From 'collapse' to urban diaspora: the transformation of low-density, dispersed agrarian urbanism

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In the tropical regions of southern Asia, Southeast Asia and the southern Maya lowlands, the management of water was crucial to the maintenance of political power and the distribution of communities in the landscape. Between the ninth and sixteenth centuries AD, however, this diverse range of medieval socio-political systems were destabilised by climatic change. Comparative study reveals that despite their diversity, the outcome for each society was the same: the breakdown of low-density urban centres in favour of compact communities in peripheral regions. The result of this, an 'urban diaspora', highlights the relationship between the control of water and power, but also reveals that the collapse of urban centres was a political phenomenon with society-wide repercussions.

Keywords: Angkor, Anuradhapura, South Asia, Maya lowlands, tropics, water management, low-density urbanism, climate instability

Past agrarian-based, low-density urban tropical societies in the western and eastern hemispheres faced significant climatic challenges. These included: distinct wet and dry seasons; tropical storms or monsoons with torrential downpours; hurricanes or typhoons; variable water quality; prolonged droughts; and rainfall-dependency. In southern Asia, Southeast Asia and the southern Maya lowlands (south-east Mexico, Belize and northern Guatemala) between the ninth and sixteenth centuries AD, the primary, low-density urban centres broke down. This process was largely triggered by long periods of climate instability, defined here as the magnitude of seasonal weather pattern changes that persistently interfered with the food and water supplies necessary to support growing populations and infrastructure systems. Particularly critical was the impact of this instability on large-scale water management, which formed one of the key foundations of political power by providing the means to integrate dispersed subjects. Political dynasties fell or transformed, with some relocating to adjacent regions, while the farmers who supported those dynasties endured, retaining sustainable agricultural practices, albeit reconfigured across the landscape. The low-density dispersed urban landscape faded away and the urban world re-created itself in a more compact form in new locations and regions along the peripheries. This movement across

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the landscape we term *urban diaspora,* when people abandon not only the urban centres but much of the metropolitan heartland and move to peripheral areas where different kinds of networks and economic and political foci emerge.

Pre-industrial, agrarian-based, low-density urban societies in tropical settings were situated between the centripetal pull of political centres and the centrifugal forces of agricultural demands. We illustrate here how water management, political infrastructure, sustainable agricultural practices and climate change were implicated in the urban diaspora of three tropical societies. In each region, despite differences in politics, social organisation, water control and economic basis, the consistent outcome was a move to the regional periphery, indicating that a broad operational process was involved (see Fletcher 2002, 2004, 2010). One of our key points is that while socio-political systems varied, it was the impact of climate change on the infrastructure that generated destabilisation; this played out in a variety of ways in different social systems. Urban diaspora was not a post-collapse state of being but rather a behavioural adjustment to long-term climate instability by low-density urban societies.

Low-density urbanism in the tropics

Tropical areas are notable not only for their seasonal vagaries, but also for their dispersed and varied biodiversity that is mirrored in settlement patterns and people's reliance on a mosaic of adaptive strategies (Fletcher 2009, 2012; Scarborough & Burnside 2010). People increasingly transformed the landscape, especially through small-scale hydraulic and agricultural features, without much political interference (Hawken 2007; Scarborough & Lucero 2010; Gilliland *et al.* 2013). Farmers worked together to build and maintain subsistence features (e.g. Lansing 1991, 2006; McIntosh 2005). Political hierarchies emerged in developing urban cores for other reasons, in exchange for tribute—supplying capital, protection and organising the infrastructure that provided water for drinking and agriculture and controlled flooding (Coningham 1999; Lucero 2006; Coningham *et al.* 2007; Fletcher *et al.* 2008). Cities came to integrate thousands of people socially and politically, and they provided places for markets, exchange and religious institutions, and for elites to display their wealth and power (Lucero 2003, 2007; Coningham & Gunawardhana 2013). While people, ideas, goods and information flowed in and out of central places, mobility was scheduled around seasonal agricultural regimes.

In low-density cities, agricultural and open land is interwoven with massive urban infrastructure and a dispersed residential population (Graham 1999). The urban-rural population was simultaneously agriculturally based and civically integrated (e.g. Pottier 2000; Fletcher 2012; Isendahl 2012). The rural world was therefore interdigitated and entangled with the urban world through an extensive, varied crop economy based on profitable trees, swidden (slash and burn) agriculture and engineered fields, and an urban-based water management infrastructure. The central areas of low-density cities are centripetal because they draw people in via political, social, economic and religious means. The surrounding areas are centrifugal because people settle across the landscape in farmsteads and villages mirroring the dispersed agricultural and natural resources interspersed with managed forests and grazing land. Farmers relied on flexible subsistence strategies involving local small-scale production and exchange, and water and agricultural systems. The populace supplied staples, local goods, labour and services (e.g. maintaining transportation routes) via tribute and exchange, effectively funding the political economy. People became beholden to a centralised political elite for access to water via central reservoirs during annual drought. In the agricultural (rainy) season, farmers worked their fields throughout the non-urban landscape.

