

## Fortification as a human response to late Holocene climate change in East Timor

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### Abstract

We present evidence for a significant shift in human landscape use in post 1000 AD East Timor towards fortified and defensively-oriented settlement sites. We propose a model of agents selecting to invest in fortification building that is based on the spatial and temporal variation in the availability of rainfall-dependent resources. These resources may have been significantly impacted by climatic events associated with ENSO variation, and we discuss spatial and temporal correlation with ENSO warm phase frequency and dates of initial fortification building.

Hundreds of stone walled structures are visible on hilltops and cliff edges in the contemporary landscape of north coastal East Timor (Figure 1). These structures are remembered by local inhabitants as places occupied in the past during a time of internecine warfare, mostly before living memory. Recent archaeological work supports the interpretation that these structures served as fortified settlements, and that people shifted suddenly to this settlement pattern only after 1000 AD, despite over 35,000 years of human occupation of Timor (e.g. Lape 2006). In this paper, we propose a model based on rainfall dependent resource distribution across time and space that could explain this sudden shift in settlement pattern, and then apply paleoenvironmental and recently collected archaeological data to test this model. Of particular interest is the history of the El Niño Southern Oscillation (ENSO), which may have had considerable impact on East Timor during the past 1000 years. In recent decades, El Niño caused drought in much of Island Southeast Asia and the Western Pacific. Although there are not yet any paleoenvironmental data from East Timor itself, a variety of proxy data from regions with demonstrated teleconnections to East Timor's climate indicate that El Niño events were much more frequent in the past than in the 20th century. Below we will review the culture history of East Timor, introduce our model, test it with archaeological and paleoenvironmental data and discuss the results.

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### *Culture history of East Timor in a regional context*

Prior to its separation and subsequent independence from Indonesia in 1999, East Timor had seen relatively little attention from archaeologists. Most work published to date has been conducted on an uplifted limestone plateau in the easternmost Lautem district, where dates of human occupation as early as 35,000 BP have been identified in several solution cave sites (O'Connor 2003; O'Connor and Veth 2005; O'Connor, *et al.* 2002; Spriggs, *et al.* 2003). The rich rock art of this region has also been subject to recent investigation (Lape, *et al.* in press; O'Connor 2003; O'Connor and Oliveira in press).

This research, building on earlier work in the 1950s and 1960s (Almeida 1961a, 1961b; Almeida and Almeida 1959; Almeida and Zbyszewski 1967; Glover 1970, 1986), indicates that East Timor's culture history follows patterns found elsewhere in Island Southeast Asia. The earliest sites dating to 30–40,000 BP are in limestone caves, probably because caves provide better conditions for preservation and site visibility. Between 4000 and 3500 years ago, there was a shift from a hunting/fishing/gathering economy to a farming economy, characterized archaeologically by the presence of domesticated animals including pigs, chickens, dogs, agriculture and earthenware pottery (Bellwood 1997, 2004). Goats were likely to have been introduced after 1000 AD. Although Glover claims a date of 5000 BP for goats in East Timor, this is not supported anywhere else in Island Southeast Asia (Glover 1986). Rice agriculture

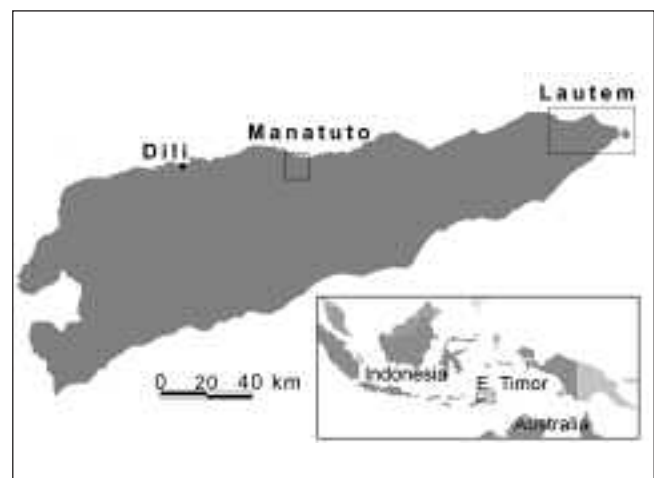


Figure 1. East Timor.

appears to have been practiced in the Philippines, but early agriculture in southern Island Southeast Asia, including Timor, is poorly understood (O'Connor 2006; Spriggs 2003). It is likely to have included the cultivation of fruit and nut bearing trees, sago and root crops such as taro and yams (Latinis 2000; Stark and Latinis 1992). Land use probably combined swiddening and utilization of existing wetlands for appropriate root crops. The introduction of metal tools to the region sometime after 2000 BP probably allowed more intensive land clearance in a wider variety of forest ecosystems than stone tools and fire alone. Irrigation systems were not introduced into the region until the first millennium AD, probably later than that in East Timor, although there are few hard data on the history of agricultural practices.

Regarding settlement patterns, evidence from cave and rockshelter sites in East Timor indicates continued use of these areas from the earliest human presence on the island to today. Caves are still used for ceremonial purposes and in recent memory were places of refuge during warfare (Pannell and O'Connor 2005). However, we have much less evidence for human settlement outside of caves and rockshelters in Island Southeast Asia. In East Timor, coastal shell middens have been dated to the post 4000 BP era, and we have found undated lithic scatters and the fortified sites discussed in more detail below. In other parts of Island Southeast Asia, a similar bias to cave sites exists for the early "Neolithic" period (4000–2000 BP), with a few exceptions (Lape 2000a; Simanjuntak and Forestier 2005). More non-cave sites have been excavated dating to the post 2000 BP period, and these sites provide some insight into settlement patterns. By this time, if not earlier, people were living in houses clustered into villages and towns in much of Island Southeast Asia, particularly the better documented coastal areas (Bacus 1999; Bulbeck, *et al.* 2001; Bulbeck and Prasetyo 2000). A rich documentary record, particularly for times after the arrival of first sustained contact with Europeans after 1512 AD, also supports the archaeological evidence (e.g. Reid 1988, 1993; Stoler 1989; Wolters 1999). Both lines of evidence also suggest that raiding and trading were dominant in the social systems of Island Southeast Asia, including East Timor (Fox and Soares 2000; Gunn 1999; Junker 1999).

