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URBAN ECOLOGY IN THE ANCIENT TROPICS
Foodways and urban forms

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Introduction

With roots tracing back to the nineteenth century and the study of 'natural' ecosystems, in the 1970s urban ecology emerged as a sub-discipline integrating the natural, engineering, social, and humanist sciences (McDonnell 2011). Adding to the primary scope of urban ecology focusing on the recent past, the present, and planning for the future (e.g. Forman 2016), archaeologists use a deep temporal frame of reference for analyzing socio-ecological processes in urban systems (e.g. Redman 2011). Typically employing an anthropocentric perspective on these interactions and combining data from disparate and complementary sources, archaeologists study what people have done, explain why they did so (by testing and evaluating a multitude of social, economic, cultural, and/or ecological interpretive frameworks), and link outcomes to specific legacies, consequences, and trade-offs of anthropogenic transformations of landscape (Isendahl and Stump 2019). Archaeology can extend the frame of reference and spatial and temporal scale of analysis for urban ecology scholars and planners addressing the wide range of issues and challenges presently associated with cities and urban systems (Isendahl and Barthel 2018).

In urban ecology (e.g. Douglas and Ravetz 2011: 253), food is often conceptualized as a provisioning 'ecosystem service', defined as the benefits an ecosystem affords human well-being, directly and indirectly. But the specific foodways of a particular area are the result of both environmental affordances (*sensu* Gibson 1986) and human selection processes, such that not all edible foods are cultivated and promoted. As a result, urban foodways result from a complex 'chain of activities connecting food production, processing, distribution, consumption, and waste management, as well as all the associated regulatory institutions and activities' (Pothukuchi and Kaufman 2000: 113). Counihan (1999: 19) suggests that, 'In every culture, foodways constitute an organized system, a language that—through its structure and components—conveys meaning and contributes to the organization of the natural and social world.' Waterman (2018: 521) argues further that 'foodways have primary importance in how the forms and occupation of built environments come into being' and thus have 'power to determine urban form' and shape future development trajectories of landscape ecologies. These positions provide the starting point for this chapter. Which urban built forms and socio-ecological landscapes have foodways determined in the ancient tropics? Drawing on data from the Indian subcontinent,

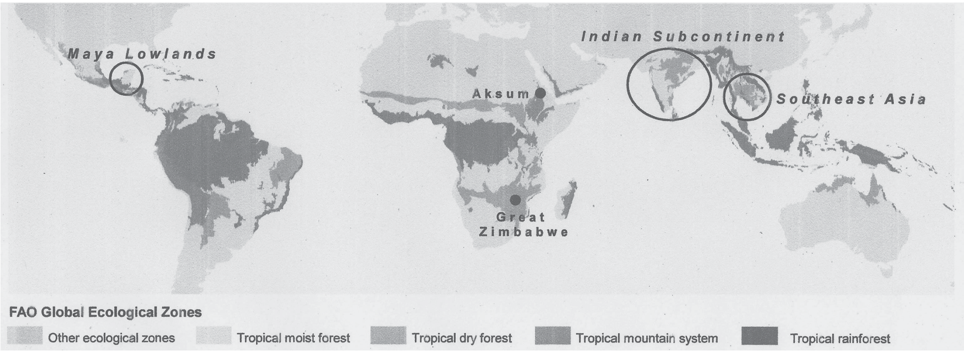

Figure 2.1 The regions discussed in the chapter

Source: Map by Federica Sulas (modified from map of tropical forest ecological zones based on *Global Ecological Zones*, second edition, FAO; Creative Commons)

Southeast Asia, sub-Saharan Africa, and the Maya lowlands (Figure 2.1), we examine archaeological evidence for the linkages between foodways and urban forms.

