The Himalayan Vertical Archipelago: Climate Change, Glacial Lake Insecurity, and Institutional Capacity in the Khumbu Himalaya

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One way to better understand the ways in which climate change is currently affecting the Himalayan region is by focusing on the vertical distribution of the complex natural and social transformations that are occurring across the steep gradients of the range. Interdisciplinary research from the Andes and Himalayas focusing on the common relationships between natural and human systems in mountainous areas has long argued that these landscapes often resemble vertical “archipelagos” that are defined by unique “zones” of bioclimate and human activities (Murra 1972; Guillet 1983). According to the “verticalists,” human civilizations have historically sought to utilize as many bioclimatic zones as possible by linking them together through institutional networks of resource management, production, and exchange. While the larger verticality hypothesis on the origins of mountain civilizations is likely to remain unsettled, the tiered archipelago model that emerged from these debates has proven to be a useful conceptual framework that might be utilized in a more limited and contemporaneous fashion to provide insights into the distribution of bioclimatic zones across the Khumbu region of the Nepalese Himalayas, how they are linked together by networks of social institutions, and the ways in which current patterns of climate change are differentially affecting vertical zones and human vulnerability to glacial lake hazards.

The Himalayan Vertical Archipelago
The Nepali Himalaya contains some of the most precipitous terrestrial escarpments on the planet. From the Terai outer plains, the Southern slope of the range soars more than 8,500 meters in as few as 100 kilometers. The Khumbu area, which is located in the upper Dudh Koshi river basin and contains several of the highest peaks on the planet – including Mount Everest (8848m) and Llotse (8516m) – is even steeper as it ascends nearly 6,000 meters in just 60 kilometers. The extreme height of the range, its altitudinal gradient, and the monsoon precipitation regime that feeds the 482 square kilometers of glaciers in the upper basin (~10% of Nepal’s glacial coverage), have created niches for 11 different bioclimatic zones, which have disproportionately concentrated species biodiversity along the sharp uplift of the range between 1,000 and 3,000 meters. Nepal is home to more than 1,988 animal species and 6,280 plant species (ICIMOD 2007b).

The social systems spread across these bioclimatic zones are differentiated as well and communities generally decrease in size as elevation increases. Along the range and at the base of the highest peaks in the world are the 278 glaciers that provide meltwater for irrigation, hydropower, and human and animal consumption at lower elevations (ICIMOD 2007a). Beneath the glaciers, meltwater and precipitation supports wetlands where yaks and cows are pastured. Below the high grazing areas, households cultivate high elevation crops such as corn, barley, and potatoes. Approximately 80% of households are engaged
in smallholder agricultural and livestock production. Beginning in 1953, when Mt. Everest was first
summitted, the frozen upper zone of the Himalayan archipelago was incorporated into social networks of
production and exchange through rapidly increasing mountain tourism, trekking, and climbing activities.
Because there are no roads above 2,000 meters, local Sherpa populations and livestock are also the
physical links between the airstrip at Lukla and these new zones of economic production and
consumption. Tourism has increased rapidly over the past several decades and the communities of the
region have become very dependent on income from this sector. Tourism-related livelihood income
generation has also come to affect other livelihood production activities, such as agricultural, because
crops are often harvested to accommodate the main expedition season, which begins in October and
continues until the monsoon rains begin in April or May.

The social institutions that link human activities across the diverse bioclimatic zones of the region are
comprised of several predominant political, economic, and cultural networks. These linkages consist of
patterns of economic production, social reproduction, and natural resource management. Perhaps the
most pervasive set of networks are economic exchange relationships that link households across
elevations and to larger markets through subsistence activities such as agriculture, livestock, and labor.
This dense web of relationships allows for the provision of human necessities such as food, water, shelter.
However, the productivity of these webs is mostly insufficient at higher elevations as poverty rates are
pervasive. Linkages between these economic networks and natural resource management activities are
largely focused on short-term resource
maximization strategies and natural resource exploitation, rather than longer-term strategies
with broader management objectives. However, small community-scale collaborative
management activities related to activities such as irrigation, potable water, and pasture
management have been successfully developed in many places.