Since 2003, we have been investigating the stone walled structures common on certain parts of the landscape of the Lautem and Manatuto districts on the north coast of East Timor (Chao in press; Lape 2006). These sites appeared similar to fortified settlements found in certain other parts of Island Southeast Asia and Oceania, most of which date to the same period, 1100–1700 AD (Field and Lape in preparation). Based on an admittedly cave-biased archaeological record, these fortified settlements represent a dramatic shift in landscape use by people in north coastal East Timor. Although it isn't clear where people were living outside of caves and rockshelters prior to 1100 AD, they were not living on cliff edges or hilltops. Below, we present our model of settlement locale choice that may explain this shift.

### *Climate sensitive settlement choice model*

Frameworks based on evolutionary ecology are useful for incorporating environmental changes into models of human behavior (e.g. Dyson-Hudson and Smith 1978; Kennett, *et al.* 2006). These frameworks can be used to map the highly complex adaptations to environmental changes by both human and non-human organisms within ecosystems. An externally introduced change, such as a rainfall anomaly, will stimulate a variety of responses by organisms within ecosystems, which in turn will stimulate a variety of counter-responses and adaptations in linked organisms. By definition, all organisms will adapt to new conditions (or perish), and changing conditions provide both new opportunities and challenges for these organisms. Human cultural responses are of course extraordinarily complex, as culture and memory cannot be reduced to biological adaptation. However, it is a realistic project to model human response options within an evolving ecological system, incorporating factors such as predictability, risk, and bet-hedging (e.g. other papers in this issue, Kennett and Clifford 2004; Kennett and Kennett 2000).

Our model proposes a causal link between fortification building and spatial and temporal changes in the availability of rainfall-dependant resources. Although many factors undoubtedly affected the choices available to people in East Timor with regard to settlement locale and fortification building, we assume that resource predictability was a primary factor affecting these choices. Furthermore, precipitation is a major limiting factor for agricultural resources in contemporary north coastal East Timor and was probably a major factor in the past. Late 20th century ENSO warm phase events have been associated with drought in most of Island Southeast Asia including Timor, and data suggests that this held true at least for the late Holocene as well. The model we present here tests the assumption whether resource unpredictability in certain temporal and spatial arrangements is linked to fortification building. This test applies only to the initial construction of fortifications on a landscape. We assume that once fortifications are built and available to inhabitants, the nature of subsequent conflicts and responses to environmental change will be qualitatively different (M.W. Allen 2006; Ferguson 2006). Our simple agent-based model has three primary components which predict initial fortification building in *time* and *space*:

1. People will choose to invest in building fortified settlements only when they rely on spatially fixed and restricted resources. Most archaeologically documented occurrences of fortifications occur in agricultural societies where land tenure is key to subsistence (Ferguson 2006), or in non-agricultural societies where key resources are dense and spatially restricted, such as for salmon in Coastal Northwest North America (Maschner and Reedy-Maschner 1998).
2. People will choose to invest in building fortified settlements during periods of unpredictable resource availability. "Predictability" is a moving target, as

changing conditions constantly influence memory and therefore predictions of future conditions. Since our understanding of climatic change remains temporally coarse, we can simply say that if droughts start to occur much more frequently, and when this increasing frequency would be noticeable to people (significant changes at century level periodicity), then we can assume that memories of climate will not coincide with actually-occurring climate and are thus unpredictable.

3. Fortifications will appear in regions that a) contain resources tolerant of climate change (creating conditions for relative surplus) AND b) are adjacent to regions with resources intolerant of climate change (creating conditions for relative deficit). We predict that spatial resource imbalance is a necessary requirement for initial raiding and response to raiding (including but not limited to fortification building). In these situations, people from resource deficit areas will raid nearby regions with surpluses, either to gain access to stored food, or to take possession of resource-rich land. Once this process begins, it may continue for a variety of reasons even if resources become balanced again.

To test this model, we will map rainfall dependant resource availability over time and space in East Timor, then test whether fortifications preferentially appear in times and places predicted by the model.

#### *Food production, water and storage*

For about 3500 years, people in East Timor have relied at least in part for food on agriculture and domestic animals, as discussed above. Wild plant and animal resources from both terrestrial and marine contexts were also likely important components of subsistence, and remain so today in many parts of East Timor. Most forms of agriculture in East Timor would have been highly dependant on sufficient and timely precipitation, and wild plant and animal resources would have also been dependant on rain, though perhaps less critically. We emphasize that it is not simply precipitation *amount* that affects resource availability, but also (and perhaps more importantly) precipitation *timing* and *stability*. In 2005, for example, East Timor experienced a severe food shortage and starvation became a major concern to the UN and other relief agencies. Manatuto, one of East Timor's rice production centers, actually produced an average amount of rice on an annual basis that year. However, according to local informants, the harvest season was delayed because of the delay in the onset of the previous rainy season. Even with the aid of complex irrigation systems, delayed rainfall resulted in a severe food shortage because people tend to not have enough storage to cope with an unexpectedly late harvest. More serious and long-lasting droughts may result in near total crop failure, for which only international aid can save people from starving.

