The Global Implications of Tibetan Interdependence

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ABSTRACT

Tibetan history is marked by its inability to become independent of foreign occupiers and antagonists. Today, it is under the coercive rule of China, which claims it as a historical possession. This is quite ironic in the sense that Tibet's long-term desire for autonomy transgresses one of the fundamental principles of Buddhism, namely, the notion that all phenomena arise together in a mutually interdependent web of cause and effect. A careful look at the present state of the world's food and water supply would lend much credence to such a belief. Indeed, if current projections and trends are accurate, particularly those concerning climate and population, then the disappearing glaciers on the Tibetan Plateau will impinge upon every corner of the earth. After reviewing how Tibet has come to occupy this prominent place at the center of global affairs, possible scenarios are explored as to how this will materialize in the ensuing decades. While all such prognostications can be subject to question, what seems certain is that humanity's place on an increasingly fragile planet is inextricably linked to the future of Tibet.

INTRODUCTION: COMPLEX NON-LINEAR SYSTEMS

That all phenomena arise in a reciprocal or mutually dependent manner is a guiding principle of Buddhism. Nothing exists independently; therefore, all things are empty. They are empty because they are transient. The forms they take today perforce must change tomorrow. Because it is a transient entity, Tibet has come into being due to a series of past events, takes form in response to current conditions, and eventually will become a factor influencing future phenomena. It should be noted that this is not a linear progression, but an organic unfolding of vast complexity. What is commonly referred to as "Tibet" is an arbitrary distinction amongst innumerable others, all of which participate in a causal network. Highlighting a single node is simply a means of entry into the network itself. Each node, in fact, relates to all others in a mutual and dynamic manner. It is thus an ontological impossibility to speak of Tibet without also considering those nodes in its closest proximity.

While both historical and current interactions between Tibet and other proximate entities help induce the veneer of complexity of this system, there are recurrent patterns or cycles, some taking the form of feedback loops, which lie deep below. Such patterns can help to intensify or attenuate change depending upon the parameters within which they are operating. Land use and water allocation practices can be cited as two examples that have changed with the advent of the nation-state. In recent times, population pressures and unstable climate conditions have introduced two other sets of parameters to the system's inherent complexity.
As the source of the major river systems in Asia, the Tibetan Plateau is, in many respects, an ideal point of entry for the study of a complex non-linear system. The purpose here is to highlight the interdependencies of the causal relations that comprise this system by tracing the underlying patterns of the rivers themselves, which begin as glaciers, turn into headwaters, flow through gorges, are augmented by tributaries, and eventually disperse into deltas. In order to understand such hydrological cycles, the historical and current parameters that have the greatest influence on them are addressed. Predictions regarding future transformations, including probable interactions with other vital planetary systems, constitute the final part of this study.

THE TIBETAN PLATEAU: GLACIERS AND GRASSLANDS

Formed about 55 million years ago when India collided with the Asian continent, the Tibetan (or Qinghai-Xizang) Plateau has an average elevation of over 4,000 meters above sea level and covers an area of about 2.3 million square kilometers. Surrounded by most of the tallest mountains in the world, such as the Himalayas in the south, the Tibetan Plateau consists primarily of Xizang (the Tibetan Autonomous Region) and Qinghai as well as parts of Yunnan, Sichuan, and Gansu provinces in China. The plateau contains the world's third largest store of ice in its 46,298 glaciers, which contributes to the largest river runoff from any single location on earth. These rivers provide water for about three billion people, or 40 percent of the world's population. The glaciers on the Tibetan Plateau, due to their high altitudes and low latitudes, are highly susceptible to changes in temperature; in fact, the Tibetan Plateau has been following a distinct warming trend, especially in the winter months, since the mid-1950s (Duan et al., 2006; Liu & Chen, 2000). As a result, almost all of the glaciers are in retreat (Ding et al., 2006; Yao et al., 2007) with their ice melting rapidly (Matsuo & Heki, 2010). Indeed, the evidence, both empirical (Inman, 2010; Kehrwald et al., 2008; Liu et al., 2006; Liu et al., 2009; Pu et al., 2008; Wang et al., 2008; Xiao et al., 2007; Yang et al., 2008; Yang et al., 2010; Zhao et al., 2004) and anecdotal (Larmer, 2010; Yardley, 2006), indicates an ominous warming of the Tibetan Plateau (see Eriksson et al., 2009; Gou et al., 2008; Xu, J. et al., 2009).

