990): “the relationship between the natural demographic factors (population increase) and the ecological conditions (cultivable land), combined with a thousand years of sophisticated irrigation technology and ‘selective breeding’ of the best rice varieties, had been maximized, and could not have developed much further until there was either a significant increase in population to clear, irrigate, or otherwise make virgin land suitable for cultivation, or until new rice varieties and modern machinery were introduced” (Aung-Thwin 1990:37).

It is important to recognize that the majority of literature focuses on the highly productive “granaries” that were targeted for extensive irrigation and wet-rice production. However, production is unlikely to have been limited to these areas. In fact, within the intermediate area between Bagan and the Minbu granary there are vast stretches of land under contemporary dry-land cultivation which produce crops such as peanut, palm sugar, sesame, and much more. Further, modern farmers transform former river beds into productive field systems immediately after the wet season, taking advantage of the fertile soils exposed as rivers recede (Figure 3.7). These lands far exceed those currently deemed uncultivable. This raises the question of why they have been ignored in the literature and inscriptions. Perhaps in the past these were considered unworthy of state investment, and they thus remained outside of state control, but formed a crucial component of local production strategies.

Figure 3.7. Myanmar Field systems constructed along a dry river bed (Left) and in a cultivated intermediate area (Right).

The Bagan population was divided into the Buddhist priesthood, a multi-tiered monarchy, and a support population. Rulers laid claim to all agricultural and human resources, although extraction and production was split between these three stakeholders (Aung-Thwin 1990:167). Local populations used the fields for subsistence as well for taxes paid to the ruling monarch. In terms of agricultural production, the king could claim a “tithe”, one-tenth of all produce of rice-lands, orchards, and gardens, although this rate could fluctuate based on whether the monarch provided seeds, water, land, or religious exemptions and pledged labor (Aung-Thwin 1990:42-45). There were two categories of land ownership, crown and religious. Crown owned lands are subdivided into ne mre (land to stay on), lup mre (land to work) and ca mre (land to eat off). Only lup mre lands were subjected to agricultural taxes, while the other two categories required taxes in other forms, such as services for the crown (Aung-Thwin 1990:45). Religious lands were subdivided into wutthugan, ayadaw wutthugan, and bobabaing wutthugan (Aung-Thwin 1990:44). Wutthugan lands were owned by the religious institutions and farmed by individuals who were pledged along with the land. These lands generated no taxes. Ayadaw wutthugan refers to lands where royal donors have pledged their tithe to religious institutions, as opposed to the monarch. Bobabaing wutthugan refers to lands that were pledged by private individuals, but they generally follow the
principals of Ayadaw wutthugan lands. On these lands surplus was split in three ways; one-tenth to the religious sector, one-third to the landlord, and the rest to tenants. By the end of the Bagan Dynasty (late 13th century CE), there had been a significant change in both production and land use. By the 15th century, much of Upper Myanmar was in turmoil with the movement of populations and abandonment of large sections of the kingdom (Aung-Thwin 1990:34).

The agricultural landscape cannot be considered to have ever been in a static state, nor should the monarchy or religious institutions considered in this way. Over time these system of organization went through various transformations, with the long-term effect to “strengthen administrative centralization, to augment the political and coercive authority of the state, and to elevate standard norms at the expense of local traditions” (Lieberman 1987:164). This would have had impact on the administration and intensification of granaries, but it did not always disrupt or change the production systems on the local scale, especially those of the more rural farmers who were able to maintain more consistent routines (Aung-Thwin 1990:34).

Java

“The rural population work wet and dry rice fields, plough them with oxen, and harrow them. They plant seeds in seedbeds before transplanting the seedlings to the fields and they harvest crops. There are dry fields, where root crops of various kinds grow, and stands of fruit trees and coconut and sugar palms… In remote areas of the countryside there is also evidence of extensive areas of forest which are also the site of agriculture, horticulture, and cattle-grazing” (Worsley 2012:105).

Java presents a variety of different agricultural and organizational systems that developed and changed over the course of its history. Our interests begin with the Mataram Kingdom (716-930 CE) of Central Java, which became the most productive “rice bowl” in Indonesia at that time (Hall 2011:122-123, 125). The socioeconomic organization of Central Java was based on economic and/or ecological regional units (watak; Hall 2011:15, 127). Watak consisted of several integrated village clusters (wanua) that function together to manage and administer regional rice field irrigation systems. Leaders of watak were referred to as rakrayan and they emerged from local village councils (rama) based on their prestige and personal wealth. Growth occurred in two fashions; incorporating more villages into the wanua and increased social differentiation and trade in the wanua. In this manner dynasties expanded in the 9th century, creating political stability that maintained local production and market networks necessary to expand authority with a vast network of watak (Hall 2011:123, 127-128). This created central loci for family networks with larger and more fertile lands, important water control systems, and/or significant trade connections (Hall 2011:128). Two important sites developed during the Mataram era; Borobudur in the Kedu plain, and Prambanan, between Mount Merapi and the Gunung Kidul hills. Both are located in important agricultural zones that were necessary for promoting each dynasty (Christie 2007:239-240; Degroot 2009; Lopez Y Royo 2005:31; Murwanto 2004:459-461). These temple complexes are central to the ruling rakrayan’s wanua, and they demonstrated the power of these lineages and their association with centralized locations and important agricultural lands. Through this system of social organization the Javanese rulers created both a bottom-up power movement in their own wanua, at the same time as they promoted a top-down power structure over the watak (Hall 2011:128). During the 8th century CE inscriptions describe the Mataram Kingdom gifting tax-free territory, called sima (Hall 2011:144). These involve the transfer of local rights by a rakrayan to cover the expenses of temples or individuals and groups. Ruling rakrayan did not usually own the land or tax rights but had to negotiate with the rama or subordinate rakrayan. In this way leading
rakrayan, with limited administrative capacities, could transfer the local production to community temples associated with subordinate lords, and thus gain recognition. The exchange provided a network of reciprocity between the local community and the royal court through which leaders could draw on local labor and production for community projects, such as converting agricultural lands (Hall 2011:144). Thus, sima grants functioned to demonstrate royal power and authority in the surrounding watak, and to build infrastructure.

This type of social organization is important when considering the development and maintenance of agricultural production, with both dry and wet-rice production providing most of the subsistence, agricultural tax income, and marketable goods (Christie 2007:237, 243). During the Mataram period the system was comprised of relatively small scale wanua integrated by a watak, which facilitated local and regional production of wet-rice. During the 9th century CE these communities were pressured into developing intensive wet-rice bunded fields which required the management of networked irrigation systems (Christie 2007:243). Nevertheless, the importance of local organization continued due to the persistence of individual ownership of field systems (Christie 2007:243). Even with the larger networks, the agricultural strategy was maintained at a local or regional level with little need for centralized administration (Hall 2011:124). The first inscriptions appear at this point, referencing officials responsible for the administration of irrigation and conversion of lands to wet-rice production (Hall 2011:138). The importance of wet-rice production is indicated by the fact that over 80% of later 1st millennium CE sites were located within 500 m of a river (Mundardjito 1993:10; Christie 2007:240). This concept of rakrayan and watak and the initial drive towards the centralization and singular authority of the Mataram kingdom was the basis of future social organization throughout Java’s history (Hall 2011:122-123).

During the late 10th century CE there was a movement away from Central Java to East Java, and the concomitant development of a new Kahuripan Kingdom (1016-1045 CE) under the rulership of Airlangga, followed by the Kediri and Singhasari Kingdoms focused on the Brantas delta, Brantas and Solo river basins, and Malang Plateau (Degroot 2009; Hall 2011:135-6, 138, 148). There was a subtle shift in the political and economic organization that focused more on international trade (Hall 2011:130, 149). Changes were seen in the traditional socioeconomic organization. The watak, now called wisaya, were overseen by a royal administrator (sopana) who superseded the village rama, and who had the ability to negotiated directly with the king (Hall 2011:150). Rakrayan were moved into a court-based role as regional agents, changing their dependence on personal wealth and religious sway to accountability to the court and king (Hall 2011:150). This created more differentiation between state and local authorities. Sima grants were increased to formalize Java’s political and cultural integrity by establishing a local presence with political, and economic implications. Thus, the ruling dynasties were able to register both lands and their legal status, connecting both the farmers and non-farmers to a ruling court (Hall 2011:143-144). A common practice was to grant tax breaks and uncultivated lands to encourage agricultural expansion and investment in both the agricultural landscape and irrigation systems to increase the income of wisaya or wanua (Hall 2011:144). This encouraged communities to invest time and labor to convert and expand dry fields into irrigated wet-rice fields, specifically along the fringes of settled territories (Christie 2007:241-246). By the 11th century the investment in both wet-rice cultivation and irrigation systems had greatly accelerated (Christie 2007:237). Although this necessitated a loss of taxes at the local scale, regional rulership was compensated by an acknowledgment of status and rulership, and they secured a stable support population and
consistent production that was facilitating by higher density settlements, making subjects easier to assess and tax (Christie 2007:246; Hall 2011:144-145). The delta and river basins provided a well-drained plain that was navigable for trade and communication between the productive highlands and trade ports (Hall 2011:140). The fertile Brantas and lower Solo river plains were exploited through the expansion of wet-rice fields and associated irrigation systems, which provided the state with the largest source of tax income (Christie 2007:244). The river plains were, however, prone to sever flooding during the wet season, something that was only overcome by initiating complex systems of dams and canals and a regional, centralized, management network that went well beyond earlier, local efforts to this problem (Christie 2007:240; Hall 2011:138, 140). The necessity and pressure to export surplus provided an ideal environment for the expansion of royal power through their involvement in agricultural production and water management (Christie 2007:244). For all of the post-9th century CE centers there are inscriptions that record major investments, including organizing local rama or sopana, in the construction and management of regional hydraulic systems (Hall 2011:138-139). The kings provided expertise and management of regional systems in return for reciprocal rights over agricultural production. Management skills were then passed onto local farmers, which educated them in the regulations and use of the systems (Hall 2011:138-139). Thus, kings were able to influence agrarian practices without forcing change or becoming overtly involved (Christie 2007:247). This suggests that a local, bottom up, desire for communities to initiate the conversion from dry to wet-rice production was still active (Christie 2007:242). Decisions to move in this direction may have been based on the increased fertility the captured waters brought, the increased predictability and volume of production, or efforts to combat population pressure (Christie 2007:242). This royal policy further increased settlements, and expanded both wet-rice agriculture and regional irrigation systems (Christie 2007:241-242; Hall 2011:136, 140). This process accelerated during the Kediri and subsequent Singhasari Kingdoms (1222-1292 CE).

The short lived Singhasari Kingdom was followed by the Majaphit Kingdom (1293-1406). Significant changes occurred during the latter dynasty. The rice trade to the archipelago drastically increased, requiring an investment in road systems to support a wide network of markets that united rice producing hinterlands with coastal trade ports (Hall 2011:260). Over time, as this demand for food increased, so did cultivation (Hall 2011:271). This period’s expansion is mirrored in a change in political and economic organization. The rulers networked reciprocal relations with the wisaya remained important. However, by the 14th century the power of the intermediate rama, the tax collectors of the wanua or wisaya, was waning (Hall 2011:261). The Kingdom favored a more direct payment through individuals directly answerable to the state, not dependent on local authority (Hall 2011:262). Further, local producers made payments through local ceremonies that emulated the pomp and circumstance of the royal court. This process allowed for smaller tax payments and ultimately a greater surplus for the producers to sell, which encouraged the community to increase its productive output. The court gained from the sale of this surplus in markets which were subjected to additional taxes (Hall 2011:271). Thus, slowly relinquishing the level of taxation on the hinterlands increased the Kingdom’s prosperity which came about principally through the increased taxation of coastal markets and trade activities, which allowed for greater revenues that the royal court could spend on domestic activities (Hall 2011:274). This resulted in even greater expansions of wet-rice production in both East and Central Java.

The extensification of Java’s agricultural production is still visible across the landscape today, eliciting the comment during our field trip: “Java is really just one big farm!” (a comment that does not do this agricultural landscape justice). In fact while Java exhibits a massive anthropogenic
landscape, there are endless complexities hidden within it (Figure 3.8). Each field system is micromanaged down to the individual padi field. Management includes both the physical construction and maintenance of the bunded fields or terrace walls, but also extends to precise water diversion methods, as well as crop selection and timing. This is reminiscent of the Apa Tanis of Arunachal Pradesh, India, who know the expected productivity of each bunded field, and as soon as actual productivity declined measures were taken to return the field to its previous state (Furer-Haimendorf 1962). Throughout Java there is a diversity of crops grown that exploit the various niches presented as one moves across the landscape. Crop diversity is not restricted to different areas, but also changes during different times of year, and based on the previous crops grown in a specific field. The complex agricultural landscape is dizzying to comprehend, with different crops grown within meters of each other, at different stages of growth, and in some cases overlapping. It is further complicated by the precise placement of specific crops to physically ensure the fields stability (i.e., to inhibit erosion or maintain bund stability). This results in an exceptionally productive agricultural strategy that, overtime, has created an anthropogenic landscape that often appears as a magnificent artwork.

![Figure 3.8. Extensification, diversity, and complexity in Java (Top Left Kediri, Bottom Left Candi Selogriyo, Right Dieng Plateau).](image)

**DISCUSSION**

This study provides important insight on the resilience of agricultural strategies within a sample of Southeast Asian charter states. There are some general similarities that need to be outlined first. All states are located in ecological zones that proved conducive to agricultural production and to an extent, intensification. Typically tropical environments, especially forests, are described a poor agricultural zones due to soils that are sometimes thin, usually poor in nutrients and acidic, as well as highly weathered (Kricher 2011:362-363, 373-374; see Chapter 1). However, in all these cases not only did agricultural production occur, but these regions became some of the most productive zones in the world. This can be attributed to several factors. Within each of these zones there are a diverse ecological niches that comprise a landscape with the capacity to support a variety of different crops and productive strategies. Each charter state developed, or had “granaries” (extensive field systems) in close proximity to important water
sources. These water sources included larger rivers, tributaries, or numerous streams. Using both natural and modified movements of these water sources, and taking advantage of the soils and nutrients within the water, people were able to create highly productive agricultural zones. Further, as irrigation systems were developed, states had the ability to distribute these benefits to larger expanses of land, often capturing water for use during the dry season. These natural qualities came hand in hand with rice, a crop that flourishes in such conditions. All these qualities provided charter states with the ability to compensate for stresses and fluctuations, both natural and cultural, allowing them to maintain their regime of agricultural production. This is an essential quality of a resilient system. However, to understand the vulnerability and resilience, one must expand the scope of inquiry to include the complexities and entanglements of a socio-ecological system as a whole. This approach explores the inextricable interconnectivity that ties together humanity and nature. In the case of agricultural resiliency, as in many systems, this involves humans, the environment, and the reactions to changes in various cultural and natural sub-systems (Walker and Salt 2006:31). Like all systems, socio-ecological systems are always in a state of change and adaptation. To understand the charter states and their agricultural strategies as coupled socio-ecological systems one needs to explore their history and social organization. The adaptive cycle is a heuristic device that provides an excellent method to model these complex relationships over time. There are four phases through which the system flows; exploitation (r), reorganization (K), release (Ω), and conservation (α).

The exploitation (r) phase is a period of diversity and exploitation, benefiting from multiple agricultural strategies that take advantage of the heterogeneous nature of Southeast Asia. The agricultural systems at this time involve both a diversity of production methods and crops. All the charter states experience this phase in their early stages. A common similarity that appears in all states is that they neither develop in isolation nor out of thin air. There are preexisting societies with knowledge of both crops and agricultural systems. Thus, the states develop amidst diverse agricultural strategies with a solid agrarian foundation, typically exploiting both dry and wet-land conditions. This period is a time of high resilience, low connectivity between individual systems, and a low productive capacity (Hollings and Gunderson 2002:32).

This flows into the conservation (K) phase. During the transformation from r to K the heterogeneous agricultural strategy becomes more homogenous. The process is emphasized by states applying pressure to increase the production through mono-cropping (wet-rice) and systematic expansion of a singular production technique (padi) at the expense of the diversity that was inherent in the past agricultural strategy. Overtime there is an expansion and intensification of the agricultural systems, as seen in the conversion of non-agricultural lands to padi production and the expansion of padi zones into dry-land production zones. To accomplish this states are playing an increasingly direct role in the agricultural strategy of the people. This occurs subtly through the increased dispensation of tax breaks, land grants, and incentives in the Javanese Kingdoms. More obvious approaches in Bagan include relocating people, expanding and investing in granary sub-regions, as well as state or monastery owned lands. In Angkor there is expansion along the Tonle Sap and Mekong basin as well as incursions into Northeast Thailand. Evidence also suggests that there were large-scale conversions of dry-land production areas to formal banded fields around Sukhothai. The drive for this intensification and extensification of the agricultural systems can be the result of increasing market opportunities and demand (Java), population pressures (Angkor and Thailand), demand for religious obligations (Bagan), or a combination of some or all of these. Clearly this is experienced by all states; however, there is variability both in the timing and methods. As state agricultural strategies pass through this phase there is an
increasing interconnectedness between agricultural systems, as is apparent in the progressively integrated irrigation systems that connect bunded field systems. The result is the same in all cases: an entanglement of the state in the production of a mono-crop (rice) through a singular strategy (padi production). The end of this phase exhibits an increasingly predictable and productive strategy, although a rigid one in terms of purpose and capacity to manage change. In other words, the rigidity and connectivity of the agricultural systems leaves the strategy vulnerable, with little capacity to adapt to stresses and fluctuations (Hollings and Gunderson 2002:43-44).

Following the K stage is a transition to the release (Ω) phase, characterized by an abrupt and dramatic release of resources, what archaeologists have referred to as collapse. This begins with the penultimate point of the K phase, with a highly rigid and now fragile agricultural strategy susceptible a catalyst(s), either internal or external, with the capacity to flip the system out of its current regime (Folke et al. 2004). This catalyst(s) previously may not have had such a dramatic effect on the system, but due to the structural vulnerability of the agricultural systems, they can no longer mitigate such a fluctuation (Hollings and Gunderson 2002:45). What needs to be asked is if all the states in question reach the peak of the K phase in terms of their agricultural strategy. The peak would be represented by the maximization of all cultivatable lands. It is within this examination that the true differentiation between states appears.

As discussed during the Bagan period, it is argued that there was a maximum production reached amongst its granary sub-regions (Aung-Thwin 1990:37). In Sukhothai and the Khmer kingdoms there is a lack of solid archaeological evidence to suggest that the full maximization of formal bunded fields occurred before the political disintegration. However, the expansion of the Khmer kingdom into Northeast Thailand suggests a desire for new cultivatable lands, and perhaps the maximization of the wet-rice production along the Mekong basin and Tonle Sap. Amongst the Javanese Kingdoms there is clear evidence for the vast increase in wet rice production, yet the full extent of this expansion is archaeologically unknown. Despite the lack of archaeological evidence on these maximization periods, it can be argued that in the eyes of the state both Bagan and Angkor had reached their peak of exploitation, while Java and Sukhothai had not. The result of this is several strong entanglements which reveal a series of increasing vulnerabilities. First, as previously discussed, a strong entanglement develops between the state and the agricultural strategy due to the increased involvement and dependence of the state on agricultural production. Thus the entanglement, fluctuations, and catalysts are no longer limited to the agricultural production or the environment, but now include the state as a whole, and all the trappings that come with it. Second, the conscious decision to focus on padi production reduces the resilience and adaptability afforded through the practice of employing multiple production techniques. Third, in a similar manner, the focus on mass production of a singular crop, wet-rice, negates the security provided by the exploitation of a multi-crop system. Finally, the expansion and conversion of agricultural and non-agricultural lands not only requires a high investment of labor, and continued managerial skills, but reduces the land available to avoid the second and third vulnerabilities.

As a system passes through the Ω phase all accumulated resources are released, connections are broken, and predictability is lost (Hollings and Gunderson 2002:45). In the capacity of agricultural strategies this is represented by the disintegration of large interconnected field systems and the managerial structure. There are two cases that the Ω can be clearly viewed; Bagan and Angkor. Both present a period of turmoil and disintegration of their political and economic power, and subsequent collapse of the agricultural strategy, but they occur in different fashions. The demise of Bagan occurred during the 14th century, and by the 15th century much of the lands were abandoned (Aung-Thwin 1990:34). This has been suggested to have been the result of a strong
entanglement between the state and religious sector, placing too much demand on agricultural production (see other Chapters in this report). This ultimately led to the likely mismanagement and subsequent abandonment of the granary sub-regions. The demise of Angkor is debated, and currently attributed to a variety of causes. Angkor presents a shift away from the agricultural productive areas to key maritime trade locations by the 15th century. Recently, Buckley et al. (2010) have presented climatic data that suggests a period of drought and severe flooding during the mid to late 14th century corresponding with the deterioration of many irrigation canals and the later movement of the capital. The droughts, and subsequent severe rains, would have caused significant problems for padi production, ultimately effecting both subsistence and surplus. Due to the primary focus and lack of variability found within the agricultural strategy, it would have been difficult to endure these fluctuations. This would have been escalated with the collapse of the highly integrated irrigation system. It is important to consider the timing of these climatic shifts in terms of the demise of Bagan as well; it may well have caused similar problems with their rigid system of granary sub-regions, decreasing the ability to grant gifts to the religious sector. In these two cases it can be argued that the collapse of the agricultural systems was likely an important contributing factor, but it was not the sole reason for state collapse (Buckley et al. 2010:6749). Thus, for Angkor and Bagan the end of the Ω phase represents a time of low connectivity, low capacity, and slowly increasing resilience. In both Thailand and Java we see a political and social transition to the Ayuddhaya Kingdom in the former and Islamic Mataram Kingdom in the latter (Hall 2011:280-286; Welch 1998:227). There appears to be no significant collapse of the agricultural strategy with the demise of the kingdoms, and instead they continue under new rulership. In this manner the agricultural strategy never experienced a regime shift and continued in the K phase.

The final phase of the adaptive cycle is reorganization (α). This phase is characterized by the re-development of an agricultural strategy with a great diversity of techniques and crops. During this phase new and old production strategies are combined, creating new relationships between the cultivators, plants, and management schemes. This ultimately creates new systems with little interconnectivity and certainties, yet with higher resilience (Hollings and Gunderson 2002:35, 45-46). It is questionable if these charter states truly experienced a α phase. The agricultural strategy of Java and Sukhothai never experienced the Ω stage and continued within the K phase. The Bagan Empire experienced a period of political disintegration during the Ω phase which led to the reduced efficiency of the granaries. However, the full collapse of the agricultural strategy is likely to never have happened. Instead the agrarian population experienced only a sublet and impermanent change due to their disengagement from a centralized polity during the Mon and Mongol occupation (Aung-Thwin 1985:198). They continued living amongst the anthropogenic landscape, and employed the same managerial principals. Thus, it could be argued that they skipped this phase to continue within the r-phase. Angkor, now under Ayuddha rule, would have experienced this reorganization phase to a greater degree than the other states. With many of the irrigation systems now in-filled and not functioning, and the shift of the capital, remnant populations would have been less water dependent and less reliant on intensive production systems. The α-phase provides the basis for the explosive r-phase that continues the adaptive cycle. However, it is likely that most of these states never experienced this phase.