Precipitation anomalies can have a negative impact on resources whether wetter or drier. For example, in dry years, people may experience problems with swidden scheduling, such as shortened growing seasons, germination failure

(desiccation) and increased predation from parasites and animals (Conklin 1961, 1975). In extreme conditions there may be drinking water shortages. Wet years can also negatively affect resources in normally drier areas, including problems with swidden scheduling, germination failure (fungi, erosion), top soil erosion and inadequate burning for weed control. Mosquito-borne diseases such as malaria and dengue fever also tend to increase in wet years.

As demonstrated by recent El Niño effects in East Timor, the immediate impacts of droughts would have been disastrous for agricultural productivity, with widespread crop failure and food shortages, exacerbated by a lack of stored food. In our model, we predict that these droughts would have been most acute if El Niños were widely spaced in time, or were the first in a series of closely-spaced events. Otherwise people would have adapted to predictable drought by increasing food storage capacity (including the use of domestic animals as storage units), developing trade relationships, moving cultivation to higher rainfall zones and/or selecting domestic plants and animals with greater drought tolerance. As El Niño does not appear to have significant impact on marine resources, we might also see a shift to those resources as a buffer. These adaptations should be visible archaeologically, and we plan to investigate these in the future.

Drought effects food production, but it can also impact drinking water supplies. Water is in short supply in the limestone karst area of Tutuala, in the Lautem district. Current residents of Tutuala village must walk several kilometers down to a reliable water supply, for example. Water sources are few and well-known, and underground sources that can be tapped with wells are rare. We mapped those in the Tutuala area to see if the fortified sites were associated with them, but there was no clear association. In the oral traditions, water sources were rarely "owned" by one clan, but usually have shared ownership, suggesting cooperative use of limited water. The stories also often associate with stories of immigration from the low limestone islands to the north like Leti.

In the extremely dry north coast of East Timor, it is only viable to grow *padi* or wet rice in areas that are close enough to permanent rivers to use irrigation. Rivers used for irrigation therefore distort the effective precipitation distribution by making water captured from the wet highlands available in the dry lowlands, but only in areas quite close to the river basin. The lower Laclo River valley, which empties into the sea near Manatuto, is one such area. Manatuto, while receiving less average annual precipitation than Tutuala, has a more reliable water supply. The Laclo River flows permanently, and even in the driest years when flow ceases in some of its tributaries, the geological formations in Manatuto are amenable to accessing subsurface aquifers. This distortion effect is complicated. If mapped, we would place the "effective" rainfall clines very close together along the river edges determined largely by local topographic relief, which affects people's abilities to construct irrigation channels and irrigate agricultural fields. Therefore, the overall effect of negative rainfall anomalies

in this riverine system would be to increase the desirability of lands close enough to the river to be useful for irrigated gardening. Land even just a few hundred meters away from the river may be totally unproductive if it is too difficult to irrigate.

#### *Precipitation pattern and seasonality in East Timor*

Average annual precipitation is not evenly distributed across East Timor. Rainfall varies by primarily by elevation, with higher elevations generally receiving more precipitation (Figure 2). Monsoon patterns also affect the distribution of rainfall, causing the south to be generally wetter than the north (Durand 2002). This uneven distribution of precipitation is the major cause (along with temperature, geomorphology, soil chemistry and other factors) of East Timor's ecologically diverse landscape. In some areas, precipitation clines are closely spaced, with different niches in close proximity to each other. The eastern part of the Lautem district is one such area. While short term droughts would affect agricultural viability in every cline, humans may have been able to quickly adapt to lower rainfall by shifting cultivation to wetter areas to the south or in higher elevations by moving relatively short distances. In other words, the same agricultural methods would still work by moving to nearby areas, "following the rain" up or down slope. Wild plant and animal resources would also presumably be available in different zones depending on average rainfall, and animals may have also simply moved

to different areas to find habitats for which they were best adapted. In general, the proximity of several different rainfall zones in eastern Lautem would have made it an attractive place for farmers during unpredictable climates compared with ecologically homogenous landscapes such as the island of Leti to the north, or areas on the north coast to the west of Lautem. In these areas, rainfall clines are more widely spaced, which means that people in search of wetter areas in times of drought would have to travel further. The ecological diversity of these areas of closely spaced rainfall clines may have also attracted immigrants, raiders and traders looking for more productive agricultural land or agricultural products.

#### *Past ENSO and drought in East Timor*

In recent years, data about late Holocene climate changes in the Pacific have become available in more geographical areas and at an increasing variety of time scales (e.g. Moseley 1997; Moy, *et al.* 2002a; Salinger, *et al.* 1995). While this period in Island Southeast Asia has still seen relatively little attention from palaeoclimatologists, researchers are beginning to outline broad climate patterns for the region (Haberle 2000; Haberle, *et al.* 2001; Hope 2001). For the post 1000 AD era, ENSO-related climate patterns appear to be a dominant environmental force in Island Southeast Asia (Gagan, *et al.* 2004).

ENSO is a highly complex phenomenon with global effects. In the recent past for which instrument data are