Although air temperature and precipitation are the two main influences on the mass balance of a glacier (Pu et al., 2008), its location (Ding et al., 2006) and elevation (Rikiishi & Nakasato, 2006) are also determining factors. For glaciers located in the central and western part of the plateau, changes in the minimum temperature appear to be most important because at lower temperatures, more ice forms, thereby establishing a thicker base of mass volume. These glaciers also receive most of their precipitation during the summer, so higher temperatures produce less snowfall, which results in greater absorption of solar radiation. Liu and Chen (2000) contend that the weakening ability to reflect sunlight is responsible for the excessive warming on the Tibetan Plateau. By contrast, maritime glaciers in the south and east are more sensitive to maximum (summertime) temperatures due to their dependence on the monsoons (Gou et al., 2008). Yang et al. (2010) found that higher summer temperatures create stronger monsoon winds, and the commensurate increase in moisture leads to greater melting when the ratio of rain to precipitation increases. That is, more rain means less snow, which, in turn, translates into a shrinking glacial mass.

In addition to the debilitating effects of warmer temperatures, the concentration of black carbon, or soot, accelerates the melting of glaciers by reducing their ability to reflect light (i.e., their albedos), thereby enhancing their absorption of solar radiation. Higher concentrations have been found during the spring when most melting naturally occurs (Ming et al., 2009). Some studies have found the Tibetan Plateau particularly susceptible to this phenomenon, apparently because increasing emissions of black carbon from South and East Asia (i.e., India and China) are transported to the glaciers by winds during the monsoon seasons (e.g., Flanner et al., 2007). Dust from the surrounding deserts might also factor in the decline of seasonal snow cover and the concomitant reduction in surface albedo (Rikiishi & Nakasato, 2006). In any case, the glaciers' rapid retreat since the 1990s...
correlates with an increase in industrial activity and the significant amount of black soot it produces (Xu, B. et al., 2009).

In comparison to the majestic glaciers, little attention is being paid to the detrimental effects of warmer temperatures on permafrost, which helps regulate runoff from the glaciers to nearby grasslands and rivers. As it thaws, the water tables go down, thereby shrinking the wetlands. In fact, the entire alpine ecosystem, including the vegetation cover and soil composition, depends on a stable layer of permafrost (Wang et al., 2006). The permafrost, however, is melting quite rapidly (Jin et al., 2000; Xiao et al., 2007), half of which is expected to disappear by the end of this century (Cheng & Wu, 2007; Li et al., 2008). As the wetlands dry up, they not only emit methane into the atmosphere, one of the most potent greenhouse gases, but also become inhospitable to plant life, which, in turn, increases desertification. This positive feedback loop thus contributes to warmer temperatures, more intense (sand) storms, and soil erosion (see Wang et al., 2007). Moreover, a hotter and drier Tibet compromises the yearly monsoons - a critical link in the hydrological cycle (Sato & Kimura, 2007).

The primary ecosystem of the Tibetan Plateau is grasslands, which cover about 70 percent of the land surface. Although its causes are in dispute, the grasslands, akin to the glaciers over the past 50 years, have been degrading. In Qinghai Province, for example, about 90 percent of the grasslands are in a depleted state (Miller, 2005). Harris (2010) observes that their degradation, to the extent that it can be quantified, is likely due to multiple interacting factors (see Klein et al., 2004). Moreover, the relative importance of each factor seems to depend on the geographical area, with climate change having the greatest influence in the colder (northern and western) regions and anthropogenic activity, primarily overgrazing, being the predominant force in the warmer (southern and eastern) areas of the plateau (Zhang et al., 2007). Nonetheless, the grasslands provide their 5 million inhabitants, most of whom are Tibetan, with sufficient pastures to support about 12 million yak and 30 million sheep and goats (Miller, 2005).

