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978-1-107-03008-4 — Monsoon Rains, Great Rivers and the Development of Farming Civilisations in Asia
Peter D. Clift , Jade d'Alpoim Guedes
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Introduction

1.1 Climate and Farming Societies in Asia

Today roughly 60% of the world's population resides in Asia under the influence of that continent's monsoon system, which dominates the regional climate and is, in turn, linked to surrounding climate systems in the Indian and Pacific Oceans, as well as Australasia. Asia is also the home of some of the earliest and longest-lived farming societies in the world, as well as some of the earliest urban cultures. Variations in the intensity and timing of rainfall, changes in temperature, and switches in the courses of rivers that rely on monsoonal rains have been tied to changes in the location and density of ancient settlements, and to the types of subsistence strategies employed by these sites' inhabitants.

In this book, we explore how variations in the intensity of the Asian monsoon have influenced the development of different farming strategies throughout Asia and how, in turn, humans have developed solutions to deal with periodic fluctuations in processes that are driven by the Asian monsoon. Variability in the monsoon will continue to test the resilience of farming strategies in the future. It is generally, if not universally, accepted that we now live in an age of continued climate change that seems likely to have been caused by human activities rather than being part of a natural cycle. The vast majority of climate scientists now agree that human-induced emissions of CO_2 and methane to the atmosphere are one of the most important causes of the changing climate we are now experiencing (Solomon et al., 2009; Zeebe et al., 2016). We use the past as the key to the future in showing how past variations in the temperature, precipitation, and changes in river systems, which are influenced by the monsoon, may have impacted past societies and examine the solutions that these societies came to in order to address these changes. This process is expected to hold importance in predicting what may happen in the future in the context of a warming global environment.

Although global climate has been relatively stable since the start of the Holocene, around 10,000 years ago, it is also apparent that even during this relatively stable phase that there have been significant perturbations. The period of maximum warmth in the Early-Mid Holocene was followed by a cooling phase after around 2000 BCE (Stager and Mayewski, 1997; Wanner et al., 2008). Since that time a number of climatic cycles have been observed, including the Roman Warm Period (250 BCE to 400 CE), the Medieval Warm Period (950–1250 CE) and the Little Ice Age (1550–1850 CE). These have found their expression through the intensity of summer monsoons in Asia because of coupling between the climate systems of the high latitudes and those in equatorial regions. Conversely, there is evidence for feedback between processes controlling the monsoon in Asia and climate systems elsewhere in the world (Ivanochko et al., 2005). In particular, we focus on the relationships between intensity of Northern Hemispheric Glaciation and the strength of summer monsoon rains because on longer timescales these appear to be closely correlated.

In the biophysical sciences, humans are sometimes seen as alien to or even parasitical on the physical environment. In an extreme representation, the role of humans is not to function as stewards but to conquer tame and subdue the environment (Beinart and Coates, 1995). Conversely, some historians and ethnographers have looked at the environment as a mere background and at climatic change as being so slow, so vast in scale, as to be virtually irrelevant (McIntosh et al., 2000). In archaeology a similar tension is present, with some approaches (particularly those highlighted in popular media) being deterministic about the role that climate played (Diamond, 2005) to others that ignore the role it could have played and critiquing approaches that invoke climate as attributing it to great or too simplistic a role, or ignoring the role played by human agency (Brumfiel, 1992; Erickson, 1999). Indeed, the majority of approaches trying to link ancient climate to changes in ancient subsistence strategies have been largely correlative: that is to say, they take changes in one variable, normally a paleoclimatic proxy and correlate this with known changes in the archaeological record. The paleoclimate community is often guilty of the latter when trying to ascribe greater significance to their findings. Archaeologists have also had difficulties in employing the paleoclimatic record in a way that allows them to accord it an appropriate role and evaluating its impact has also often been either to correlate (Contreras, 2015; d'Alpoim Guedes, 2016; d'Alpoim Guedes et al., 2016c) or conveniently ignore its potential role.

Inherent in any approach that takes into account the role of climate are ideas about "collapse" (Diamond, 2005; Fagan, 2004). While the term "collapse" is often applied in the media, what exactly is meant by this process is often unclear. Tainter (1988) argues that collapse takes place when we see a rapid loss of an established level of sociopolitical complexity. Tainter (1988) was careful not to imply that a loss of centralized control or hierarchy was somehow negative. We argue, alongside most archaeologists, that new ways of operating and organizing society are often simply adaptive: while these might be intolerable to those in positions of power, they may give greater agency and benefits to those that may have been oppressed by entrenched systems.