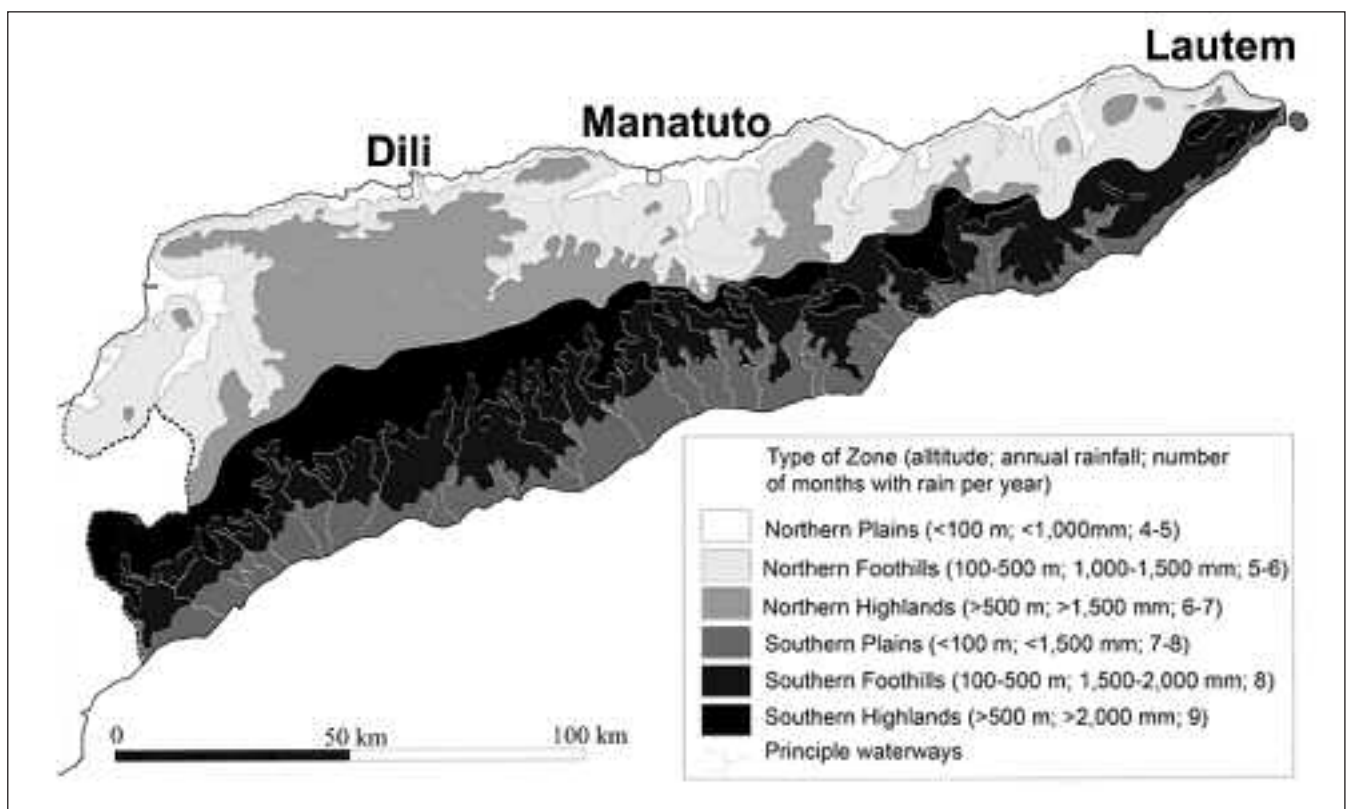


Figure 2. Precipitation in Dili, average vs. 1997-98 El Niño, showing lower average precipitation during dry season and delayed onset of rainy season, adapted from Ministry of Forestry, Agriculture and Fisheries, Timor Leste ([http://www.timor-leste.gov.tl/MAFF/English/climate\\_and\\_hydrology.htm](http://www.timor-leste.gov.tl/MAFF/English/climate_and_hydrology.htm))

available, ENSO warm phases, or El Niños, are associated with decreased rainfall on the order of 40–60% and slightly decreased Sea Surface Temperatures (SST) in much of Island Southeast Asia (M.S. Allen 2006; Field 2005; Folland 2002; Gagan *et al.* 2004). For example, the strong El Niño of 1997–98 caused major droughts throughout much of Island Southeast Asia, which exacerbated anthropogenic burning to cause widespread, uncontrolled forest fires (Terry, *et al.* 2001). ENSO induced SST variation is relatively low in Island Southeast Asia due to the moderating influence of the Indo-Pacific Warm Pool (IPWP). Strong El Niños during the recent past have been associated with relatively minor SST anomalies in the range of 0.5 degrees in Island Southeast Asia. This suggests that, unlike in west coast of the Americas, ENSO in Island Southeast Asia is primarily a terrestrial phenomenon, and its impact on marine ecosystems comes from erosion and runoff effects in nearshore ecosystems rather than SST anomalies.

Preliminary data suggests that increased interaction with the Pacific Intertropical Convergence Zone (ITCZ) in the mid Holocene enhanced ENSO and established modern periodicity at about 5000 BP (Gagan *et al.* 2004). However, the long term history of ENSO in Island Southeast Asia is still under investigation and we cannot assume that recent patterns held true throughout the post 1000 AD period. In this paper we rely on evidence for ENSO frequency and intensity from other regions and assume straightforward and stable teleconnections to local Island Southeast Asian conditions and stable geographical patterning. With regard to this geographical patterning, Island Southeast Asia appears to be in the center of a zone of negative precipitation anomalies during recent El Niño events, and therefore may be less susceptible to minor spatial shifts in the phenomenon (in contrast to the central Pacific, where even more caution is advised). With regard to chronology, high resolution records are now available for South America that can pinpoint the timing and relative strength of ENSO events in the Holocene and earlier with some certainty (Moy, *et al.* 2002a, 2002b). These data show a dramatic increase in El Niño events well above modern levels from 1100–1600 AD, with a peak from 1300–1400 AD.