Overgrazing has been blamed on traditional (i.e., Tibetan) practices that are anachronistic and unsustainable. The solution has been a rational approach to livestock production that includes a prohibition on grazing in select areas to allow for recovery, resettlement of nomads into semi-permanent camps and cities, and the implementation of animal husbandry practices (Harris, 2010). Critics counter that these policies are politically motivated insofar as they provide the Chinese government with a means of controlling a peripatetic population on the nation's periphery by embedding them in the larger market economy (e.g., Karan, 2009). Moreover, such policies, which are supported by significant subsidies, exacerbate the problem of overgrazing by decreasing the herder's mobility (Bauer, 2005). This is further compounded by outside pressures to increase livestock production. In effect, attempts to develop the plateau in a sustainable manner have apparently failed because they have not taken into account the time-honored migration patterns and diverse socioeconomic networks of the indigenous nomadic herders (see Foggin, 2008; Miller, 2005).

Such traditional practices seem to have been linked to relatively stable population patterns. Since 1950, however, the Tibetan population has more than doubled (Karan, 2009). In response, the Chinese government instituted strict birth control policies in the 1990s, which have led to rapid fertility declines and a replacement-level birthrate (Childs et al., 2005). Over the same period, there has also been an influx of non-Tibetans migrating from other parts of China enticed in part by the plateau’s huge reserves of mineral ores. Additional economic migration since the mid-1990s has been spurred by substantial subsidies designed to increase tourism to the area (Fischer, 2008). As population densities have increased, so has the focus on livestock production, which has led to the soil erosion and desertification associated with overgrazing (Gou et al., 2008). Further attempts to modernize the region, including a reliance on industrial agriculture to produce cash crops, are apparently undermining its ecological integrity (see Allen, 2009).
THE MAJOR RIVERS OF ASIA

Shrinking glaciers, thawing permafrost, and a compromised grassland ecosystem are indicative of the increasingly precarious condition of the Tibetan Plateau. As the hydrological heart of the Asian continent, such perturbations portend significant transformations elsewhere. The main arteries of this circulatory system, the rivers, and the recurring patterns and fluctuating parameters within which they currently function, are thus the focus of this section.

Brahmaputra: A River Eroded

Beginning in Tibet as the Yarlung Zangpo, which, at a mean elevation of over 4,000 meters, is the highest river in the world, the Brahmaputra runs eastward for nearly 2,000 kilometers before cutting deep gorges in the Himalayas. At this point the river makes a sharp turn westward as it enters the northern Indian State of Assam, where its rich waters nourish the forests and agricultural communities in the highlands. The river then turns southwest merging with other streams and rivers, including the Ganges, before entering Bangladesh, supplying the basin with large amounts of alluvium as it gradually makes its way to the Bay of Bengal. The lower course of the river is subject to severe flooding, especially during the monsoon season (Asia Society, 2009).

The Brahmaputra, like most of the rivers in this study, is a trans-boundary river under various degrees of stress. Because the river basin is home to 662 glaciers, it is at risk from warming temperatures (Xu, J. et al., 2009). The subsequent increase in precipitation is expected to intensify erosion, particularly on the plateau, where there are already high rates of chemical weathering due to certain geologic conditions, such as rapid tectonic uplift, steep channel slopes, and high stream power (see Huang et al., 2009). Land erosion and large deposits of silt are also the result of flooding and deforestation. In addition, hundreds of dams are planned for the Brahmaputra and its tributaries ("Large dams," 2010). Dams do not merely affect water flows, but, by interfering with the hydrological cycle, transform all relations that are intimately linked to it. Their cumulative effect on a single river can be even more pronounced. In the case of the Brahmaputra, the dams under construction or consideration not only have the potential to cause conflicts in the future, especially if water is diverted, but are certain to exacerbate the human and ecological consequences associated with increased flooding and erosion (Ranjan, 2010).