Middleton (2017) reviewed how ideas about "collapse" have been presented in both popular media and the archaeological literature, often in an oversimplifying manner. He highlighted, for instance, how authors like Diamond have used a Neo-Malthusian perspective to make collapse synonymous with "declines in population" that have causes inscribed in humans' role within ecosystems: ones to which few archaeologists subscribe. We aim to avoid these simplistic notions of social change that these authors critique and rather focus on highlighting the adaptive strategies employed by humans when faced with changing climatic conditions. We seek in this book to achieve a middle ground: one that neither ascribes a deterministic role for climate, nor ignores its presence, but one that seeks to provide a higher resolution picture of the intensity, nature and type of changes in the mean state of climate and more specifically how the monsoon, may have impacted the agricultural strategies they employed. Throughout this book, we also recognize that the relationship between humans and the environment is not uni-directional: humans themselves impact and change their surrounding environment.

Although we touch on the impact changes in climate may have had on different societal units, when relevant, we focus specifically on the effects that changing variables had on one aspect of human enterprise: their subsistence regimes and farming systems. Rather than purely drawing correlations between changes in rainfall or temperature with documented shifts in human subsistence, we strive to understand the mechanism via which changes in these variables might have impacted field or settlement locations, crop growth or the ability to access certain resources.

A growing literature in resilience theory (de Vries, 2006; Minnis, 1999; Redman, 2005; Redman and Kinzig, 2003; Van de Noort, 2011) and "human ecodynamics" and "socioecological aspects" of the human past (Barton et al., 2012; Kohler et al., 2007; McGlade, 1995; Van der Leeuw and Redman, 2002), which sees humans as agents that actively shape their own environment through niche construction, but also as being embedded within their ecosystems and coevolving with them is more in line with the approach we seek to adopt in this book. Like other organisms, humans have modified their subsistence strategies to ensure their ultimate success, often through thousands of years of trial and error. We thus chart changes in adaptive subsistence strategies used by humans without assuming that any of these shifts involve a type of "collapse": whatever that term might mean. Here, we prefer the term "mode shifts" to describe abrupt changes toward new and discrete climate states. These are shifts in climate that go beyond the normal range of variation and that create a new stable state that is characterized by a new suite of climatic conditions. It is often these fundamental shifts in biophysical systems that have precipitated new responses from humans.

Rather than focus on any particular theoretical framework, we highlight the traditional systems of ecosystem and plant management employed by humans inhabiting the monsoon region in the past. We argue that Asian farming systems are the products of thousands of years of human, plant, and ecosystem coevolution and thus form unique adaptations to the ecology of monsoon Asia. This wide range of strategies may prove to be our greatest asset as we face ongoing and future climatic change. These systems have been developed through trial and error over the course of thousands of years: periods of time that have encompassed a wide range of different states of the monsoon.

1.2 The Monsoon in Asia

In this book we consider how the development of climate, and particularly the monsoon system, has affected the development of agricultural strategies across Asia and, in turn, how decisions made by humans resulted in changes in the landscape. The development of the monsoon itself will be addressed in much greater detail in the following and subsequent chapters, but here we introduce the term and explain what is meant when we talk about this. The monsoon is a seasonal climate system with a summer and winter component. Most continental masses have a monsoon system (Kim et al., 2008), but the one affecting Asia is much stronger than most because Asia is much more extensive and has higher elevations than most other continents. Despite this, the Asian monsoon can be thought of as the single largest component of the global monsoon that enhances regional precipitation by drawing the Intertropical Convergence Zone (ITCZ) deep into continental interiors. The latitude and geographic features of Asia increase its ability to experience strong seasonal temperature variations. In its most basic form, the monsoon is the product of the pressure differences between the continent and the surrounding oceans, with summer heating resulting in a continental low-pressure system, while in the winter a high pressure area develops over Siberia (Manabe and Terpstra, 1974; Wang, 2006; Webster, 1987). This has the effect of driving onshore winds from the Indian and Pacific Ocean toward the Asian interior in the summertime, while in the winter winds blow out of the continent toward the south and east, often carrying large volumes of eolian dust (Arimoto, 2001). In Asia, this results in a reversal of the atmospheric circulation seen elsewhere in the world where summer heating is greatest at the equator, not in the mid latitudes. The net result of this is that mid latitude Asia is not desert-like, as seen in Africa or the Americas, but is well supplied by summer rains, making it habitable and fertile for human settlement.