Paleoclimate data typically does not have season-level resolution. However, because recent ENSO warm phase events have proceeded in a predictable manner over the course of a calendar year, we can predict different effects depending on the seasonality of normal rainfall patterns. For example, in East Timor which is affected by the Southeast Asian monsoon, most rain falls in the months of November–March, with very limited rain during other periods (Durand 2002). People have adapted to this pattern in farming practices, scheduling burning towards the end of the dry season in September–November, and planting as soon as the first rains begin, usually late November–December. In contrast, other parts of Island Southeast Asia have the heaviest rain during the June–August monsoon, or in some cases they may have two equal rainy seasons per year. El Niño events are strongest during December–

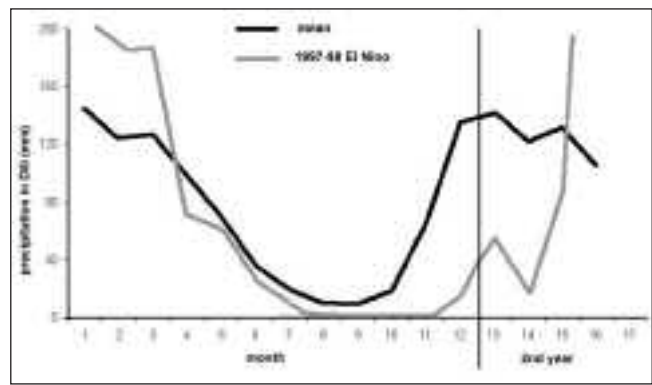


Figure 3. Climate zones in East Timor, adapted from Durand (2002).

February, which coincides with what are normally the highest rainfall months in Timor. Thus Timor will experience a greater impact on total annual rainfall during El Niño events compared with places which get the bulk of their rain in June–August, when El Niño impact on precipitation is typically much weaker. The overall effect of El Niño in East Timor is that the dry season is extended and rainy season shortened (Figure 3).

Fox and Soares (2000) illustrated in detail the effects of this change in precipitation amount and timing during the 1997–98 El Niño on farmers’ decision making in the eastern Lesser Sunda islands, including East Timor. These islands were more affected by the 1997–98 El Niño than other parts of Indonesia because of the prevalence of single-crop corn (maize) farmers who are dependant on rains in December and January. Farmers in the coastal regions of the eastern Lesser Sundas lost roughly 50% of their corn crop during this El Niño (Fox and Soares 2000:181). The study found that farmers had sufficient seed reserves for no more than two attempts at planting, as increasing seed reserves came at the expense of food reserves. Although corn did not exist in East Timor and any other places in Southeast Asia before the European contact in the early 16th century, the unpredictability of precipitation timing and stability during El Niño events may have had similar catastrophic impacts on other crops with similar scheduling regimes.

#### *Fortified sites in the Lautem district*

The stone structures near the villages of Tutuala and Ira Ara in the Lautem district play an important role in contemporary cultural practice as sacred places, sites of clan histories and places of other kinds of social memory (Lape 2006). They are considered to be old village sites (*lata irinu* in the regional Fataluku language) by local residents (McWilliam 2002, 2003; Pannell and O’Connor 2005). The remains of fortified settlements vary somewhat in form, but generally they consist of dry-stacked limestone rock walls from 1.5–4 m in height, and 1–3 m in width at their base enclosing areas of 500–3000+ m<sup>2</sup>. The sites are located on hilltops or cliff edges. In the latter case, walls tend not to extend along the cliff edge suggesting that the steep drop off served a defensive purpose. Stone features (e.g. platforms

and lower walls) are found enclosed within these outer walls. The exterior walls have an opening or doorway, and in some cases the entrance is walled for several metres to form a narrow twisting hallway. Many of these sites also contain sacred wood or stone markers (*sikua* or *saka* in Fataluku). These markers, along with stone platforms (*chaluluturu*, Fataluku for “ancestral grave”), are a focus of contemporary ritual practice (see also McWilliam 1991, 2001, 2002, 2003; Pannell 2004; Pannell and O’Connor 2005).

We have identified most of the fortified sites existing on the landscape in the surveyed areas marked in Figure 4. These include eighteen fortified sites in the Tutuala area and two in the Ira Ara area. Thousands of years of swidden burning and farming in this steeply sloping region, as well as occupation activities themselves, have contributed to sediment disturbance and erosion. This has had implications for dating occupation periods (discussed in detail in Lape 2006). A fortified site in the village of Ira Ara proved to have deeper deposits with intact stratigraphy when excavated in 2005. Dates obtained for the Tutuala sites range from 2300 BC–1920 AD, although as discussed in Lape 2006, these sites were likely fortified in the 15th–19th centuries AD. The Ira Ara site is more securely dated to the 15th–19th centuries AD (Table 1).

Pottery and faunal assemblages recovered from test excavations are similar to those recovered from Neolithic occupation sites in caves in the area, such as at Lene Hara and in open sites, such as Tutunchau. These include fragmented undecorated earthenware pottery, marine shell, and animal bone. The presence of food remains and utilitarian pottery in these assemblages suggest that these

sites were domestic spaces with long term occupation, and not just military redoubts or short term refuges, although this is subject to further testing and analysis. Oral traditions in Tutuala and Ira Ara also support the view that these sites were fortified villages which were continuously occupied (until the population moved to the next place). People in Tutuala and other parts of East Timor remember a time of *perang saudara* or *perang ratu* (Indonesian), literally “brotherly war” or “clan war”, which predated Portuguese colonial administration. Headhunting and slave raiding themes are also common in clan histories stories, echoing a long tradition of headhunting in Southeast Asia (Hoskins 1996). Additionally, many place names, clan names and histories suggest migration from other places. These names (such as *Leti*, *Oirata*, *Malei*, and even *China*) can be traced to nearby and distant islands. In some cases, familial and economic ties were maintained with these places until quite recently (Josselin de Jong 1937).