Politically, Nepal was long isolated from outside influences by a royal monarchy for much of its
history. However, beginning in 1959, successive waves of instability and political unrest radically
altered this order. Since then, political changes in the country included the return of the monarchy, the
failure of several different democratic administrations, and then a 12-year civil war that led to the creation
of several revolutionary or insurgent movements. In 2007, the Communist Party of Nepal transformed the
national government yet again into a democratic republic. One legacy of the near-constant state of
violence and political upheaval in the country over the past 50 years is that political governance structures
and relationships of legitimacy and trust throughout the country have been either weakened or
completely destroyed. Perhaps the most severely affected political networks have been those between
the capital, Kathmandu, and ethnically diverse populations at higher elevations. The failure of these
political networks has had significant negative impacts on the country’s economy and infrastructure and,
while political instability has lessened over the past few years, new networks have yet to be fully reformed.
Like many post-conflict societies, the failure of state institutions of control in Nepal has also been
accompanied by the weakening of national systems of natural resource management and control.
However, while this has been the case for much of the country, large-scale conservation activities in
Khumbu region have remained intact. This appears to be largely the result of two key factors. First,
because the region is host to several of the world’s tallest mountains, it has become a location of global
significance and new transnational political and economic networks have been established with the
region. These new linkages have also been accompanied by a significant influx of bilateral and
multilateral aid and assistance programs and the long-term presence of professional staff from a variety
of international agencies, and have significantly affected natural resource management activities in the
Khumbu, largely through the creation of Sagarmatha National Park in 1976, and its designation as a
Natural World Heritage Site in 1979.
The other major factor influencing conservation activities in the Khumbu, which perhaps explains why the impacts of the Maoist insurgency were not as significant in the region are the strong Sherpa cultural and ethnic networks and institutions that link human activities across the vertical axis of the range. After migrating to Nepal several centuries ago, the Sherpa population (est. pop. 145,622 in 2001) became the predominant ethnic group in the Khumbu above the community of Llukla (Pangboche is the oldest Sherpa community in Nepal and incidentally, the second largest concentration of Sherpas outside of the Khumbu is in New York City). During the past 50 years of political instability, when many national political networks disappeared in the region, they were frequently replaced by kinship-based Sherpa networks. The replacement of state networks was further facilitated by international conservation agencies when Sagarmatha National Park (see below) was created, since only local Sherpa populations can own land in the park. In addition, the rapid growth of the tourism industry, and the fact that Sherpas are world-renowned for their high elevation endurance, has allowed kinship-based Sherpa networks to control the provision of lodging, food, transportation, and expedition support that links tourists to the highest elevations on the planet.

![The Mount Everest Region of Sagarmatha National Park (Source: NASA 2010 EO-1 Image; GIS by author)](image)

**Climate Change and Glacial Lake Insecurity in the Khumbu**

Over the past several decades, global climate change has spurred a set of complex set of inter-related natural transformations across the Nepal Himalayas and the Khumbu region. According to recent research, air temperature across most of the region increased significantly over the past century and the rate of warming has accelerated over the past few decades at a rate of .06 to 0.12°C/year (ICIMOD 2007a). Increases in temperature have been accompanied by decreasing trends in precipitation and reductions of total seasonal snowfall. The combined results of these changes have been consistent and pervasive reductions of glacial coverage in the region. Between 1960 and 2001, low elevation glaciers retreated across the Dudh Koshi basin at an average of 5 to 10 meters per year. This rate has been much higher in some instances and has also been accelerating. For example, the
average recession rate of the Imja glacier (see adjacent images) between 1960 and 2001 was 59 meters per year, but over the past half-decade it has been retreating an average of 74 meters per year. The cumulative range of retreat of glaciers between 1964 and 2001 across the entire Dudh Koshi basin was a minimum of 400 meters and a maximum of 2,340 meters. The magnitude of the associated volumetric reductions of glacial ice may never be known because comprehensive measurements were never completed before the glaciers began to recede.