It is clear that the adaptive cycle provides important insight into the resilience, entanglement, and vulnerabilities of these past states and their agricultural strategies. What is missing, to a certain degree, is a differentiation between the agricultural strategies of the state versus that of the local agrarian population. This appears in two fashions. First, traveling through the study areas there
appears to be a significant amount of crops and large stretches of land viable for creating a productive agricultural landscape that are outside of the agricultural strategies of past state governance. This is especially true when considering the diversity of supplemental crops, household gardens, and intermediate areas suited for cultivation. Second, in light of the adaptive cycle’s K and Ω phases, and the notion of scaled panarchy, it may be possible to break the agricultural strategy into two; state and local. We see a high degree of investment and dependence of the state on intensive wet-rice padi production, which created an inextricably strong entanglement. However, at the local scale the agricultural strategy was likely practiced in a much more diversified manner, one that would have included a diverse suit of crops, household gardens, and productive areas discounted by the state, on top of the regular obligations and returns from working state lands. Together these would have played an important role in the local agricultural strategy, increasing local resilience. This would have occurred in such a fashion that the agrarian population would have existed outside of the state’s entanglements to some degree, and thus, at least partially, fallen outside of the overarching macro adaptive cycle of each state. Confirming this observation is the presence of a local agricultural strategy that existed both before and after the rise and eventual demise of these state-level societies, and their more extensive agricultural strategy.

**FUTURE WORK**

The extent and depth of scholarship in Southeast Asia is beyond impressive. Nevertheless, there are three areas specific to agricultural studies that should be addressed in the future. First, there is a consistent lack of paleobotanical research throughout the study areas, especially outside the granary sub-regions, that would provide invaluable information on both the diversity and intensity of crops grown, but also may identify suites of cultivates that have not been anticipated. Ethnographic and contemporary studies play an important role in this area, but they lack the historical perspective that archaeology provides. A second area that could use more intensive research is in the relationship between the nature of social organization and specific agricultural strategies. Several authors provide excellent work on this topic, including Aung-Thwin (1984; 1990), Hall (2011), and Christie (2008). However, there are large voids that need to be filled. This is especially apparent when considering the Early Siamese Kingdom. The final area is the singular focus on the primary crops and traditional strategies/techniques. Throughout Southeast Asia an abundance of intensive research focuses on the domestication, movement, and intensification of rice, as well as the spread of padi and dry-land strategies. This is an important area of study, but I fear that it may overshadow the importance of other strategies and crops, both staples and supplementals. There are references that allude to this but there is little work dedicated to them. This in itself may be a product of both the nature of archaeological record in a tropical environment and/or the lack of paleobotanical studies that focus on this topic. Further, the majority of archaeological work in Southeast Asia has traditionally targeted the main centers. Recently, some useful research has explored the areas surrounding these epicenters, for example the LiDAR efforts conducted by Damian Evans and other (Evans et al. 2013; Fletcher et al. 2004). The study of the rural support populations, their agricultural strategies and settlement patterns, are a clear avenue for future work.
CONCLUSIONS

Through the process of conducting this research, questioning the current discourse, and applying the adaptive cycle, it becomes apparent that problems with the agricultural strategy alone could not, nor was it likely to have, caused the demise of the charter states in question. This does not discount the role these problems may have played, however. The insights gained from visiting these centers, experiencing the extent and complexity of the agricultural landscape and exploring contemporary production regimes, suggests that the local agricultural strategies of the support population is vastly different, and much more resilient, than that of the state. While the charter states were stressed the mono-cropping of wet rice through padi fields, or dry-rice production when this was not possible, the support population practiced diversified production with a variety of crops and productive strategies, exploiting lands the state ignored, as well as household gardens, and partially fallowed fields. This productive divide is often overlooked when studying state level societies, with rural populations simply being lumped in within the overall plan of state initiatives. In constrast, rural populations often persisted after the demise of state authority, and they carried with them the seeds for succeeding state-level formations (the “remember” component of panarchy theory). It is this resilience that contemporary states need to attempt to recapture in their future planning excercises.

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“Somewhere between the cosmological past and the modern present scholars lost the Southeast Asian city and put Chicago in its place” (O’Connor 1983: 1). Western notions have shaped the way we see cities all over the world, as we strive to fit indigenous cities into the mould of the Western urban center. The indigenous urban centers of Southeast Asia have often been left out of the category of a “city” due to the restricted definition of urbanism (Fletcher 2009: 7; O’Connor 1983: 1). The boundless cities of Southeast Asia are marked by a unique settlement pattern known as low-density urbanism. Low-density, agrarian-based urbanism is a characteristic of tropical societies with marked seasonal differences in rainfall. Examples include the epicenters of Angkor (Cambodia), Bagan (Myanmar), and Sukhothai (Thailand; Fletcher 2009: 14; Fletcher 2012: 288). These areas of delimited settlement space grew food within their urban zones, and there was no real distinction between city and hinterland (Fletcher 2009: 4-7, 14). In such settlement systems, epicenters, or city centers, take up a large amount of space on the landscape. However, my specific epicenter study focuses on what happens inside the city walls themselves, as seen at Angkor, Bagan, and Sukhothai, to determine entanglements, and assess resilience and vulnerability.

My focus for this study is epicenter of tropical charter states. Specifically, I am evaluating the quality of epicenter data sets considered relevant to the study of socio-ecological dynamics. To do this, I need to consider the long-term dynamics that would help build our understanding of entanglement and resilience in tropical states. The charter states that are the focus of this report are Sukhothai of the Siamese Empire in Thailand, Angkor of the Khmer Empire in Cambodia, and Bagan of the Burmese or Bagan Empire in Myanmar. I conducted my fieldwork in these epicenters between December 12th, 2013 and January 1st, 2014.

My field research aims to evaluate data by looking at the quality, type, and availability of specific data types relating to epicentres in the specified Southeast Asian charter states. This study is important for understanding tropical societies of the past, and for building on our knowledge of entanglement across disciplines. Understanding the past may help us better comprehend problems facing current tropical societies. In terms of methods, during my field work I talked to local scholars and visited sites to acquire photographic evidence to fill in the gaps in the available literature. Specifically, I took photographs of features that are not often a subject of interest, such as the city walls, I also took detailed notes at each site visited, and visited museums to gain further knowledge that was not available through other means.

Important to my research is the definition of terms. For my research, the “epicenter” is the central, anchoring element of the three Southeast Asian polities. In each of these places, the epicenter is where the ruler resides, and each place also has religious importance for the broader population. Every other part of the state is, to some degree, subject to and under the control of the epicenter. Using Ian Hodder’s (2012: 175) definition, “entanglement” is “the archaeological sensitivity to the complexities and practical interlacing of material things… entanglement comes about as a result of the dialectic between dependence (the reliance of humans and things on each other) and dependency (a constraining and limiting need of humans for things).” A society can
create sustainability by utilizing a diversity of resources. However, the complexity of the society’s entanglements creates a network of dependence – diverse entanglements create more resilience and stability, while decreasing diversity makes a society less resistant to perturbations, and hence collapse (Hodder 2011: 188). In other words, an epicenter’s resilience can determine its fate when a political system is faced with issues. Was a particular epicenter, and the political system centered on it, vulnerable to collapse, or was it able to remain resilient and sustain itself through the particular hardship(s)?

BACKGROUND

Each of the states to be examined are termed “charter states” by Victor Lieberman (2003: 23), meaning these states were established prior to 1350 CE, and served as the basis for politics and culture that was emulated by later states (Aung-Thwin 1985: 26; Rooney 2008: 26-27). These low-density, agrarian centres lasted for half a millennium and were characteristic of their respective cultures (Fletcher 2009: 14). Miksic (2000: 107) calls the classic empires of Southeast Asia “orthogenetic,” meaning they are associated with stability and ritual and the archaeological record of them is often replete with monumental structures. These types of cities occur in places of surplus stable crop production. For example, Angkor, Bagan, and Sukhothai are all known for monumentality and are located within a fertile rice growing zone. The surplus crops are redistributed, but the manufacturing activity does not take place in the monumental areas. There is also a distinct lack of a dense population associated with these centers (Miksic 2000: 107, 109).

The Southeast Asian city is unique. As opposed to the tenets of Central Place Theory or the “market model,” Southeast Asian states reflect a more personal urban model that created a network of fictive kin and a community within each city (O’Connor 1983: 4). The people of the Southeast Asian city actively share symbols and meanings across both the city center and the hinterland, which serves to unite the often sprawling kingdom (O’Connor 1983: 5). People were connected through an ideology to the city itself, which was accepted as the ideological center of the kingdom (O’Connor 1983: 11). The various symbols displayed in the city created a superficially connected community and a hierarchy, where identities of the people were based on where they fit within the hierarchy, with the power based in the city center itself. The Southeast Asian city made it possible to be civilized, yet not fully urban in the Western sense, through this community of symbols (O’Connor 1983: 12).

It was previously thought that the broader settlement pattern of the Khmer empire was of a large rural hinterland population scattered across the landscape that supported the sacred ceremonial center of Angkor (Coe 1957: 410). However, more recently, surveys have been done to provide a more complete picture of Angkor, including AIRSAR and LiDAR, which are able to model the landscape by penetrating the dense foliage of the tropics (Fletcher and Pottier 2002: 26-27). LiDAR has been done over Angkor to help researchers better understand the complexity settlement pattern associated with this urban centre. At Angkor, the use of stone masonry was limited to religious structures. The residences of the kings and monarchs were made of wood and thatch, but often with ceramic tiles (Evans et al. 2013: 1). Through LiDAR, we can see evidence of city blocks with occupation mounds and human-made ponds (see Figure 4.1).
This formalized space continues beyond the central area, and extends over thirty-five square kilometres. The kings of Angkor implemented urban development projects, usually involving the construction of new religious temples, all with a focus on expanding Angkor to legitimate their claims to the throne (Bentley 1986: 282). Temples are high-density nodes which became anchoring elements for the empire. Temple complexes at Angkor tended to have their own enclosures and moats, such as Angkor Wat and Angkor Thom, which both have a perimeter wall and moat with four gates (see Figure 4.2; Evans et al. 2013: 1-4).
Bagan emerged out of an earlier Pyu village in 849 CE, and grew to be a large, fortified city. As it grew, Bagan expanded in all directions, continually developing and centralizing resources in the region (Aung-Thwin 1985: 21). In the late 11th century and early 12th century CE, different aspects of the Burmese kingdom were combined at Bagan. The spiritual aspects of Theravada Buddhism, the military might of the Burmese, and the traditions and culture of the Pyu and the Mon came together to create the culture of Bagan (Aung-Thwin 1985: 23; McCloud 1995: 31). The two centuries following the foundation of the fortified city were a period of development and centralization of resources around the epicenter. Labor was imported from neighbouring territories and the ideologies of legitimate authority were becoming more clearly defined (Aung-Thwin 1985: 21). Bagan’s rise to power was supplemented by importing artisans, and as in the Buddhist tradition of legitimating power, building monuments was necessary for accumulating merit (Aung-Thwin 1985: 22-24, 26). Accumulating merit was an important concept in all Buddhist empires, including Angkor and Sukhothai, where one would strive to accumulate merit by investing labour or money into the Buddhist religion to secure a position in the next life (Aung-Thwin 1985: 43-46). The growth of wealth at Bagan secured the power of the royalty and the upper class elites.

The palace was enclosed within the walled city of Bagan. The epicenter defined by these walls also held temples, monasteries and their lands, and some residences of elite citizens. “The capital city was the seat of government – the religious, cultural, and ceremonial center of the kingdom – but not necessarily the heart of its economic resources. It was the conceptual and physical source from which political patronage and redistribution of goods and power commenced and the source from which merit flowed” (Aung-Thwin 1985: 99). The people who actually built the temples and palaces, however, would not reside within the capital city, which was more of a “showcase” of the kingdom itself (Aung-Thwin 1985: 100).
“This history of Sukhothai is inextricably entwined with that of the region” (Rooney 2008: 17). In power from approximately 1220-1350 CE, Sukhothai was on the edges of three different zones of influence – the Khmer of Angkor, the Mons of Myanmar, and the Burmese of Bagan (Coedès, 1966: 124-125, 141; Rooney 2008: 17-18). Sukhothai rose in power after the two greatest powers in the region, the Khmer Empire and the Burmese Empire, declined. Sukhothai was heavily influenced by each kingdom each of these empires; Angkor, in particular, as it was under Angkor’s power in the 12th century during the reign of Jayavarman VII (Rooney 2008: 18-19). The Thai eventually led a revolt against the Khmer, but it was not until the 13th and 14th centuries CE that they began to integrate their own styles into their architecture (Coedès, 1966: 141; McCloud 1995: 31). Sukhothai had several ecological advantages that helped it both expand and maintain its power. Due to its location at the apex of the main river flood basin, it was able to control water allocation over the entire region (McCloud 1995: 31; Rooney 2008: 15).

While the majority of structures in Sukhothai were Buddhist, this religion did not completely usurp traditional animism (Coedès, 1966: 142; Rooney 2008: 30). An inscription from the empire’s most famous king, Rama Khamheng, says that there is a spirit the ruler must worship so that the empire will be prosperous. This is similar to the “nat,” or spirits from the indigenous religion of Bagan, and the royal linga of Angkor, which both symbolize an integration of religions and the unifying and protective role of the king (see Figure 4.3; Coedès, 1966: 142). As practitioners of Theravada Buddhism since the mid-13th century, the people of Sukhothai, like Bagan, also practiced accumulating merit (Rooney 2008: 31). The Buddhist temples of Sukhothai symbolically represented Sukhothai’s political might and position as the religious core of the region (Rooney 2008: 40).

**FINDINGS**

Through my field work I was able to explore many different aspects of my research sub-project. I examined the architectural components of each epicenter, assessed the methods, energy, and resources behind their construction, evaluated building styles and decorations, investigated their spatial arrangements and overall plan, and attempted to determine the functions and meanings behind buildings and other features.

At Angkor, it is mainly religious structures that have lasted over the ages, as many other components of the built environment were made from perishable materials, including the palaces of the various kings. On the ground, Angkor looks like a formal space divided into city blocks, and LiDAR has revealed house mounds and other features. Examining both what can be seen with LiDAR, and the structures that still exist today, reveals that the epicenter of Angkor is a highly formalized urban center that conforms to an orthogonal, cardinally aligned grid pattern. A typical Buddhist temple was oriented east, the direction the Buddha faced when he achieved enlightenment under the Bodhi tree, and this trait is ubiquitous throughout the region where this religion is practiced (Rooney 2008: 40). The most well-known anomaly is that Angkor Wat, originally a Hindu temple, is orientated towards the west, which has led some to believe that Angkor Wat is actually tomb (see Figure 4.2; Coe 1957: 409; Coedès 1947: 84).

As the Angkor urban matrix extends out beyond the epicenter the settlement pattern becomes less structured. Overtime, however, even the more rural parts of the empire begin to take on a more structured appearance. Finally, a city wall was constructed at the peak of the Khmer Empire, effectively separating the inner epicentre from the rest of the urban sprawl. It is distinct from the temple enclosures at Angkor Wat and Angkor Thom (Evans et al. 2013: 1-4).
Bagan’s structures were almost entirely religious in nature, including stupas and Buddhist temples. A stupa is a solid structure that was influenced by burial mounds in India. It was usually used to house relics of the Buddha or royal remains (see Figure 4.3; Rooney 2008: 43). Only very early structures at Bagan exhibit some Hindu influence. Depictions of the Buddha are ubiquitous throughout the structures of Bagan; although some are modern, many are originals. In addition to sculptures and engravings of the Buddha, there were paintings done on the interiors of the buildings which are still preserved in many places. Numerous temples and stupas have gold facades that have been maintained over the years. The walled portion of Bagan, punctuated by 12 gates, is relatively small in size and contains a palace. Indications are that this walled area was only for the royal family, high ranking members of the court, and guards (Aung-Thwin 2012: 69, 79; See Figure 4.4). The gates for the fortified walls were symbolic in nature, with four main gates at North, South, East, and West, and two gates added on either side to create twelve, a number which represents the signs of the Zodiac (Aung-Thwin 2012: 69). Within the city walls there are several religious temples and stupas, as well as the remains of one palace. Outside the walls there are additional temples and monasteries.

Figure 4.3. An example of a stupa at Bagan, the Shwe Zigan Zedi, which is particularly notable as it once housed many depictions of “nat” spirits.
Figure 4.4. Map of Old Bagan, showing the epicenter within the walls (Design Printing Services).
At Sukhothai the “spatial arrangement of monuments is argued to have evolved gradually” (Grave 1995: 245). Dawn Rooney (2008: 18) explains that the rise of Sukhothai was a slow process, as it took time to emerge from beneath the rule of Angkor. A clear example is the temple Wat Si Sawai (see Figure 4.5), which began as a Hindu temple under the reign of the Khmer, and was later altered for the Theravada Buddhist tradition of Sukhothai (Rooney 2008: 19, 96-99). Wat Si Sawai was one of the many buildings located in the inner city, within the fortified walls of Sukhothai. Within the city walls are the most important religious structures, including Wat Mahathat, the largest temple at Sukhothai. Wat Mahathat, with its layout and shape, is a marker for the Khmer influences over the region, but it still contains a distinctly Thai motif with its lotus bud stupa (see Figure 4.6; Rooney 2008: 47). Wat Sa Si may contain the remains of a king, indicating the presence of a burial practice that places the kings in the city walls and within stupas, a common practice across Southeast Asia for artifacts of the Buddha.

Figure 4.5. Wat Si Sawai, notable as a Hindu structure that was later repurposed for Theravada Buddhism.
The city walls of Sukhothai consisted of two moats and three walls (see Figure 4.7). There were gates at each cardinal direction, all of which were fortified, except for the one on the east (Rooney 2008: 73). A typical temple in Sukhothai, as in the rest of Southeast Asia, was oriented east, the direction the Buddha faced when he achieved enlightenment under the Bodhi tree (Rooney 2008: 40). This may explain the lack of fortifications to the east. The San Luang Gate to the north may have been associated with a marketplace situated just outside of the walls, giving further credence to the notion of orthogenetic city, where manufacturing and economic activities do not take place within the epicentre itself (Aung Thwin 1985: 99; Miksic 2000: 107; Rooney 2008: 108).
DISCUSSION

Data Set Strengths and Weaknesses

The strengths of my datasets are rooted in my being able to direct my attention to what is needed for my research. Overall, I noted plenty of diverse data concerning epicenter plans, decorative motifs, architectural features, and spatial arrangements. Each of the sites visited had various forms of information, in English, which would not have been available to me without physically going to these places. By visiting these sites I was also able to interact with local scholars and tour guides to flesh out the information presented in the aforementioned sources. I was able to physically explore layouts and spatial arrangements, as well as get a more experiential understanding of the monumentality of the three epicenters.

One of the weaknesses of my datasets is the things that cannot be seen, especially those structures that did not withstand the tests of time. All of the ware no long gone, along with any other perishable adornments and local features. However, in Angkor, with recent LiDAR surveys, we are starting to see, for the first time, house mounds and structures that cannot be viewed by the naked eye (Evans et al. 2013: 1). There are no similar surveys being done at Bagan and Sukhothai, unfortunately. Thus, for now, it remains difficult to build a comprehensive understanding of the people living in and adjacent to these epicenters.
Epicentral Resilience and Entanglement at Angkor, Bagan, and Sukhothai

Angkor’s collapse was multi-faceted, and, therefore, must be as a product of the interactions between factors operating at multiple scales of time and space (Evans et al. 2013: 5). In Angkor, we see the increasing investment, and therefore entanglement, with epicenters. This is exemplified by the rise of monumentality, as kings created new, more impressive capitals, and built new, even more ostentatious structures, in order to establish and enhance their legitimacy. This leads to the question of sustainability: how long can the land and resources provide for the overall population when increasingly more resources are being drawn into the epicenter? The kings, and their followers, depended, more and more, on the features they had created for administrative and religious purposes.

LiDAR is an important tool for understanding tropical societies and the interactions populations have with their environment. The LiDAR data suggests that the expansion of the urban area, which occurred as part of the ongoing legitimacy exercise, as well as the struggle to maintain water systems and clear land for agriculture, likely resulted an overextension of the political and economic capabilities of the state, leading to failure of some infrastructure components, and deforestation, which ultimately weakening the epicentre, leaving the elites who ruled from it vulnerable, and ultimately hastening state collapse. Understanding the interactions between humans and their environment can assist us in our efforts to explain the collapse of the Khmer Empire, and help us understand the nature of early urbanism in tropical forest environments (Evans et al. 2013: 4).

Elsewhere, Bagan elites struggled to find and control labor to work the productive land available to them, and for a while they were able to maintain power over the people by fostering the Buddhist practice of accumulating merit (Bentley 1986: 284, 294). The idea of accumulated merit not only affected what the kings did during their lives, and how they were perceived by the population, but added legitimacy to their reigns. Kings of Bagan accumulated merit during their lifetimes by donating to monasteries. Unfortunately, this gave monasteries a vast amount of wealth, which would have normally filled the state’s coffers, which meant that Bagan could no longer maintain its armies or its aristocracy (McCloud 1995: 31). The kingdom’s wealth was so depleted that when Bagan fell, it is said the “monasteries were gorged with wealth but the royal treasury was empty” (Bentley 1986: 284).

In Bagan, the practice of accumulating merit can help us understand the shift from resilience and vulnerability. The monasteries and temples claimed too much of Bagan’s productive labour, and the wealth fell into the hands of the monks, leaving Bagan unable to maintain its defensive forces or its aristocracy. Still, the state could not disentangle itself from the Buddhist-merit trap in order to respond to potential threats, and it was left vulnerable when Kublai Khan invaded in 1287 CE, which may have finally brought down the state and its epicentre (McCloud 1995: 31). The Buddhism of Bagan, however, did have a successful reorganization after the collapse of Bagan, and it was able to continue by reframing itself, therefore becoming more resilient, as an ideological entanglement for the people. The temples and stupas of Bagan are still active Buddhist sites to this day.

In Sukhothai, power declined gradually, as their labour dwindled due to constant fighting with other states in the region. The water management system fell into disrepair, which affected the agriculture and led to an inadequate amount of food for the people of the kingdom. The control of the epicentre began to slip and the state began to slowly disintegrate. When a warring state from the south, Ayutthaya, began to take control of its lands, Sukhothai was forced to pay
tribute to them, further depleting already sparse resources. Eventually, Sukhothai reorganized as a much smaller city under the power of the Ayutthaya, which absorbed Sukhothai, not by force, but by politics, and through marriage. We can see this in the change of monumentality, as the grand structures at the height of Sukhothai’s power were no longer built after coming under the control of Ayutthaya (Grave 1995: 248).

Understanding how these entanglements led to decline is important. Sukhothai depended on agriculture to feed its population, which required labour for the irrigation system. With manpower directed elsewhere, Sukhothai struggled. However, while the epicentre did fall from its position of power, it remained resilient, as it continued on into the 18th century (Rooney 2008: 25). It was eventually able to reorganize into a much smaller city that could meet the demands of a smaller population.