While documentary history about the Tutuala area is restricted to the 20th century, other parts of Timor were described by the first chroniclers as having a large number of small polities, based in the interior mountains and perpetually at war with each other (Pigafetta 1969; Pires and Rodrigues 1944; Prapañca and Robson 1995; Ptak 1998; Reid 1985, 1988; Wallace [1869] 1986), a feature of other places in pre-colonial Island Southeast Asia as well (Junker 1999; Lape 2000b, 2000c). By the middle of the 20th century, the use of most indigenous fortified villages had changed significantly from places of permanent occupation to irregular use for ceremonial activities and for strategic military sites in the 25-year long resistance by East

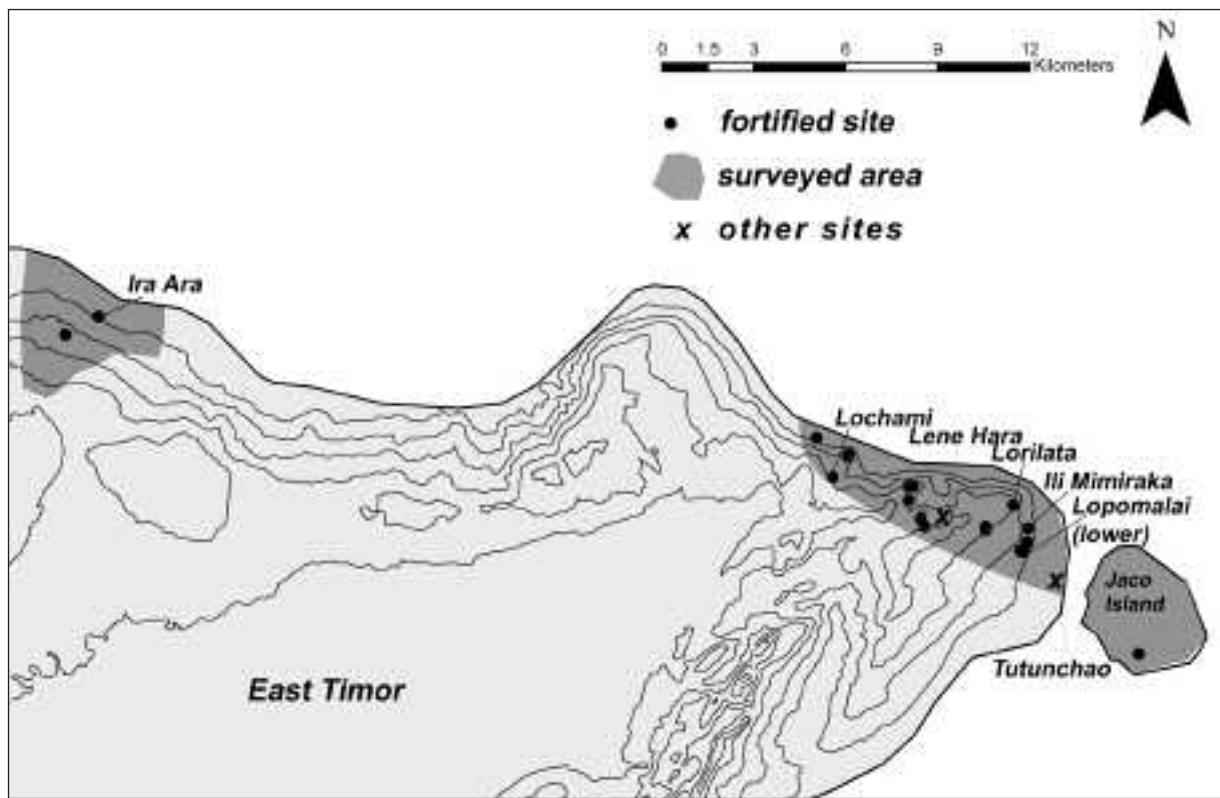


Figure 4. Lautem area sites.

site name	unit	depth below surface (cm)	sample material	lab number	method	uncalibrated age (BP)	calibrated date*
Ira Ara	2	burial 1	marine shell	Beta-214263	AMS	600 +/- 40	AD 1650-1810
Ira Ara	2	burial 1	charcoal	Beta-214264	AMS	80 +/- 40	AD 1680-1740
							AD 1800-1930
							AD 1950-1960
Ira Ara	3	burial 2	human bone	Beta-214265	AMS	360 +/- 50	AD 1440-1650
Ira Ara	3	burial 2	charcoal	Beta-214266	AMS	310 +/- 40	AD 1470-1660
Lekpaturen	2004 TP1 L5	55-72	charcoal	Beta-196470	AMS	310+/-40	AD 1460-1660
Lekpaturen	2005 TP03 F1	65-66	charcoal	NTU-4533	C14	<200	AD 1800-1950
Lekpaturen	2005 TP03 L7	120-124	charcoal	NTU-4475	C14	300+/-55	AD 1452-1668
Lekpaturen	2005 TP02 L5	120-124	charcoal	NTU-4546	C14	1290+/-60	AD 649-878
Malarahun	TP2	70-80	charcoal	NTU-4674	C14	410+/-60	AD 1420-1530
Lama #4							AD 1540-1640
Bukit Aiteas	TP1	115-125	charcoal	NTU-4669	C14	410+/-40	AD 1430-1520
							AD 1560-1630
Bukit Aiteas	TP1	125-135	marine shell**	NTU-4729	C14	1310± 40 BP	AD 1015-1202
Bukit Aiteas	TP1	135-145	charcoal	NTU-4656	C14	780± 55 BP	AD 1150-1300

Table 1. Radiocarbon dates of fortified sites (see Lape 2006 for additional dates for Lautem area sites).

\*Calibration for radiocarbon dates to 2-sigma calculated using INTCAL 98 (Stuiver 1998)

\*\**Terebralia sulcata*, marine reservoir correction not applied

Timorese to Indonesian annexation (Pannell and O'Connor in press).