Ganges: A River Polluted

Arising from a confluence of five rivers, the Ganges runs from the central Himalayas in Nepal through northeast India across the plains to the Bangladesh border. The main source of the Ganges is the Gangotri glacier, which has been receding 10 to 30 meters per year since the middle of the last century (Marwah, 2004). Himalayan glaciers supply about 30 to 40 percent of the water for the 500 million people who live in the river’s watershed (Wong et al., 2007). As a result, the Ganges is most likely to be affected by the decreasing snowfall in winter and earlier snow melt that has been attributed to warmer temperatures (Kaser et al., 2010). Rising sea levels, also associated with climate change, are causing salt water to flow into the Ganges at its mouth, further compromising its quality (Dhar, 2009). Scarcity is thus predicted by 2030, if not sooner, when the population along the river and its tributaries is projected to be about twice its current size (Hammer, 2007).

In terms of quality, the Ganges is one of the most polluted rivers in the world. Pollution is attributed to many factors, including industrial runoff (toxic chemicals, carcinogens), domestic sewage, and the practice of using the river to dispose of dead bodies. Government efforts to clean the river through the use of wastewater treatment plants have largely failed due to their inadequate design (they cannot remove microorganisms) and their inability to operate during frequent electrical blackouts and floods (Hammer, 2007). In order to
compensate, India has become the world's largest user of groundwater upon which 60 percent of its irrigation systems depend (Asia Society, 2009). Using groundwater for drinking or irrigation, though, is not an option for many in the river basin due to contamination from naturally occurring arsenic (Singh, 2006). Hence, the importance of surface water supplies.

Indus: A River Depleted

Beginning in the glaciers of the Himalayas, the Indus River runs from China and India through Pakistan where its tributaries merge with the Kabul River before entering the Punjab plains. From there it passes through the flood plains of Sindh and its large delta before debouching into the Arabian Sea. The Indus basin has the largest number of glaciers (3,538) in India, and is, therefore, quite susceptible to warmer temperatures (World Wide Fund for Nature [WWF], 2005). These glaciers supply the Indus with 70 to 80 percent of its water, half of which is used for irrigation (Xu, J. et al., 2009). Consequently, the loss of melt-water poses a significant threat to the food security of the 180 million people who live in its watershed (Immerzeel et al., 2010).

The Indus Basin Irrigation System is the largest gravity-fed, contiguous irrigation system in the world. Although designed to equitably distribute water over large areas, less than 40 percent of the water extracted for irrigation eventually reaches crops. Such inefficiencies are contributing to water scarce conditions in Pakistan, which obtains about 80 percent of all its water from the Indus River. Deforestation has also contributed to water scarcity as less tree cover along the river has allowed more sediment to wash downstream, thereby diminishing the storage capacity of reservoirs (Asia Society, 2009). In fact, the Indus basin has lost over 90 percent of its original forest cover, including significant portions of its mangroves in the delta (Wong et al., 2007). Due to reduced flows of freshwater and saltwater intrusion, the delta is now one-tenth of its original size. Although the government continues to provide substantial subsidies to facilitate agricultural development, domestic cereal production has been inadequate, so Pakistan must import wheat. Due to projected increases in population and continued water scarcity, severe shortfalls of grain are expected by 2020 (Asia Society, 2009).

Mekong: A River Divided

The Mekong River runs from Qinghai, China, along the border of Laos and Burma. After entering Laos, it then becomes the border with Thailand for over 600 kilometers before entering Cambodia and finally southern Vietnam on its way to the South China Sea. The river basin is the largest in Southeast Asia with over 73 million people living in its watershed. About 80 percent of the population in the Lower Mekong Basin (i.e., Laos, Thailand, Cambodia, and Vietnam) depends on the river for sustenance (Osborne, 2009). Although the lower basin is the most productive river fishery in the world due to annual wet season flooding, it is threatened by 58 existing and 149 proposed large dams. Overfishing is also a huge problem because most subsistence fishing goes unrecorded (Wong et al., 2007). Climate models predict that an increase in severe droughts and upsurge in flooding, particularly after 2030, will further compromise the fisheries in the basin (Mekong River Commission, 2009).