CONCLUSIONS

By comparing these three epicentres, we can learn more about the similarities and differences in their network of entanglements. In order to do this, we have to examine the evidence in the field, and consider it along with the available historical information and scholarly literature. We can better understand what entanglements led to collapse by looking at the failures and successes of each of these states. In each case, the collapse has been described as being more of a slow decline, with the state weakened by multiple strains placed upon it, such as the fragile infrastructure of the water systems, agricultural failures, and overextended building projects that were usually religious (ideological) in nature. Many issues emerged because the elites who lived in the grandiose epicenters outgrew their labour base, leaving the state unable to draw on the resources and manpower needed to sustain itself.

The fieldwork done here will guide my thesis, which will consider these issues in more detail. By looking at religion and ideology, as expressed in epicentral plans, architecture, and adornments, we can see how people, especially elites, were entangled with these places. We can then assess just how the huge labor investments in epicentral court complexes initially made early tropical states resilient, but also how increasing entanglement with these superlative centers eventually led to certain vulnerabilities that could not be overcome.

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CHAPTER 5
SOCIO-ECOLOGICAL ENTANGLEMENT IN TROPICAL SOCIETIES:
A STUDY OF EPICENTERS IN JAVA, INDONESIA

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During May-June, 2014, members of the Socio-ecological Entanglement in Tropical Societies (SETS) project visited the island of Java, Indonesia, in order to assess data relevant to the archaeological study of resilience within complex societies. Over the course of the period spanning CE 800-1500 AD, four different Charter States emerged, expanded, and eventually declined across Central and East Java. These early tropical states facilitated the movement of people and materials throughout the region, and built large communities, ultimately leaving behind complex religious monuments and myriad archaeological remains. The specific Charter States that were focused on during this segment of the SETS project were the Mataram (Medang), Kediri (Kediri), Singhasari, and Majapahit (Trowulan) kingdoms. By visiting these areas and exploring what the environment is like, and what archaeological remains have survived, we were able to build on the SETs Project’s existing comparative sample of tropical societies (Iannone 2013). Such a comprehensive, integrated history of early tropical states will ultimately promote the comparison of resilience across the world’s tropical zones, using both past and present examples.

This chapter specifically explores similarities and differences across the Javanese Charter States to determine how the epicentral court complexes of these kingdoms were designed, and how these integral spaces functioned. By establishing the different roles, statuses, and activities that framed the use and meaning of these central places, and how they reflect the nature of their elite inhabitants and users, the support people who lived in their vicinity, and the resources required for their construction and maintenance, we are able to explore how the legitimacy of societal elites, and specifically rulers, was intricately “entangled” with these material settings (Hodder’s 2012). Such an investigation will allow the SETS project to explore certain factors that may have contributed to both the rise and fall of the various Javanese Charter States, and to ultimately compare our findings with the results derived from other research that SETS is carrying out across South and Southeast Asia.

EPICENTERS IN SOUTHEAST ASIA

Epicenters in Southeast Asia exhibit a distinct set of features. Gordon V. Childe (1950) was one of the earliest anthropologists to discuss the revolutionary decision to move into an urban context, and to explore what features these urban centers have in common. He developed these criteria by examining archaeological evidence from different early civilizations, including the Maya, Mesopotamians, and Egyptians. Childe’s criteria include, but are not limited to: 1) a more extensive and densely population than previous settlements; 2) accommodation of additional classes; 3) monumental public buildings; and, 4) a ruling class supported by a social surplus. By looking at what kind of spaces existed in these urban centers, and how they functioned, Childe’s criteria can be used to determine which building-types should be present, and what the absence of these can potentially mean. Elsewhere, Jacques Dumarçay (1991) posits that all royal palace complexes (e.g., epicenters) in Southeast Asia are based on three key functional spaces: 1) housing for the ruling family; 2) settings for the practice of religion and ceremonial court activities; and,
3) features that help advertise the extent of the king’s powers in the kingdom. Essentially, these monumental cores place rulers at the center of a microcosm of the broader universe. Considering Childe and Dumarçay’s criteria, I believe that the kingdoms in Java did have true epicentral court complexes, and that these places attracted larger populations and fostered the emergence of even more powerful elites and rulers over time.

Architecture allows for ideas, both religious and political, to be exhibited on a monumental scale. Each of the Javanese kingdoms created their own epicenters/cities based on beliefs, and adorned them with reliefs and other meaningful images. While all reliefs and texts found throughout these epicenters should be reviewed with an eye for both their propaganda and creative qualities, Dumarçay suggests that the reliefs at Borobudur (Central Java) likely show what Javanese palaces might have looked like. For example, Figure 5.1 depicts what an elite residence or throne room may have looked like, and how people may have interacted with such a space. This particular relief shows an image of the Buddha at the center of the palace, something which is quite common throughout Java.

Figure 5.1. Borobudur relief.

Architecturally, Javanese epicenters were built along a linear axis, with each quadrant representing a different facet of society (Miksic 2009, 2012). The cardinal directions held a large importance in Javanese literature and religion. Many of the temples are symmetrical in their build and design. We also know that each individual component of the architecture held meaning.
O’Connor (1983) points out that the Javanese people only put walls around the actual royal palace (the residential complex of the ruler), while the Malays did not have any walls, and the Burmese built walls around the entire city. He suggests that this variation relates to the different ways in which the urban center and the ruler were viewed in each society. In the case of Java, O’Connor notes that while Trowulan does have gates these are not connected to walls that extend around the epicenter. Rather, several smaller walled spaces have been found which likely served to provide privacy and security for elites. There was apparently no need for a large, walled urban center for the defense and good of the population (Miksic 2000). This may imply that Trowulan and its elites were more concerned with their own security, and that they used walled compounds to create boundaries between themselves and the rest of society, not unlike the way the Buddha was surrounded by walls in the reliefs of Borobudur (see above). Other reliefs, such as one from Candi Sukuh in Central Java, show multiple wooden buildings with ceramic tile roofs within what appears to be one of these walled complexes (Figure 5.2). The gate and walls that encompass the compound suggest a level of protection and restricted access.

Figure 5.2. Relief at Candi Sukuh.

Javanese epicenters, such as Trowulan, are also not connected to any waterways, such as rivers, meaning people would have had to travel overland to reach them. Trowulan did build large reservoirs within its urban matrix, such as the Segaran pool (Figure 5.3), which could have been used to fill canals, and feed water to ritual centers, such as Candi Tikus (Figure 5.4). Other than temples and gates, epicentral buildings in Java were built largely from wood, and being a perishable material, this means that it is difficult to locate such structures archaeologically. Soekmono (1967) discusses ancient Chinese records which confirm that most house were made from wood and covered with palm leaves. This tradition has continued throughout the tropics
today, even with the invention of harder and more durable materials. Thus there is significant continuity in construction practices.

Figure 5.3. Sagaran pool looking south towards Mount Kelud, Trowulan/Majapahit.

Figure 5.4. Candi Tikus, Trowulan/Majapahit.
Ratu Boko, Central Java

Ratu Boko is a large complex found on the top of a hill near Prambanan, Central Java. It contains multiple compounds, building terraces, and wall. The function and meaning of this complex has been debated since its first exploration by scholars. The Ratu Boko complex is arranged in similar fashion to the Trowulan epicenter, with the cardinal directions being used to orient the directions of walls and terraces. One of the compounds, the sprawling southeastern compound, includes nine courtyards containing numerous residential buildings, gardens, religious structures, ornamental pools, and “water tanks.” Dumarçay (1991) argues that Ratu Boko was a “kraton” (an epicentral palace), because it fits his criteria for such a complex (see above), and because of its similarity to eighteenth and nineteenth century sultans palaces in the region. In contrast, Veronique Degroot (2006) firmly believes that this Ratu Boko was a monastery because it contains inscriptions that reference similar Buddhist monasteries in Sri Lanka, and because it has architectural similarities to these. Finally, Miksic (2004) also refers to an inscription at the base of the Ratu Boko hill that refers to a Javanese ruler having resided there, implying that the might have been multifunctional. While visiting to these archaeological remains, I personally came to the same conclusion as Degroot did. With the multiple features of both the Hindu and Buddhist religion, meditation caves, and multiple remains of different temples, the religious connotations of the site are too prevalent to ignore. I would therefore agree that Ratu Boko was likely used as a monastery, rather than a palace/epicenter. Iannone (personal communication, 2014) does point out, however, that known epicentral complexes at Angkor and Bagan also contain numerous religious features of the both the Hindu and Buddhist faith, and thus their presence does not necessarily rule out the interpretation that Ratu Boko did serve as a palace/epicenter at some point in its existence. Ultimately, Ratu Boko could have had numerous functions over its long history, and it may have started as a monastery and been turned into a kraton later on (or vice versa). However, without a larger material culture data set and inscriptive record to work with, and few if any contemporaneous epicentral complexes from the same area to compare with, it remains difficult to determine Ratu Boko’s true significance.

DISCUSSION

The SETS field trip to Java was very enlightening. Many of the ancient temples are still used in religious practices and ceremonies to this day. In the past, these temples, and the various epicentral complexes, were associated with certain rulers and dynasties. Dumarçay believes that the epicentral palaces/kratons were clearly meant to symbolically display the power, wealth, and legitimacy of the state and its ruler, and that this was achieved through the multifaceted architectural, monumental, and inscriptional inventories that made up these complexes. In addition, by building other public works in their name, such as reservoirs, gates, and temples, the ruler built their merit, which was crucial to their position in the state hierarchy. Ultimately, by visiting the region and conducting on-site visitations, archaeologists are able to see things that the literature cannot or does not describe, and it also allows them to ascertain what kind of research still needs to be done. Pictures are not always sufficient for learning about the details of a relief or the angles of a building. In addition, by personally visiting these places archaeologist are able to determine exactly how one space articulates with the next, which is another thing that cannot be done without physically moving through these spaces.
Issues with the Data Set

The main issue with the available data set is that very little archaeological excavation of epicentral urban settlements have been conducted to date in Java, other than the work carried out at Trowulan/Majapahit. Most archaeology has been focused on temple complexes. Unfortunately, because the state capitals were situated in good locations, modern cities often built up over top of the ancient ruins. Soekenmo (1967) believes that both Singahsari and Kediri are modern cities built on the foundations of the ancient capitals, but no remains can be seen of these on the surface. While travelling around Java I found that contemporary populations use every single space available to them to either build or farm on, which makes finding any ruins of urban centers very difficult. Miksic (2009) believes that in the case of Trowulan, farmers in the area have lowered the landscape by almost 2 meters since the time the former capital was active. This has impacted the underlying architecture and hindered our ability to see the remains of the former city today. Because farmers are so reliant on their system of agriculture it has also proven difficult to try to excavate for buried features. Ground penetrating radar with test pits would be useful could be used in this situation to determine the location of archaeological features. More field research is also needed in order to learn about how the epicenters might have related to their natural environments and the built environment that comprised their sustaining area. With traditional building materials like the brick being scavenged from ancient buildings to be used in the present, the inability to recover many perishable materials that would have formed the bulk of construction materials, and limited excavations focused on past urban centers, epicenter archaeology within Java appears to be slowing down rather than picking up. Still, well there are problems concerning acquiring new data, the information scientists do have still allow for some cross-cultural comparisons to be made, and some more specific observations concerning epicentral resilience are also still possible.

Socio-ecological Entanglement in Javanese Epicenters

Entanglement theory is based upon the notion that there is a relationship between how dependent humans become on things – especially as societies grow in size and complexity – and how reliant these things are on humans for their construction and maintenance (Hodder 2012). Key to resilience modeling is that these entanglements can “guide” the development of a society because they often create a level of path dependency which limits the options available to a system when change needs to be managed in the face of unexpected perturbations (Gyles Iannone, personal communication, 2014). Interestingly, the Javanese people recognized the importance of good land and water, so they frequently moved their capitals, implying that they were able to disentangle from a central place in order to establish a new one in a more productive area. This practice allowed them to maintain options, and it thus promoted societal resilience. By seeking out new territory, and ultimately new avenues of power through the control of better land and water resources, the elite continuously worked on legitimizing their claim to the throne, and their right to rule. This ability to disentangle from a place of power was a characteristic of all of the Charter states in the SETS sample, and although it clearly has resilience implications, the practice was normally framed in ideological terms: at the outset of their rulership new leaders often moved to establish a new capital in order to demonstrate their abilities, and confirm their legitimacy, (Gyles Iannone, personal communication, 2014). The ability to maintain resilience and promote legitimacy was also enhanced in Java because of the numerous volcanoes that occur in this region, the periodic
eruption of which provided nutrients to their surrounding agricultural lands. Depending on the location of these eruptions, they could have fostered movement (i.e., newly productive lands became attractors), or, alternatively they may have enhanced the ability to stay in place (i.e., because they replenished existing agricultural lands). The downside was that people had to contend with the risk of eruptions, which brought short term chaos, and could even foster significant societal changes, such as forced, unplanned movement of the capital, as may have happened in the case of the Mataram Kingdom of Central Java.

CONCLUSIONS

While the focus of this research is limited to the epicenters and the types of spaces and meanings the defined these central places, the results of this study can be added to those of the other SETS sub-projects to increase our ability to develop an integrated history for each Charter state, and to document shifts in resilience over time. By creating such integrated histories, SETS can begin to compare across the different tropical state formations to search for both similarities and differences in the various coupled socio-ecological systems. It is our hope that this data can then be used to inform human-nature interactions in contemporary societies.

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CHAPTER 6
SETS 2013 PHASE I SETTLEMENT STUDY: ANGKOR, BAGAN, AND SUKHOTHAI

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The 2013 SETS Phase I settlement research sub-project is focused on the socio-ecological dynamics of past communities across time through the examination of a small sample of ancient tropical societies. The overarching aim of the study is to explore the development, patterning, and organization of a variety of ancient Southeast Asian charter state settlement systems, with particular emphasis on how these systems, human-thing entanglements, and socio-ecological adaptations made these communities more or less resilient over time. This archaeological study involves the utilization, analysis, and evaluation of numerous data sets related to human occupation and land-use patterns for each of the various charter states explored. The settlement research program discussed herein was conducted in the modern Southeast Asian countries of Cambodia, Myanmar (Burma), and Thailand. The specific charter states under study include: the Khmer Empire (802-1431 CE) of Cambodia, the Burmese Empire (950-1300 CE) located in Myanmar, and finally, the Early Siamese Kingdom (1238-1378 CE) of Thailand.

The ancient charter states of Angkor (Khmer), Bagan (Burmese) and Sukhothai (Early Siamese Kingdom) are considered to be “charter states in the sense that each realm, as the earliest extensive indigenous polity in its area, provided a political, territorial, and high cultural charter for subsequent generations” (Lieberman and Buckley 2012:1056-1058). The 2013 SETS Phase I settlement study fieldwork was conducted over a period of approximately two weeks (December 15-31, 2013), and included visits to museums, archaeological sites, and several modern Southeast Asian communities. Settlement nodes within the Khmer Empire, centered on Angkor, were visited over a period of four days, while the architectural remains of the Burmese Empire, centered on the capital of Bagan were visited for five days, and lastly, settlement units that comprised the Early Siamese Kingdom, centered on the ancient capital of Sukhothai, were also visited for a period of five days. The purpose of the site visits and literature review was to evaluate the different data sets related to ancient settlement nodes, patterns, and systems, including the assessment of data quality, kind, and availability for each of the different charter states.

SETS PHASE I SETTLEMENT STUDY RESEARCH GOALS AND QUESTIONS

The main goal of the 2013 SETS Phase I settlement study was to explore the development and organization of settlement nodes in a sample of past tropical societies, including the charter states of the Khmer Empire, the Burmese Empire, and the Early Siamese Kingdom, with particular emphasis on how these settlement systems made communities within the different charter states more or less resilient over time. The low-density urbanism footprints, the distribution of support populations, and how this distribution reflects the location of intensive agricultural, water-management, and other integrative features were of primary concern, were the central focus of this study. The subsequent section outlines the specific low-level research questions designed to generate a broader understanding of the dynamic character of past Southeast Asian socio-ecological organizational strategies.

In an effort to better understand the dynamics of socio-ecological organization within the charter state sample, and the resultant patterning of different settlement units and changing land-use strategies across the landscape over time, the following questions were addressed, including:

1) What types of settlement units (i.e., buildings and building clusters/complexes) were developed and constructed by each of the various Charter States?

2) For each of the Charter States, when and where on the landscape did the various types of settlement units first emerge?

3) Did any of the settlement units experience increased popularity through time?

4) When were the different types of settlement units ultimately abandoned?

5) What factors contributed to the emergence, increased popularity, and eventual decline of specific settlement units?

6) What types of statuses, roles, and activities were based in the various settlement units?
   a. Did these statuses, roles, and activities change over time, and if so, why?

7) Did the methods and materials used to construct and maintain specific settlement units change over time?
   a. Were there fluctuations in labour, material, construction, and building maintenance costs over time?
b. Which settlement units were the most costly to construct and maintain, and if so, who was responsible for the construction and maintenance of these costly settlement units?

8) Did the various Charter States develop and situate particular types of settlement units in close proximity to water-management, agricultural, or integrative features?
   a. If so, did these patterns change with time, and under what circumstances did these changes occur?

9) In general, how were support populations patterned and distributed across the landscape within each Charter State?
   a. Did this settlement patterning change over time, and if so, why?
   b. If settlement unit patterns associated with construction, development, maintenance, organization, sponsorship, and distribution were dynamic, and changed over time, did these changes coincide with the greater state-level developments that were occurring among the various Charter States?
   c. In what ways do the changing settlement pattern relate to the degree of resilience exhibited by specific settlement units and the broader communities of which they were part?

10) Does the concept of specialized “settlement clusters,” as advocated by Isendahl and Smith (2013), McIntosh (1991), and Scarborough and Valdez (2009), have explanatory power with regard to explaining the relationship between different settlement units on the sub-regional scale?

Ancient Southeast Asian settlement research programs that consider paleoenvironmental conditions, including this study, have significance because the results of such examinations will contribute to larger efforts focused on the socio-ecological adaptive strategies, resilience, and material entanglements of tropical societies in the past. Correspondingly, a firmer understanding of the strategies, challenges, and successes of ancient low-density urban tropical societies established through archaeological investigations may inform modern land-use practices and community organization in contemporary tropical low-density urban or high-density rural settlements.

SETS Settlement Study Methods: Data Collection and Analysis

The principle research methods employed within this study involved field reconnaissance conducted at several archaeological sites, as well as the observation and examination of contemporary low-density settlement distribution and patterning. Detailed note taking and photographic documentation of archaeological sites, museum visits, and meetings with local scholars were complemented by a review of primary literature sources, including historic texts and published academic sources.

THEORETICAL APPROACH AND BACKGROUND

Theoretical Orientation

The current archaeological investigation utilized a variety of approaches concerned with the study of past human settlement patterns, social organization, and land-use practices within tropical environments. Models related to ancient socio-ecology and tropical low-density urbanism have been coupled with theories regarding climate change, adaptive responses, material entanglements, social reorganization, resiliency, and state-level “collapse”. It is important to consider that “environments and human populations are not entirely separate phenomenon but are intricately interrelated and that a change in one affects change in the other” (Kealhofer 1996:112). Therefore, choice of settlement location can be best understood in terms of local and regional environmental conditions, and the social, religious, economic, and political organization of humans (Wilén 1982:63). The socio-ecological approach to ancient settlement patterns “focuses on the dialectics between ecosystems, socio-cultural systems and human agency, specifically in relation to the resilience of food and water security systems or human-environment adaptive strategies” (Barthel and Isendahl 2013:232). Within the various tropical charter states in question, the low-density urbanism footprints or “high-density ruralism” and “ruralopolis-like” nature of the distribution of support populations across the landscape is ultimately a consequence (and therefore an expression) of this ancient human-environment interface (Qadeer 2000; Scarborough et al. 2012). Tropical low-density urbanism in the past is understood as an adaptive response that imitated the vast ecological diversity and low individual species density of the tropics themselves, where large urban sectors were dedicated to agriculture, forming dispersed settlement clusters within highly engineered “agro-urban” landscapes (Barthel and Isendahl 2013:227; Cowgill 2004:539; Evans et al. 2013:12595; Scarborough et al. 2012:21).
Another line of thinking emphasizes human-thing entanglements, focusing on the dialectic between humans and the things that they produce and depend upon, and which in turn also depend on human for their creation and maintenance (Hodder 2011a, 2011b). The highly dispersed nature of settlement units within low-density urban systems required a variety of integrative mechanisms to connect clustered rural hinterland populations with epicentral, urban temple-complexes and administrative nodes (Evans et al. 2013:12595; Penny et al. 2006:599; Scarborough et al. 2012:22; Simon 2008:172). The many integrative features, settlement units, and the technologies and resources required to construct and maintain them over time, created a plethora of human-thing entanglements and dependencies within each charter state. The ability of these states to successfully devise and maintain various adaptive strategies, such as large-scale agricultural and water-management projects, was dependent on the population’s ability to effectively construct, manage, and preserve material things within a tropical environment (Evans and Travaglia 2012:205; Evans et al. 2013:12598; Hodder 2011a, 2011b). Thus, socio-ecological resilience is considered the capacity of a social system, through its web of human-thing entanglements, “to absorb shocks, utilize them, reorganize, and continue to develop without losing fundamental functions” (Barthel and Isendahl 2013:225). In the tropics, human-environment adaptive strategies and their capacity for resiliency are closely related to regional ecological conditions and climate (Buckley et al. 2010; Iannone 2008; Lieberman and Buckley 2012). Significantly, evidence suggests that the rise of the charter states and the polities of Angkor, Bagan and Sukhothai were the result of stronger monsoons, higher rainfall, and more evenly distributed rainfall throughout the year during the Medieval Climate Anomaly (900–1300 CE), which spurred agricultural and population growth within this period. In contrast, the following Little Ice Age climatic episode, an era of more volatile and concentrated precipitation, resulted in heavy floods intermixed with extended periods of drought (Lieberman and Buckley 2012:1050,1074). Although the various charter polities developed successfully for several centuries, devising impressive strategies related to agrarian-based subsistence practices, they eventually contracted to a point of “collapse”. State-level “collapse” within the tropical charter polities is recognized as a loss of sociopolitical complexity, or the inability of populations to cope with or recover from, prolonged regional climatic fluctuations and changes in the same ways and to the same extent in which they had previously weathered environmental disruptions (Iannone 2008:2083).

**SE Asian Charter State Settlement Patterns: Low-Density Urbanism, Clusters, and Regional Nodes**

Much of what is currently understood about ancient Southeast Asian settlement patterns and social organization comes from historic texts, travel accounts, and modern studies of religious inscriptions and art. Recently, in addition to the introduction and expansion of traditional excavation and survey programs, archaeologists have begun to employ new methods of data collection within tropical environments, including the use of geographic information systems and LiDAR remote-sensing, when examining ancient low-density built environments and land-use practices (Chase et al. 2012; Demarte and Alfano 2013; Evans and Travaglia 2012; Evans et al. 2007; Evans et al. 2013; Scarborough et al. 2012). Similarly, where previous studies focused primarily on large temple-complexes and other impressive masonry structures, contemporary scholars have now begun to include the patterning of less conspicuous, but equally important, small mounds and associated ponds that represent typical commoner households within examinations of ancient Southeast Asian settlements.