#### Fortified sites in the Manatuto district

From 2004 to 2006, we conducted a survey and excavated a series of test pits in the Manatuto area on the north coast of

East Timor. The survey area, about 40 km<sup>2</sup>, covers the lower floodplain of the Laclo River and the Lamessana lagoon to the east (Figure 5). In general, the lowlands in this triangle-shape area are flooded annually, and it is bordered by at least two steps of marine terraces and adjacent mountains up to 500–800 meters in elevation. We attempted full-coverage

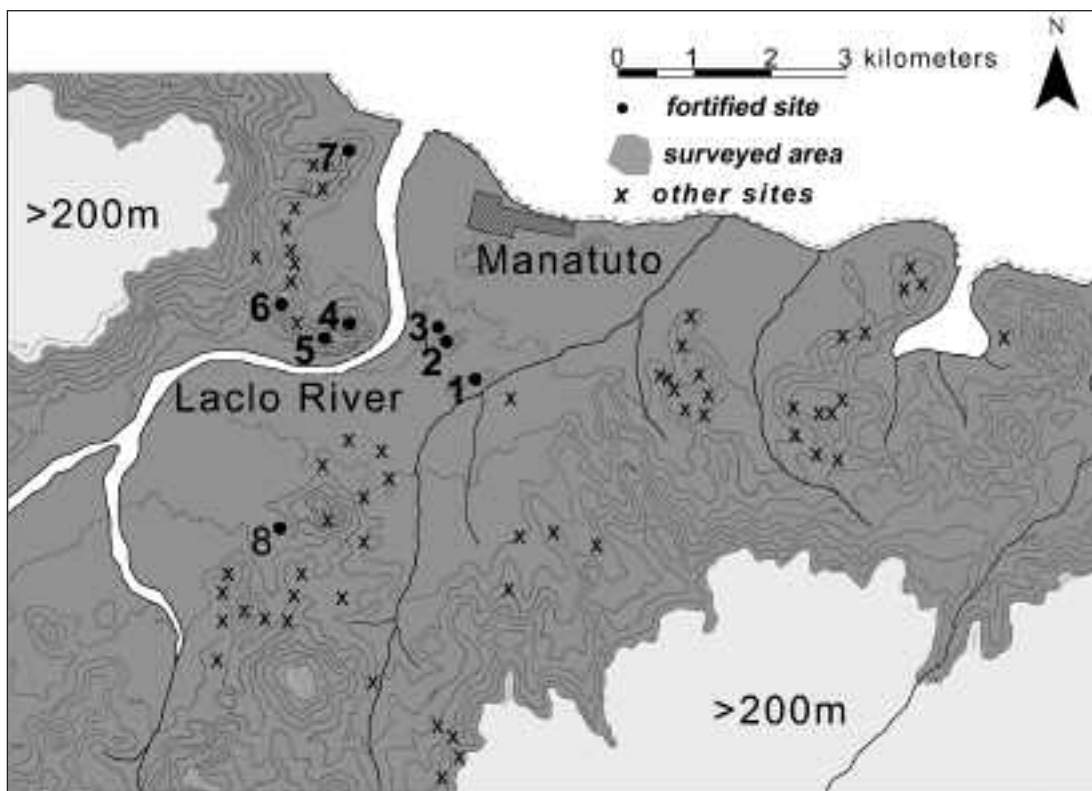


Figure 5. Manatuto area sites. Fortified sites include: 1) Lekpaturen, 2) Soraha, 3) Soraha Barat, 4) Bukit Aiteas, 5) Malarahun Lama #1, 6) Malarahun Lama #4, 7) Hataro #5, 8) Luri.

Site	Period I AD 1400-1550		Period II AD 1550-1650		Period III AD 1650-1725		Period IV AD 1725-1850		Period V post AD 1850	
	count	%	count	%	count	%	count	%	count	%
Lekpaturen	5	4	91	79	17	15			2	2
Soraha	1	3	19	66	7	24	2	7		
Soraha Barat	1	10	9	90						
Bukit Aiteas			9	53	8	47				
Malarahun Lama #1	5	26	11	58	2	11	1	5		
Malarahun Lama #4			13	87	2	13				
Hataro #5			11	100						
Luri			13	29	19	65	3	6		
Total (identified sherds)	12	5	176	70	55	22	6	2	2	1

Table 2. Asian tradeware seriation from Manatuto area fortified sites, all samples from surface collections. Number (%).

survey except where there was no surface archaeological visibility, such as in the rice paddies where we only surveyed on the dikes and uncultivated edge areas near the villages and foothills. In the less vegetated terraces, random walkovers covered most of survey area. Our three-season survey has identified 60 sites and at least 22 isolated finds. Eight of these sites are located on hilltops with substantial walling and terracing and have been dated to the 11th to early 18th century AD based on radiocarbon dates and Asian tradeware seriation (Tables 1 and 2) (Chao in press).

The eight fortified hilltop sites all have restricted access and far-reaching views overlooking the Laclo River mouth and lowland plains. The sizes of these sites vary from 100 to 200 metres in length and they have similar layouts. In the center of the site, there often is an oval or rectangle-shaped raised platform of varying heights, which has rock-piled features on the corners. In some cases, these platforms are the focus of contemporary ritual practice, such as sacrificial rites before planting and after harvest. Surrounding the platform, several levels of terraces are divided by lines of low rock-piled walls and/or dry-stacked walls of 1–2 metres in height. In most cases, walls extend to the cliff edge and the steep drop-off or slopes in all directions would have served a natural defensive function. Examples include the Bukit Aiteas, Malarahu Lama #1 and #4 sites, which may cluster into one large site connected through the path on the hilltop ridge.