The Asian monsoon is known to vary on a variety of timescales, some of them linked to the tectonics of the Asian continent and especially to the uplift the Tibetan Plateau (Molnar et al., 1993; Prell and Kutzbach, 1992) and Himalaya (Boos and Kuang, 2010; Clift and Webb, 2018), while others are modulated by other climate systems, especially the El Niño-Southern Oscillation (ENSO)(Lau and Wang, 2005). Over longer time periods there is a link between monsoon strength and the onset of glaciation in the northern hemisphere because it is often argued that summer monsoons are linked to the intensity of solar insolation (Clemens et al., 2010; Gupta et al., 2005), although this simple model has recently been called into question (Clemens et al., 2018). Strictly speaking, the monsoon represents an atmospheric pressure system and, therefore, it is experienced in the form of winds. Our association with the monsoon and rainfall comes about because around the Indian Ocean, and especially in southern parts of China and Indochina, the winds bring moisture from the ocean, which is then precipitated over the land and especially against the southern topographic front of the Himalaya, as well as in the east against the eastern flank of the Tibetan Plateau. In Arabia, however, summer monsoon winds are strong but mostly dry, with an important exception in southern Oman.

Because rainfall is crucial to farming systems in South and East Asia, and the vast majority of this is brought by the monsoon, there is a link between the strength of summer monsoon rains and the productivity of the agricultural systems, which sustain civilizations across the continent. That is not to say that the link is simple or linear but agriculture without sufficient rain at least seasonally is not practical. A quick look at the Earth's climatic belts shows that typically the mid latitude regions are generally arid regions. Deserts dominate in such areas as Afghanistan. However, regions at similar latitudes in India and southern China are humid, disrupting the global climatic pattern. The underlying reason for this distortion is the strength of the Asian monsoon system that draws moisture deep into the continental interior. Without the Asian monsoon, the population densities that we have in these regions would be unsustainable (378 people/km^2 in India compared to 43 people/km^2 in Afghanistan) and more akin to those known in North Africa and Arabia. The monsoon is, therefore, fundamental to the maintenance of farming society in Asia, as it has been since humans first began to farm on the continent.

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1.3 Environmental Impact of the Monsoon

The greatest dangers to human societies are rapid changes in environment that do not give sufficient time for people to respond and adjust. It thus helps us to understand the potential risks from changes in the monsoon if we can understand how the modern monsoon influences environment and human settlement. Figure 1.1 shows the time averaged annual rainfall across Southeast Asia based on data from NASA's Tropical Rainfall Measuring Mission (TRMM) covering the period 1998 to 2007. The satellite data is in accord with rain gauge data in showing the strongest rainfall across the Eastern Bay of Bengal, northeast India, and parts of Indochina. Rain is also strong in southern China and along the Ganges River valley adjacent to the Himalaya, as well as along the western coast of India. The vast majority of this precipitation is monsoonal and can be compared with the environment of Asia to assess what impact this rainfall has. Figure 1.2 shows ecological zones for the same area. It should be remembered that at these same latitudes in Africa we see widespread desert conditions in the Sahara, and even slightly further to the west deserts exist in Afghanistan and through much of the Middle East. Without, the Tigris and Euphrates rivers much of Mesopotamia would be uninhabitable. Indeed, there is even a significant desert in western India and southern Pakistan, the Thar Desert, which lies on the western edge of the monsoon rainfall. This desert is significantly