In the southern Maya lowlands, Sri Lanka and mainland Southeast Asia, the agrarian-based dispersed cities varied considerably in size. The largest Maya centres covered around 100–200km^2, while Anuradhapura and Angkor were between about 500 and 1000km^2 in extent. The South Asian examples were also distinct primate cities in their regions, in contrast to the Maya region with its multitude of centres and kings. Rice was the main staple for the Khmer and Sinhalese, while the Maya relied on maize; the Maya also differ in that they did not have metal tools, beasts of burden, major road systems or access to an extensive international maritime trade network. To retain as much consistency of comparison as possible, our study addresses the largest examples in each region: the Khmer capital of Angkor in Cambodia (ninth–sixteenth century), the Sinhalese capital of Anuradhapura in Sri Lanka (fourth century BC–eleventh century AD), and the major Maya capital of Tikal in Guatemala (sixth–tenth century AD) (Figure 1). The central areas of these cities encompassed palaces, temples, causeways, reservoirs, plazas, elite residences and markets, illustrating their role in attracting and integrating rural subjects. About 750 000 people lived dispersed over the 1000km^2 of Greater Angkor between the twelfth and thirteenth centuries (Fletcher *et al.* 2003; Evans *et al.* 2007; Coe 2008). There may have been as many as 250 000 people in and around Anuradhapura (Coningham & Manuel 2009), and perhaps as many as 60 000 in the immediate environs of Tikal (Culbert & Rice 1990).

The focal role of the central areas is illustrated by the capacity of the courtyards of the three great monasteries of Anuradhapura to accommodate 30 000 pilgrims, while their individual stone rice containers could have fed over 1000 monks at each sitting (Coningham & Gunawardhana 2013). In Angkor, the late twelfth-century temple of Ta Prohm had a staff of 12 640 living nearby supported by 66 625 farmers (Kapur & Sahai 2007: 52–56). At Tikal urban plazas could hold over 10 500 people (Inomata 2006: tab. 1), who participated in royal ceremonies and feasts with foodstuffs presumably supplied by subjects and from royal reserves (Masson & Freidel 2012). All three low-density urban societies encompassed immense urban water systems that served as the core for the political economy; this focus is critical in understanding the increasing complexity of engineered landscapes and concomitant political vulnerability. While some factors are unique to the tropics, any political system is vulnerable when intertwined to the extent where changing conditions affecting one link can have major repercussions throughout the system.

Water management in the tropics: seasonal ebb and flow

Water is the essential element of life, hydrating people, watering fields and serving as a vital component in the manufacture of ceramics, plaster, cement and bricks. Controlling water is necessary; accessing it is another matter entirely and depends on several factors including seasonality, amount, intensity and timing. Seasonal rainfall is critical in tropical areas and