Four hilltop sites were excavated: Lekpaturen, Malarahun Lama #4, Bukit Aiteas and Soraha. Soraha lacked stratigraphic integrity, so we did not date any samples. Other sites had sufficient stratigraphic integrity and produced good radiocarbon sequences, supported by stylistic dates on imported tradeware. Radiocarbon dates on charcoal samples from Lekpaturen and Malarahun Lama #4 indicate that these sites were likely first occupied between 1450 AD and 1650 AD. The earlier date of 650–880 AD at Lekpaturen is probably anomalous as the sample was recovered from a layer containing post-1550 AD tradeware. Bukit Aiteas dates indicate an initial occupation as early as 1150–1300 AD (Table 1). As with the Tutuala and Ira Ara dates, they fall in an unfortunate area of the radiocarbon calibration

curve and return uncertainties that can span two centuries. In addition, this precision is enhanced for the Manatuto area sites by Asian tradeware ceramics found in pottery assemblages (tradeware was not present in the Tutuala and Ira Ara sites). On the basis of the 5-phase chronology from surface collected tradeware samples (Table 2), the hilltop sites were in Manatuto mostly occupied from mid 16th to early 18th century AD, while as suggested by the excavated radiocarbon samples, some sites would have been occupied somewhat earlier, before tradeware was widely exchanged in Island Southeast Asia. These dates fall within the radiocarbon chronology and represent a refinement of that chronology, with the normal caveats associated with stylistic dating.

It should be noted that the survey area has been continuously inhabited for at least three millennia, but these hilltop sites are the only places that people chose to live on by the 16th and 17th centuries AD, while the numerous earlier sites that we have found on the terraces and floodplain were abandoned during this period. Many of these earlier sites also lie further from the Laclo river basin (Figure 5). While some of these areas are now connected to the extensive modern irrigation system, others (such as the Lamessana Lagoon area) cannot be irrigated without mechanical pumps.

#### *Testing our model*

Our model predicts that fortifications would appear on a landscape under three conditions: 1) where resources are spatially constrained; 2) when they are temporally unpredictable; and 3) in relatively resource rich (buffered) areas that are next to relatively resource poor areas. The record of fortifications on the landscapes of Tutuala, Ira Ara and on the lower Laclo River in Manatuto meets these conditions. a) All three areas were largely dependant on agriculture for subsistence. b) In all three areas, fortifications appear on the landscape primarily between 1150–1550 AD. This corresponds closely to the 1100 to 1600 AD period when El Niño frequency increased above earlier periods. However, the fortification building peak of 1450–1650 comes somewhat later than the El Niño event



frequency peak in 1300–1400 AD. c) Fortifications in these three areas are situated in or near areas that would have had relatively viable agriculture (through rainfall or irrigation) even during extended droughts, and are adjacent to areas that lack drought-tolerant agricultural potential.

This final condition requires some additional discussion. In Tutuala, irrigation is impossible and past agriculture must have been swidden, as it is today. While swiddening assumes mobility (fields are currently fallowed after 3–5 years of use), this mobility is currently constrained by clan-level land ownership systems that limits movement within defined territories. We must assume that people in the past would have also been limited in their ability to find new viable agricultural lands far from their home base for our data to fit our model. Those clans whose territories included multiple rainfall zones or clines would have had an advantage over those who did not during periods of decreasing and unpredictable rainfall. Jaco Island, which falls entirely within one rainfall cline and has no groundwater, had only one fortified site, a much lower density than that recorded in the mainland Tutuala area. In the Ira Ara area, rainfall clines are spaced further apart and fortification density is lower than in Tutuala. However, the Ira Ara site itself is directly adjacent to a spring (*ira ara* means “water source” in Fataluku), which probably allowed for limited irrigation in the slopes below to the sea in the past as it does now. In the Manatuto area, pre-12th century sites are located across the entire survey area. During later periods, when we see evidence of decreasing and unpredictable rainfall, only areas on hilltops very close to the Lacleo River have sites, and these sites are all fortified. We interpret this pattern as evidence that people preferentially settled and fortified hilltops directly adjacent to these viable areas during these times, in defense against those who live in more distant regions who were suffering food shortages.

Some of the data does not obviously fit the model. There are several pre-1000 AD dates from fortified settlements in both Manatuto (explained above) and Lautem (Lape 2006). Given the over 35,000 year occupation history of East Timor, it is possible that these early dates represent pre-fortification use of these hilltop or cliff edge sites. A more problematic disjunction between the model and the data is that the majority of the dates for the fortified sites cluster around the 1450–1650 AD period, which is later than the El Niño frequency peak of 1300–1400 AD. As suggested above, these later sites may have been built as a result of social forces indirectly related to resource shortages, and may have instead been the adaptation to a system that had already begun to be fortified several hundred years earlier. The large radiocarbon uncertainty may also explain this apparent discrepancy. Despite this possible temporal disjunction between resources and fortifications, our spatial data still suggest that fortifications were built preferentially in areas containing drought resistant resources.

### Conclusions

In summary, the evidence presented here suggests that fortification building was associated with decreasing and

unpredictable rainfall in time, and in areas of drought tolerance next to areas lacking tolerance in space. We plan to further refine and test this model in the near future, both in East Timor and other areas. The present case study would be improved by a) refining the construction and occupation chronology for the fortifications through additional survey and excavation; b) further testing of the model by surveying in other areas with a variety of real or effective precipitation clinal densities; and c) collecting local palaeoclimatic proxy records to supplement global records. Further improvements would come from a better understanding of past agricultural crops and practices and of the use of marine resources as potential buffers during droughts in East Timor. We also have only an outline of past regional interactions and the frequency of trading and raiding in the region. While currently lacking, all of this data should be obtainable in the East Timor archaeological and paleoclimate record.

More broadly, this model could be applied to a variety of situations globally. Cases where rainfall limited agricultural production and where ENSO systems affected rainfall would be good candidates for comparative study, such as the western Pacific or the Colorado Plateau region of North America. Areas with other types of spatially constrained resources that might have significantly varied over time, such as the Pacific Northwest of North America reliant on salmon, might also be candidates for application of this model. Ultimately, we hope the approach we have detailed in this paper can be used to move beyond simple deterministic interpretations of past landscape use and begin to resolve the complex factors that influence human social decisions.

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