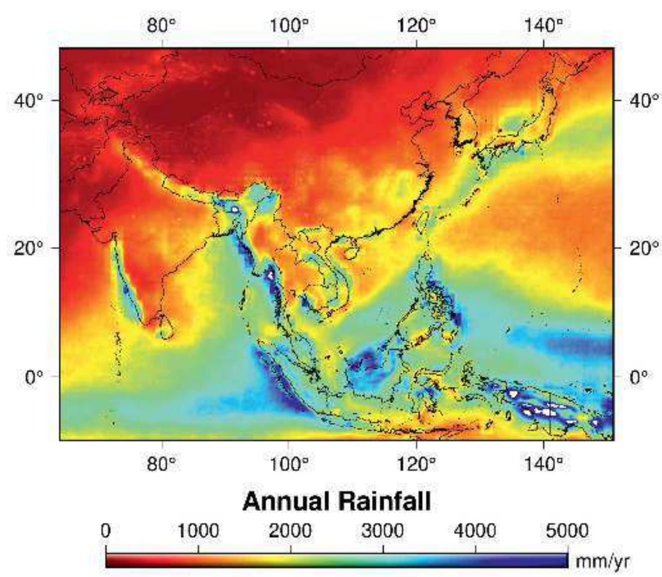

Figure 1.1 Map showing continent-wide mean annual rainfall in mm/year. Data from NASA TRMM spanning 1998 to 2014 (http://trmm.gsfc.nasa.gov/). Figure courtesy of Bodo Bookhagen.

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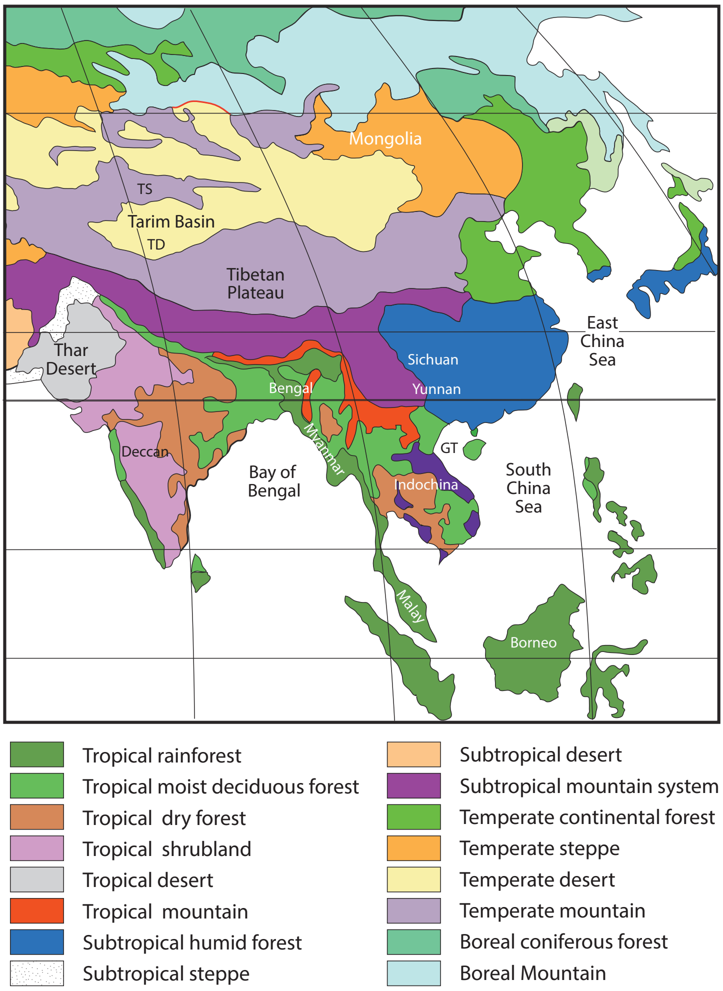

Figure 1.2 Vegetation ecozones of monsoonal Asia. Map from the Food and Agricultural Organization of the United Nations (www.fao.org/home/en/). GT = Gulf of Tonkin, TS = Tian Shan, TD = Taklimakan Desert.

influenced and supplied with sediment by summer monsoon winds (East et al., 2015; Singhvi et al., 2010) but, as Figure 1.1 shows, the precipitation is weak in the western part of the subcontinent. Figure 1.2 reveals significant zonation of vegetation that is at least partly linked with latitude, as it is in other parts of the world. As we go further north in Asia there is a gradation into temperate deserts and steppe, before the sparse, high-latitude coniferous forests of the Arctic Taiga.

The high areas of the Tibetan Plateau have their own special flora that are uniquely adapted to high altitude conditions (i.e., cold and dry; Figure 1.2), but also to the relative aridity of the northern and western plateau (Figure 1.1). The pattern we see now is one of tropical rainforest or moist deciduous forests throughout Southeast Asia and the islands of Indonesia, as well as in Bengal and other parts of northeast India. There is a clear gradient from east to west across India from tropical forests and swamps near the Ganges–Brahmaputra delta, toward the west and the deserts around the Indus Delta in southern Pakistan. Tropical forests exist along the west coast of India, immediately adjacent to the coast on the western flank of the elevated Deccan Plateau. As might be expected, there is a close parallel between the intensity of monsoon precipitation and the abundance of tropical rainforests in low latitudes across South and Southeast Asia. Where monsoon rain is weak, we instead see deserts developed, as in the Middle East.