One consequence of the rapid glacial retreat occurring across the region is that massive quantities of water have been released from the frozen heights of the Himalayan vertical archipelago, which has resulted in a number of significant new climate change-related threats to human vulnerability. The most significant new vector of vulnerability has been the creation of a large number of new glacial lakes. Since 1960, more than 35 new moraine-dammed or supraglacial lakes have appeared in the watershed and the overall area of moraine-dammed lakes has increased 217%. Because the moraines holding these massive quantities of water are loosely consolidated and often partially frozen, they are also inherently unstable and have a very high likelihood of creating glacial outburst floods (GLOFS) that would have disastrous cascading effects on downstream natural environments and human settlements. While only 12 instances of GLOFs have ever been recorded for the entire country (one of which occurred in the Khumbu in 1985), the Dudh Koshi basin now contains at least 12 glacier lakes that have been classified as potentially dangerous. Half of these 12 lakes are growing rapidly and are expected to eventually breach their moraines (Ibid.).

The fact that a number of new lakes have appeared beneath the glaciers of the Khumbu region clearly illustrates that climate change-induced warming is altering glacial mass balance dynamics. That one or several of them, in the absence of any preventative action, will eventually breach their moraines and release massive quantities of water downstream is deeply alarming and should provide a compelling rationale for urgent mitigation efforts. However, while the risks associated with accelerating glacier retreat and increases in glacial lake hazards are rapidly increasing, the political, social, and cultural networks that currently exist in the region have little capacity to affect the increasing probability that (1) a GLOF will occur in the future, and (2) it will have disastrous consequences for human well-being downstream.

There are at least several reasons why the current constellation of networks and institutions that link the vertical archipelago of the region do not possess the necessary capacity to address these urgent challenges. This includes factors related to resource mobilization, legitimacy, technical capacity, and efficacy. First, the weakening of political networks due to civil upheaval in the country reduced the ability of the state to mobilize the necessary economic and technical resources. While some hazard assessment and risk reduction activities have been undertaken at a few lakes by the Nepali government (e.g. Imja Tsho and Dig Tsho), or were executed by international organizations and research teams (e.g. ICIMOD, TMI), thus far these efforts have been very limited due to resource availability and were temporally intermittent. Furthermore, the weakening of political institutions in the country has also eroded the legitimacy of state institutions to make claims as the exclusive arbiter of public welfare. Post-conflict societies like Nepal are often crippled by the lack of this legitimacy, which frequently limits the state’s ability to enforce any activity that might incur social or economic consequences. Another reason is that the current economic and cultural networks that link the vertical structures of the Khumbu region are even less able than state institutions to address these challenges. For example, household or small-scale economic networks do not have the necessary spatial extent, and therefore the efficacy, to implement watersheds-wide hazard management activities. Furthermore, Sherpa institutions, while very effective at managing economic resources and providing services to tourists, are even less capable than state institutions at leveraging the necessary resources, technical capacity, and legitimacy to accomplish hazards management activities.

Finally, and to further exacerbate the challenges facing local populations in the Khumbu, the mere absence of any legitimate and reliable institutional capacity to address the increasing likelihood that a disastrous GLOF will occur in the Khumbu in the near future is also a problem, primarily because of the uncertainty it creates. For example, if emergency monitoring systems were to be installed the region, and the organization responsible for their installation is not perceived as legitimate, local populations might simply ignore any warnings that are generated. In addition, if the emergency monitoring systems are not reliable, they might also induce “disaster fatigue” after the first one or two false alarms, and and ignored from that point onward. Furthermore, if the physical safety of the monitoring systems cannot be
guaranteed, they might be stolen, which frequently occurs in high elevation settings across the planet. This lesson has already been illustrated in the region as the first emergency monitoring network that the national government installed was removed, disassembled, and then turned into pipe bombs and explosives by insurgents to further erode the legitimacy of the state during the recent civil war. Finally, and perhaps most importantly, the absence of this capacity can lead to widespread uncertainty, fear, misunderstanding, the manipulation or exploitation of fearful people, and social conflict. Currently, all of these instances have either occurred or the potential for them to occur is increasing throughout the region.