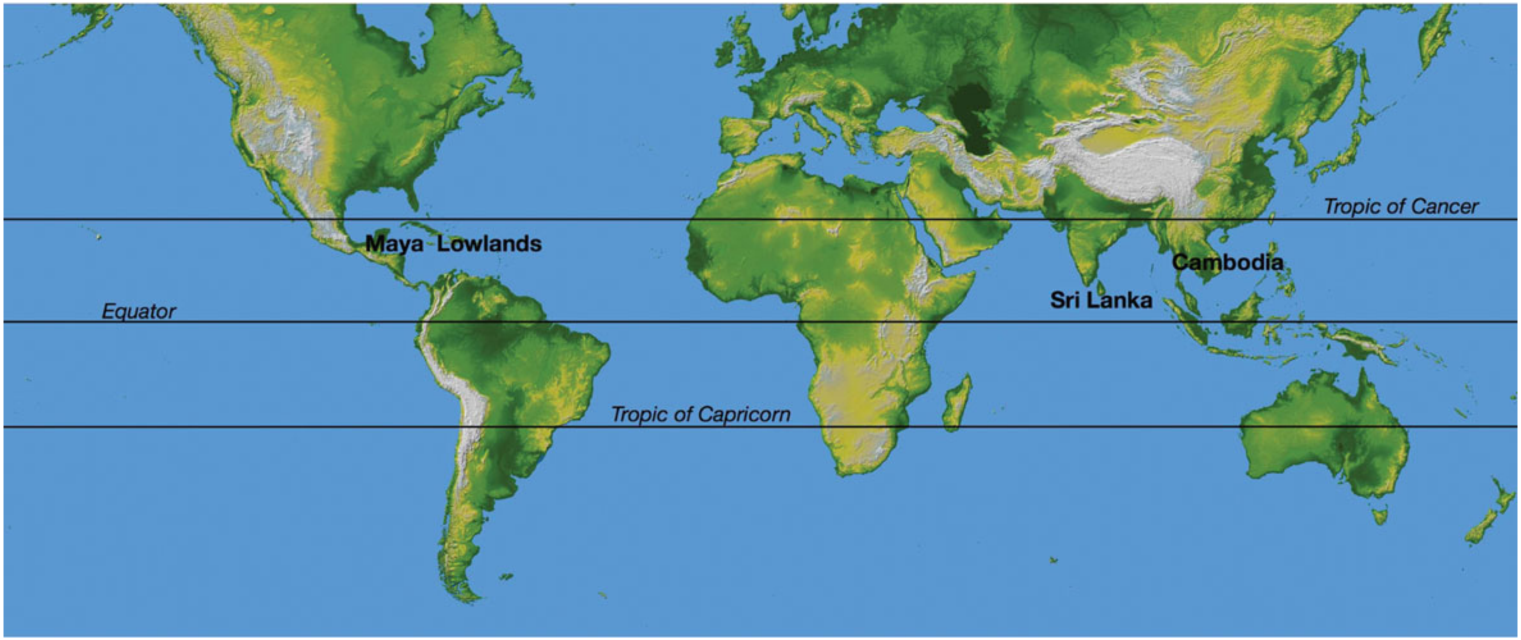

Figure 1. Tropical zone and areas mentioned in text; generated by L.J. Lucero using a map courtesy of NASA/JPL/NIMA; available at: http://photojournal.jpl.nasa.gov/catalog/PIA03395 (accessed 29 April 2015).

affects all aspects of society. In such rainfall-dependent societies, predicting when the rains will begin is crucial for agricultural scheduling and replenishing reservoirs (Scarborough 2003). Humidity and seasonality intensify the threat of agricultural pests and waterborne diseases unless agricultural and water-management strategies are coordinated (Lansing 1991; Miksic 1999). Water thus needs to be contained and distributed in the rainy season, conserved in the dry season and allocated throughout the year. Rulers ensured functioning water systems through varying modes and degrees of control in return for subjects' goods, labour and services. That said, long-term and drastic climate change, which can result in flooding and prolonged droughts, disrupts planning and management, schedules and mobility flows to and from centres (Lucero 2002; Buckley *et al.* 2014).

Rural communities maintained local small-scale water systems, and in due course the populace maintained the state-managed urban ones (Brohier 1934; Leach 1959). Initially, water features required centralised management to engineer and build. Once in place, however, a large labour force replaced technological skill to expand and maintain them (Scarborough & Burnside 2010). Reservoirs supplied water for food production and in the long dry season drew in the dispersed farmers who needed access to potable and distributable water. As water systems increased in scale and complexity, reservoirs and associated channels and roads increasingly affected urban layout and assimilated people. Water features were built next to temples and palaces, but also comprised a part of the cosmological landscape by recreating primordial waters central to their origin stories. This tripartite arrangement literally and figuratively represented the close connection between water, power and cosmology.

Angkor is famous for its sophisticated and massive *baray* (artificial reservoirs), such as the West Baray (16km^2 of water enclosed by over 15 million cubic metres of embankment) located near the central palaces and temples. The Khmer built the two largest *baray* between the ninth and eleventh centuries, measuring approximately 7–8 × 2km and 2–5m deep (Fletcher *et al.* 2008) (Figure 2). They were filled and drained using a complex system of canals that extended for hundreds of kilometres (Evans *et al.* 2013). *Baray* were the central units of a tripartite system that spread water out over the northern part of Angkor, channelled it into *baray* and sent some out of the eastern exit channels into the southern canals (Kummu 2009). The system served two main functions: canals flowing south-south-west to the great lake, Tonle Sap, acted as drains to dispose of water, while canals flowing south-south-east allowed the distribution of water downslope across the richer rice-producing lands near the lake, assisting the growth of the relatively high-yield rice by ensuring the supply of water at the critical start and end of the growing season. As the annual rainfall of 1500mm largely falls between May and October, rice production was especially vulnerable to early and late season vagaries. Supplying water by successively skimming and reloading the *baray* created a risk-management mechanism for ensuring stable crop supplies to cover potential shortfalls of rice for about 100 000 to 200 000 people (Fletcher *et al.* 2003).

Anuradhapura is located in the Dry Zone of Sri Lanka with an annual rainfall from 1300–1450mm between December and February (Figure 3). With a carrying capacity of 0.4 individuals per km^2 and largely seasonal water sources (Coningham 1999), it was necessary to store water during the dry season. The construction of reservoirs near the city started in the fourth century BC. At the same time, independent cascade systems were constructed