The Indian subcontinent

By 6500 years ago, there is archaeological evidence for the use of domesticated wheat, barley, and millet in the Indian subcontinent; in addition, people made use of cattle, sheep, and goats as multipurpose meat/dairy/wool/leather animals, some of which may have been independently domesticated and others of which had Near Eastern ancestry (Wright 2010). Those animals and plants served as the subsistence base for population centers of urban size starting in the mid-third millennium BCE in present-day western India, Pakistan, and farther west into Iran. These early cities show evidence for continued use of wild resources, particularly fish as food and shellfish as raw materials (Belcher 2009). Although there are hundreds of known sites from this period grouped into regional cultures such as the Indus Valley civilization and the Ahar-Banas culture, the number of actual cities was relatively small (a half-dozen or less) and they were located several hundred kilometers apart.

Rather than the population pressure that affects the viability of today's subcontinental cities, the delimiting factors of ancient urban and rural subsistence were wholly natural, including the seasonal monsoon (which has variable intensity and amplitude from year to year), tectonic uplift (which changed river courses in both rapid and subtle ways), and the global onset of a drought cycle that started c. 2100 BCE and that was particularly intense in the Indian subcontinent c. 2000 BCE (Walker et al. 2012). Cities were abandoned at this juncture and there was no urbanism evident in the subcontinent until a thousand years later, although the proliferation of villages throughout South Asia in the interim confirms the continued use of domesticated plants and animals with an increasing experimentation with rice as a grain that had numerous Asian (primarily Chinese and Indian) wild progenitors (Silva et al. 2015).

A resurgence of urbanism in the subcontinent began in the early first millennium BCE with the establishment of dozens of cities along major watercourses including the Ganges, Narmada, Tapti, Brahmaputra, and Krishna Rivers. Rice cultivation was a significant component of labor organization in the regions surrounding both cities and religious institutions (e.g. Shaw 2007). The advent of writing systems in this time period enables us to have a first-person view of the way in which rice became codified as a preferred food, a status that it retains in the region to this day (Smith and Mohanty 2018). Although animal protein was widely available and there is evidence for the continued consumption of wild animals at urban sites, cultural constraints on meat-eating accompanied the advent of Buddhist and Jain religious traditions. The conscious abstention from meat is a factor that must have had a structural effect on urban provisioning ecosystems (similar to in the Neotropics, see below), although little research has yet been directed to this question.

It is clear that the variability of the surrounding environment, and particularly the variability of rainfall, affected production strategies related to urban consumption. As was the case elsewhere in the world where environments were characterized by relative fragility (e.g. northern Mesopotamia; see Wilkinson et al. 2014) and inter-annual rainfall variability (e.g. West Africa; see Guyer 2015), ancient farmers in the Indian subcontinent managed rainfall fluctuations in ways that enabled them to capitalize on bumper harvests of storable grains as a buffer against years when monsoons either failed altogether or were overabundant and caused catastrophic floods (other unpredictable events included typhoons). Rural food production infrastructures would have included small-scale village level interventions such as field bunds and localized dams rather than large-scale canals or other irrigation works. From the urban perspective, however, the presence of bottom-up diversified agricultural production systems resulted in a cost-effective approach to provisioning, as cities could draw in many sources of supply without expending the energy to directly manage agricultural production (a successful strategy elsewhere in the world as well; see Zeder 2003 for Mesopotamia and Pyburn 2008 for Mesoamerica).

The development of territorial states starting around the sixth century BCE contributed to the growth of cities up to 600 ha in size as anchors of political and religious institutions. In subsequent centuries, states became more formalized through bureaucracies and administrative control, but in many cases political leaders still delegated the development of agricultural land and the day-to-day decisions of food production to local institutions such as temples (Stein 1960). Given the complexities of the environment, the resultant strategies of indirect management and localized control proved to be a more resilient and nimble response to environmental variability than the centralized state-controlled agricultural practices of the subsequent medieval and modern eras.