The only exception to this general pattern is along the topographic front of the Himalaya where altitude and orographic rainfall effects dominate (Figure 1.1). In all other cases, those lands lying south of latitude 20° N are well covered by dense forest. Likewise, in China, especially in eastern China, we see the growth of some subtropical forests across much of the central and southern part of the country, transitioning north into temperate forests. These lie to the east of the Tibetan Plateau and extend as far west as the Sichuan Basin. The vegetation in China mostly differs from that seen in Indochina and Bengal because it lies further north. Much of the moisture delivered to southwest China is, moreover, coming across Indochina from the Bay of Bengal (Drumond et al., 2011), so that some of the precipitation is lost on the hills in Myanmar and Yunnan Province. It is this topographic barrier that accounts for the tongue of temperate forest that extends toward the Gulf of Tonkin from the more extensive regions of such flora in the southern Tibetan Plateau. It is noteworthy that some parts of western Indochina also have a less dense forest cover. This partly reflects slightly higher elevations and also the topographic barrier of the coastal mountains, that extend through Myanmar and into the Malay Peninsula. These are a focus for orographic precipitation for the moisture moving to the northeast from the Bay of Bengal. Biomes become more arid moving into central Asia away from the East China Sea, because as the East Asian Summer Monsoon front moves away from the coast it drops its moisture across eastern China, aided by the progressive increase in altitude going west. Further west in the region of the Tarim Basin, north of the Tibetan Plateau and south of the Tian Shan, the precipitation is negligible, allowing the Taklimakan Desert to form in this rain shadow.

We demonstrate that the pattern of floral and ecological zones in Asia is largely a function of altitude and latitude, but that rainfall intensity, largely governed by the strength of the summer monsoon is also important. Monsoon intensity, often focused by topography, accounts for the gradient in precipitation from east to west across the Indian subcontinent, for the strong rainfall in western coastal India, and for the south to north decrease in rainfall across eastern China. We might reasonably expect, therefore, that when the intensity of the summer monsoon changes, the environments in these parts of Asia would be subject to potentially significant change. This is particularly important for human settlement because these also happen to be the regions that are most heavily settled in the present day, but also regions that in the past played an important role in the development of the different systems of cultivation that sustain these areas today (Hosner et al., 2016; Roberts et al., 2016).

Figure 1.3A shows the population density within South and East Asia in 2000 and particularly highlights the high concentrations found in the Indian subcontinent and in Eastern China and more specifically within the Valley of the Ganges–Brahmaputra River, in the Sichuan Basin and in Eastern China especially in the lower reaches of the Yangtze basin and north, all the way to the Bohai Sea. Other population concentrations observed include that on the Red River delta plain in northern Vietnam, around the Mekong Delta in southern Vietnam and Cambodia, as well as a smaller concentration in the Chao Phraya delta in Thailand. Those population densities located close to the coast are at less risk from losing sufficient water supplies in the form of rainfall because precipitation in those areas is not entirely driven by the strength of the Asian monsoon, although a decrease in the summer monsoon would affect the volume of rainfall even in those places. Coastal regions are, however, more vulnerable to the effects of sea-level rise. The particularly extensive continental shelves of Southeast Asia, especially the Sunda Shelf, and the East China Sea were fully exposed at the Last Glacial Maximum (LGM) and were progressively inundated during the deglaciation. Times of rapid rise would have been potentially damaging to early settlements, for example, the 8.2-thousand-year-ago (ka) Event but especially Meltwater Pulse 1-A (14.7–13.5 ka) during which sea level rose around 20 m in only 500 years (d'Alpoim Guedes et al., 2016a; Weaver et al., 2003). Regions within the continental interior that only receive significant rainfall because of the summer monsoon winds would be most strongly affected by a change in intensity, with the exception of regions in Southwest Asia that also receive winter rainfall brought by the westerly jet, mostly particularly in the form of heavy rain associated with atmospheric vortices known as “Western Disturbances” (Hunt et al., 2018). Further east the winter is a drier season, away from coastal zones.