**Fostering New Institutional Adaptive Capacity**

The accelerating pace and scale of environmental changes occurring in the Khumbu region of Nepal are not only compelling testimonials from the icy edge of climate change, they also pose clear and imminent threats to human welfare and safety across the Himalayan vertical archipelago. While climate change is transforming the region, and will very likely accelerate during the next several decades, its consequences do not need to inexorably lead to unavoidable natural disasters and widespread suffering and human tragedy. On the contrary, many of the worst-case scenarios might be avoided through the creation of new hazard management institutions to enhance glacier monitoring and evaluation activities and foster more effective natural resource management activities. The creation of new institutional capacities is therefore a critical necessity that needs to be accomplished immediately. Below are several considerations that seek to inform any effort to enhance institutional adaptive capacity and long-term resilience.

- **Doing Nothing Is Not an Option.** As several lake hazards studies have illustrated, in the absence of any effective hazards management activities, one or several lakes in the region will create GLOF events. In the worst case scenario, this could result in significant human mortality, widespread damage to agricultural land and crops, livestock losses, and the destruction of critical infrastructure. In addition, the current absence of any effective institutional capacity has the potential to further exacerbate uncertainty and social conflict in the region. Furthermore, as recent debates surrounding the Kyoto Protocol have illustrated, climate change has now become inextricably intertwined with larger questions of social equity and environmental justice, as it is disproportionately affecting the most vulnerable populations that have historically had the least intensive carbon lifestyles. The Khumbu region is a harbinger of these debates because climate change is rapidly transforming the region and is creating a number of significant risks for local populations. In fact, the high mountain glaciers are where many of the effects of climate change are the most advanced and, therefore, any decision or attempts to avoid larger questions of both equity and mitigation in the Khumbu will not only have highly probable and very tragic human consequences, but significant social and political repercussions through the precedents that are established as well.

- **Foster Hybrid Institutions.** Mitigation efforts should build upon the diverse array of cultural, economic, and political networks that are present in the region and foster the creation of new hybrid institutions that include state, private, and civil society actors. In addition, because political relations of legitimacy and efficacy are currently very difficult to rebuild, but are critically important, capacity building efforts should also emphasize the need for legitimacy, efficacy, and enforcement.

- **Enhance Adaptive Capacity.** Because climate change is likely to accelerate over the next century, and the impacts of these changes are highly likely to be unexpected and diverse, new hazards management institutions and systems should be designed to provide maximum flexibility for monitoring, assessment, and mitigation efforts. In addition, maximizing adaptive capacity will also enhance the long-term resilience of these institutions as well as the security and reliability of hazards monitoring systems.

- **Work at the watershed scale.** Any mitigation efforts to enhance adaptive capacity must also be “scaled” appropriately such that they are spatially comprehensive and consistently deployed. In
the Khumbu region, this will require concerted hazards monitoring and evaluation activities across the entire basin, the development of effective evaluation procedures, and the creation of a reliable emergency warning system. Scaling up to the watershed can also enhance the legitimacy hazards institutions.

- **Plan for Disaster Assessment and Recovery.** Finally, although mitigation activities should primarily be fostered to prevent the future occurrences of GLOFs and other glacier-related hazards, mitigation, and planning efforts should also focus on the creation of disaster assessment and recovery capabilities. In doing so, this will enhance the long-term resilience of hazards management institutions and address the fact that although we have enhanced our understanding of the enormous vulnerabilities that climate change is creating in the region, a high degree of uncertainty about future events is likely to be a permanent challenge.

**Literature**