Southeast Asia

Southeast Asia's earliest urban centers arose in the river valleys and coasts early in the first millennium CE, nearly 2500 years after the earliest documented evidence for plant and animal domestication. Across the urbanizing mainland, rice formed the dietary base: but people also relied on domesticated bovids (cattle and water buffalo), pigs, poultry, and dogs for labor, protection, and food. No clear transformation from foraging to farming characterizes Southeast Asia's tropics, where broad-spectrum diets remained the norm until shortly before the appearance of cities. Agrarian urban centers emerged first in mainland Southeast Asia's alluvial lowlands (Stark 2006); coastal port settlements followed soon thereafter (Manguin 2002), but none matched the scale or complexity of the inland cities until the sixteenth century's Age of Commerce (Reid 1993: 62–77). The Lower Mekong Basin hosted the region's earliest and largest agrarian cities (e.g. Stark and Bong 2001). The basin is part of a hydrographic system linking the Tibetan Plateau to the South China Sea, and its tributaries provided an intricate communication and transportation system connecting communities for millennia. Encompassing present-day Laos, northeast Thailand, Cambodia, and southern Viet Nam, the Lower Mekong Basin formed an integrated political system from the ninth to fifteenth centuries CE during the Khmer empire.

Rice farmers across the homogeneous alluvial plain of the Mekong delta mastered the monsoon climate and its annual floods which watered their fields: their riverine and lacustrine environment provided rich aquatic resources (fish, crustacean, turtles) that formed the protein dietary basis throughout the premodern period. As in South Asia, population pressure played a lesser role in structuring Southeast Asia's early urban centers than did climate and hydrology.

Foodways constrained and facilitated premodern urbanism in the Lower Mekong Basin, whose settlement clustered largely along the Mekong River, its tributaries, and lake shorelines. The tropical monsoon climate of protracted rainy seasons and flooding defined the agricultural system; its early first millennium CE surpluses likely provisioned visiting coastal settlements. Bovids supplied power for both plowing and wheeled transportation in the dry season, and waterborne transport connected settlements during each year's peak floods, when up to half of the Mekong delta was inundated. Pigs recycled household garbage and provided a meat source; ducks consumed pests from wet-rice padi fields.

Premodern Southeast Asian farmers adapted to the Lower Mekong Basin's resources through dispersed rural strategies. Then, and until the late twentieth century, most Khmers lived in small rural hamlets of house mound clusters; each mound held space for buildings, work spaces, economic trees, and house gardens (Delvert 1961: 196–7). Khmer smallholder strategies paired infield-outfield cultivation with small ponds to practice an intricate annual production cycle that included multiple rice varieties tailored to the annual flood cycle (Fox and Ledgerwood 1999). The delta's protohistoric cities represent one enduring Khmer settlement form (Delvert 1961: 211–12), whose residents interacted with settlements and dispersed rural hamlets spaced across the alluvial plains.

In the third century CE visiting Chinese emissaries described the Lower Mekong Basin's earliest urban pulse as the Kingdom of Funan. Angkor Borei (Cambodia) was the polity's largest inland settlement, and urbanism emerged in the early centuries CE after populations mastered rice farming with the annual flood regime (Stark and Bong 2001). They encircled their 300 ha settlement with thick 4 meter tall walls, whose internal and external moats shielded inhabitants from rising waters. Within the walls were areas of dense residential clustering, and areas left open for gardens and trees. Beyond the walls were largely mounded rural hamlets located within half a kilometer of prime agricultural fields, and a complex array of small shrines to Indic and animist deities whose care was needed to ensure the annual agricultural cycle. Funan's 'cities' were agro-urban centers on an alluvial landscape, and their farmers channeled rice surpluses to the coast through canal and riverine networks to feed coastal ports and visiting traders. Located in some of the delta's most fertile rice-growing regions, these early first millennium settlements remain occupied today.