The main concern for those in the lower basin is how the dams will affect agriculture and fisheries downstream, especially Tonle Sap Lake in Cambodia, which relies on seasonal changes in the level of the Mekong to provide nourishment for rice and fish (Strangio, 2009). Richardson (2009) contends that dams in the upper reaches of the river threaten both fish stocks, already under pressure from over-harvesting and pollution, because they interfere with the river's natural flood and drought cycle, and the rice fields in the Mekong Delta in Vietnam because a reduction in flow translates into more seawater intrusion and salinization. Despite the existence of the Mekong River Commission, established in 1995 by Laos, Thailand, Cambodia, and Vietnam, with China and Burma becoming "dialogue
partners” a year later, there has been little consultation between countries with each maintaining the right to develop the river (Osborne, 2009).

Salween: A River Threatened

The Salween River flows from the Tibetan Plateau southward through Yunnan Province in China (where it is known as the Nu), forming the border between Burma (Myanmar) and Thailand, then entering Burma before it empties into the Andaman Sea. The Salween is the second largest river basin in Southeast Asia, and home to about six million people. The population along the Chinese and Thai-Burma borders is comprised mostly of ethnic minorities who rely on rice paddy farming and swidden (slash-and-burn) cultivation. Although it has the distinction of being one of the last free flowing rivers in the world, China is planning 13 large hydropower projects (dams and reservoirs) without consulting its riparian neighbors. In addition, Burma and Thailand have plans to build up to twelve dams on the Salween in a region threatened by frequent landslides and earthquakes (Wong et al., 2007).

Opposition to dam construction from environmental and human rights groups has twice led to their suspension by the Chinese government. However, under the guise of promoting clean energy, and in response to pressure from state-owned power companies and provincial governments, the hydropower projects have recently been approved (Watts, 2011). In Burma, where such projects are often associated with human rights abuses and natural resource exploitation, there has been strong resistance to any dam construction on the Salween. For instance, fighting along the Thai-Burma border in 2009 between the Karen National Liberation Army and the Burmese Army displaced thousands of people just to the south of the planned Hat Gyi Dam, many of whom were forced to forgo environmentally benign lifestyles for refugee camps (Talenywun, 2009). The situation is analogous in the river’s estuary, where the proposed dams will alter the fragile balance between the Mon people and their environment by disturbing the seasonal flows and quality of the water and sediment, thereby having adverse effects on agricultural and fishing practices (Mon Youth Progressive Organization, 2007).

Yangtze: A River Exploited

The Yangtze River is the longest in Asia and third longest in the world. Beginning in Qinghai Province, it flows eastward across central China before emptying into the East China Sea at Shanghai. The Yangtze is home to one-third of China’s population, or about 430 million people. As such, the basin accounts for 40 percent of China’s freshwater resources, more than 70 percent of rice production, 50 percent of grain production, over 70 percent of fishery production, and 40 percent of China’s GDP. The water, however, has become unfit for drinking due to pollution from large-scale industrial development and agricultural runoff. In addition to suffering from eutrophication, the Yangtze is increasingly carrying large amounts of sediment from erosion and damming, much of which is trapped in reservoirs. As a result of decreasing water quality, the river has become the source of many infectious diseases (Wong et al., 2007).

Future dam construction will clearly exacerbate these problems. Yardley (2007) reports that water pollution is worsening in tributaries of the Yangtze after construction of the Three Gorges Dam. From depleted fisheries and less sediment flowing downstream to severe erosion and landslides, the largest hydropower project in the world has completely altered the river's ecology. Still, more than 100 dams, including 12 on the river’s mainstream, are in the planning or construction phase (International Rivers, 2009). To compound matters further, not only has the glacier in the Tibetan Plateau that is the source of the Yangtze River been retreating since 2004 (“Glacier at source,” 2010), but the monsoon belt has also moved southward (Zhai et al., 2005). Together, they have been responsible for increasing erosion at the headwaters and more frequent flooding downstream. Finally, the long-term ecological consequences of diverting large amounts of water from the Yangtze...
River to the drought-stricken North China Plain as part of the South-North Water Transfer Project are still uncertain (Yang & Zehnder, 2005).