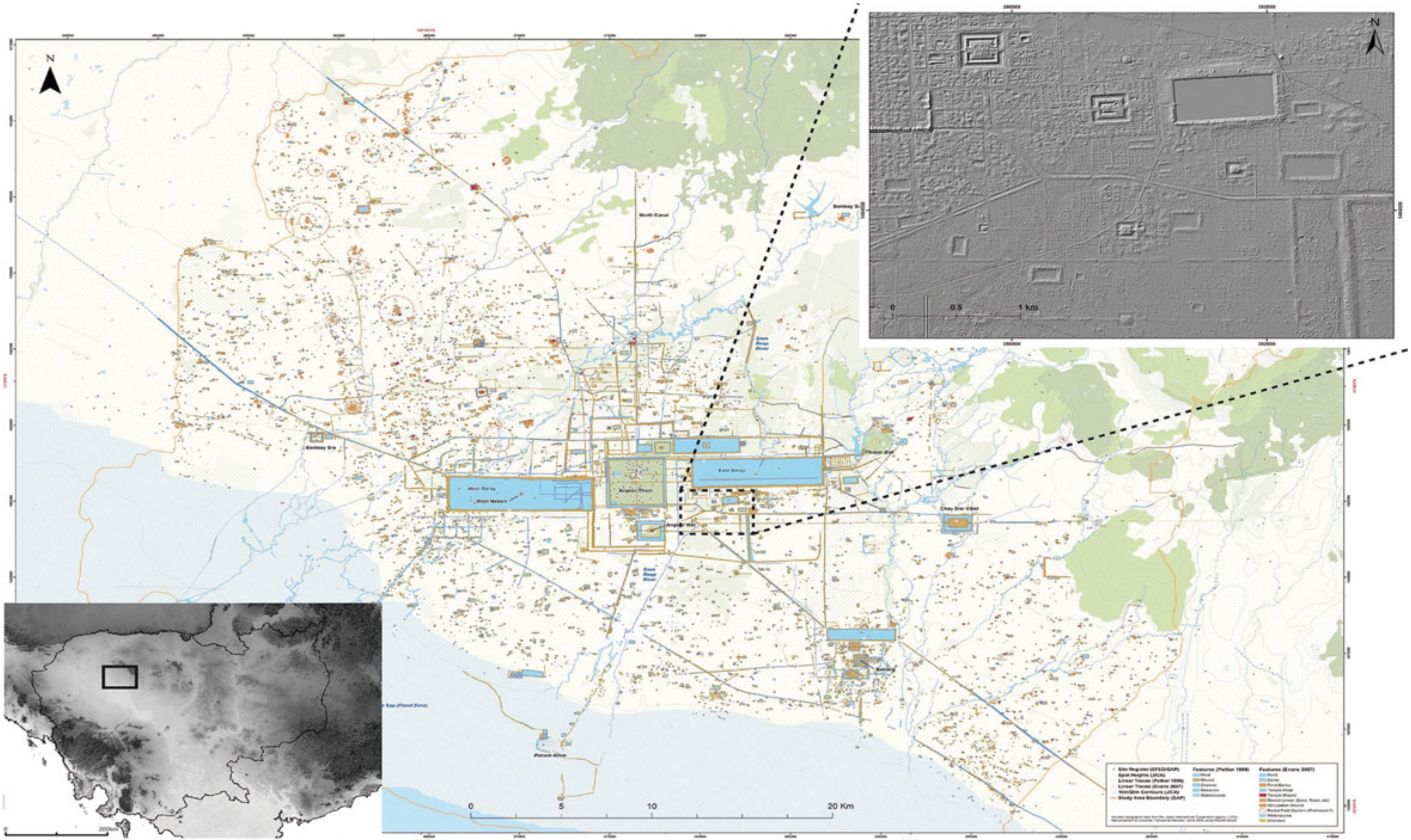

Figure 2. Angkor water systems; the close-up shows temple complexes and moats and reservoirs (rectangular, flat); generated by D. Brotherson; courtesy of APSARA, D. Evans and C. Pottier; LiDAR image courtesy of KALC and NASA Shuttle Radar Topography Mission.