By the ninth century CE, Funan descendants established a new polity in northwest Cambodia in an area now known as Angkor (Evans et al. 2007). The Angkorian plain paralleled the Mekong delta in its fertility, replenished annually by floods, and farmers practiced similar techniques to those employed earlier. At least 36 rulers established sequential capitals over six centuries in the 1000 km^2 area now called Greater Angkor. Most reigns involved the construction of large state temples in the capital and secondary temples across key provinces. Greater Angkor housed political elites, artisans, and communities attached to the state to support its infrastructure. There are several competing explanations for why the Khmer empire arose and how it operated, but most scholars concede that the capital's fourteenth- or fifteenth-century collapse occurred when the state could no longer protect its labyrinthine water management network against an increasingly unpredictable climate (Buckley et al. 2010). What collapsed was the capital; ongoing archaeological research suggests that rural settlement in the region continued to the present day.

Urban ecology provides a lens for studying both resilience and vulnerability in tropical agrarian systems like the premodern Lower Mekong Basin. Two sources of resilience include a bottom-up diversified agricultural production system that Funan and Angkorian farmers practiced before, during, and after these episodes of peak urbanism (like those described for the Indian subcontinent), and an agro-urban tradition that ensured food security through its dispersed settlement structure. The Mekong delta's cities never collapsed, but they lost primacy in response to changing political winds that moved traders to other regions. Angkor's urban configuration contrasted markedly with delta urbanism in its elaborate water management system, which required continuous maintenance. However, climatic shifts that disrupted a fundamentally predictable monsoon cycle generated investment and labor demands that Angkor's inhabitants were no longer willing or able to meet.

These two Mekong Basin examples illustrate how local ecological conditions both enabled and constrained food production systems and urban form. Agro-urbanism, labeled differently, has a long tradition in Southeast Asia that may be explained through the food security inherent in this system (Barthel and Isendahl 2013). Premodern Southeast Asian cities had large garden and infield areas, and such cities continued into the colonial and recent past: Palembang, for example, had substantial padi fields within its boundaries in the 1970s (Miksic 2009: 3, 15; Reid 1993: 88–90). Southeast Asian megacities represent a regime shift that appeared in the colonial period competition for international markets, with often disastrous consequences. Waterborne infectious diseases, particularly malaria, cholera, and typhus, entered densely-packed urban centers and generated high mortality rates. With the exception of a revolving set of coastal port cities (and the island of Java), most of Southeast Asia remained deeply rural – and intermittently agro-urban – until the last century.

Sub-Saharan Africa

In sub-Saharan Africa, rainfall has long been considered as a main variable controlling the rise and demise of agro-urban societies such as those emerging in the highlands of northeastern Africa and the Zimbabwe Plateau in the first and second millennium CE.

In the highlands of northern Ethiopia and Eritrea, the kingdom of Aksum emerged in the late first millennium BCE as the latest development of a long trajectory of mixed farming and sedentism (Phillipson 2012). Thriving over volcanic soils and woody savannah vegetation, and supported by two rainy seasons per year, plow farming and livestock herding provided the backbone for the Aksumite kingdom to develop. By the early first millennium CE, Aksum was controlling a vast region across highland, lowland, and coastal regions, at times stretching even further across the Red Sea. While fertile, the Ethiopian-Eritrean ground also provided a number of challenges for Aksumite farmers who had to negotiate changing rainfall controlled by the monsoon winds and clayey, swelling soils. Yet, vast amounts of food had to be produced to support a burgeoning urban population of administrative and religious elites, craftsmen, and traders across the kingdom. The ox-drawn plow would prepare the land and control drainage and soil erosion for growing wheat, sorghum, and the indigenous teff, which would be sown just before the first rains – a crucial prediction farmers had to master to secure their harvest. While crops were growing, farmers could be engaged in other activities such as building the Aksumite famous monumental stelae and palaces. Water supply was secured by reservoirs built where rainfall could be best captured, groundwater tapped, and water infiltration controlled (Sulas 2018). Cut into the bedrock and often stonewalled, large water reservoirs were placed next to main residential quarters, while springs and wells were scattered across the agro-urban landscape (*sensu* Isendahl 2012). Aksum's urban layout appears tailored to this integrated agroecological system.