The tropical low-density urbanism footprints of the Khmer and Burmese Empires, and the Early Siamese Kingdom, shared many organizational principles based on a common worldview and analogous ecological conditions that resulted in similar settlement patterning and use of the landscape. Typically, large agglomerations of religious architecture or temple-complexes served as epicentral administrative and integrative nodes for a highly dispersed support population (Cowgill 2004:527; Evans et al. 2013:12596; Hudson et al. 2001:51; Moore et al. 2012:145; Mudar 1999:6; Welch 1998:210-211). Surrounding each religious-administrative node was a vast low-density system of household and village settlements interspersed among considerable tracts of agricultural land and connected to the epicenter via large-scale transportation and irrigation networks. These polynucleated resource-specialized settlement clusters networked to form larger districts, which at the height of each charter state’s fluorescence, were directly linked to the preeminent capital polity through a web of socio-religious interactions and economic interdependencess (Isendahl and Smith 2013, McIntosh 1991; Scarborough and Valdez 2009).

**The Charter States: A Brief Introduction**

The ancient Khmer Empire (802-1431 CE), located in the Mekong Delta region of Central Mainland Southeast Asia, was centered on the capital of Angkor, which represented an immense low-density urban complex that stretched from the Tonle Sap Lake in the south to the Kulen Hills in the north. The Khmer Empire itself extended far beyond the borders that defined the charter state of Angkor, extending along the coasts of modern-day Cambodia and Vietnam.
as well as portions of Thailand and Laos (Evans et al. 2007; Fletcher et al. 2008:661; Lieberman 2003:215-216; Penny et al. 2006:599). Angkor arose as the charter polity of the Khmer Empire during the 10th century, gaining prominence in the region due to its development of riverine and lacustrine transportation and communication routes, rich fisheries, and successful seasonal flood-farming along the shores of the Tonle Sap. These ecologically-based economic advantages greatly increased agrarian yields, support population levels, and the overall socio-political and economic influence of its rulers throughout the region (Lieberman 2003:218,223). The collapse and reorganization of the Khmer Empire followed extended conflicts with Mongol assisted Thai incursions, coupled with ecological strains and the deterioration of favorable Medieval Climate Anomaly climatic conditions, resulting in a shift to coastal maritime economic activities and the fall of Angkor as an inland capital polity (Lieberman 2003:242).

The ancient Burmese Empire (950-1300 CE) was located in the western portion of the Southeast Asian mainland and was centered on the capital of Bagan (Pagan), situated on the Irrawaddy (Ayeyarwady) River in Upper Myanmar (Hudson et al. 2001:48; Lieberman 2003:85). The rich alluvial soils and tropical climate of the region provided extensive cultivable lands and permitted rice growing in the surrounding plains both to the north and south of the capital. The Irrawaddy and its tributaries also provided a means for maritime access and important riverine transportation and fresh water resources (Lieberman 2003:88; Stadner 2013:12-15). Although the Burmese are recognized as the historically dominant group in the region, they followed the Pyus, who were the first to settle the area sometime during the first or second century CE. Early Pyu contact with inhabitants of India and Sri Lanka resulted in a ritual system that included both Buddhism and Hinduism (Lieberman 2003:89-90). Following a period of Pyu political strife, Burmese warriors and settlers began to occupy the region, first settling in well-irrigated areas and, significantly, taking over the old Pyu site of Bagan. Upon their arrival the Burmese quickly intensified irrigation-based agriculture and adopted the Buddhist belief system of their predecessors. However, the region remained politically fragmented until the late 900s. At this time Bagan extended its control over the northern interior. The growth and prosperity of Bagan as a charter polity is largely due to its location between the rice-growing districts of Minbu and Kyaukse, its access to north-south riverine transport, and proximity to Mount Popa, an important and sacred hilltop site (Lieberman 2003:90-91). Internal socio-political turmoil, increasing external invasions, and regional climate change all influenced the decline of Bagan’s prosperity. Following the collapse of Bagan as a major polity, settlement in the Irrawaddy basin region reorganized and once again became fragmented and less cohesive socio-politically (Lieberman 2003:87,119-120).

The Early Siamese Kingdom (1238-1378 CE) was located in the Central Mainland region of Southeast Asia and was centered on the ancient capital of Sukhothai, located 12 km west of the Yom River, a tributary of the Chao Phraya River system within the Central Plain of Thailand. This region is framed by three ranges of hills including the Saphan Hin, Phra Bat Noi and, the Phra Bat Yai (Rooney 2008:15; Silapacharanan 2013:28). At its height, Sukhothai was linked to Si Satchanalai, an important religious center located 70 km to the north by the Thanon Phra Ruang (royal road) which served to connect these centers, and facilitate both economic and social exchanges (Rooney 2008:22-24). The rise of Sukhothai and the charter state of the Early Siamese Kingdom coincided with waning Khmer influence in the region and its abandonment of control over strategic outpost settlements. The fall of Sukhothai as a charter polity followed increasingly unstable climatic conditions, the death of King Ramkhamhaeng, and a period of protracted warfare with the Burmese Empire, which resulted in the weakening of the capital and its hold over its former vassal city-states (Lieberman 2003:241; Rooney 2008:19-25).

The following section presents the SETS 2013 Phase I Settlement Study results, and addresses the low-level research questions outline above in the form of a discussion of the overall settlement patterns and systems identified within the sample of ancient Southeast Asian tropical charter states.

SETS PHASE I SETTLEMENT STUDY RESULTS AND DISCUSSION

Data Assessment

An assessment of the quality, kind, and availability of datasets related to ancient Southeast Asian settlement patterns and systems for each of the tropical charter states within this study has revealed several encouraging strengths and, unfortunately, some frustratingly significant weaknesses. To begin, given the relative paucity of published archaeological reports, and the limited number of long-term archaeological projects currently operating within this region, it is imperative that one visit the ancient polities of Angkor, Bagan and Sukhothai for oneself in order to better understand and appreciate their simultaneous monumentality and the diffuse nature of their agro-urban, low-density settlement distributions. In order to support or refute, and therefore reconcile, historic accounts with the growing archaeological record, regional multi-scalar and intensive survey-exavcation programs are required to establish and refine chronologies and histories while also exploring the methods, means, and patterns of settlement unit construction.
and distribution for each of the charter states. Issues of contemporaneity concerning the many visible settlement units, nodes, and integrative features across the landscape cannot be determined without excavation efforts. In addition, the visibility of small support population household mounds is often obscured, both by modern communities occupying ancient settlement locations, and the tropical forest environment itself, which makes the identification of small, low-relief house mounds and ponds difficult.

The advantages or strengths of the available datasets related to ancient Southeast Asian settlement patterns include the longevity of particular settlement nodes and the continued use of ancient religious temple-complexes. Travelling the countryside in the areas previously occupied by the charter states in question provided insight into past settlement patterns and land-use practices and a greater appreciation of the low-density urbanism footprints of these ancient empires. The problem of low-density urbanism and the study of past settlement system dynamics and human-thing entanglements in tropical environments is also enhanced by the existence of valuable historical texts and surviving artwork, such as the stone carvings within temple-complexes, that provide basic information regarding daily life and social organization in the past.

Data Analysis: Addressing the Questions

This section revisits the low-level research problems outlined above in the form of a discussion that has been divided into four broad segments, the aim of which is to present the data in a way that reduces redundancy and organizes the questions in terms of broader topics. This discussion incorporates all of the available data, including that gathered from both written texts and site visits to various settlement nodes within each charter state. Although these archaeological site visits focused primarily on the charter polities of Angkor, Bagan and Sukhothai, trips further afield were also conducted when possible, and the results of the latter will also be discussed when relevant.

Settlement Units and Patterns. The various tropical charter states under study shared many religious, ideological, and economic qualities, and they had access to similar, all of which influenced social organization and resulted in commonalities in settlement unit types, patterning, and locations within the different regions. The architectural inventory that comprised the low-density urban networks of the Early Siamese Kingdom included small households, royal palaces, religious temple-complexes, field and city walls, moats, and several integrative features, such as market places, roads, canals, bridges, dams, and large reservoirs. Evidence for the existence of small household groups arranged in a grid pattern can be found within the city walls of ancient Sukhothai and Si Satchanalai, while those located outside these boundaries take on a less formal pattern. These numerous household settlement units are represented by low earthen mounds, and they often have small rectangular ponds oriented to the east and located within a few meters of these remnant substructures. Additionally, and similar to many households within greater Angkor, the houses of the support population were often located along waterways and on the shores of lakes, and these were normally stilted or constructed on floating platforms (Silapacharanan 2013:31). Although these former household settlement units are archaeologically invisible, there are many contemporary examples along the Tonle Sap in Cambodia today.

The layout of the major temple-complexes of the Early Siamese Kingdom represent cosmograms and mimic a Bramanistic worldview, with Mount Meru at the center (Rooney 2008:30). Temple-complexes at Sukhothai and Si Satchanalai (which are similar in plan to those of the Khmer Empire) are typically enclosed by walls and moats, rectangular in plan, and contain a primary and central temple that is oriented to the east and surrounded by several additional temple structures. The buildings found within these temple-complexes include a central stupa (temple), assembly hall(s), and an ordination hall (Rooney 2008:40-44). Although temple-complexes generally include several stupas and assembly halls, they only contain a single ordination hall. These particular structures were oriented to the east, often facing water, and situated to the north of the central and largest stupa (Mudar 1999:5-6). In general, many temple-complexes from the Early Siamese Kingdom charter era were walled, mounded, or surrounded by raised earthen embankments that served to demarcate and enclose these sacred spaces.

The basic elements that comprised the low-density urban network of the Khmer Empire, much like those of Sukhothai, included small household groups, royal palaces, huge religious temple-complexes, field and city walls, and a variety of integrative features, including rest houses, fire shrines, hospitals, market places, roads, canals, bridges, dams, moats, ponds, and often enormous reservoirs known as baray (Evans et al. 2013:12595). The layout of the massive moated temple-complexes within the Khmer Empire were also cosmograms that represented the Hindu universe, with Mount Meru at the center of a sacred mountain range surrounded by a cosmic sea (Freeman and Jacques 2013:47-48). The small household settlement units of ancient Angkor are also represented by low earthen mounds with rectangular ponds oriented to the east, and much like those of Sukhothai follow a grid pattern within the city walls while those outside the borders are less formally organized.
Similar to the engineering of landscape within the Khmer Empire, the basic elements that comprised the low-density urban and agricultural systems of the ancient Burmese Empire included the small residential structures of the support population, royal palaces, temple-complexes, field and city walls, moats, and integrative mechanisms, including roads, granaries, market places, ponds, and reservoirs (Grave and Barbetti 2001; Hudson et al. 2001:52). Religious temple-complexes were often located near small ponds and/or agricultural fields, and these were demarcated by brick walls that encompassed several stupas and temple buildings (Moore 2004; Moore et al. 2012). Within Bagan, and beyond its walls, residential settlement units and small village clusters were often demarcated by wooden fences, arranged in grid patterns, and located near permanent or seasonal water sources, including ponds and reservoirs.

Although the methods and materials used to construct and maintain commoner and other residential settlement units within each charter state remained relatively consistent over time, there were changes in the construction of larger religious temple-complexes and integrative features, such as roads and large-scale irrigation and agricultural works, within these ancient low-density urban environments. The majority of settlement units within the built environment of the ancient Khmer Empire, including the abodes of both commoners and sub-elites, as well as the king’s relatives and senior officials, were constructed from perishable materials such as wood and thatch, while brick masonry was typically reserved for religious architecture and the ruling king’s residence (Daguan 2007:49-50; Evans et al. 2013:12595). The only difference being the residences of royalty often included ceramic roof tiles and different types of wood. Masonry building materials included clay fired bricks, as well as those carved from sandstone and laterite (Freeman and Jacques 2013:26). Within the Burmese Empire temple-complexes constructed of masonry, sandstone, and laterite could be found scattered amidst cultivated fields and villages that were comprised primarily of structures made from perishable wood materials and built on low, earthen mounds (Moore 2004:4). Building materials used for the construction of large temples and religious structures within the Early Siamese Kingdom also included fired clay bricks, sandstone, and laterite which were often covered with stucco. Occasionally, slate was also incorporated into the door- and window-frames of structures within temple-complexes. Consistent with those of the Khmer and Burmese Empires, the abodes of commoners and other non-religious structures consisted of perishable wood and thatch materials set atop low, raised-earth foundation mounds.

Presumably, the least costly settlement units included the small, simple wood and thatch abodes of commoners. Similarly, the wood and thatch houses of the elite class, although significantly larger and more lavish than those of commoners, and sometimes utilizing ceramic roof tiles, were also relatively cheap in comparison to the inputs required to construct and maintain large religious and administrative masonry structures. The latter were the most costly architectural features in terms of labor, material, and maintenance, along with the integrative features associated with the political, religious, administrative and economic activities of elites. Within each charter state, these masonry buildings and large integrative mechanisms were sponsored by the king and occasionally by lesser nobles, while the households of commoners and sub-elite families were the responsibility of individual families and small corporate groups themselves.

For the populations of the various tropical charter states the initial choice of habitation within each region was ultimately linked to available water sources and prime agricultural lands. Therefore, these areas were the first locations for the development of large temple-complex nodes and support population settlement units, including household groups and small village clusters. Within the Khmer Empire settlement first concentrated in the Mekong Delta and the region immediately surrounding the Tonle Sap Lake and its floodplains. The Early Siamese Kingdom established its first settlement units along the Yom River, a tributary of the Chao Phraya River system, while the first settlements that comprised the Burmese Empire were developed along the Irrawaddy River in the dry zone of Upper Myanmar. Over time, changing socio-ecological conditions and socio-political dynamics within the different charter states resulted in agricultural surpluses and population growth, which expanded on this initial settlement patterns. As a result, low-density urbanism footprints were eventually extended into relatively marginal areas.

Within the Khmer Empire, the Burmese Empire, and The Early Siamese Kingdom elite merit-based systems of monastery building and sponsorship promoted the settlement of marginal areas, often on the fringes of existing urban settlement clusters and epicentral nodes (Evans et a. 2007:14281; Evans et al. 2013:12598; Grave and Barbetti 2001:85; Hudson et al. 2001:51; Moore et al. 2012:158; Welch 1998:213). These previously undeveloped or “greenfield sites” were rapidly transitioned into embryonic “peri-urban interface” zones, where new settlement clusters and sub-regional administrative districts were formed, creating additional urban-rural interactions and dependencies that were incorporated into larger regional systems (Simon 2008:170-172). This pattern of development saw the sponsorship and construction of new temple-complexes to attract growing support populations. Such communities would continue to expand until the number of household reached a point where the community might be called a village, which would in turn warrant additional state-level temple-complex developments, further extending the low-density agro-urban pattern across the landscape.
The basic elements or settlement unit types within each charter state remained relatively consistent over time. However, there were changes in social organization as agrarian yields and population levels increased, resulting in the development of additional settlement nodes that arose from additional merit-based, elite-sponsored religious temple-complexes. The development of these new settlement nodes also required the funding and building of additional integrative mechanisms, including roads, canals, rest houses, markets, temple-complexes, hospitals, administrative nodes, and both household and village-level units.

Although many ancient temple-complexes and the settlement units of their associated support populations were ultimately abandoned with the collapse of each of the charter state polities, some religious complexes and building clusters have maintained their importance as sacred spaces, and have remained in use for centuries. Similarly, areas with rich alluvial soils and permanent water sources, such as in the Mekong/Tonle Sap Lake, Irrawaddy, and Chao Phraya river systems of Cambodia, Myanmar and Thailand respectively, although having experienced periods of climate change and social reorganization, continue to be occupied into the present day. Those temple-complexes and associated communities that developed recently, often marginal agricultural zones, were typically the first settlements to be abandoned. The long-standing epicentral capitals of Angkor, Bagan and Sukhothai, and their many sub-regional satellites of resource-specialized communities, were heavily influenced by broader climatological and ecological perturbations over time, making even these heartlands far less resilient, and ultimately unsustainable. In the face of changing ecological conditions and the resultant socio-political and socio-economic turmoil and reorganization that resulted, support populations tended to relocate to more economically viable and stable areas where food security would be better assured. Thus, the factors affecting the creation, development, popularity, and decline of specific settlement units are linked to the larger socio-ecological, political, and economic trends also experienced by the ruling elites within each charter state.

**Social Organization.** Due to the high level of inter-regional cultural contact and the resultant similarities in the religious and political organization of the inhabitants of the Khmer, Burmese and Siamese charter states, there were also several socio-economic commonalities that largely determined how these communities were organized, and which defined the roles performed by each segment of society. The majority of the commoner or support population that inhabited the small house mounds within each charter state served an agricultural role, providing rice and other foodstuffs for redistribution by the king and ruling elites of the numerous sub-regional temple-complex administrative nodes. Commoners also provided labor for the construction and maintenance of state-owned buildings, water-management features, and agricultural fields. Additionally, a growing percentage of the support populations also began to assume the roles of merchants, artisan, or tradesperson over time. In times of political strife support populations were also called upon to serve as warriors in defense initiatives, and occasionally, conquest enterprises. Small household units were, ultimately, the settings for a variety of different resource-specific activities. Conversely, the settlement nodes of the large masonry temple-complexes within the various charter polities represent a different set of activities more representative of the elite segment of society. This included individuals who conducted religious, ceremonial, artistic, and administrative roles within each city. The rulers of the major capitals also governed several smaller subordinate centers within their spheres of influence. The many temple-complex administrative nodes and the settlement units that comprised the low-density support populations formed clusters and districts that were organized hierarchically, and were dynamic over time.

**Support Populations.** The low-density urbanism footprints of the various charter states developed in similar fashions because settlement patterning and social organization were closely linked to regional ecological conditions and shared socio-religious and political traditions. Ancient masonry temple-complexes served as epicenters and important administrative nodes, facilitating social relationships, trade, redistribution, and communication within a large and dispersed support settlement system. These low-density urban centers acted to integrate and unite smallholder hinterland populations into larger clusters forming districts that together constituted and delimited the territorial realms of each empire. Therefore, the support populations within each charter state were distributed across the landscape in a low-density urban, or high-density rural, pattern that was related to local resource availability, such as prime agricultural lands, freshwater sources, and transportation routes. Thus, the development of the many agricultural fields, water-management features, and other integrative mechanisms, including roads, canals, temples, rest houses, and hospitals, is closely related to the growth, evolution, and expanding distribution of urban support population units within each charter state.

Given the ephemeral quality of wood and thatch structures, the low relief of small residential mounds (i.e., substructures), and the archaeological invisibility of stilted structures, much of what is known of commoner households, and support populations in general, comes from historic accounts, and more recently studies using remote-sensing technologies. However, it is generally accepted that the distribution and organization of support populations within the various charter states, although following a typical, or relatively consistent, low-density informal patterning, was dynamic and did change over time. The main difference is that, as the low-density urban footprint developed, it began...
to expand into increasingly marginal areas within each region, requiring the construction and elaboration of integrative mechanisms such as roads and canals. Larger tracts of agricultural land were required to support growing populations, and a merit-based system of temple-complex construction sponsored by the ruling elite ultimately expanded charter state settlement and territorial boundaries while simultaneously harnessing additional lands and resources (Lieberman 2003:227-228).

Initially, the support populations within each charter state were situated in close proximity to important religious temple-complexes that were themselves often located near prime agricultural lands, permanent fresh water sources, and communication routes. These religious complexes served as nodes for local social interactions, communication, trade, and redistribution within each charter state, and they thus attracted commoner support populations, thereby increasing settlement density both within the confines of the city walls and the growing peri-urban areas surrounding their immediate borders.

The settlement patterning of the charter indicates a preference for situating specific types of settlement units in particular locations. The many temple-complexes and individual temples themselves often marked the paths of traditional ritual pilgrimage routes, and additional integrative settlement units, such as rest houses, fire shrines, and hospitals were built along these roadways. Over time, and with the expansion of the low-density footprints of each charter polity, rice fields, water canals, moats, and reservoirs were also constructed or enlarged to further integrate (and thereby control) areas of settlement occupation.

With regard to illuminating the relationship between, and articulation of, the different settlement units on the sub-regional scale within each charter state the concept of “specialized settlement clusters,” as advocated by Isendahl and Smith (2013), McIntosh (1991), and Scarborough and Valdez (2009), exhibits substantial explanatory power. Ancient tropical urban settlement clusters are understood to have developed slowly from an undifferentiated rural landscape of individual communities that gravitated together, but avoided assimilating into a single entity. Rather, individual clusters formed a complex network of small resource-specialized communities or nodules of dense settlement distribution that eventually coalesced into satellite districts that served larger polities, such as the charter era Southeast Asian capitals of Angkor, Bagan, and Sukhothai, and the many Classic Maya city-states of Mesoamerica (McIntosh 1991:199-207). The hierarchical socio-economic, and socio-political relationships of resource-specialized communities resulted in a network of interdependencies that acted, over the long-term, to bind small settlement clusters into larger districts and sub-regional systems that were ultimately based on small community-level nodes (Scarborough and Valdez 2009:211-212,218-221). These settlement clusters, or nodes, represented specialized and discrete corporate groups that both attracted and provided services to growing hinterland support populations. The spatial hierarchy of settlement clusters within the charter states of Southeast Asia is also similar to the low-density urbanism expressed in the ancient Maya settlements of tropical Mesoamerica, where houses and patio groups were arranged into spatial clusters that together formed larger districts. In both regions, these districts were the key intermediaries between the ruling authorities of the charter polities and the “lesser” families and neighborhoods of smaller satellite settlement clusters (Scarborough and Valdez 2009:137). Therefore, it was the agro-urban transformations of small household groups and villages that fashioned the specialized settlement clusters which later developed into larger districts, surrounding larger central nodes, that ultimately encompassed the low-density urbanism footprint that defined the settlement patterns of the various charter states (McIntosh 1991:208).