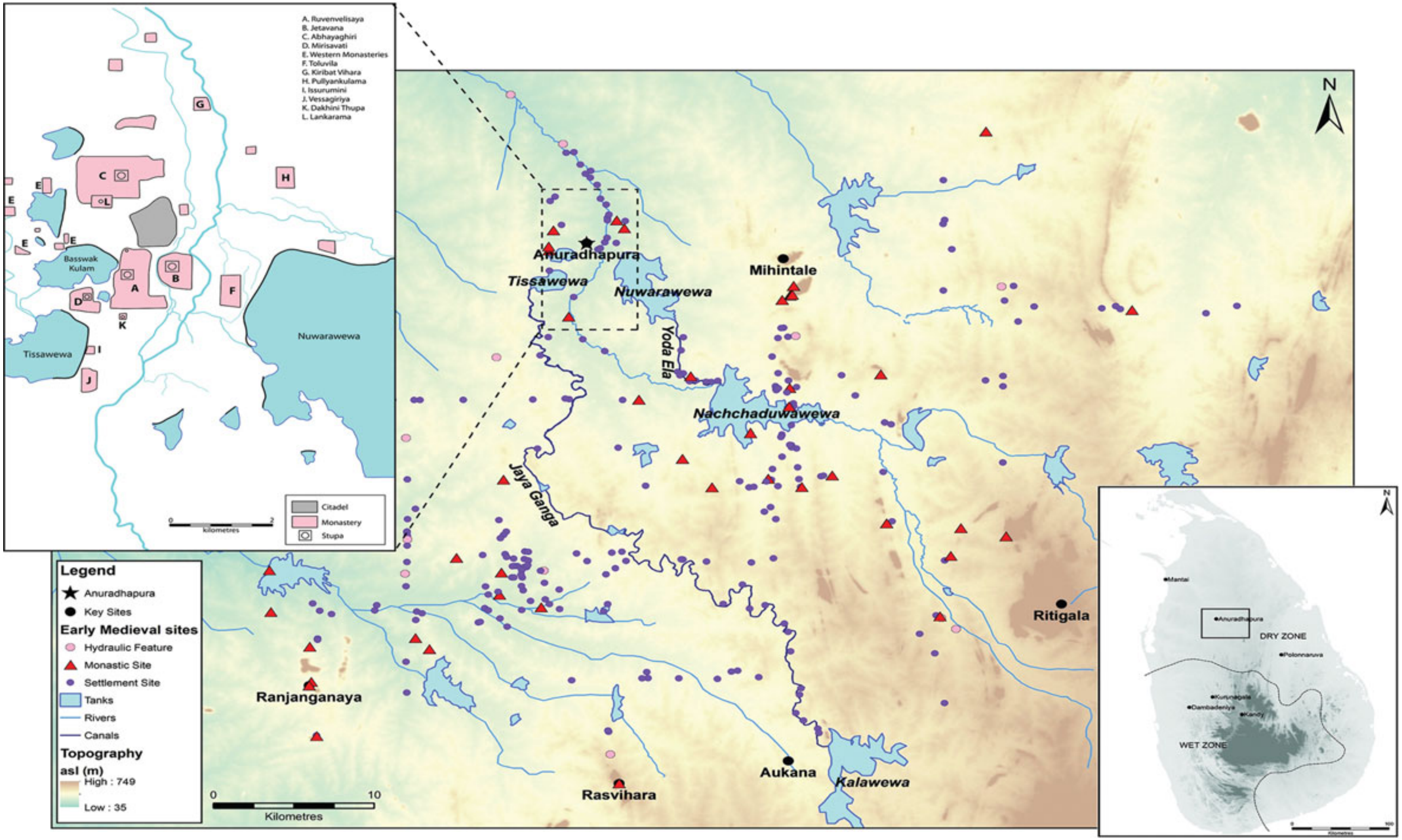

Figure 3. Anuradhapura, Sri Lanka, showing settlement and water systems during the Early Medieval Period; generated by M. Manuel.

in the hinterland (Coningham & Gunawardhana 2013). People relied on irrigated rice as a staple, augmented by kitchen gardens and swidden cultivation known as *chena* (Coningham 2006). As the central area and its ring of Buddhist monasteries expanded, so did the capacity of its reservoirs with the construction of the Tissawewa (5.5km^2) in the third century BC and Nuwarawewa (9km^2) in the first century AD. By the fifth century, increasing demand led to the building of timber and stone annicuts (dams) and the cutting of feeder canals, such as the 87km-long Jaya Ganga and Yoda Ela, which linked major reservoirs to more reliable sources in the hill country via storage reservoirs such as the Kalawewa (25.8km^2) and Nachchaduwawewa (17.8km^2). This arrangement mirrored the social and political hierarchy whereby the upper tiers were maintained and managed by the elites, and individual cascades were maintained by local communities and monasteries.

The most powerful Classic Maya centres in the southern Maya lowlands, such as Tikal and Naranjo in Guatemala and Calakmul in Mexico, are located in areas with some of the best tropical soils for maize agriculture but little or no surface water (Fedick 1996). The rich soils are dispersed in variously sized pockets that correlate with settlement density and political power in a managed forest landscape (Ford & Nigh 2009). There were hundreds of centres, each with their own king; the degree of power and number of subjects varied dramatically and was based largely on the amount and distribution of fertile agricultural soils, means of water containment and access to trade routes (Lucero 2006). Annual rainfall varies regionally and ranges from 1350–3700mm between July and December. Much of this is absorbed by the permeable karst landscape, making its capture and storage essential (Scarborough 1993). The Maya began constructing reservoirs *c.* 100 BC with passive or concave micro-watershed systems where water was diverted by gravity downslope and stored, as seen at El Mirador and Nakbe in Guatemala (Scarborough & Gallopin 1991). The Maya abandoned these centres by AD 150, probably as a result of silting problems, forest mismanagement and climate instability. Between *c.* AD 550 and 850, the Maya engineered large-scale water systems—convex micro-watershed systems built upslope on hilltops and ridges that comprised reservoirs, dams and channels. Excavations of reservoirs at Tikal also show that the Maya used sluices, filtration systems and switching stations (Scarborough *et al.* 2012) (Figure 4). Water features were distributed across the urban layout. Processional roadways (*sacbeob*) connected religious or residential compounds and also served as dams and diversionary devices. There were also terraces, as seen at the regional capital of Caracol, where soils are less fertile (Chase *et al.* 2011).

Maintaining water quality is a necessary but challenging feat in the humid tropics where standing water provides prime conditions for the build-up of noxious elements (e.g. nitrogen) and the proliferation of water-borne parasites and diseases (e.g. hepatic schistosomiasis, cholera and so on) (Burton *et al.* 1979). The Maya maintained water quality by selecting certain hydrophytic and macrophytic plants to transform artificial reservoirs into constructed wetland biospheres (Lucero *et al.* 2011). The presence of *Nymphaea ampla* indicates clean water. This sensitive water lily proliferates on reservoir surfaces and was common in royal iconography and inscriptions, signifying the close relationship between kingship and water management (Lucero 1999). A similar situation existed in South Asia where the lotus (*Nelumbo nucifera*) symbolised creativity and represented the potential of all beings to rise above suffering and embrace purity (McArthur 2002). As long as kings provided potable