Ruling residential and funerary complexes occupied the foothills of Beta Giyorgis, overlooking gently sloping land into the Aksum plain. Alluvial soils and water resources would support small cultivated plots and limited grazing in the core urban center. Around it, lower elite residences and small farmsteads formed a dispersed and loosely spaced, peri-urban settlement with large arable fields and pastureland where surplus food production could be protected and easily moved to and across the core urban area. Such an urban form was highly dependent on steady food production and circulation, while appearing far less vulnerable to changing rainfall. Indeed, increased rainfall and dry spells occurred coincident with important socio-political transitions, eventually leading to the decline of the Aksumite kingdom around the ninth century CE (Fattovich 2010). Yet, as the capital's urban core contracts, Aksum peri-urban settlement gradually increases and persists for the next thousand years or so (Sernicola 2017) – several of the crops attested from the late first millennium BCE are still grown today, and the ancient reservoirs continue to provide the most reliable water supply for local communities (Sulas 2018).

Further south, the southern Zambezi Basin provided a safe and resourceful environment for the urban settlement at Great Zimbabwe to develop and expand in the early to mid-second millennium CE (Pikirayi 2001). Supported by cattle herding, small-scale farming, metalworking, and trade, Great Zimbabwe grew as a booming regional capital, thriving well into the eighteenth century CE (Pikirayi 2006). Great Zimbabwe's built environment was characterized by extensive dry stone monumental architecture, open green areas, and marshy grounds (Sinclair et al. 1993). The maintenance of open green areas and marshlands were important for maintaining ecosystem services and sustaining food security (Sinclair 2010). Individual complexes were surrounded by daub structures (Chirikure et al. 2017), and while internal space in these complexes appears tightly packed, the presence of sizable open areas and terraces in between might have supported small-scale farming, gardens, and the keeping of small livestock. Large cattle herds were best kept at safe distance for health and sanitation reasons, possibly grazing the slopes and valleys surrounding the core urban area. Water provision could also be more easily managed with large reservoirs supplying the core urban population and food produced within, while wells, springs, and wetlands supported people, herds, and crops across peri-urban and rural areas. Control and adaptation to topographical variability appear to have been crucial: recharging water at the slope increases soil moisture for most of the dry season, whilst low seepage extends the period of wetness in adjacent areas. Springs and wells, sustained by productive aquifers, supplied water to the urban and peri-urban communities during the long dry months following the rainy seasons. At the core of the urban settlement, large reservoirs were placed at the bottom of the Hill Complex to supply water to the ruling elite (Pikirayi et al. 2016).

While different in nature, the examples of ancient Aksum and Great Zimbabwe suggest that a deep knowledge and tailored management of local ecological conditions were key to developing food and water security for early urban societies. While changing geopolitical and trade conditions took a dramatic toll on sub-Saharan, past urban systems, farming and herding communities of these early urban societies had the capacity to adjust and mitigate major changes. In contrast with modern emphasis on centralized and large-scale land and water management for urban provision, past urban societies at Aksum and Great Zimbabwe employed dynamic and flexible approaches to use and conserve land and water in a dispersed settlement pattern. Whether through water reservoirs or household cultivated plots, food and water security were tailored to specific topographic positions for maximizing harvesting, conservation, and distribution. Rather than focusing on one particular resource, being rainwater or cattle, diversified agroecological practices appear to have sustained foodway diversity and security at times of stability as well as during major socio-political shifts.

The Maya lowlands

Urban foodways of pre-Columbian (i.e. pre-1492) complex societies in the Neotropics (the tropical and subtropical regions of the Americas) were in two respects markedly different from their contemporaries in Africa and Asia: (1) no major domesticated animal species dominated subsistence economies (such as cattle, horse, sheep, goat, pigs, or chicken; the exception, the Andean llama, is a highland species); and (2) technologies made no use of the wheel for transportation or metal tools in manufacturing, construction, weaponry, or farming. Despite these 'constraints' – that is, constraints relative to the tropics in the eastern hemisphere – numerous urbanized or semi-urbanized complex societies developed in several sub-regions of the Neotropics, possibly including Amazonia (Heckenberger et al. 2008), during the pre-Columbian period.