**Yellow: A River Exhausted**

The Yellow River (Huang He) is the second longest river in China and the most silted river in the world. Beginning in Qinghai Province, it first moves north through the Loess Plateau, then turns south, before heading east for a total of 5,500 kilometers as it flows across Northern China making its way to the Bohai Sea. It is the source of water for 140 million people, most of which is withdrawn for agriculture. Not only are the lakes at the headwaters of the Yellow River drying up mostly due to warmer temperatures and less precipitation, but the glaciers feeding the river are also shrinking (Yardley, 2006). The upshot has been increasing desertification in the river's upper reaches and a significant decrease in runoff. In 1996 the river was dry for 133 days, and, in 1997, a year exacerbated by drought, it failed to reach the sea for 226 days. If current climatic, demographic, and economic patterns persist, serious water shortages are predicted across the region in the next 10 to 15 years (WWF, 2005).

A lack of water has already reduced crop outputs along the river's basin. This is being compounded by extremely inefficient irrigation practices, where more than half the water allocated for agriculture is wasted (Wang et al., 2005). In addition to shortages, water quality is being severely compromised by discharges of municipal sewage, industrial wastewater, and agricultural chemicals (Xia et al., 2002). One-third of the Yellow River is unfit for agriculture, aquaculture, or industry, while only 16 percent is deemed safe for domestic use. Wang et al. (2006) show how both scarce conditions and substandard water quality are exacerbated by the construction of dams and reservoirs. Built primarily in order to meet the needs of irrigating crops, subsequent agricultural demands have contributed, in the manner of a positive feedback loop, to the steady reduction in water discharge. A substantial decline in fishermen's catches coupled with species extinction are further indicators of how such human-induced parameters are transforming the river (see Watts, 2007).

**TIBET IN A GLOBAL CONTEXT**

Like the Tibetan Plateau from which they spring, the major rivers of Asia are under varying degrees of stress, their natural flows attenuated by dams, reservoirs and canals, their fragmented use predicated upon geo-political concerns, and their hydrological integrity threatened by altered precipitation patterns, over-extraction, and pollution. Most observers rightly foresee a potential crisis, one that is bound to affect the entire populace of the region. However, climate change and overpopulation are issues not circumscribed to the Asian continent. It is the same for the inevitable food and water shortages predicted to occur elsewhere if current trends continue. All countries participate in the global economy; therefore, what occurs on the Tibetan Plateau is bound to have a rippling effect across the entire planet. It is imperative that those connections be made explicit by placing the heart of Asia (i.e., the Tibetan Plateau) in its proper global context.

**Climate and Population Projections**

The complex array of interactions involved in global temperature change, including those between the hydrological cycle, cloud feedback, solar radiation, and ocean dynamics, make it difficult to foresee future developments. Indeed, small perturbations in non-linear systems can produce a sudden series of cascading consequences. With these caveats in mind, the Intergovernmental Panel on Climate Change (2007) estimates that the average surface temperature of the earth is likely to increase from 1.8 to 4.0 degrees Celsius by the end of the twenty-first century, that this increase will be more pronounced over land and at higher altitudes, that warming in Northern and Central Asia, including the Tibetan Plateau,
is likely to be well above the global average, that winters will warm more than summers and nights more than days, that daily minimum temperatures are expected to increase, that the monsoon intensity will be greater due to increased precipitation, that glacier melting will be enhanced by precipitation that occurs more as rain and less as snow, and that there will be a significant thawing of permafrost. In sum, the cumulative effects of global warming trends on the Tibetan Plateau, and, by extension, the rest of Asia, clearly point in a negative direction.