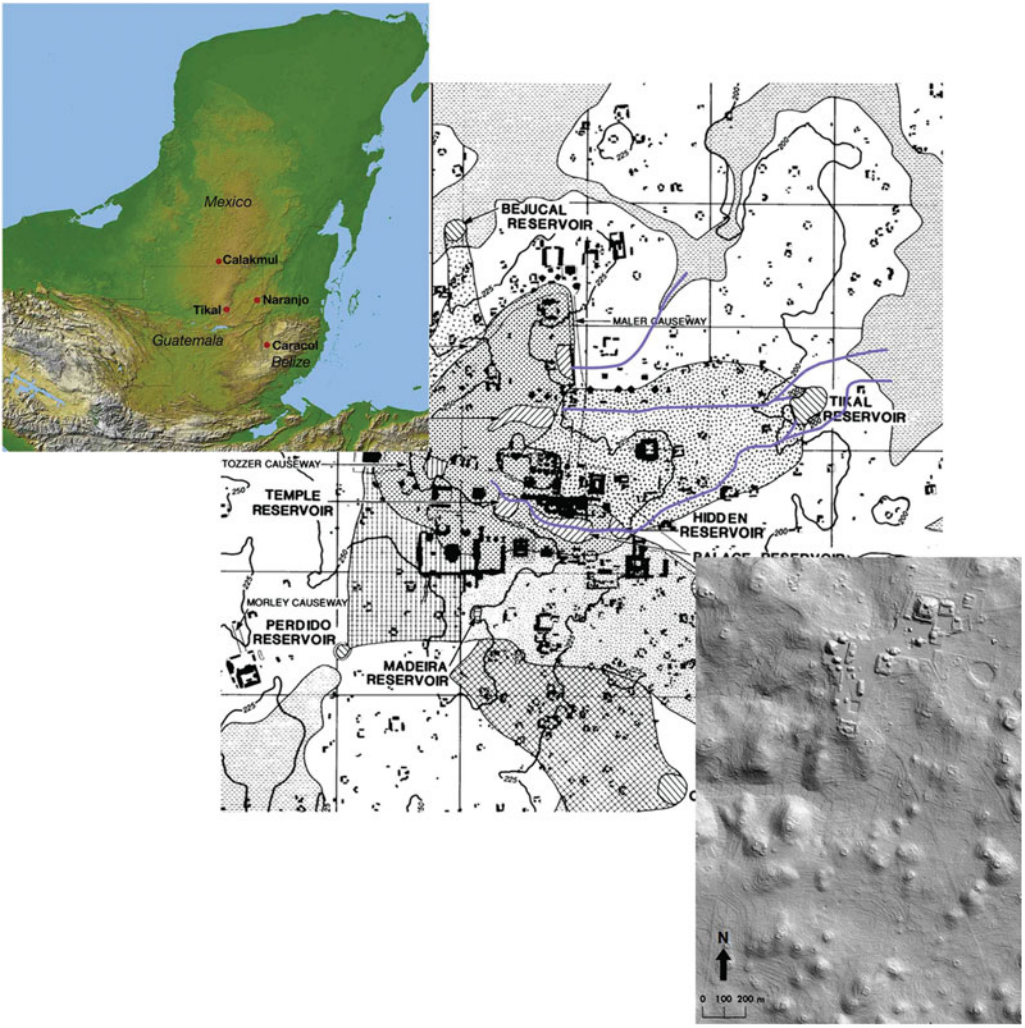

Figure 4. Maya lowland water systems and settlement; centre image shows reservoirs and catchment areas in Tikal; blue lines signify major arroyos (500 × 500m squares) (generated by C. Carr in Scarborough et al. *2012: fig. 1, courtesy of V. Scarborough). Lower right image illustrates dispersed settlement on hilltops, terraces and reservoirs (depressions) at Caracol, Belize (Chase* et al. *2011: fig. 6, used with permission of the UCF Caracol Archaeological Project). Maya map generated by L.J. Lucero courtesy of NASA/JPL/NIMA. Available at: http://photojournal.jpl.nasa.gov/catalog/PIA03364 (accessed 29 April 2015).*

water and maintained other integrative facilities and events, subjects remained loyal and political security remained intact.

A distinct feature of these tropical societies is their growing reliance on increasingly elaborate, complex and intricately linked water systems. Dependency on these systems could continue so long as external circumstances did not change. But they did change, via climatic instability in each area at various times, severely weakening water networks to the extent that they eventually failed. As a consequence, people from all walks of life left the dispersed urban landscape and its central nodes in search of more reliable sources of water and economic opportunities.

Climate instability and the urban diaspora

While it is relatively common for political systems to fluctuate in scale and place (e.g. building new capitals, replacing dynasties), something in these tropical cases resulted in the inhabitants largely abandoning not only the urban centres but also much of the metropolitan heartland. Former subjects continued farming, but many did so in different areas within smaller community networks and engaged in a different kind of urbanism on the periphery of the former states. The dispersal involved the disjunction between five major components: the urban hierarchical political system; substantial infrastructure; urban-rural integration; diverse farming practices; and climate change.