**Entanglement and Resilience.** The data currently available regarding the settlement patterns of the ancient Khmer Empire, the Burmese Empire, and the Early Siamese Kingdom of tropical Southeast Asia inform us about entanglements, resilience, and issues of socio-ecological vulnerability on many levels. The dependencies of humans and things entanglements, related to the reliance of humans on the things that they create and the things (tools, labor inputs, etc.) required to maintain them, creates a complex web of social, economic, political, and environmental interaction (Hodder 2011a, 2011b). In ancient times, these interactions were largely dependent upon local or sub-regional resource availabilities and the sustainable use of these resources. In tropical Southeast Asia and ancient Mesoamerica, for example, integral resources included lithic materials (clays, minerals, and rocks), fresh water sources (including the harnessing of rainfall), and land amenable to arboriculture (for foodstuffs and housing materials) and the cultivation of rice and other agricultural products. With respect to the low-density urbanism, or high-density ruralism, footprints of the charter states, “urban resilience” is associated with the degree of diversity in food production and distribution that is available to urban residents over time. Similarly, the “socio-ecological memory” of low-density urban inhabitants, or the transference of information across generations, collectively fashions the mnemonic foundation for resilience (Barthel and Isendahl 2013:225). The tools and infrastructure required to unite and integrate the various settlement units within the different charter states required constant upkeep, and during periods of cultural florescence, demanded the expansion of many integrative features, including temple-complexes, agricultural fields, and irrigation works. The many adaptive strategies and integrative mechanisms that were developed throughout the Medieval Climate Anomaly were based on past socio-ecological memory. Although they proved to be
highly successful during that time, in the subsequent Little Ice Age conditions changed, and without previous experience in dealing with such extreme climatic shifts, large-scale water management projects and agricultural efforts began to fail, spurring social unrest and political instability (Lieberman and Buckley 2012). Social memory and tradition may also be associated with entanglements related to the importance of place, where particular locations are revered and hold social significance, such as Mount Popa in Myanmar, a popular pilgrimage destination to this day (Hudson 2004:194; Moore et al. 2012:144). Adherence to traditional settlement locations and the maintenance of habitation and temple-complex sites within the vicinity of sacred places, which were located in increasingly marginal, and less productive areas, proved too costly in terms of food security, and support populations within the charter states reorganized as a result. The smallholder support populations of the charter states fared best during region-wide climatic changes because it was the low-density, resource-specialized settlement clusters, comprised of households and small villages interspersed among agricultural plots and local water sources, that supported larger socio-economic entities, including districts and sub-regions. In short, it was the autonomous food production and food security of support populations that provided the surpluses required by the king and ruling elites to maintain their hold and preeminence in society (Barthel and Isendahl 2013:230). Thus, the socio-economic vulnerability of the elite classes within the large urban centers of the charter states rested in their ability to maintain socio-political controls over vast areas of land. However, the socio-ecological resiliency of ancient tropical societies was ultimately based on the ability of support populations to successfully reorganize during periods of political change, and simultaneously navigate a dynamic web of social relationships and entanglements while developing valuable new socio-ecological memories.

CONCLUSIONS

Archaeological investigations indicate that the patterning of ancient settlements across the landscape in many tropical zones of the world, including those of Southeast Asia and Mesoamerica, were often closely linked to socio-ecological strategies. Similarly, the adaptive ability and resiliency of state-level socio-economic and socio-political structures within several ancient low-density urban centers and their hinterlands were heavily reliant on the successful subsistence-based land-use strategies of their support populations. Past civilizations such as the Classic Maya, the Khmer and Burmese Empires, and the Early Siamese Kingdom experienced, navigated, and successfully exploited favorable environmental conditions only to “collapse” in the face of prolonged climatic change. This archaeological research program was designed to examine past examples of human settlement patterning and adaptive strategies during periods of climate variation in order to inform contemporary concerns regarding the modern populations settled in similarly changing tropical environs. The results of this study indicate that the low-density urbanism footprints of past state-level societies were most resilient when individual households and settlement clusters maintained food security via independence in food production and decisions related to its management. Therefore, the patchwork of settlement and agricultural space that embodies modern low-density urban landscapes can gain resilience through the continued existence, and thoughtful integration of autonomous, small-scale, self-supporting rural and peri-urban communities.

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The area of focus for this project is the Java region of Indonesia, more specifically the modern communities of Malang, Kediri, Trowulan, Yogyakarta, Magelang, Wonosobo, Dieng Plateau, and Surakarta. The past Charter States that form the sample for analysis include the Central Java Mataram/Medang Kingdom (CE 732-1006), and the East Java kingdoms of Kediri/Panjalu (CE 1045-1221), Singhasari (CE 1222-1292), and Majapahit (CE 1293-1527). The investigations were conducted from May 13th until June 13th, 2014.

The region of Java is riddled with volcanoes that have erupted periodically, covering the territories of past civilizations. Ancient Javanese civilizations adapted to their natural disaster prone environment by creating settlement structures that were wood-based and easy to deconstruct and move. Both factors have meant that settlement studies in the Java region of Indonesia are very limited. The lack of physical evidence for settlement is at least partially the result of natural disasters, such as volcanic eruptions and earthquakes, which destroyed buildings. Also, the building materials for settlement structures were almost all natural, and thus perishable. Currently, the only observable settlement evidence in Java are the brick remains located in the city of Trowulan, and the structures illustrated in base reliefs on various temples throughout the region.

The purpose of this research paper is to explore the communities that inhabited these settlements, explore the dynamics relationship between these groups and their natural environment, and assess how the available resources shaped the development of the early Javanese settlement pattern.

Data was captured through photographic documentation, field notes and sketches, general surveys of the land, and thorough investigations of literary sources. Museums, such as Trowulan Museum and the Museum Malang Tempo Doelo, provided me with key interpretations and findings through educational signage. In Trowulan there were physical ruins of a brick habitation settlement that had been exposed through excavations. The base reliefs on many temples (Candi) also offered me physical evidence of various structures and settlement components.

**BASIC CONSTRUCTION TECHNIQUES**

As discussed in detail by Waterson (1990), traditional Javanese domestic structures were built with natural resources that can be found all over Southeast Asia. The traditional house (Joglo) is constructed of resources that can be found nearby the community. For most buildings the dominant building material is wood. Teak, Cengal, and Ironwood are considered the best hardwoods for building. These woods are described as being dense, and they contain oils that make them resistant to termites. The alternative to these hardwoods is bamboo. Bamboo is a resource that is highly versatile and readily available in most locales. Bamboo can be used for flooring, framing, woven screens, and roofing. Another important resource is palms. Palms can also be used for flooring and thatching, and the wood can be used as scaffolding for construction. Grasses are also used for thatching and roofing.

According to Roxana Waterston (1990), to support the structure of houses whole trunks of hardwood trees are used for posts. The durability of these hardwoods means that these posts are able to last up to 150 years. Wooden buildings were constructed without nails using the “tongue
and gulls” system (Figure 7.1). Using this mortise technique, columns are locked into place, creating posts that use the friction of wood to absorb the shocks of daily life. Buildings constructed in this manner are quite resistant to earthquakes. House beams are placed on stone foundations. The core structure of a traditional house consists of four columns and double beams (Prihatmaji et al 2010). By building without nails, houses and buildings were easily dismantled and reassembled in new locations. Depending on the size and number of helpers, some houses could be carried away fully intact (Waterson 1990). Transportability was important in East Java due to the threats of volcanic eruptions, earthquakes, and invasion.

![Figure 7.1: Tongue and gulls connection, a mortise of columns and tenon of stone foundation, which is the connection system used for traditional Javanese structures.](image)

The traditional pile built structures were built raised from the ground on columns (Figure 7.2). The functionality of a raised structure was too have an open space close to the ground for:

- cattle
- smoke out insects
- build further stability for earth quake proofing
- Draw in cooler air
- Disposing of debris inside the house
- Avoid Malaria by living in a range higher than mosquitos
Figure 7.2: Tradition Javanese wooden houses that can be found in East Java. The photo on the left is a Toba Batak and the Photo on the Right is a pile built home in the Malay Peninsula. The photo on the left exhibits smoking out insects in the home (modified from Waterson 1990).

FINDINGS

Due to the lack of archaeological remains, the base reliefs on temples (Candi) offered me the best physical evidence for various residential structures and different types of settlement components. These base reliefs provided a window into the past, as they contained various examples of indigenous imagery depicting houses and other settlement buildings, usually incorporated into scenes emphasizing religious iconography. By examining these depictions in conjunction with the results of detailed research by Roxana Waterson (1990), I have been able to identify a number of structure types, and ascertain their purposes. The following figures emanate from the locations that had base reliefs depicting domestic structures and other aspects of ancient Javanese settlement patterns.

City of Malang: Candi Jago, Singhasari Kingdom

A Kuwu is an open walled long house pavilion. The purpose of a Kuwu is to serve as a meeting place for men, it is also hypothesized to be a granary. Figure 7.3A and B show are examples of
Kuwu found on base reliefs at Candi Jago, Malang, attributed to Singhasari Kingdom (Waterson 1990).

**Figures 7.3:** The kuwu is an open walled longhouse pavilion used as a meeting place (from Candi Jago, Malang).

**Figure 7.4:** Figure “A” (Left) Is a photo of a Karo Batak head-house (Geriten; modified from Waterso 1990) Figure “B” (right) is a base relief on Candi Jago, Malang, that may be a rendering of the Karo Batak head-house.

The Karo Batak head house settlement structure is a place to store skulls of important clan ancestors as a custom. Figure 7.4A is a photo of the Karo Batak Head House taken by Roxana Waterson (1990). Figure 7.4B may be a base relief rendering of the Karo Batak Head-House at Candi Jago, Malang.
City of Blitar: Candi Penataran, Majapahit Kingdom

The base reliefs at Candi Penataran, Blitar, resembled those found at the Majaphit capital of Trowulan. The roofs of one of the settlement features depicted oriental steeple architecture, as seen in Figure 7.5. Many of the buildings depicted at Candi Penataran appear to be roofed with clay tiles, as seen in Figures 7.6A, B and C. One image of a residential settlement also included a courtyard, which was a common occurrence in Trowulan residences (Figure 7.7). There were also illustrations of gates and walls which may have delineated a boundaries and barriers. These are seen in Figure 7.6A and Figure 7.8.

**Figure 7.5:** The roof shape of this structure resembles the oriental steeple style roofing at Trowulan (from Candi Penataran, Blitar).

**Figure 7.6:** 76A (left) shows a base relief depicting a clay roofed, open walled pavilion. Figure7.6B and 7.6C (center and right) are residential settlement with clay tile roofing (all from Candi Penataran, Blitar).
Figure 7.7: Base relief illustration displaying a residential settlement with a stone courtyard. (from Candi Penataran, Blitar).

Figure 7.6: Base relief displaying a gate and a wall which may have delineated a boundary, or been used for security (from Candi Penataran, Blitar).
City of Kediri: Candi Tegowangi, Majapahit Kingdom

Candi Tegowangi’s base reliefs exhibit the same features as other settlement depictions from the Majapahit Kingdom. These characteristics include structures with clay roofs, and a boundary system of walls and gates (Figures 7.9, 7.10A and 7.10B).

Figure 7.7: Base reliefs at Candi Tegowangi, Kediri, with images of houses with clay tiled roofs.

Figure 7.8: A (left) and B (right) are base reliefs from Candi Tegowangi, Kediri, showing walls and a gate.
City of Kediri: Goa Selomangleng, Majapahit Kingdom

The two hermitage caves (Goa Selomangleng) were visited, one south of Tulungagung, and the other in Kediri. They are believed to have belonged to the Majapahit Kingdom. The Goa Selomangleng located south of Tulungagung is a chamber carved out of stone, situated near a spring (Figure 7.11). The reliefs carved inside the cave depict a traditional house that resembles a wooden structure with a peaked, palm thatch roof (Figure 7.12). The reliefs in the Goa Selomangleng in Kediri (Figure 7.13) depict a possible Kuwu/meeting pavilion (Figure 7.14), as well as a possible granary on a forested hillside (Figure 7.15).

Figure 7.9: Goa Selomangleng south of Tulungagung.

Figure 7.10: Base relief found in the Goa Selomangleng (hermitage cave) south of Tulungagung depicting a thatched roof building.
Figure 7.11: Goa Selomangleng (hermitage cave), Kediri.

Figure 7.12: Carved relief in Goa Selomangleng (hermitage cave), Kediri, depicting a possible Kuwu/meeting pavilion.
Figure 7.15: Carved relief in Goa Selomangleng (hermitage cave), Kediri, possibly depicting a granary.

Yogyakarta: Prambanan, Mataram Kingdom

The base reliefs from the Central Javanese Mataram kingdom not only depict much larger structures when compared to their East Javanese counterparts in the Singhasari and Majapahit kingdoms, the architecture and materials also appear to be different. The Prambanan settlement depictions are found in very detailed base reliefs. In some instances it appears that the residential buildings have palm panelling (Figure 7.16), as seen in the book “The Living House” (Waterson 1990).

Figure 7.13: Base relief from Prambanan depicting a residential building with palm panelling.
The roof illustrated in Figure 7.17, also from Prambanan, is known as a saddle roof. It is thought to resemble the ships that Indonesian sailors’s used to travelled around the archipelago. According to Waterson (1990), the roof is predominantly used with wall-less structures. The lack of walls is compensated for by the steep and long roof system that can endure heavy rains.

Figure 7.14: Base relief at Prambanan displaying a residential structure and a Kuwu/pavilion or granary.

Figure 7.15: Base relief from Prambanan depicting an open-walled pavilion (kuwu) or granary.
Surakarta: Candi Sukuh, Majapahit Kingdom

The base reliefs at Candi Sukuh resemble other depictions of Trowulan-style settlements, with walls, gates, and clay-tiled, oriental, steeple-style roofs. The image in Figure 17.9 portrays all of these distinctive features enclosed by walls and gates typical of the Majapahit Kingdom. Of note, however, is that the style of the reliefs is very different from those found at Trowulan.

![Base reliefs of Candi Sukuh exhibiting the Majapahit Kingdom enclosed by gates and walls.](image)

**Figure 7.16:** Base reliefs of Candi Sukuh exhibiting the Majapahit Kingdom enclosed by gates and walls.

Candi Sukuh is known to be a temple for fertility, and it makes some sense that some of the reliefs found in this temple complex are open-walled pavilions and granaries. Agriculture production is clearly associated with fertility, and the granary may signify abundance.

**Other Evidence for Settlement**

Other than what could be discerned from reliefs, there was very little evidence for actual traditional buildings to be witnessed in Java. What remains in some places are the stone platforms and bases for the post that made up the framework for elite structures. These foundations can be seen in the Yogyakarta area, at Candi Utama Seltar (Figure 17.20), and Ratu Boko (Figure 7.21).
Figure 7.17: Stone platform for an elite residential structure with distinctive foundations for posts or pillars, Candi Utama Seltar, Central Java.

Figure 7.18: Stone platform of an elite residential structure showing distinctive foundations for posts or pillars, Ratu Boko, Central Java.
In areas with no material evidence settlement, I extrapolated from the available literature to determine what resources were needed to create a suitable domestic environment. Some of the qualities of a suitable community were:

- Available materials: hardwood (teak, cengal, etc.), bamboo, palms
- Proximity to water: rivers, springs, or rainfed pools
- Fertile land: often near volcanoes
- Cosmological reasoning: hilltops

By observing the land, I was able to determine where settlement could have existed. In the various base reliefs, domestic structures are often surrounded by resources such as trees. The notion of low-density urban sprawl is consistent with literature on ancient Java kingdoms. The contemporary settlement pattern that I observed while travelling in Java was settlement located in clusters, and it was tethered to major transport corridors, either rivers or roads (see Figures 7.22 and 7.23). Although contemporary urbanization may seem low-density, there is a high level of functional differentiation associated with specific locales, which fosters broader regional integration. Examples of this are seen in specific areas that specialize in minerals, wood, pottery etc.

**Figure 7.19:** Miniature diorama of the contemporary Trowulan landscape in the Trowulan Museum. The diorama exhibits a clustered settlement patterning along transportation corridors.

**Figure 7.20:** Miniature diorama of contemporary Trowulan in the Trowulan Museum. The diorama exhibits clear clustered settlement patterning.
While travelling to the Dieng Plateau, I was able to observe the settlement patterns in Figure 7.24. The land was intensively cultivated in a patchwork of crops. Between the rich fields were small settlement clusters.

Figure 7.21: Observed clustered settlement pattern and organization in the Dieng Plateau.

Archaeological Remains of Settlement

While observing the archaeological remains of Majapahit Kingdom settlement features at the Trowulan Museum, I also found the educational signage at the Trowulan very helpful for interpreting the site. The following information was collected from the signage associated with settlement excavations:

“The house is interpreted to be rectangular, measuring 5.2 m long and 2.14 m wide. The space is relatively narrow for a living space and can accommodate 2-3 people at the most. The ladder consists of 3 steps, laid on the North side of the building foundation. This shows that the building is facing North, and 10 degrees to the East. Each step measures 90 cm long, 50 cm wide, and 25 cm high. The floor of the building is not covered in bricks, as they may have gone missing. The floor consists of hardened dirt, mixed with small pottery and brick fragments. The foundation is made of bricks. Each brick measures roughly 28 cm long, 18 cm wide, and 5 cm high. The tallest foundation is made of 10 layers of bricks. The adhesive between the bricks is made of dirt/mud roughly 0.5-1 cm thick. This building has courtyards on the North and East sides. The courtyards are located 50 cm lower than the foundation. The Northern courtyard is paved with gravel (small round andesite stones), laid in a rectangular shape, framed by horizontally laid bricks. The combination of gravel and bricks is unique. This courtyard pattern/layout is found in other Trowulan excavation sites. The Northern courtyard measures 6 m long by 4 m wide. The purpose of the flooring of this type is convenient for the home’s residents, because the courtyard does not become muddy during the rainy season or dusty during the dry season. To avoid puddles, the Northern courtyard is equipped with 2 open gutters/sewers running East-West and North-South. Both sewers/gutters intersect with gutters
that surround the building. The gutter is 16 cm wide and 8 cm deep, with brick surfaces. Based on the height of the base surface of the gutter, it was concluded that the water runs from South to North. In other excavation sites in the courtyard of Trowulan Museum, we found a water pipe embedded in clay near the building. According to Archeological data stated above, we were able to reconstruct the shape of the house. During the reconstruction process, archeologists considered data found in other excavation site in Trowulan, which is supported by ethnographic data. This type of home is still observable in Bali today.” (UNESCO 2014)

The following photos were taken at the settlement excavation at the Trowulan Museum.

Figure 7.22: A Majapahit residential floor plan exposed at the Trowulan Museum.

Figure 7.23: A Majapahit courtyard of small andesite stones at the Trowulan Museum.
Figure 7.24: Various ceramics uncovered within the Majapahit settlement ruins at the Trowulan Museum (Sherds of both ceramics and stoneware were found. They originated from countries such as China, Vietnam and Thailand).

Figure 7.25: One of many wells associated with the Majapahit settlement ruins at the Trowulan Majapahit Museum.
Figure 7.26: Recreation of Pendopo Agung, a Majapahit house, at the Trowulan Museum.

Figure 7.27: An artist’s conceptualization of a Majapahit house-lot, with a house, courtyard, and granary (at the Trowulan Museum).
DISCUSSION

The strengths of my data are that I was able to see some physical evidence of settlement structures and overall settlement patterning while in Java. The Trowulan ruins offered evidence for how big a house-lot was, and how much living space was necessary for those who inhabited the capital of the Majapahit kingdom. I was also able to envision the lifestyle of the inhabitants of these settlements, and understand the broader network that the Majapahit kingdom crafted for its citizens.

The base reliefs on temples offered a “best practice” type approach to theorizing settlement structures in various regions. To reiterate, other than the evidence presented at Trowulan, little archaeological data is available for commoner domestic structures because they were principally constructed from perishable materials. The base relief imagery was therefore a very significant data set. I was able to use these reliefs, in conjunction with Roxana Waterson’s (1990) book, “The Living House,” to identify types of structures, and to determine their possible function. The reliefs also offered broader insights into the nature of communities, and society as a whole. For example, it was common for the base reliefs of the Majapahit Kingdom to show settlements with walls and gates. These images raised questions, such as: “Why did they need gates or walls?” or “Who or what were they trying to keep out of their homes and/or communities?”

The data that I collected on the project provided significant insights about ancient Javanese settlement that complemented my initial literary research. Unfortunately, the physical evidence for settlement was not consistent throughout the regions. Only certain areas offered base relief imagery. In areas where no physical evidence was available I theorized what qualities would have made a livable space for a community. By studying the building materials required to create the houses described in the literature, and depicted in base reliefs, I formulated ideas concerning what resources were available, or what land would have been suitable, for settlement. In the end, however, the more comprehensive archaeological evidence for Majapahit settlement I examined at the Trowulan Museum certainly provided me with some idea of just how limited my data base really is.

It was very interesting to find that the majority of Javanese (where data was available) used wooden building materials, although the archaeological evidence from Trowulan, where bricks were used, demonstrates that this was not always the case. Another difference I noted while examining the various base reliefs in the different region was that roof and wall paneling styles varied considerably. Sometimes there would be no walls at all, but the structure would have a large roof that covered the entire structure. The differences in roofing could reflect different building functions, or even different cultural traditions. For example, many roof styles were designed to look like traditional Indonesian ships (Waterson 1990). The roofing styles could also have been an adaptation to the materials that were locally available, or even the nature of the weather conditions in the area. Roxana Waterson (1990) argues that the steep roofs of palm leaves were quite durable, even during the monsoon season. The steepness of the roof was almost 180 degrees to the ground, which allowed the rain to rapidly flow off before it could seep through into the structure. Regardless of the aforementioned differences, it does appear that the style of granaries and open-walled meeting pavilions (kuwu) were consistent throughout Java.

Most of the structures discussed in this paper were transportable wooden buildings, with the exception of the brick architecture at Trowulan. It is difficult to determine whether wooden housing was abandoned for brick, or if the brick home was a symbol of wealth. The brick construction at Trowulan may have also been an option of convenience. Trowulan was a manufacturing community that did not have rice paddies within the city itself (Haendel et al 2012).
In an urban community with 200,000 people, brick architecture may have allowed for the conservation of space and resources. The excavation descriptions from Trowulan did say that the brick homes were quite narrow. These smaller houses may be a response to a lifestyle that was not based on farming, meaning space was used efficiently by establishing smaller plots for families that did not require significant space for the processing and storage of agricultural produce. Such houses may also signify greater permanence, and diminished need for periodically establishing new house sites.

As previously mentioned, the supplies and materials used to construct traditional Javanese settlements were conveniently located close to the communities themselves (Dove 1985). Certain building materials, such as bamboo and palms, were likely always available nearby. Whether this was true of the preferred hardwoods is unknown. The risks associated with traditional Javanese housing were; resource scarcity, termite attacks and fungi, lack of maintenance, earthquakes, and volcanic eruptions. A study of durability was recently done for traditional Javanese wooden houses, focusing on their resistance to earthquakes, which appears to be significant (Prihatmaji et al. 2010). Unfortunately, the best timber for such buildings, which was listed earlier in this report, is now limited in quantity and/or too expensive to be used by the average family.

At the same time, the traditional home can have major impacts on the natural environment. Before the appearance of human populations the natural environment exhibited considerable biodiversity and abundance. Especially after permanent human settlements begin to be established, the natural landscape is impacted by growing consumption patterns. According to UNESCO, Trowulan was once covered in teak trees, which made initial surveying difficult. There are now few if any teak forests present at Trowulan (UNESCO 2014).

From what I witnessed in Java, contemporary settlements form clusters, often along roadways or other transportation corridors. Much of the surrounding natural landscape has been modified for agricultural purposes. The purpose of the clustering could be to protect land. Specifically, settlements may be confined to clusters so as to not over-use land best employed for agriculture, and so that urban sprawl does not extend into the surrounding forests, which contain valuable resources. Still, as rice paddy production increases over time, so too do the size and complexity of the communities who farm them, ultimately attracting temples construction, and even armies (Dove 1985). This form of entanglement occurs in most societies that are built on agricultural surplus. The issue is that the support of such complex adaptive systems is put at risk if production levels drop in the event of a drought, or some other perturbation that affects yields. Finally, something that requires more investigation, given the above, is the observed change in Javanese settlement patterns over time, from clustered villages and hamlets to the more grid-like system of Trowulan (Miksic 1999).