In the Maya lowlands – an area of some 250,000 km^2 in present-day southeastern Mexico, Guatemala, and Belize – state-level polities and urban centers emerged during the first millennium BCE. Maya civilization was highly complex and economically and politically heterogeneous, with a long-term history that suggests cycles of growth, decline, and reorganization during the course of the Preclassic (2000 BCE – 250 CE), Classic (250–1000 CE), and Postclassic (1000–1550 CE) periods (Chase and Scarborough 2014). Hundreds of large settlements were constructed; some that grew to form cities of considerable sizes, others that remained relatively modest. Cities and towns formed part of larger polities of networked settlements and support zones that were changing in terms of the size of state jurisdictions and political configurations, and that at no time were organized to comprise a hegemonic super Maya lowland state. The city of Caracol, for instance, was occupied for about 1300 years until abandoned in 900 CE and had a population of 100,000 that extended over some 200 km^2 at the height of Classic urban development at the end of the seventh century (Chase and Chase 2016). At Caracol, the Maya constructed a large civic-ceremonial center, a complex network of causeways linking the city with other settlements, agricultural terraces, and a system of water reservoirs. The abandonment of Caracol forms part of a more wide-scale process of political, economic, and social change in the central Maya lowlands that is often referred to as the Classic Maya collapse. At several cities, however, while political leadership structures disintegrated, a major proportion of urban dwellers seems to have remained to work the land in these agro-urban landscapes, at least for a time.

Despite diversity and change over space and time, however, the basic spatial pattern of most Maya urban centers forms variations of a common theme that can be labeled 'agro-urban landscapes' (Graham and Isendahl 2018), but Maya cities have also variously been described as 'forest gardens' (e.g. Ford and Nigh 2015), 'garden cities' (e.g. Dunning and Beach 2010), and 'green cities' (e.g. Graham 1999). The main components of Maya agro-urban landscapes were the numerous domestic household residential units that populated them, dispersing from urban centers of civic-ceremonial and elite residential building complexes of social arenas that provided economic, political, social, and religious urban functions. Built areas were interfingered with land used for food production, including household gardens, infields, orchards, and other green areas, that are believed to collectively have provided a significant share of the staple maize, beans, and squashes consumed within these settlements as well as many other vital ecosystem services. Among the Maya, as well as other pre-Columbian cultures in Mesoamerica (present-day Mexico and northern Central America), maize emerged as the most salient crop from initial domestication in the early to mid-Holocene until today, as reflected in archaeological and cognate data, including being a key component in narratives of ethnogenesis (Freidel et al. 1993). However, the balance of food diets varied over time, from one region to the next, and among different social groups, with a significant proportion of the total food resource framework consisting of a range of other cultivated domesticates and harvested wild plants, supplemented by domesticated (e.g. dogs), semi-domesticated (e.g. turkey), and non-domesticated (e.g. deer, armadillo, birds, and fish) fauna (e.g. White 1999). Classic Maya societies were politically hierarchic, but the farmsteads that embodied the agro-urban landscape formed production units adaptable to function within different socio-ecological structures, including much flatter forms of social organization.