Severe climatic instability from the ninth to eleventh centuries (increasing temperatures and prolonged droughts) and the fourteenth to sixteenth centuries (decreasing temperatures and increasingly severe wet periods and droughts) strained embedded water systems. Analysis of annual ring growth of speleothems from caves and from trees provides a detailed history of long-term weather patterns, as do sediment core data from lakes and reservoirs (e.g. Penny *et al.* 2006, 2007; McNeil *et al.* 2010; Medina-Elizalde *et al.* 2010; Mueller *et al.* 2010; Day *et al.* 2012). We can now relate these to social histories (e.g. Scheffran 2008; Buckley *et al.* 2010, 2014; Zhang *et al.* 2011; Lieberman & Buckley 2012; Lucero *et al.* 2014).

The relationship between climate change and societal transformation is complex and multidimensional (e.g. Turner & Sabloff 2012; Iannone 2014). The demise of dispersed urbanism in each region was a unique sequence of events, yet led to a similar outcome—urban diaspora. For Angkor, climate change came in the form of "protracted periods of drought and deluge rain events" (Buckley *et al.* 2014: 1); this interpretation is based on tree-ring data (Buckley *et al.* 2010). In this diaspora, much of the residential population disappeared from Angkor and its vicinity and established small towns in a wide arc from Battambang along the southern side of the Tonle Sap, along and up the Mekong River (Figure 5), and in a great arc through Isan far to the north. Khmer elites moved towards the Phnom Penh region, initially migrating between multiple capitals (Thompson 2004: 33). By the sixteenth century the centre of royal power had shifted to the Phnom Penh area (Groslier 2006: 118–20). In the late nineteenth century only eight small villages existed in central Angkor (de Lajonquière 1911).

In Sri Lanka settlement decreased within a radius of 15km in central Anuradhapura from a peak of 292 sites in the Early Medieval period to only 11 by the eleventh century (Coningham & Gunawardhana 2013). This decline was paralleled by the abandonment of the urban core and most monasteries in the central and outer areas. The extended network of reservoirs and canals suffered breaches and silted up due to lack of maintenance (Brohier 1934 Part II: 8). The area was not entirely abandoned, as small communities still practised swidden cultivation prior to the nineteenth-century recolonisation of the Dry Zone (Gilliland *et al.* 2013). The silting and abandonment appear to have been accompanied by a corresponding sudden high-amplitude increase of the South West Monsoon, which would have resulted in both severe drought and an increase in cyclonic storms within the