All climate scenarios incorporate certain expectations about population. Demographic projections, in turn, make assumptions about fertility rates that are often difficult to foresee. Slight variations can result in huge population increases over time due to their exponential nature. Uncertainties also abound due to limitations in data collection and methods of analysis. The most often cited figure from the United Nations of 9.2 billion people for 2050 is based on a medium-fertility assumption, which takes into account assumptions about mortality and migration. Other projections, such as those by the International Institute for Applied Systems Analysis (IIASA), concern probabilistic ranges, namely, an 80 percent likelihood that world population in 2050 will be between 7.8 and 9.9 billion (Leahy & Peoples, 2009).

At present, the world population is increasing by 80 million each year, even though population growth rates have been declining since the early 1970s (Kunzig, 2011). Significant population growth until the middle of this century is projected for Asia, which already has four of the seven most populous countries on earth: China, India, Pakistan, and Bangladesh (IIASA, 2008). According to the UN medium projection variant wherein fertility, mortality, and migration levels are held constant, the combined populations of China and India by 2050 will exceed three billion while the populations of Pakistan and Bangladesh are expected to increase by 80 percent and 35 percent, respectively (United Nations, 2009). All told, there will be approximately one billion more people living on the Asian continent by the middle of this century, most relying upon the water pulsing through the Tibetan Plateau.

**Water and Food Forecasts**

The importance of the glaciers on the Tibetan Plateau in regards to the world's water cannot be overstated, particularly in light of the climate and population projections discussed above. Of the three percent of water on earth that is fresh (i.e., drinkable), less than one percent is accessible, with most either frozen in icecaps or locked away in deep aquifers. While there is still more than enough to satisfy current needs, water is unevenly distributed across the planet. In consequence, 1.4 billion people currently live in water scarce conditions, where access to freshwater is limited and of dubious quality, while 450 million suffer from water shortages (United Nations Environment Programme [UNEP], 2008). If projected increases in global freshwater use are accurate, then about two-thirds of the human population will live in countries or regions with absolute water scarcity by 2025 (Food and Agriculture Organization of the United Nations, 2007).

Since 75 percent of global water consumption is used for agriculture, shortages are bound to constrain food production (UNEP, 2008). To what degree is open to question, however, given the array of factors involved. This is compounded by the uncertainty of climate forecasts. While early studies suggested that warmer temperatures would have a minimal effect on global agricultural production (e.g., Rosenzweig & Parry, 1994), recent research is much more alarmist in its forecasts, particularly for South Asia, which is expected to have the largest declines in crop yields of any region in the world (Erda et al., 2005; Nelson et al., 2009). One reason appears to be that earlier studies did not take into account the effect of elevated ozone levels on crop fertility (Long et al., 2005). Wang and Mauzerall (2004) claim that increased concentrations of ozone in East Asia will reduce grain production substantially by 2020. Another factor is the rise in minimum nighttime temperatures, which have been shown to have a negative effect on rice grain yields (Peng et al., 2004). This
is particularly troublesome for rice-producing countries like Vietnam and India, where minimum temperatures are expected to continue rising.

Equally disturbing are falling water tables, which due to chronic overpumping of groundwater, is now a widespread global problem (Brown, 2008). In Pakistan, for instance, 20,000 tube wells are being added each year, even though the groundwater table has been falling across the country since 1998 (Bhutta & Alam, 2006). The situation is analogous in other Asian countries, such as Bangladesh, which relies on groundwater for 75 percent of its cultivated land (Zahid & Ahmed, 2006). Most troubling are the depleted aquifers in China, where 80 percent of grain production comes from irrigated land. As a result, China's agricultural output is expected to decline from 5 to 10 percent by 2030 (Zeng et al., 2008). For countries that can afford to do so, imports of virtual water (i.e., food) are the most direct way of addressing insufficiencies. However, there is no guarantee that the global food system will be able to satisfy growing demands, which are expected to double by 2050, as the world's largest grain exporters, such as Australia (Asia Society, 2009) and the United States (Laurence, 2011), continue to deplete their aquifers.

FUTURE SCENARIOS

The influence of warmer temperatures on the Tibetan Plateau in terms of water scarcity coupled with increasing demands for food and energy from growing populations constitute two vital parameters within which Asia's main rivers now flow. Of the myriad ways in which these interconnected and complex regional and global issues might be addressed in the future, three overarching scenarios appear to be the most plausible.