**CONCLUSIONS**

Evidence for ancient settlement, and settlement studies themselves, are rare in Java. Still, by reviewing the literature and examining the physical evidence concerning building techniques and styles, and considering the nature of contemporary settlement patterns, I was able to advance my inquiry into the nature of settlement in past Charter States. The contemporary settlements that were visited on the field trip demonstrated considerable specialization of function. Every city and village specialized in specific commodities. This must have been the way that different communities, large and small, contributed to the larger economy in the past as well.

As mentioned by Dove (1985), the spread of people and growth of population, and concomitant increase in societal complexity, was driven by greater investments in rice agriculture. This must have had detrimental effects on the environment overtime, leading to degradation, and the loss of
raw materials that had been traditionally used to build the majority of settlement features. Trowulan was once described as having been covered in teak, but mass consumption of this resource means that there is little teak left in the area of the old Majapahit capital. The shift towards a new type of settlement pattern at Trowulan over time, one that was less agricultural oriented, more grid-like, with sewage and well systems, allowed for the emergence of a new type of urban community with a large population of 200,000 people. The Majapahit Kingdom was the largest empire in Java to date, and it is interesting to see how the settlement associated with the capital of this kingdom was structured in comparison to the kingdoms that preceded it. The latter were generally organized into clusters, with buildings being made of biodegradable materials. In contrast, the brick buildings of Majapahit hint at a very different type of community having existed at Trowulan, and they also suggest that traditional building materials may have become scarce. The questions that still need to be addressed are: Why and how did the residential structures transition from wood-based to brick based? How did the design of a brick home become introduced to Java? In what ways does this shift signify a concomitant change in the nature of community and society as a whole? What does this tell us about entanglements and resilience over time? More research need to be done to answer these questions. As SETS continues its investigations, some answers to these queries will hopefully emerge.

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CHAPTER 8
INVESTIGATING THE SOCIO-ECOLOGICAL ENTANGLEMENT OF INTEGRATIVE MECHANISMS IN EARLY LOW DENSITY AGRARIAN TROPICAL STATES: CASE STUDIES FROM CAMBODIA, MYANMAR, THAILAND, AND JAVA

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My specific contribution to the SETS project is to examine and compare the integrative mechanisms for a sample of tropical charter states. In particular, this research evaluates the quality of these integrative mechanisms as they pertain to the investigation of long-term socio-ecological dynamics and entanglement. Polities and states seek to increase economic, socio-political, and ideological integration, and attempt to simultaneously achieve this integration through both vertical power relationships of inequality, and horizontal group affiliation (Blanton et al. 1996; DeMarrais et al. 1996; Schoenfelder 2004:402). Although various methods of integration have been identified, this research will concentrate on the monumental public architecture and spaces of the built landscape (Chase and Chase 2009:17-18; DeMarrais et al. 1996:16; Lawrence and Low 1990:459,463; Lohse and Gonlin 2007; Peuramaki-Brown 2012:241; Schoenfelder 2004:402). Such integrative mechanisms may include roads, temples, monasteries, markets, administrative nodes, hospitals, rest houses, and storage facilities. The construction and subsequent maintenance of these integrative mechanisms would have been an important factor in the consolidation and stability of early tropical charter states. Thus, it is through a cross-cultural, comparative approach of these integrative mechanisms that a greater understanding of the dynamics of early complex societies may be attained (Fletcher 2012:325; see also Smith 2012).

This chapter will focus on the research performed on the following tropical charter states:
- Khmer Empire (CE 802-1431), Cambodia, centered on the capital of Angkor.
- The Burmese Empire (CE 950-1300), Myanmar/Burma, centered on the capital of Bagan.
- The Early Siamese Kingdom (CE 1238-1378), Thailand, centered on the capital of Sukhothai
- The Mataram/Kediri/Singhasari/Majapahit Kingdoms (CE 716-1406), Central and East Java, centered on the capitals of Mataram/Medang (CE 716-930), Kadari/Kediri (CE 1100-1222), Janggala/Singhasari (CE 1222-1292), and Majapahit/Trowulan (1293-1406).

Field work associated with these early tropical charter states took place over the course of two separate research trips. The first research trip took place over the course of three weeks. Four days were spent at the site of Angkor in Cambodia; five days were spent at the site of Bagan in Myanmar; and five days were spent at the site of Sukhothai in Thailand. The second research trip took place over the course of four weeks. Four days were spent in the Malang area of East Java, investigating sites associated with the Singhasari Kingdom; Four days were spent in the Kediri area investigating sites associated with the Kediri Kingdom; Four days were spent at Trowulan, investigating sites associated the Majapahit Kingdom; five days were spent at Prambanan, investigation sites associated with the Mataram Kingdom; and five days were spent at Borobudur, investigation sites associated with the Mataram Kingdom.

The goals of this research are to evaluate the integrative mechanism data sets from these various early tropical charter states. This evaluation includes assessing the quality, variety, and
availability of the data sets. Research such as this is important because it helps us build towards a transdisciplinary and cross cultural study of entanglement in tropical societies of the past. As contemporary states in the tropics are finding themselves further and further entangled in the structure and commodities of their society, this work can help elucidate some of the potential problems. On the opposite side of the coin, this work could also demonstrate how certain strategies are effective in disentangling from these structures and commodities.

The principle research methods adopted for this phase of the research by the Principle Investigator, Dr. Gyles Iannone, are based on the theory of data proximity (Iannone 2013:8). Particularly, the idea that proximity to data and first-hand accounts are crucial to comparative studies (Drennan and Peterson 2012). Of paramount importance to a data proximity approach is on-site visits to each archaeological site. It is important to point out that during these on-site visits no archaeological excavations or survey are taking place. Rather, methods employed during these on-site visits include detailed photographic and written documentation, visiting the site museums, and meeting with local scholars and experts. Additionally, and absolutely crucial, is essential background research. It is also a hope that through such liaisons, difficult to attain resources, such as primary sources, may be acquired.

BACKGROUND

As previously stated, an in depth background literature review of the sample of early charter states and their associated integrative mechanisms is essential for this research. Although the following background research is by no means exhaustive, it does provide a good foundation for our understanding of integrative mechanisms, and the role they play in socio-ecological dynamics and entanglement. Each of the sampled early tropical charter states are discussed separately below, with special emphasis on their most significant integrative mechanisms.

The Khmer Empire (CE 802-1431), Cambodia, centered on the capital of Angkor

Temple style. While temples were located within the epicenters of Angkor, various survey methods indicate that peripheral temples were ubiquitous throughout the greater Angkor landscape (Pottier 2012:18), where they functioned as “nodes in an extended, polynucleated settlement complex” (Evans et al. 2013:2, 3; see also Evans et al. 2007:14280). “The temples were an important component of the settlement pattern and of the economy, acting as nodes within a redistributive network that had the massive and well-known sandstone temples at the centre of Angkor as its apex” (Hall 1992; see also Evans and Traviglia 2012:201). During the Classic period there were two types of temples constructed: state and ancestral temples (Coe 2003:97). Some of the earliest of these were commissioned by Indravarman – one of the earliest state temples being Bakong, and an ancestral temple being Preah Ko. The creation of these temples appear to have been expected of each new ruler (Coe 2003: 101, 107; Dumarçay and Smithies 1995:85; Stern 1954). The variety of temples, particularly in the quantity of materials used in their production, shows a hierarchical “corpus”, and suggests the ability of a centralized power with the means to organise an impressive workforce (Pottier 2012:18).

The moated temple style is common throughout Angkor, which may be a local tradition that predates Indic influence in Cambodia (Piphal 2012:191-192). During the mid-10th to 11th century, temple complexes go from having many subsidiary buildings, to complexes with only a few. This suggests that the role of the temple compound changed from one that involved much of everyday life, to one that was exclusively religious (Haendel 2012:213-214, 216).
The earlier Angkor temples were constructed of brick, with sandstone embellishments and stucco covering. However, in the Classic period (CE 802-1327) construction techniques changed to using sandstone and laterite as construction materials (Coe 2003:73, 97, 155, 156). Laterite is a ubiquitous material which may have been quarried from as close as the barays and canals at the heart of Angkor, and as far away as the deposits close to Phnom Kulen (Engelhardt 1996:158; Carò and Im 2012; Coe 2003:156). Laterite could be difficult and time consuming to quarry, as the laterite blocks must be mined while under the water table so it is still wet and soft, and then allowed to harden in the air. Sandstone, on the other hand, came from as far as 30 km from the center of Angkor (Carò and Im 2012; Coe 2003:156), but it was arguably easier to mine.

It appears that temple complexes were constructed and maintained through corvée labour – unpaid labour imposed by the state (Coe 1957: 410; Coedès 1947). The amount of labour and materials required to build these temples would have been staggering. All construction had to be carried out with the assistance of learned Brahmans. In addition, the monuments had to be laid out on “pure soil,” so massive excavations had to take place, followed by the infilling of the site with sand (Coe 2003: 157). Temple rituals would have also been lavish affairs (Coe 2003:184).

(TEMPEL) Monasteries. Temple monasteries were built during the late 12th century, during the reign of the Buddhist king Jayavarman VII. These were extremely large compounds which were small moated cities onto themselves. An inscription states that over 12,000 people, the majority of which were monks were employed within the walls of Ta Prohm (Coe 2003:126; Jacques 1999:138-142). Banteay Kdei continues to be used today by Buddhist monks (Coe 2003:126). In approximately CE 889-890, Yashovarman I commissioned the construction of 100 ashramas, which were hermitages or ascetic retreats. However, these were made of wood, so the only evidence that they existed are the remaining inscribed stelae (Coe 2003:102).

Libraries. Although it is unlikely that these often paired structures ever held manuscripts, “libraries” became characteristic of Khmer temples/religious complexes. It appears that these buildings had two functions: 1) as the location of a fire cult: and, 2) a place to worship the “Nine Planets” (Coe 2003:107; Dumarçay and Smithies 1995:101; O’Naghten 2000:50-53). However 13th century Chinese envoy Zhou Daguan does describe the use of written documents on perishable paper. Thus, it is possible the libraries did hold manuscripts of some kind (Coe 2003:189).

Roads. Throughout various stages of the Classic period, the Khmer Empire encompassed much of mainland Southeast Asia. Through a network of roadways, the capital of Angkor was connected to major provincial centers, in addition to thousands of small, temple-based settlements (Coe 2003; Hendrickson 2007, 2012; see also Evans and Traviglia 2012:201). Evidence of road transport includes over 1000 km of earthen road embankments and associated stone bridges (Hendrickson 2010:481; 2011:447; 2012:86, see also Aymonier 1900-01; Lunet de Lajouquière 1902, 1911), artistic depictions of transports on temple bas reliefs (Hendrickson 2012:86), and the translation of ancient texts which describe the construction of roads and rest-houses during the late 12th century (Hendrickson 2012:86; see also Coedès 1941). This evidence lead to the discovery of a complex transportation network that consisted of primary and secondary roads (Coe 2003:97, 157; Fletcher et al. 2004:135; Hendrickson 2012:97), intra settlement causeways/roads/embankments (Coe 2003:97; Evans et al. 2013:3; Fletcher et al. 2004:135), and masonry bridges (Brugier 2000; Coe 2003:97, 152; Dumarcay and Smithies 1995:106). Through the use of LiDAR and detection of linear features on the landscape, it appears that canal and water distributor embankments would have had a dual function for water management and, perhaps more importantly, for transportation (Acker 2012:30; Fletcher 2000; Evans et al. 2007:14280; Evans and Traviglia 2012:208; Fletcher 2000; Fletcher et al. 2004:135; Fletcher et al. 2008:662; Fletcher
and Pottier 2002:26-27). It appears that roads and waterways worked as in integrated network, as roads bisect the space between major rivers (Hendrickson 2012:97). Additionally, it appears that these networks included infrastructure, in the form of rest houses and water tanks (trapaeng) located at intervals along the roads, in order to support the movement of travellers throughout the Khmer landscape (Hendrickson 2012:86). The most extensive transportation network existed from the 11th to 13th century under Suryavarman I, Suryavarman II, and Jayavarman VII (Hendrickson 2010:481; 2012:93).

There were six major roads. These principle roads were raised up 2 to 6 m to avoid the inundating waters, and ranged from 10 to 25 m wide (Coe 2003:115, 151, 152). The road from Phimai to Angkor (approx. 300 km) was one of the greatest roads in antiquity, and was known as the royal road; it had numerous bridges and rest houses (Coe 2003:115, 151; Dumarçay and Smithies 1995:46). Bridges were an important part of the road network, with over fifty known bridges constructed of laterite, some up to 160 m long, all made of corbelled arches so they would also act as weirs (Brugier 2000; Coe 2003:152). The main function of the largest bridges was to facilitate the movement of armies rather than to facilitate commerce (Brugier 2000). Additionally, bridges could also function as dams (Dumarçay and Smithies 1995:106).

**Rest Houses.** As previously mentioned, Khmer road systems were equipped with 2 types of masonry “rest house temples” spaced at intervals of 14-15 km (approx. half a day’s travel): fire shrines/dharmasalas and temples d’étapes (Coe 2003:128, 153; Hendrickson 2010:487-490, 2011:448; 2012:86). Fire shrines are single-structure temples which all have a similar plan – a long hall with a tower to the west and open “doorways” along one side (Coe 2003:152; Jacques 1999:156). Although they are called “rest houses”, it is possible that they were used for some form of fire ritual (Coe 2003; Jacques 1999:156). These fire shrines were found along the Northwest road and East road between Beng Mealea and Preah Khan of Kompong (Hendrickson 2010:487-490). The 17 laterite fire shrines along the Northwest road connecting Angkor and Phimai have been dated to the late 12th century CE and the reign of Jayavarman VII (Hendrickson 2010:490).

The second type of resthouse is the temple d’étape which translates as “staged temple.” These are large, multiple component temples dated to the early to mid-12th century, and are associated with the reign of Suryavarman II (Hendrickson 2010:490; see Boisselier 1952). Temple étapes are found only on the East road between Angkor and Preah Khan of Kompong Svay (Hendrickson 2010:490 see Grolier 1973:118). The size and composition of the temple étape suggests that they were in fact used as rest houses for travellers and people on pilgrimages (Damien Evans, personal communication 2013).

**Hospitals.** In the late 12th century, during the reign of the Buddhist king Jayavarman VII, 102 hospitals were founded throughout the empire to take care of his subjects. Most of these hospitals were located outside of Angkor proper (Coe 2003:125; Dumarçay and Smithies 1995:102).

**Markets.** Very little is known about markets, as it has been noted that ancient Khmer inscriptions completely neglect the subject (Lieberman 2003:223; Vickery 1998:300, 405-406). Lieberman (2003:59) suggests that: “In itself, the expansion of cities, mines and specialized occupations strengthened commodification insofar as non-cereal produces relied on markets for food and material more heavily than did the average peasant.” Coe (2003:149) adds very little to the discussion of markets, but does suggest that markets were held every day. However, there were no shops, but rather the women laid out their trade items on mats on the ground (Coe 2003:149).

**Administrative Nodes.** The Khmer Empire was vast, and certainly required administrative nodes scattered across the landscape. These appear to have been, for the most part, provinces rules by royal family members.
The Burmese Empire (CE 950-1300), Myanmar/Burma, centered on the capital of Bagan

Temple/Sutpas. Temples (temples with hollow cores), stupas (temples with solid cores), and structures that combined these two types of architecture, first emerge in what Aung-Thwin and Aung-Thwin (2012:65) termed the Urban period (200 BCE to 9th century CE), prior to the Burmese Empire. The early temples and stupas of Bagan likely evolved from the earlier Mon and Pyu architectural styles. However, in the mid–late 12th century CE temples and stupas demonstrated Theravada Buddhist influence, as expressed in Bodhgaya sikhara type and Sri Lankan type architecture (Gutman and Hudson 2004:165-166). Relics of the Buddha are thought to be housed in some of Bagan’s religious architecture, and this attracted Buddhist pilgrims from all over Southeast Asia (Aung-Thwin and Aung-Thwin 2012:100).

Based on The Inventory of Inscriptions, the Burmese Empire produced 3000 monuments over three centuries – temple construction began to rise in the middle of the 11th century CE, peaked at the end of the 12th century (with most temples built between 1150-1200 and into the 13th), and began to decline in the middle of the 13th century (Aung-Thwin 1985:177; Aung-Thwin and Aung-Thwin 2012:90; Gutman and Hudson 2004:166-167). It appears that by the early thirteenth century the land around the walled epicenter, now known as “Old Pagan,” had become so densely packed with ritual architecture that large clusters of these monuments were developing further afield, to the east (Gutman and Hudson 2004:169; see also Aung-Thwin 1985). Construction of Bagan’s many temples and stupas required large investments of money, materials, and labour (Gutman and Hudson 2004:166). Massive quantities of construction materials were required, such as bricks, mortar, gold, copper, plaster, paint, wood (Aung-Thwin 1987:173-174). The exterior of the temples were completely plastered in antiquity. Inscriptions state that plaster was made with lime, sand, milk, and honey. The use of milk and honey would have made the plaster relatively expensive to produce, and suggests an intensive dairy and honey bee industry existed (Aung-Thwin and Aung-Thwin 2012:90). The massive Buddha images were constructed of stucco over a brick base, while stone (comparatively rare at [Bagan]), bronze, wood, and laquer were also used (Gutman and Hudson 2004:166).

Inscriptions suggest that money was also required to pay the numerous artisans (masons, carvers, carpenters, painters, metal smiths, etc) involved in the construction (Aung-Thwin 1985:169; Aung-Thwin 1987:173-174; Aung-Thwin and Aung-Thwin 2012:90-91). The Burmese Empire relied on paid labour, not slave labour (Aung-Thwin and Aung-Thwin 2012:89), and this would have added to the monetary expenses of the monument’s patron, particularly if it were the king. Labour was performed by commoners who were organized through a “cellular” or geographical pattern (Aung-Thwin 1985:74). Most of the work was completed by bonded groups made up of clients who served in a client-patron relationship known as “kywanship” (Aung-Thwin 1985:74-75). These bonded individuals could be either voluntary or involuntary. These people could be kywan, those bonded to private individuals (Aung-Thwin 1985:74, 81-84); purā kywan, people bonded to the saṅgha or Buddhist institution (Aung-Thwin 1985: 74, 85-87); or kywan-tō, those attached to the crown (Aung-Thwin 1985: 74, 87-91; see also Lieberman 2003:113).

Temples were commissioned/donated by the king and other wealthy private benefactors as a means of “gift giving” in order to acquire immediate social recognition, but more importantly, to accumulate spiritual merit for the next life (Aung-Thwin 1985:169, 172; Dumarçay and Smithies 1995:25-26). Surprisingly, studies of inscriptions suggest that those donating the most monuments were non-royal elites (Table 8.1). However, it appears that royalty was donating the monuments
of the highest quality, while some kings focused their investments in maintaining earlier buildings rather than building new ones (Dumarçay and Smithies 1995:12).

Temple building was also an economic means to redistribute wealth to workers/commoners (Aung-Thwin 1985:172-173). Because commoners were being paid for their services, they had the means to donate substantially to religious institutions (Aung-Thwin and Aung-Thwin 2012:90). But again, most of the commoner donations were not as high value as those that came from the upper echelon of the commoner class.

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</table>

Table 8.1: Distribution of monument commissions by social status. Based on a sample of 220 inscriptions chosen during the period CE 1100 to 1250 (Table modified from Aung-Thwin 1985:240; see also Gutman and Hudson 2004:166-167).

**Monasteries.** Chinese ambassadors visiting the Burmese empire noted over 100 Buddhist monasteries, all lavishly decorated with gold, silver, and multi-coloured paintings and needlework (Coedès 1964:257). As previously discussed, by the early 13th century CE the area around the walled epicenter of Bagan had become so grossly populated with buildings that major new clusters of buildings developed, such as the monastic settlement of Minnanthu. The Inventory of Monuments indicates that during the 13th century there is a significant rise in the construction of walled monastic compounds, albeit with smaller associated structures. Gutman and Hudson (2004:169; see also Aung-Thwin 1985) suggest this is a reaction to dwindling economic resources. For this reason, we see smaller buildings and an expansion of monastic influence at this time.

Prestigious monastic complexes that were commissioned generally consisted of at least one temple, in addition to a monastery, schools, a library, rest houses for individuals on pilgrimages, and several latrines (Aung-Thwin 1985:176, from Luce and Maung Tin 1928). Many of the monasteries were on large acreages and were completely self-sufficient, with the ability to feed hundreds of monks from their own lands (Lieberman 2003:117). In addition to commissioning the buildings, large tax free acreages were donated to the monkhood by wealthy elite (principally officials) and members of the royal family and king in order to acquire merit (Aung-Thwin 1985:176; Lieberman 2003:95). This linked the state and church economically (Aung Thwin and Aung Thwin 2012:84). The largest alms and donations came mostly from aristocrats and royalty, although commoners also participated, and pilgrims would continue to patronize these religious locations long after the initial donation funds were depleted (Aung-Thwin 1985:176; Aung Thwin and Aung Thwin 2012:84; Lieberman 2003:117). Religious estates had their property maintained, and temples and monasteries kept up, purā kywan, who in turn were provided with either land or its produce (Aung-Thwin 1985:108).

The local economy was centered on patronized religion through the construction and maintenance of the temples and monastery complexes, without which Aung-Thwin (1985: 176, 181) argues the entire economy of the Burmese Empire would have stagnated. He states further:

“It was only after several hundred years of searching for merit and salvation that these tax-exempt endowments of land and labour became a drain on government resources; and it is only
then that the decline of the state can be related to temple building – even then not so much to building per se but to the perpetual tax-exempt status of temple lands and their labor. In short, although temple building was in large part responsible for the formation of the unified state beyond the level of regional and localized political groups, it also subsequently helped destroy it, but not for the reasons that have been conventionally given” (Aung-Thwin 1985-170).

These temple-monasteries literally became large land owners who were exempt from taxation, which took wealth away from the king. Ultimately, this autonomous religious institution constricted royal administration and rendered it partially redundant (Aung Thwin and Aung Thwin 2012:85; Lieberman 1987:170-171; 2003:113-114). Library. As previously stated, prestigious temple-monastery complexes would have included a library (Aung-Thwin 1985:176, from Luce and Maung Tin 1928). These libraries likely would have been a fair size, such as the Pitakat Taik library built in 1058 CE, which could hold 30 elephant loads of scriptures (Dumarçay and Smithies 1995:26).

Roads. There is little emphasis placed on describing the land transportation networks of the Burmese Empire within the literature. Roads appear to have been a secondary importance as means of consolidation through trade, and the flow of goods and cultural ideas, as the main thoroughfare for Bagan was, and continues to be, the Irrawaddy River, which provides access to Lower Burma and maritime trade (Gutman and Hudson 2004:170; Lieberman 1987:165, 167). “Long-distance transport and communications across these upland zones have always been restricted compared to movement within the Irrawaddy basin or between the delta and ports around the Bay of Bengal” (Lieberman 1987: 165, 167). As Aung-Thwin and Aung-Thwin (2012:81-8, 101) suggest, the Irrawaddy River was the best means to transport the army, and it was also important for integrating the inland center of the kingdom and the coastal trade centers, known as the “upstream-downstream” paradigm. Furthermore, they argue that what was really being “moved” were not the bulk goods themselves, but the rights to that wealth, and that these were moving in the opposite direction, from the king to his provincial governors. Thus, there was little need for the typical road networks required to move large amounts of goods from the provinces to Bagan (Aung-Thwin and Aung-Thwin 2012:101).