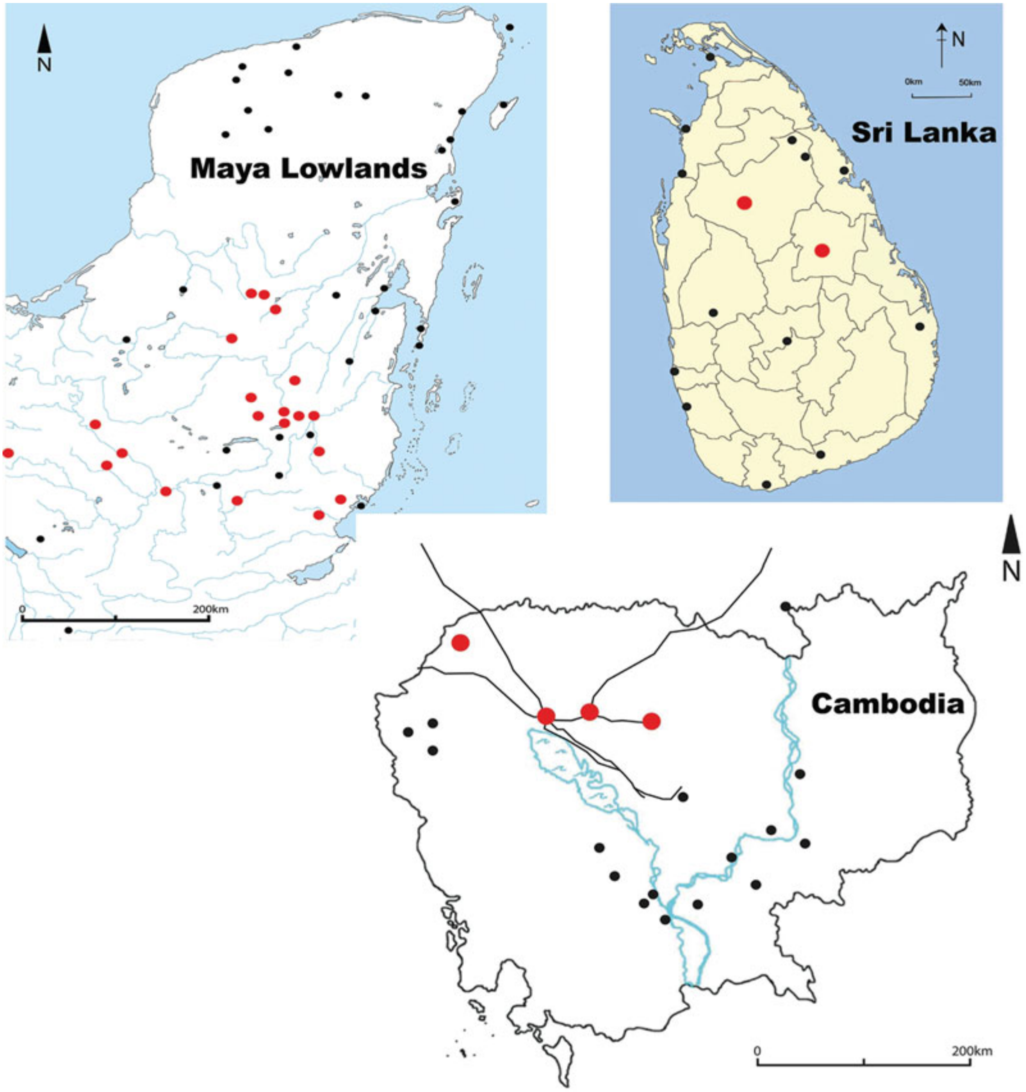

Figure 5. Urban diaspora in three tropical regions (red–black dots); generated by D. Brotherson.

North East Monsoon (Jung *et al.* 2004). The decline of Anuradhapura is linked with the later growth and expansion of its successor, Polonnaruwa. That city was also abandoned in the thirteenth century, but not before its leaders constructed the immense 'Sea of King Parakramabahu' covering 87km^2 (Gilliland *et al.* 2013). The court then shifted southwards through the compact capitals of Dambadeniya and Kurunagala, and then up into the hill country and the Wet Zone, eventually basing the capital at Kandy (Coningham 1999), while towns increasingly began to concentrate along the coast (see Figure 5). The destabilising of Anuradhapura corresponds with the increasing temperatures of the eleventh and twelfth centuries; the later shifts correlate closely with severely reduced monsoon rainfall over a multi-decadal period between the fourteenth and fifteenth centuries, as indicated by oxygen isotope analysis of a stalagmite from a cave in east-central India (Sinha *et al.* 2007).

In the Maya area, speleothem data from a cave in north-west Yucatán, Mexico, show that at least eight prolonged droughts struck between *c.* 800 and 930 AD. These droughts negatively affected reservoir systems (Medina-Elizalde *et al.* 2010) and exacerbated existing problems, including population growth, overuse of resources and erosion caused by deforestation (Lucero *et al.* 2011; Dunning *et al.* 2012). During these tumultuous times, not only did kings at smaller centres challenge political powers on the battlefield, as recorded in inscriptions, but royal subordinates also began to appear in the iconography alongside their kings (e.g. Yaxchilán, Copán and Piedras Negras) and to co-opt royal symbols for their own use (e.g. Copán; Fash 2005) (Martin & Grube 2008). In the AD 800s, Maya farmers withdrew their support from kings who no longer fulfilled their obligation as water managers and subsequently abandoned monarchs and centres (Lucero 2002). Kings lost their means of support and abandoned their capitals, relocating elsewhere and either dying out or reverting to what their forebears had been—elite landowners. While rulers lost power, farmers persevered by living in smaller communities or migrating out of the interior nearer to the coasts and along major rivers where market towns and trade flourished (Sabloff 2007; Graham 2011), as seen at Chichén Iztá, Chetumal, Cozumel and Bacalar, among others (Masson & Freidel 2012) (see Figure 5).

Concluding remarks

Low-density urbanism, extensive and diverse farming, dependence on massive infrastructure, severe climate change and a complex interaction with political systems appear to be the major factors triggering urban diaspora in diverse regions. The intricacy, complexity and magnitude of water management and political power in the southern Maya lowlands, Southern Asia and Southeast Asia had increased in tandem with increasing inflexibility and decreasing diversity, creating greater urban-rural interdependence. While the interlocking systems may initially have coped with changing circumstances, including climate extremes, they eventually failed.

Each society played out a unique history due to its internal characteristics, but urban diaspora was the consistent outcome. We know that people from all walks of life abandoned the former urban centres and their environs, drastically reducing the populations of the metropolitan heartlands. Rulers either moved away and adapted by creating new political institutions (Khmer, Sinhalese), or disappeared altogether (Maya of the southern lowlands), while most of their subjects survived by continuing to farm and by shifting location to participate in new urban networks. As these cases show, political collapse does not equate with societal collapse (see Lucero 2006: 24–25; McAnany & Yoffee 2009; Middleton 2012). Indeed, the area beyond the central Buddhist shrines of Anuradhapura displayed a growth in non-Buddhist cults and ritual practices close to dwindling reservoirs. At Angkor, areas of bunded rice fields were in use to the south of the East and West Baray in the nineteenth century, and swidden still occurred on dry upland slopes, as it did in the Dry Zone of Sri Lanka. Maya farmers still worked their dispersed fields near permanent water sources, such as Lake Petén Iztá in Guatemala and the Belize River in Belize.

In the end, the different histories of kings and farmers relate to the different constructs in which they existed: inflexible *vs* flexible strategies; a reliance on massive *vs* small-scale diverse water systems; and entrenched and rigid *vs* resilient and adaptable systems. Although noticeable cultural differences and specific political pathways existed among these tropical societies amidst the waxing and waning of political histories and sustainable agricultural practices, the significant overall similarity is the trajectory of urban diaspora. The combination of dependence on massive infrastructure, low-density urbanism and severe climate change has some resonance in the present day, a topic that we plan to examine in the future.

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