In the first scenario there are concerted efforts to stabilize population, primarily through poverty alleviation and the education of girls (Hunter, 2008), and greenhouse gas emissions, mainly through efficiency and a full-scale transition to renewable energy, with the long-term goals of decreasing both (see Brown, 2008). The 1994 International Conference on Population and Development and the 1997 Kyoto Protocol were attempts by the United Nations to achieve these aims, but they have clearly failed due to political, economic, and religious resistance. They still might be implemented in the future or reemerge in alternate manifestations although their likelihood of having a significant effect decreases with time. Such an empirical approach to these issues, which entails fundamental changes, also lends itself to adaptation efforts in accordance with the precautionary principle, as well as local, regional, and international collaboration (e.g., Strategic Foresight Group, 2009).

In an alternate scenario, concerted efforts are made to maintain the status quo. This includes attempts to address the situation through policy changes concerning, for example, water rights and regulations (see Biswas, 2007; David, 2004). It also relies on technological fixes, such as building artificial glaciers (Schell, 2010), seeding the clouds with iodine to produce more rain (Larmer, 2010), carbon capture and sequestration to offset global warming (Breeze, 2008), and bioengineering rice crops to survive for weeks under flood waters (Biswas, 2007). Other components are market-based solutions, such as privatization of public water utilities (Gies, 2009), and grand social schemes (e.g., the resettlement of nomads - Foggin, 2008) that ultimately fail to address the underlying causes of the problem and may in fact intensify its consequences to the degree that very few are prepared to deal with it in the future. As a whole, they constitute a sort of piecemeal, or political, approach that mostly deals with symptoms and is clearly reactionary rather than proactive.

Finally, there is a fatalistic scenario which assumes that the consequences of climate change are inevitable, and that it is prudent to focus on how best to mitigate the most adverse amongst them. One way is through market adjustments or by altering agricultural techniques (Fischer et al., 2005). A more controversial tack is to attempt to counteract those consequences through geo-engineering planetary systems (see Schneider, 2008). Some of the more widely discussed proposals include injecting sulfate aerosols into the stratosphere in order to reflect sunlight back into space (Brovkin et al., 2009), or fertilizing the oceans with iron.
to stimulate uptake of carbon dioxide by phytoplankton (Denman, 2008). The inability to adequately field test any of these experiments is one limitation (e.g., Watson et al., 2008). Another is the difficulty in foreseeing unintended outcomes (Robock, 2008), such as altering the hydrological cycle (Bala et al., 2008). A further issue concerns achieving global consensus, which has also bedeviled the empirical approach thus far.

CONCLUSION: FREEZE TIBET

The causal network of which the Tibetan Plateau might be construed as one of its life-giving nodes ultimately covers the entire planet. Trying to foresee its future transformations is thus fraught with uncertainty given the array of unknown variables involved and the complex interactions between them. Still, the scenarios outlined above can serve as the basis for much needed discussion before worsening conditions might demand a more immediate response.

Creating awareness of the far-reaching nature of the issues involved, especially among the populations in Asia likely to be most affected, would appear to be a priority. The collective weight of their understanding could then be brought to bear on international negotiations, such as those concerning poverty, population, and pollution. The goal ought to be to make the plight of the Tibetan Plateau as pertinent as that of the starving polar bears or the disappearing island nations when discussing, for instance, the manifold implications of a warmer world. With that in mind, and as a first step, it may be time to replace the continuing call to "Free Tibet" with "Freeze Tibet" - a mantra more befitting an interdependent age.

NOTES

1. Often referred to as the "roof of the world," "third pole," or "water towers of Asia," the Tibetan Plateau might better be construed as the "heart of Asia" insofar as it is a prominent and central part of the continent's geography, maintains the vital flow of water through its rivers, and regulates the circulation (i.e., climatic) system. The aforementioned mechanical metaphors simply fail to convey the plateau's dynamic nature, namely, its unusually hot core, relentless rising and falling, and volatile mix of earthquakes and erosion.

REFERENCES