There is some reference to possible roads in the literature, although these are very minor, and no concerted effort has been made to carry out an exhaustive study. Lieberman (1987:167) suggests that increased warfare and raids in the 11th century CE may have caused Bagan to become more involved in bringing the northern area of Burma under consolidation, and this may have brought more focus to inland trade routes, perhaps requiring more, or at least improved roads. Additionally, Dumarçay and Smithies (1995:9) mention gated entry points into the walled center of Bagan, although they do not discuss the roads that lead through these gates.

Rest Houses. Rest houses appear be a part of temple/monastic complexes, rather than being part of the transport network infrastructure (see Aung-Thwin 1985:176, from Luce and Maung Tin 1928). There is very little in the literature regarding the rest houses of the Burmese Empire.

Markets. Although Lieberman (2003) discusses the market economy of the Burmese Empire at length, the literature neglect the issue of local or state markets for the most part.

Administrative Nodes. Within the literature Aung-Thwin (1985:103) describes taik/tuik which were essentially settlements located between the Bagan epicenter and the agricultural hubs or “rice baskets” of Minbu and Kyaukse. They primarily functioned as administrative nodes and fortified outposts on the frontier of the expanding empire. During the reign of Aniruddha, 43 forts were stationed along the Irrawaddy River, and twelve fortified towns were situated in the Kyaukse
valley (Aung-Thwin and Aung-Thwin 2012:81). During the 13th century CE towns were awarded to princely or ministerial families who governed or administered specific locales and paid tribute to the king, but this strategy effectively restricted royal authority to the dry zone (Lieberman 2003:112). It is possible that monuments identified on the tops of mountain on both the east and west side of the Irrawaddy River may have served as boundary markers defining administrative, geographical, and ritual space (Gutman and Hudson 2004:169). Additionally, ports would have been extremely important for communication and the transfer of goods and ideas along the Irrawaddy River (Lieberman 1987:167). Thus, they too may have acted as important administrative nodes.

**The Early Siamese Kingdom (CE 1238-1378), Thailand, centered on the capital of Sukhothai**

The urban center of Sukhothai was originally a Khmer outpost from the twelfth to mid-thirteenth century CE, during the greatest expansion of the Khmer empire (Dumarçay and Smithies 1995:55; Rooney 2008:18). Sukhothai was taken over by two Tai chieftains in the thirteenth century (Dumarçay and Smithies 1995:56). The emergence of Thailand coincides with the emergence of Sukhothai (Tambiah 1977:74). It should be noted at the outset that the literature on Sukhothai and the Early Siamese Kingdom in general is scant to say the least. Currently, our best source of information comes from a comprehensive academic guide book written by Dawn F. Rooney (2008).

**Temples.** Beyond the walled city of Sukhothai the landscape is dotted with Buddhist temples (Higham and Thosorat 2012:257). The Sukhothai temple actually consisted of many components, and it should thus be considered a temple complex. A wall (earthen, brick, or laterite) with four entrances, or an earthen ditch usually delineated the perimeter of the temple complex, and a moat or pond was also found near the entrance (Rooney 2008:41). Within the compound was an assembly hall (*wiharn*), a long, low platform (sometimes with columns), with a smaller raised platform for the Buddha image. These halls were the location for sermons by monks, and for worshippers to pay homage (Rooney 2008:40-41). An ordination hall was also part of the temple complex, which was built on consecrated ground, and was reserved solely for the monks. Boundary stones were then placed around the ordination hall to demarcate the sacred space (Rooney 2008:43). The temple complex also included a variety of different styles of *stupas*, which were often used to house Buddha relics or the ashes of royalty. A temple complex could have many *stupas*. However, the primary stupa was found to the west of the assembly hall (Rooney 2008:43-47). Additionally, the temple complex would include a *mandapa*. These are rectangular structures that typically had solid walls on the north, south, and west faces, and an open side that faced the east. The Sukhothai *mandapa* housed the image of the Buddha (Rooney 2009:47-48). Rooney (2008:38) suggests that the sophistication of Early Siamese art and architecture climaxed in the 14th century CE. This Siamese artistic and architectural style was a mixed one, with features adopted from numerous sources, such as Sri Lanka, Dvaravati, Mon, Burma, Khmer, and Lanna added to local traditions to create a unique Sukhothai style.

Although laterite was sometimes used to form the base of temples, the majority of temples were constructed from locally made bricks (Rooney 2008:38). The exterior of the temples were then covered in stucco, which was composed of lime, sugarcane syrup, sand, animal hide, and tree bark (Rooney 2008:39). In the nearby, dependent center of Si Satchanalai, it appears that ceramics were being mass produced, including the roofing tiles for the temples and palaces of Sukhothai.
(Higham and Thosorat 2012:259). In addition, other materials, such as wood, slate, glazed ceramics, and bronze were also used in the construction of the Sukhothai temples (Rooney 2008:40).

**Monasteries.** Sukhothai is well known for its “Forest Dwellers” or Arannavasi, a particular sect of Buddhists who reside in “forest monasteries” (Rooney 2008:138-149). The first King, Ramkamhaeng, had a forest monastery built called Wat Saphan Hin as a residence for the snagkarat or supreme patriarch that he brought from Nakorn Srithammaraj (Dumarçay and Smithies 1995:56). It is also said that it was his son, King LoThai, who established the forest-dwelling sect of the Theravada Buddhist monks (Rooney 1995:23). Plots of land were also donated to various monasteries by Mhadharma IV, the last king of Sukhothai (Dumarçay and Smithies 1995:58). The ancient Inscription No. One states that most of the monasteries were located outside the walled city, particularly to the south (Rooney 2003: 29). However, archaeological remains indicate that many of the forest monasteries are located in the hills, to the west of walled city, the main monastery being Wat Aranyik (Rooney 2008:138-149).

**Roads.** The only road discussed in the literature is the Phra Ruang Road – The Royal Road of the Kings of Sukhothai. This is an earthen work linking Sukhothai to Si Satchanalai and Kampajeng Phet (Rooney 2008:22-23). It is believed that this road was built by King Ramkamhaeng in the 13th century as a major conduit for transportation and pilgrimages. Although little is known about the road, it is suggested that it was 12 m wide and 120 km long. However, others argue that it is an embankment from irrigation canals and possibly built by early settlers prior to the founding of Sukhothai (Rooney 2008: 22-23).

Other evidence that may suggest ancient Sukhothai had road systems are the four gates on the cardinal directions that provided access to the city. The San Luang Gate is the northern entrance to the city and in fact marks the end of the Phra Ruang road (Rooney 2008:108). Rooney (2003:38) also states that the ancient Sukhothai road system included bridges, and that the road and bridges were likely constructed of laterite.

**Rest Houses.** Although there is a dharmasala (rest house) located near Si Satchanalai, it actually dates to the reign of the Khmer king Jayavarman VII (Dumarçay and Smithies 1995:58; Rooney 2008: 19), and thus was not an integrative mechanism for the Early Siamese Kingdom.

**Markets.** Very little is known about markets, however, the Ramkhamhaeng Inscription, or Inscription No. One, which dates to between 1279-1292 CE, states that the people of Siam enjoyed free trade and no taxes (Rooney 2008:26-27). Additionally, the inscription also states that there was a bazaar or market, immediately outside the San Luang Gate (northern gate) of the walled city (http://www.seasite.niu.edu/Thai/inscription/inscription1.htm).

**Administrative Nodes.** Tambiah (1977:69-775) provides information on the territorial and administrative distribution of ancient Sukhothai. At the center of the kingdom was the capital, the muang luang, where the king resided. At the four cardinal points were the muang’, each ruled by a son of the king. After Sukhothai freed itself from rule of the Khmer, the Early Siamese Kingdom succeeded in bringing three neighbouring muang under its control, all within a two day march: Sawankalok, Phitsanulok, and Kamphaengpet. Thus, it is clear that the fortunes of the Sukhothai rulers waxed and waned with regard to territorial and administrative scontrol (Tambiah 1977:76). Perhaps the most well-known administrative node and dependants of Sukhothai are Si Satchanalai and Chalieng, which are located approximately 75 km to the north (Dumarçay and Smithies 1995:58-61). The form and architecture of Si Satchanalai mimics that of Sukhothai. The gates leading into the city are associated with forts, and the royal road runs out of one of these gate back to Sukhothai (Higham and Thosorat 2012:258). Si Satchanalai was an important religious and
economic center, particularly for its production of ceramics, which were often consumed by the capital (Dumarçay and Smithies 1995:58-61; Rooney 2008: 24).

The Mataram Kingdom of Central Java centered on the capital of Mataram/Medang (CE 716-930)

Due to a lack of texts there is also a limited knowledge of the history and workings of the Mataram kingdom of Central Java (Degroot 2012:121; Kulke 1991:13). The two earliest dated inscriptions of the middle period of early Indonesia are the Canggal inscription of Sañjaya of the year 732 CE and the Dinaya inscription of the year 760 CE, which belong to Central and Eastern Java, respectively (Kulke 1991:12). Additionally, Kulke (1991:15) notes that the Kalasan Sanskrit inscription (778 CE) provides information regarding the Mataram Kingdom (Kulke 1991:15). However, in general the knowledge of the Mataram Kingdom is limited to religion (Miksic 2004:242).

Temple. The earliest Indianized monuments in Indonesia are located in the Dieng Plateau of Central Java, which date to between the middle of the 7th and end of the 8th century CE (Miksic 2004:240; Romain 2011:299-300). There is evidence to suggest that there were over 400 temples or candi on the Dieng Plateau; however, due to destruction by farmers only eight temples remain (Chapman 2013:38; Romain 2011:301, 303). The temples of the Dieng Plateau formed a religious pilgrimage center located on a holy mountain (Chapman 2013:38; Romain 2011: 301-302). The Dieng Plateau provides a glimpse into early Hindu practice in the region, and its temps are the predecessors of the Borobudur and Prambanan complexes (Chapman 2013:39; Romain 2011:300).

By the mid-9th century the construction of temples in Java had reached an apogee, with the typical temple consisting of a central structure rising from a stepped base (Chapman 2013:39-40). The resulting large temple system began the process of political integration by bringing subordinate areas into this networked confederation (Hall 2011:132). The largest and most exquisite of the temples were the Buddhist monument of Borobudur and the Hindu complex of Prambanan. Both these monuments required an immense amount of labour and materials. This is demonstrated in the following quote from Chapman (2013:41):

“Borobodur invites hyperbole. Built on a natural, although altered, earthen mound, the monument required 1.6 million blocks of andesite. There are 1,460 carved panels stretching along a wall surface totalling 3 miles (4.83 kilometers). In addition to the Buddha images housed in the 72 pierced dāgoba on the upper terrace, the monument has 432 stone Buddha images displayed elsewhere. Historians estimate that as many as 200 common laborers worked on the project at any one time, with an additional possibl[e] 100 masons and stone cutters employed over the course of its construction. The result indeed a monument unsurpassed in Southeast Asia of its time.”

Although Borobodour is certainly the largest monument, the majority of temples from the Mataram Kingdom are found scattered through-out the volcanic rich soils of the Prambanan plain (Degroot 2012:123). Degroot (2012:127-130) notes that the temples of Central Java demonstrate elements of both Indian traditions and local Javanese traditions. This is suggested by their position based on local topography and the exchangeability of the entrance of the temples between the east and the west, which follows indigenous concepts rather than Indian tradition.
Monasteries. There is some discussion of monasteries associated with the Mataram Kingdom, examples of which are Gunung Pegat and Ratu Boko (Degroot 2012:123). However, there is much debate surrounding the validity of the theory that Ratu Boko is a monastery, and a number of functions for the site have been proposed. Legends suggest that Ratu Boko was the palace (kraton) of an ogre king. During the 19th century Dutch visitors accepted the legends and so Ratu Boko was identified as the palace of former Hindu-Buddhist kings (Degroot 2006:58; see also Brumund 1854: 47; Groeneveldt 1886: 80; Ijzerman 1891: 111). Later scholars, however, disagreed with the identification of Ratu Boko as a palace. A number of theories have arisen, including the use of Ratu Boko as a fortress (de Casparis 1956: 293), or a pleasure garden for the sultan (Bernet Kempers 1978: 23). However, a number of scholars adamantly argue that Ratu Boko was in fact a religious site and monastery (Degroot 2006; Miksic 2004:243; see also Brandes 1903:65; Dumarcay 1986: 51; Stutterheim 1926: 134–35).

The argument in favour of Ratu Boko being a religious site and monastery is based on a few key points: 1) the architecture of the pendopo is not appropriate for a palace; 2) epigraphic data suggests the site was influenced by Sri Lankan Buddhism, particularly the meditation monasteries linked to the Abhayagiri vihara of Anuradhapura; 3) caves at the site likely functioned as meditation caves; and, 4) there is not enough water at the site to support the population of a palace (Degroot 2006:56-62; Miksic 2004:243; Stutterheim 1926: 134–35). Although a fairly strong case for Ratu Boko as a monastery is presented, the debate as to the function of this large site continues.

Roads. Within the literature there appears to be little to no mention of a road system, as riverine networks are emphasized as being key to transportation (Hall 2011). However, Kulke (1991:12, 15) notes that the Sañjaya dynasty, prior to the rise of Mataram, was praised for protecting the royal highways which linked the lands. Additionally, Degroot (2012:127) suggests that Prambanan’s proximity to the Solo basin is commercially important, and could have been used to transport goods to the east (or receive goods from the east).

Markets. The literature deals mainly with the economic market, rather than discussions of physical marketplaces (Hall 2011). However, there appears to have been a hierarchy of markets which began with the local periodic markets known as pken/ukan (Hall 2011:132; see also Wisseman Christie 1998:348). These markets fostered local integration, but also invited external commercial traders, which facilitated the movement of local goods out to the supramarkets (Hall 2011:132).

The Kediri, Singhasari, and Majapahit Kingdoms of East Java, centered of the capitals of Kadari/Kediri (CE 1100-1222), Janggala/Singhasari (CE 1222-1292), Majapahit/Trowulan (CE 1293-1406)

In the 11th century CE, political power moved from Central Java to Eastern Java (Hall 2011: 135-137). The reason for this move is currently unknown; however, it is possible that the volcanic eruption of Mount Merapi may have contributed to the decline of the Mataram Kingdom, and initiated the movement of the capital to East Java (Hall 2011:136; Newhall et al. 2000:46). It is also suggested that the capital was moved to East Java due to ecological changes which caused water contamination and associated diseases, such as malaria (Murwanto et al. 2004:462).

The Mataram Kingdom was succeeded by the development of three kingdoms in East Java who are suggested to demonstrate a greater mix of Indian and indigenous influence (Geertz 1956:6; Romain 2011:300). After the move to East Java, the monarchy split in two with the Kediri Kingdom situated on the southeast edge of the Java river plain, and the Singhasari Kingdom on the Malang Plateau (Geertz 1956:6; Hall 2011:137). Finally, the emergence of the Majapahit
Kingdom in the 13\textsuperscript{th} century CE demonstrated the height of power in Java, and exhibited the highest levels of political and economic integration, as it exerted its power from Sumatra to Moluccas (Geertz 1956:6; Hall 2011: 253; Miksic 2000:115, 2004:250).

In comparison to Central Java, the history of East Java is better known, as there are both inscriptions and historical manuscripts (Degroot 2012:122). However, Soekmono (1971) argues that in general we still have few manuscripts and little historical texts from Java, and so its history must be rediscovered through its monuments. The integrative mechanisms of the Kediri, Singhasari, and Majapahit Kingdoms will now be discussed in unison below.

**Temples.** In Eastern Java the temples or candi are less complex than those of Central Java, and thus we see a trend of diminishing complexity over time (Haendel 2012:207; Miksic 2004:251). The temples are comparatively modest, and demonstrate a more local or indigenous style (Miksic 2004:251). The temples of Classical East Java show little evidence of subsidiary buildings being associated with temples; therefore it appears the temple complexes always function strictly for religious purposes, and that the function of them really did not change over time (Haendel 2012:215, 216). These temples were constructed of stone and brick (Haendel 2012:209; Robson 2012:253), and were scattered throughout East Java. They appear to have been regularly located outside the capitals of all the East Java kingdoms (Soekmono 1967:3). Miksic (2012:176) suggests that situating temples in rural areas, rather than the city proper, was especially evident during the Majapahit period, when the capital of Trowulan dominated the landscape. He further suggests that the location of the temples was a significant factor in determining the overall plan of Trowulan.

In comparison to the Majapahit Kingdom, the Kediri Kingdom (and probably the Singhasari Kingdom) was notable for the absence of temple compounds, as it appears that monastic cave hermitages were preferable to temples (Hall 1996:105). Miksic (2012:176-177) suggests that pudèn berundak, which are sets of terraces set on the mountain slopes, may have been considered more important as religious loci than temples. Additionally, it appears that many of the commoners had other places of worship for their own ancestral and guardian spirits, and these were likely not built of stone or brick, and thus not termed candi/temple (Robson 2012:266).

Rulers commissioned the construction of temples, and provided them with endowments for their continued maintenance (Worsley 2012:110). The construction of temples was one way the East Java Kingdoms promoted religious ideological integration. However, this was also accomplished in other ways by the rulers, the most successful of which was the Majapahit ruler Hayam Wuruk. Hall (1996:111) suggests Hayam Wuruk asserted his spiritual superiority and achieved such a high level of integration through a number of ways. First, he made a concerted effort to include and validate “parochial” religious practices by participating in local/indigenous religious rites and legitimizing the local/indigenous priests or rësi (Hall 1996:111). Evidence of the high level of religious integration of the Majapahit Kingdom is documented in ancient inscriptions, chronicles, and through the wide distribution of sacred water beakers which were a standardized ritual implement (Hall 2012: 112). Additionally, he fostered common identity throughout the kingdom through annual visits to important temples and ritual sites in the hinterlands (Hall 1996:117-118).

**Monasteries.** Information on monasteries in East Java comes mainly from ancient inscriptions and poetry. The 14\textsuperscript{th} century poet named Mpu Prapañca describes hermitages and cloister halls located close to temples (Robson 2012:257; Robson 1995). As Haendel (2012:209) suggests that, in general, only temples were built of stone or brick, perhaps the reason we do not generally see these monasteries is because they were made of perishable materials.
Again, it appears the East Java rulers commissioned the construction of the monasteries and hermitages and also endowed them with the means to support themselves (Worsley 2012:110). However, in the 13th century King Kertanagar of Singhasari issued an edict, the “Charter of Sawwardharma” which freed the priesthood from government interference; however, this also retracted any royal financial support (Miksic 2004:251).

Roads. Although scholars rarely discuss the importance of road networks in East Java, there is some evidence to suggest they existed (Miksic 2012:164; see also Robson 1995:29). The Nāgarakṛtāgama, an ancient texts, speaks of the "Holy Crossroads” and the "cosmic intersection” of the Majapahit Kingdom (Hall 1996:103). Another ancient text, the Desawarnana, describes processions that travelled hundreds of kilometers and filled the breadth of the royal highway with carriages, ox carts, elephants, and horses (Miksic 2012:166). Additionally, there is an historical report of Trowulan in 1861 which states that every road and pathway shows brickwork beneath, which were the paved roads of the ancient city (Wallace 1869:101-102, as referenced in Miksic 2012:168). Miksic (2012:166) suggests this Majapahit road network dictated the form of the royal capital of Trowulan, and that where the roads intersected was the axis mundi.

As it was the ruler’s duty to sponsor public works, they likely commissioned the construction of these suggested road networks (Hall 1996:102). Additionally, inscriptions also suggest that principle nobles of the Majapahit Kingdom ordered local officials to make their districts prosperous by constructing and maintaining public works such as bridges and main roads (Hall 1996:102; Miksic 2012:167; see also Robson 1995:167). It is interesting to note that one text from 1358 CE mentions 78 ferry crossings, providing more evidence of considerable overland traffic (Miksic 2004:251).

Rest Houses. There is little reference to rest houses in the literature. However, in his work the 14th century poet, Mpu Prapañca, states that there were many rest houses around the temples for pilgrims and wanderers to rest at (Robson 2012:255-256; Robson 1995).

Markets. It is suggested that networks of markets in East Java also integrated centers of royal administration and the hinterlands (Worsley 2012:109; Miksic 2004:246). Ancient texts describe marketplaces located within the capital of the Majapahit Kingdom (Miksic 2004:251), and located immediately outside the gateway of the Trowulan city (Hall 1996:96, 98). However, Hall (1996:96) suggests that these markets serviced local demand, and did not necessarily play a role in major long-distance trade (Hall 1996:96). Additionally, within his work, the 14th century poet, Mpu Prapañca, describes markets associated with temples (Robson 2012:257; Robson 1995). Inscriptions suggest that these markets were supervised by court officials who received payment for their services (Miksic 2004:251).

PRELIMINARY FINDINGS FROM THE SETS FIELD TRIPS

In this section I will discuss some of the findings from my field work during the research trips that took place during December, 2013, and May-June, 2014. The results will be discussed according to the geographic area and the associated tropical charter state.

The Khmer Empire and Angkor

Of the early states discussed in this chapter, the Khmer Empire, centered on Angkor, has the most scholarly literature and research results available. Thus, most of my own observations during the trip have already been discussed in the existing literature. However, what struck me was the sheer scale of the site. One cannot fully comprehend the immensity of the temple complexes and the far reaching geographic distribution of the Khmer Empire until it is experienced firsthand. The
temples of Angkor are not only awe inspiring in size, but also in their superior décor. The intricateness of the innumerable reliefs adorning the structures, again, can only truly be appreciated when in their presence. It is obvious that these monuments required an immense amount of material, labour, and skill. However, quantifying this could be quite challenging. Interestingly, discussions with new scholarly liaisons have provided new insights into possible methods of quantifying the amount of material used to construct a monument using the results from LiDAR, and through simple measurements of the structure using tape measurement in the field (Mitch Hendrickson, personal communication 2014).

I myself found every temple complex to be extremely unique, particular between those temples that were constructed during the reign of the kings that identified more with Buddhism, and those constructed by the kings who prescribed more closely to Hinduism. It has recently been brought to my attention that Angkorian temples generally follow a certain stylistic model. However, within this stylistic framework, individuals and communities altered the customary model to suite their specific needs, and these stylistic and architectural modifications can be studied spatially and diachronically (Mitch Hendrickson, personal communication 2014.). The results of such a study could demonstrate spatial and temporal changes in ideological integration, and provide insights into community identity and agency throughout Greater Angkor.