The absence of dependence on a grazing-animal complex (Graham 1999) and beasts of burden for transport and traction (no bovids, but also no pigs or poultry such as chicken, so important on the Indian subcontinent, in Southeast Asia, and sub-Saharan Africa) is likely to have important implications for how foodways determined urban form in the Maya lowlands and thus how the organization of Maya agro-urban landscapes came into being. First, with no beasts of burden or wheel-based transport technology all movement of goods in regions of the inland that lacked navigable rivers relied on people. High costs of inefficient transport technology discourage the long-distance movement of food bulk goods that can largely be cultivated anywhere and stimulates agriculture proximate to consumers. While the pre-Columbian agro-urban landscapes of the Maya were probably crammed with people walking, many carrying heavy burdens of different kinds of goods, the potential comparative advantage of particularly expedient soil and water resources to grow and trade staples leveled out relatively quickly with transport distance. This is not necessarily to say that bulk goods could not have been transported considerable distances over land, but that the returns of doing so were low from an energetic point of view. Second, without the potential traction energy of bovids, Maya farmers worked the land by hand simply with the aid of a digging stick. With this simple technology, Maya farmers were relatively unconstrained in field plot selection, not needing to weigh in that the field was workable by plow and traction animal. Furthermore, not utilizing the plow implied, on average, less transformation of the landscape to prepare for cultivation. On the other hand, other kinds of investments were indeed made to increase the productivity of the land in some areas of the Maya lowlands, for instance the agricultural terracing at Caracol mentioned above. Third, without the controllable concentration of nutrients and energy (protein, carbohydrates, minerals, vitamins, and fat) that livestock entails, household food security and wealth are focused on the dwelling, the land, and the surplus that can be generated from growing a diversity of plants. Hence, in Neotropical urban foodways the animal to vegetative protein balance was strongly biased towards the latter. Fourth, Neotropical urban ecologies put greater emphasis on hunting and fishing as sources of animal protein and other nutrients, providing an incentive to manage hunting and fishing resources more sustainably, relative to urban foodways in the eastern hemisphere. Fifth, without livestock herding, Neotropical urban foodways made little demand on land use to provide pasture or fodder. Hence, compared to urban foodways drawing on grazers for protein, a higher acreage of the urban ecosystem was available to grow plants for direct human consumption. Sixth, in the eastern hemisphere bovids, pigs, and poultry produced dung, a rich source of nutrients to manure farm plots as well as of fuel energy. Having no access to these resources, in the Maya lowlands the concentration of organic waste that the agro-urban dwellers generated collectively (e.g. charcoal, harvesting and cooking waste, and human excrements) may have formed important resources for urban food production in these Neotropical cities. Brought together, these arguments suggest that independence from stocks of domesticated bovids, pigs, and poultry may significantly have contributed to the agro-urban form of organizing Maya lowland landscapes.

Conclusion

The examples of South and Southeast Asia, the Maya of the Neotropics, and Africa indicate that there is no single type of tropical premodern urban ecology, but rather a series of urban traditions that have developed interactively with foodways patterns within the constraints of techno-economic and socio-ecological boundary conditions. Informing our understanding of the long-term trajectory of urban foodways over timescales from several centuries to a millennium or more, these examples of past tropical urban forms show the key role of local accessibility and diversity of food sources for the emergence and resilience of cities. At a time when the environmental, social, and energetic costs associated with global food systems are increasing and climate change is putting agricultural production in drought-prone areas under heavy pressure, considering archaeological data may generate new insights of urban and peri-urban agriculture (see Chapters 22 and 41) as sources for food security in the cities of today and the future (Isendahl and Barthel 2018). Ecologists often regard ecosystems in contemporary tropical cities as pristine or 'natural' until the growth of modern urbanization, but urban ecosystems have often emerged from complex processes of social–ecological co-evolution with considerable time-depth (Barthel et al. 2005). Human decision-making and practices generate both unintended and unforeseeable consequences that over longer timescales may either support or undermine the sustainability of socio-ecological systems and subsystems (Scarborough 2018). In these regions, landscape mosaics and habitat diversity that increase the resilience of urban ecosystems are often a result of farmers' strategic choices to build insurance against environmental uncertainty (Barthel et al. 2013). The archaeological data discussed indicate that there is ample scope to integrate such historical knowledge in urban ecology research and also in the design and management of modern cities.

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