1.4 Past Monsoon Environments

As noted earlier, we would expect the intensity of the summer monsoon to be affected by changes in temperature and solar insolation. Monsoon intensity has been linked to the extent of Northern Hemispheric Glaciation and the climate of the

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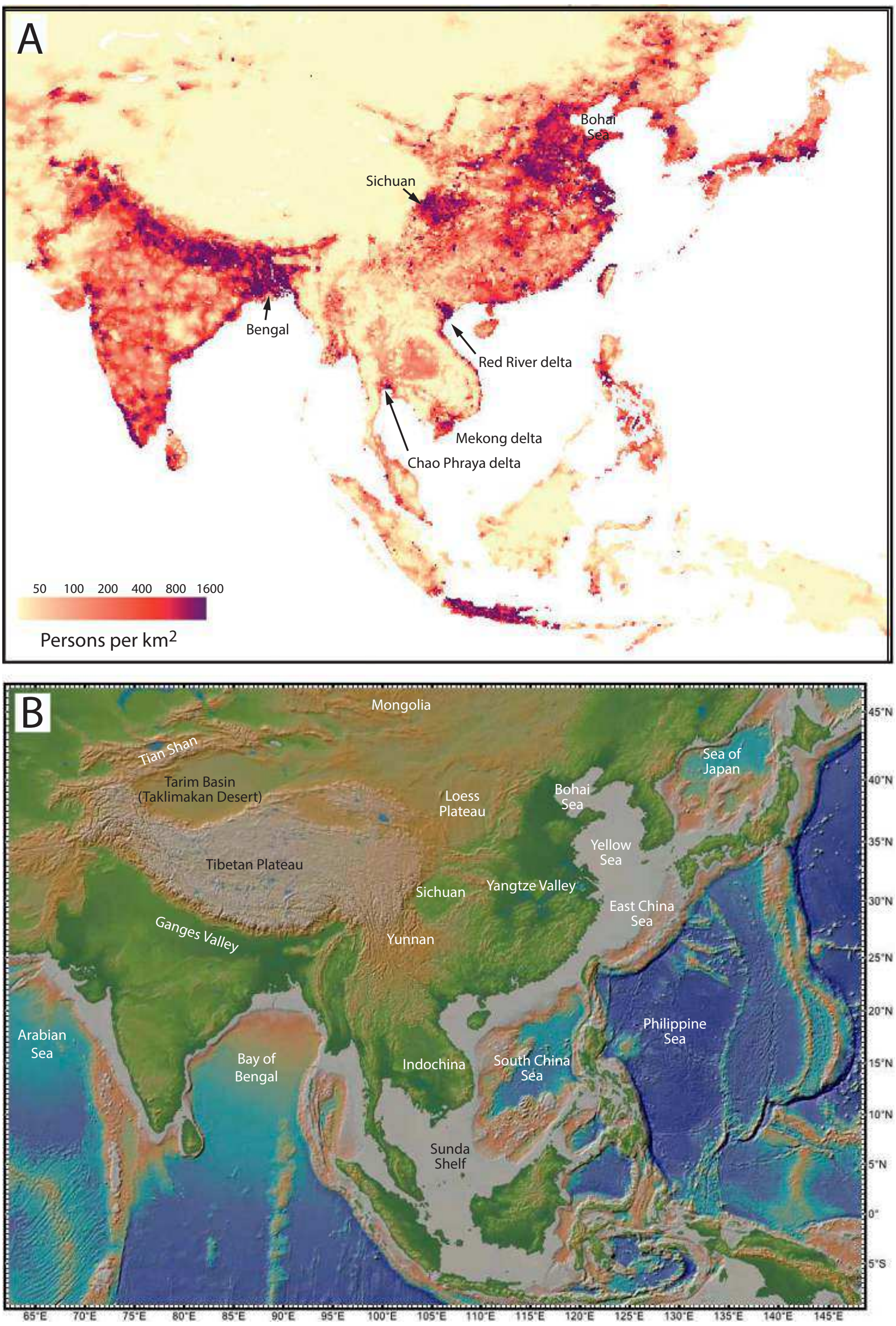

Figure 1.3 (A) Population density maps of monsoonal Asia in 2000. (B) Shaded topographic map of monsoonal Asia emphasizing the high ground in the Tibetan Plateau and to the north into the Tian Shan and Mongolia. Note the correspondence of heavily settled regions and low altitude plains in South and East Asia. Data from United Nations Environment Program/Global Resource Information Database (UNEP/GRID).