As previously discussed, much work has also been conducted on the road networks of Angkor. However, in general less emphasis is placed on the particulars of the infrastructure of the road system, the bridges and rest houses. Rest houses are much larger than I had envisioned. The temples d’étapes in particular are quite large, and are in fact a temple complex which provides all the necessary amenities for travellers. The bridges too are quite large and impressive feats of engineering, the largest and most impressive being Spean Praptos (Figure 8.1, Figure 8.2). Bridges such as this would have been extremely important for maintaining a cohesive state. Although the bridge was likely important for local traffic (I witness many locals still using the Spean Praptos Bridge), it would have been indispensable for the movement of large shipments of goods into the capital, and to facilitate the movement of armies into the territories. I would like to particularly stress the importance of the bridge for the armies, as expedient deployment of troops would have been very important, and without the bridges, movement of large armies – which would have included supplies and war elephants – would have been near impossible.

Figure 8.1: Spean Proptos Bridge, Angkor, Cambodia.
A final observation concerns the hospitals, which appear to be unique to the Khmer Empire. During my trip I visited the location of only one of the many hospitals. The site was designated The Chapel of the Hospital (Figure 8.3). All that remained was a small ornate stone structure which was the “Chapel”, as I presume the working or practical portion of the hospital was made of perishable materials and did not preserve over the years. I would venture that the hospitals were not extravagant structures, but practical facilities. Thus, what would have required funding was the maintenance of the facilities through the replenishment of certain supplies and the wages of specialized health practitioners.
The Burmese Empire centered on Bagan

Upon visiting Bagan, the center of the early Burmese Empire, it was immediately apparent why it is called “The Plain of Merit”, as temples span from the edge of the Irrawaddy River to the horizon (Figure 8.4). Although the temples of Bagan are, in general, not as large as those of Angkor, they are in many ways just as impressive, and at times superior in decoration. There are in fact a number of temples at Bagan that are massive, and which demonstrate a high level of architectural sophistication and skill. Although each temple is unique in its own right, there is a sense of continuity in architectural and artistic style throughout “The Plain of Merit”. I would suggest this is evidence of ideological integration through the Buddhist religion. What is particularly striking is the preservation of these structures, and their continued use in the present as important religious sites. Furthermore, construction of temples continues today as a means of gaining merit. This demonstrates how deeply imbedded the ideology of gaining merit is in Bagan, and how it has persisted through time, even though Bagan is not the wealthy empire of earlier days.

Figure 8.4: View of the “Plain of Merit” Bagan, Myanmar/Burma.

What was most striking of the Burmese Empire were the numerous large monastery complexes located outside the walled city of Bagan. These complexes included large tracts of land that were used to sustain themselves. Although the preserved monasteries of Bagan were not as large as the grandest monastery from Angkor, they were numerous, and at times formed entire villages, such as that of Minnanthu. One of the largest monasteries still preserved is the Lay Myet Hnar complex (Figure 8.5, Figure 8.6), which included its own temple, and a large wall with a few entrances to control access to the complex.
Figure 8.5: Lay Myet Hnar monastery complex, Bagan, Myanmar.Burma. Image shows the monastery’s large wall and domicile.

Figure 8.6: Lay Myet Hnar monastery complex, Bagan, Myanmar.Burma. Image shows the monastery’s associated temple.
Within the literature there is very little discussion of the road networks of the Burmese Empire. During my field work, however, I encountered the remains of a two-way ancient royal road (Figure 8.7). The road runs from the The-ra-ba Gate (Figure 8.8), which provides entrance into the walled city, to the Schwe-zigon-zedi temple. The remains of this ancient road run parallel with the contemporary Pagan-Nyaung-U Road, which provides a connection between the walled city of Bagan, and the communities to the north and south. I would suggest that this road was an important integrative structure, as it both physically and ideologically connects the city center to an important religious site on the landscape.

Figure 8.7: Ancient Royal Road, Bagan, Myanmar/Burma.

Figure 8.8: The-ra-ba Gate, entrance to the walled city of Bagan.
The importance of roads for the Burmese Empire has generally been disregarded due to the location of the city on the Irrawaddy River, which functioned as an important conduit for travel. However, one of the ancient state’s “rice baskets”, the Minbu region, was not located on the river. On our excursion to the Minbu region we travelled by car on a dirt road that was currently under maintenance. The maintenance was being performed mainly by women who used baskets to carry loose aggregate to be used in the widening of the road. It is possible that similar methods and personnel were used to construct roads in the past. During our visit to Minbu I observed many local people using the road, in particularly ox-drawn wagons transporting large cargos of agricultural goods (Figure 8.9). I would argue that a main road into Minbu would have been necessary for the transport of agricultural goods within the region, and that it would have been in the best interest of the land holders in Minbu to construct and maintain these road, rather than leaving to whims of the ruler.

Figure 8.9: Ox-cart driven wagon transporting agriculture produce within the Minbu region, Myanmar/Burma.

The Early Siamese Kingdom centered on Sukhothai

In comparison to Angkor and Bagan, the architectural style of Sukhothai was smaller, and less complex and ornate. However, I found Sukhothai’s architectural and artistic style to be quite uniform both within the city walls and in the periphery. I also found that this consistency in style continued in the nearby sites and administrative nodes of Si Satchanalai and Chiang. It appeared as if many of the buildings of Sukhothai were replicated at these smaller sites. An excellent example of this stylistic consistency is the Wat Chang Lom temple complexes that are found at both Sukhothai and Si Satchanalai. Both of these temple complexes employ similar (almost...
identical) elephant statues in the same way, on architecturally similar structures (Figure 8.10, Figure 8.11). I would argue that this is an excellent example of ideological integration within the Early Siamese Kingdom. However, it must be noted that in comparison to the Khmer and Burmese empires, the Sukhothai Kingdom lasted a very short time (just 140 years). Thus, we would not see the vast stylistic changes that sometimes occurred over the long spans of time evident at the other sites.

**Figure 8.10.** Wat Chang Lom, Sukhothai, Thailand.

**Figure 8.11:** Wat Chang Lom, Si Satchanlai, Thailand.
Much like the temples, the monasteries of Sukhothai were much smaller and less complex than those of Bagan. Wat Aranyik (‘the forest-dwelling monastery’) is located within the forest of the hills to the west of the walled city of Sukhothai (Figure 8.12). Although the monastery is very poorly preserved, it is evident that it was quite small and humble in comparison to those of Bagan. Additionally, even though the monasteries of Sukhothai were gifted land, they do not appear to have been located on prime agricultural lands as they were at Bagan. Thus, it appears that although Buddhist religion and ideology were important forms of integration for the Siamese Kingdom, the presence of monasteries was not nearly as costly for the ruler with regards to construction, maintenance, and agricultural land.

Figure 8.12: Wat Aranyik (‘the forest-dwelling monastery’), Sukhothai, Thailand. An example of a monk’s cell for mediation.

One structure that I found enigmatic was the solitary building located just outside the Namo Gate, the southern gate of the walled city of Sukhothai. Rooney (2008:130) does mentions this building, and suggests that it was possibly an ordination hall, but she provides very little discussion of it. However, during my field work at the site I noticed that the signage for this structure indicated that it was a “Guard Post of the City”. It is possible then, that this structure functioned as an administrative or access node for the city which helped government agents to control and monitor traffic, in the form of people and goods, upon entering and exiting the city. This gate of course provided access to the ancient “Royal Road” which linked Sukhothai to its major administrative nodes of Kamphaeng and Phet and Si Satchanalai.
The Mataram/Kediri/Singhasari/Majapahit Kingdoms centered on Mataram/Medang, Kadari/Kediri, Janggala/Singhasari, and Majapahit/Trowulan Respectively

From my field work in Java I certainly agree with the literature that there is a marked difference in the architectural and artistic style between the temples of Central Java and those of East Java. Certainly the temple complexes of Central Java, particularly Borobudur and Prambanan, are comparable to those of Angkor and Bagan in size and complexity. Additionally, you do see a strong Indian influence in these structures. In comparison the architecture of East Java is smaller, less complex, and demonstrates more indigenous influences. However, what was also striking was the consistency in the artistic iconography and style of the temples of East Java. The iconography on the temples of the East Java kingdoms is very repetitive, examples include but are not isolated to: 1) the depiction of events from the Ramayana, which form the reliefs that band around the exterior of the building; 2) the similar artistic style of the Kala heads situated over the temple doorways; and, 3) the Garudas depicted on the side and corners of the building. Although there are some stylistic differences between the kingdoms of East Java, there is a general consistency, which would suggest that maintaining ideological roots to India and Hinduism was important for the integration of the kingdoms.

Candi Sukuh and Candi Ceto, which date to the end of the Majapahit kingdom, demonstrate a major departure from the architectural and artistic style of the other temples of East Java. Not only does the iconography change to include phalli, vulva (Figure 8.13), and turtles (Figure 8.14), but the usual iconographic figures of Hinduism are depicted in an entirely new style. Candi Sukuh has received some attention from scholars, who suggest the difference in the iconography of the temple is a reflection of indigenous styles and indigenous religious cults, particularly those associated with local mountain spirits and fertility (Degroot 2012:135-137; Miksic 2004:252). Candi Ceto, on the other hand, appears to have received no attention from scholars, even though I found it to be just as unique, and seeing as it demonstrated the same iconography and artistic style as Candi Sukuh. The similarities were particularly apparent through the use of phalli, vulva, and turtle depictions (Figure 8.15). I believe these two temples, which deviate from the usual Hindu temples of the Majapahit Kingdom (and East Java in general), are examples of how integration through iconography, and thus ideology, was beginning to disintegrate and reform in a unique manner at the end of the Majapahit era.

Road networks, again, have generally been neglected in the scholarly literature on ancient Java. With the exception of Miksic (2012), the importance of overland transportation networks within ancient Java have not been thoroughly researched. I believe that this is mainly due to the fact that most conceive of ancient Java as functioning on a “Riverine System Exchange” mode, in which rivers are the most important means of transportation and shipping goods (Hall 2011). However,
Figure 8.13: Candi Sukhu, Majapahit Kingdom, East Java. Carving of phallus and vulva.

Figure 8.14: Candi Sukhu, Majapahit Kingdom, East Java. Turtle carving.
during my field work I noticed the importance of overland transport within the interior of Java; river systems are not always available. Particularly with regards to the Majapahit Kingdom, roads would have been extremely important for integrating the hinterlands, in addition to organizing its capital of Trowulan. I assume that many of the ancient roads of Java are located below the contemporary roads and highways (e.g., Miksic 2012).

Figure 8.15: Candi Ceto, Majapahit Kingdom, East Java. Carvings/statues of phallus, vulva, and turtle.

Finally, I would like to briefly address the issue of Ratu Boko, the proposed monastery of the Mataram Kingdom, located in proximity to Prambanan. Degroot (2006) quite adamantly argues that Ratu Boko must have been a monastery and not a palace due to its lack of water, associated inscriptions, and religious architecture. However, upon my visit to Ratu Boko I did not find strong evidence for either side of the argument. In particular, I find the argument that there was a lack of water to be a moot point. For if there is not enough water for a palace then there would not be enough water for a monastery either. Furthermore, would a palace not have the means and authority to have water transported up the hill? I also found that the numerous pools that are situated in a private location at the back of the complex (Figure 1.15) are reminiscent of the historical Taman Sari, or water palace of the historical Sultans of Yogyakarta. Finally, Degroot (2006:62) argues that the building at Ratu Boko are religious in nature, but then states that the pendopo was built in stages and not initially conceived as a meditation platform. As I do not feel there is enough evidence for either argument, and thus I am currently inclined to believe that the
site of Ratu Boko may have had more than one function over the course of time. Perhaps it was initially settled as a fortified palace, and was later transformed into a monastery?

**DISCUSSION**

One of the largest obstacles to researching integrative mechanisms is the lack of literature on the topic. Certainly the amount of literature available varies between the early states. While the Khmer Empire and Angkor has a fairly robust volume of literature, there is inadequate historical documents and archaeology focused on the post-Angkorian period at Sukhothai and the Early Siamese Empire (Welsh 1998: 227). The kingdoms of Java and the Burmese Empire also have little scholarly research available in comparison to the Khmer Empire. Of course we must consider that much more work has been published on these sites, . However, they are published in a different language such as Thai, French, Javanese, or Dutch, and they thus pose an issue of accessibility.

Another obstacle is the varying degrees of current research occurring within each geographic area. Again, there is a lot of ongoing work occurring in Cambodia, which includes excavations, reconsolidation, and survey through LiDAR. Surprisingly, a lot of excavation and reconsolidation was also occurring throughout Java. However, at the sites of Bagan and Sukhothai little to no current archaeology appears to be taking place. Although Bagan has many historical inscriptions, there is very little excavation, survey, and radiocarbon dating being performed to help corroborate these historical inscriptions (Aung-Thwin 2001; Higham 2001). These issues make it difficult to perform a thorough cross-comparison of the integrative mechanisms of these early tropical charter states.

This leads to another issue with the data set: the amount of information regarding each type of integrative mechanism varies. Temples have the most amount of scholarly information available, and have the most ancient texts associated with them. Thus, temples are one of the most comprehensive and comparable sub-data sets. However, markets, for example, are merely mentioned in ancient texts, and to my knowledge there has been no concerted effort to research markets or perform excavations in their probable locations. Similarly, with the exception of Angkor, road systems have received little scholarly attention, even though it seems that they would have been an important means of integration in the case of each early state. Finally, one issue with the data set in its entirety is its immense size. Mastering the range of literature is a daunting task.

**Addressing the Research Questions**

As previously stated, the goal of this research is to explore the development and organization of various integrative mechanisms within the sample of early tropical state societies. In order to provide focus to this research, a number of research questions were developed. While I would suggest that much more research needs to be completed before these questions can be answered sufficiently, a preliminary attempt to address the questions will now be made.

1. **What types of integrative mechanisms were employed by each charter state?**

Table 8.2 demonstrates what types of integrative mechanisms were employed by each charter state. It is interesting to note that while some of these types were not discussed in the literature I reviewed, they were at times encountered in the field during the research trips. Additionally, it is clear from this table that the Khmer Empire appears to have employed the full suite of integrative mechanisms.
Evidence of Integrative Mechanisms for Each Charter State

<table>
<thead>
<tr>
<th>Integrative Mechanism</th>
<th>Khmer</th>
<th>Burmese</th>
<th>Siamese</th>
<th>Mataram</th>
<th>Kediri/Singhasri/Majapahit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Literature</td>
<td>Field</td>
<td>Literature</td>
<td>Field</td>
<td>Literature</td>
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<td>Temples</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Monasteries</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Libraries</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Roads</td>
<td>Y</td>
<td>Y</td>
<td>M</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Rest Houses</td>
<td>Y</td>
<td>Y</td>
<td>M</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Hospitals</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
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<td>Markets</td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td>Y</td>
</tr>
<tr>
<td>Administrative Nodes</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

NOTE** Y=Yes; N=No; M=Minimal; C=Contemporary

Table 8.2: This table demonstrates which mechanisms were employed by each charter state. This shows whether evidence for the mechanism was found either in the literature review or while in the field during the research trips.

2. **At what point during the development of each charter state were these integrative mechanisms introduced?**

In general it appears that temples and monasteries were present at the very beginning of each charter state. Additionally, I would suggest that although there is generally little literature and few dates provided for the roads and markets, I would assume simple roads and small local markets were also present from the inception of the charter states. At Angkor, libraries were often part of temples, while at Bagan libraries we part of the monasteries. Thus, libraries were also present during the bourgeoning of the charter states. Within the Majapahit Kingdom and Burmese Empire rest houses seem to have been a part of the temple and monastery complexes, respectfully, and they were thus likely present from the beginning of the state. In contrast, literature on the Khmer Empire suggests rest houses were built during the massive expansion of the road network in the late 12th century CE. At present the introduction of administrative nodes for each charter state is difficult to ascertain, and perhaps further research of this integrative mechanism should be focused within the settlement sub-project. Finally, hospitals are an integrative mechanism unique to the Khmer Empire, and these were introduced in the late 12th century CE.

3. **When did they show increased popularity and/or energy investment?**

The Khmer Empire demonstrates a distinct increase in popularity and energy investment in integrative mechanisms during the late 12th century CE. At this time, we know that the entire suite of integrative mechanisms were being constructed and utilized. The Burmese Empire shows the highest energy investment during the 12th and 13th centuries CE, which focused on two particular integrative mechanisms. During the 12th century there is a major increase in the construction of temples both within and outside the inner city of Bagan. This increase in temple construction slowed near the end of the 12th century CE. As temple construction declines, there is a surge in the construction of large walled monasteries in the 13th century CE. It is difficult to determine if there was an increase in energy investment at a specific time, as the kingdom lasted for a very short period of time. A similar comment can be made regarding the Javanese kingdoms. However, it can
be noted that during the Mataram Kingdom energy appeared to be more heavily concentrated in the construction of temples, which then declines in the later Kingdoms. Additionally, it appears that during the Majapahit Kingdom more effort may have been placed on the road networks. The Siamese kingdom, on other hand, flourished for such a short time period of time that providing a specific time period when we see the highest energy investment is difficult. Additionally, we have the least amount of information on this charter state.

4. When were they abandoned?

At present, I find it difficult to answer this question accurately based on the current research and findings. In general, it is easier to discover when these integrated mechanisms were introduced and/or constructed, rather than when they were abandoned. Of course the simplest answer is that all the integrative mechanisms were abandoned when we see the fall of the charter states. However, particular integrative mechanisms continue to be used by the contemporary populations today. This is particularly true of the temples of Bagan, and many of the roads associated with all the charter states.

5. Who sponsored the construction and maintenance of each type of integrative mechanism for each charter state, and who physically carried out the construction and maintenance?

In general it appears that the greatest sponsor of the construction and maintenance of these integrative mechanisms for each charter state fell mainly on the shoulders of the ruler. As a rule, it seemed that it was necessary to fund public works in order to be considered a powerful and benevolent king. The Burmese Empire, however, provides evidence of sponsors also coming from outside the royal family. It seems that members of the noble and the commoner class were also major contributors to the construction of public works, particularly temples and monasteries. During the 12th and 13th centuries CE, the non-royal elite were sponsoring over half of the monuments (both temples and monasteries) within and around Bagan. During the 13th century CE, the commoners were actually sponsoring the construction of monuments at a higher frequency than the rulers. However, it remains true that the highest quality of monuments appear to have been sponsored by the ruler throughout the history of the Burmese Empire. Additionally, it should be noted that the nobility of the Burmese Empire, rather than the ruler, were likely the ones sponsoring the construction and maintenance of the roads. This is in stark contrast to the road network of the Khmer Empire, which appears to have been sponsored and maintained solely by the ruler.

6. Who managed the integrative mechanisms?

Determining who was managing each specific integrative mechanism is difficult to assess based on the current data. In general, we can assume that all managerial lines lead back to the ruler. For example, administrative nodes were generally administered by members of the royal family. There are, however, two examples of integrative mechanisms which the ruler did not necessarily have the power to administer. It is quite clear that monasteries were fairly autonomous religious institutions within each charter state, whose governance came from within (the monks) rather than the ruler. Nearing the end of the Burmese Empire, however, it appears that the monasteries were
becoming too wealthy, and at this point, the ruler does attempt to take control of the administration of the monasteries in order to funnel wealth back into the royal coffers

7. Can we assess the cost of labour, materials, and administration for each type of integrative mechanism?

The costs of materials and labour is difficult to assess from the current data. In the case of the Burmese Empire, there are inscriptions that provide information regarding the amount of materials and costs that were required to construct specific temples and monasteries. Unfortunately, these types of inscriptions are rare, and are not presently available for all the charter states. Additionally, these types of inscriptions only describe temples and monasteries, and generally do not refer to the labour and materials costs of other integrative mechanisms.

Quantification of the materials used in structures such as temples and monasteries, could, however, be possible. As previously mentioned, quantification of construction materials could be ascertained through the use of LiDAR as well as through simple tape measurements. These methods could provide us with both a diachronic and spatial picture of material investments in temples and monasteries. This may be an avenue to explore during the proposed Phase II of this project.

As the material and labour costs for each type of integrative mechanism currently cannot be assessed, I cannot determine with certainty which type of integrative mechanism required the most amount of initial investment. However, from my first hand experiences at the sites I would suggest that within each city state the temples required the most amount of initial investment. I would also suggest, based on the preliminary evidence, that both the temples and the monasteries require the most amount of maintenance and management. For temples, this would have included mainly ritual maintenance through ceremonies. Although I would conclude that hospitals required little initial investment, they would have required much management and maintenance in the form of staffing and medical supplies.

8. Which segments of the society were using each type of integrative mechanism?

This is a complex question as it is likely that a variety of segments of the society were using a variety of integrative mechanisms at varying degrees and for different reasons. In this section I will provide a simple table (Table 8.3) to demonstrate who was using each integrative mechanism. A more in depth discussion will be provided below, when addressing question nine. As can be seen in Table 8.3, I am unsure from the current data whether certain segments of the society were utilizing certain integrative mechanisms. However, I am certain that all segments of the society were utilizing temples, monasteries, and roads in one way or another.
Table 8.3: The different segments of the society that use each type of the integrative mechanism.

<table>
<thead>
<tr>
<th>Integrative Mechanism</th>
<th>Ruler</th>
<th>Noble</th>
<th>Priests</th>
<th>Commoners</th>
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<tr>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Monasteries</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Libraries</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Roads</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rest Houses</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hospitals</td>
<td>Maybe</td>
<td>Maybe</td>
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<tr>
<td>Markets</td>
<td>Maybe</td>
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</tr>
<tr>
<td>Administrative Nodes</td>
<td>Yes</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Maybe</td>
</tr>
</tbody>
</table>

9. Which segment of the society was most reliant on each type of integrative mechanism?

While it is sometimes difficult to ascertain archaeologically if a particular segment of society ever utilized any of these integrative mechanisms, it is slightly easier to infer which segments of the society were the most reliant on each integrative mechanism. Although everyone utilized the temples, I would argue that the rulers were most reliant on them, particularly for the purpose of ideological integration throughout the kingdom/empire. Monasteries, on the other hand, were utilized most readily by the monks. Monasteries were situated at the center of Buddhist communities, and they served both religious and secular purposes, as they were both a residence and a place of worship. With regards to roads it is interesting to note that while all segments of society utilized the road networks, those who were most reliant on this integrative mechanism differ between the Khmer and Burmese Empires. For the Khmer, the road networks were absolutely essential for the ruler in order to facilitate the movement of his large army. In contrast, it appears that within the Burmese Empire the road network was of less consequence to the ruler, and more important for the nobles and monasteries who controlled large tracts of agricultural land, and who needed to be able to transport their agricultural surplus.

CONCLUSIONS

This chapter has provided the results of the SETS field work performed during the research trips that took place during December, 2013, and May-June, 2014. A preliminary analysis of the literature review and on-site observations have demonstrated how each of the sampled tropical charter states exhibit a unique suite of integrative mechanisms, and how they were each reliant on particular types of mechanisms to facilitate integration. However, a common thread is the important use of temples as a means to demonstrating authority and legitimacy, and to foster integration through both religious iconography and the development of a pan-kindom identity. Additionally, temples, especially when used in conjunction with monasteries, are examples of the structures/commodities in which the early tropical states became highly entangled. Temples and monasteries not only appear to have required the highest levels of initial in-put in terms of finances, labour, and materials, but they also required the highest levels of maintenance in terms of such things as rituals and endowments. Thus, long-term investment in these large ritual complexes may made the societal superstructure of these tropical charter states less resilient over time.
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