CLIMATE CHANGE IN SIKKIM: A SYNTHESIS

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ABSTRACT

Climate change is having a significant impact on biodiversity, natural resources and society in the Himalayas. Here we synthesize the work of 22 papers on climate change issues in the Sikkim Himalayas, and propose a framework for future research and action for adaptation and mitigation. The first section of the paper delineates the status of current data on changes in temperature, precipitation, snow cover and glacier volume. The second section summarizes efforts of documenting local community experiences, observations and traditional ecological knowledge developed over decades. These papers demonstrate that such knowledge can add considerably to scientific data. The third section deals with papers measuring impacts of climate change on water, biodiversity, agriculture and livestock. These employ approaches ranging from modeling based on remotely sensed data to ground-based observations. These papers again demonstrate the urgent need for systematic information on current effects of climate change on nature as well as on society. The fourth section assesses the various approaches to vulnerability assessments. Existing strategies to cope with the negative impacts of climate change are summarized in the next section. In the final section, we urge the establishment of a state-level inter-departmental authority, with representation from government departments, academia, and civil society, to develop and implement a state-wide framework for climate change adaptation and mitigation in Sikkim. This framework should include: monitoring of climate change and its impacts; development of systematic scenarios and improved modeling; vulnerability assessments; and the design and evaluation of interventions for adaptation and mitigation.

KEYWORDS: *Himalayas, Climate Change, Framework*

Climate change is the new threat faced by governments, corporates, civil society and local communities

The fragile mountain ecosystems are specially sensitive to climate change

Climate change in the Himalayas is already having a significant impact on biodiversity, hydrology, livelihoods and almost every other aspect of the environment and human enterprise (Xu et al. 2009; Salick and Ross 2009). The papers presented in this volume summarize the state of our knowledge about climate change in Sikkim, and have implications on the fate of communities and environments throughout the Himalayas. The major findings summarized in this book regarding the state of knowledge and preparedness for climate change is applicable to a very large part of the Himalayas and beyond. In this chapter we provide a summary of major trends, critical gaps in knowledge, and steps toward a comprehensive programme on climate change research in Sikkim that could serve as a model for the Himalayas.

Climate Data

Four papers analyze available climate data. Rahman et al. (2012) summarize trends in temperature and rainfall from 1981 to 2010 at Tadong (elevation 1350 m). They find that mean minimum temperature has increased by 1.95 ^{o}C while mean maximum temperature did not exhibit any significant departure from long term average; rainfall over this 30-year period has increased by 124 mm. During the last two decades, however, rainfall has decreased both in terms of number of rainy days (loss of 14.40 days) and total rainfall (355 mm). The rate of increase in mean minimum temperature too has been highest over the last two decades.

In a related paper, in Gangtok (elevation 1765 m), Seetharam (2012) found decreases in both mean minimum and maximum temperatures from 1961 to 1990 as compared to the period between 1951-80. He also found that rainfall has decreased between 1961 and 1990. The results of Rahman et al. (2012) and Seetharam (2012) are not comparable because of the different periods involved. The limited data presented by these papers underscores the need for long-term data from multiple sites to adequately analyze trends. Furthermore these data sets are from mid altitudes. There are indications that climate may be changing more rapidly at higher altitudes in the Himalayas (Chaudhary and Bawa 2011). Moreover, presentation of means without variances does not permit inferences about statistical significance of the trends found.

Long-term data from multiple sites subjected to statistical analyses for the Himalayas does indicate that both temperatures and rainfall have increased. Shrestha, Gautam and Bawa (2012) show that between 1982 and 2006, temperatures in the Himalayas increased by 1.5°C (about three times the global average), and annual precipitation increased by 163 mm. Others too have noted similar increases in temperature and precipitation (Shrestha et al. 1999; Liu and Chen 2000; Dimri and Dash 2012).

The primary data for snow cover is even sparser than temperature and rainfall data. Luitel et al. (2012) and Basnett and Kulakrni (2012) found no discernible pattern in the amount of snow cover in the Teesta and Rangit basins from 2004 to 2008. Similarly there is virtually no information about changes in glaciers. Luitel et al. (2012) show that East Rathong Glacier in West Sikkim has receded by 460 m between 1976 to 2009. The issue of glacial melting in the Himalayas, however, is complex: of the thousands of glaciers in the region, only a few have been monitored, and large-scale observations in fact indicate that glaciers in many parts of the Himalayas are growing and in other parts receding (Scherler et al. 2011). Basnett and Kulkarni (2012) present an interesting approach to monitoring snow cover.

Overall, it is clear that the appropriate data to demonstrate changes in temperature, precipitation, snow cover and glaciers are currently lacking. The state should pursue a comprehensive programme to monitor change at a variety of locations, covering the full range of altitudes and geographical regions. The data are particularly lacking for high altitude areas (Fig.1).

Fig.1 : Ox bow lakes at Lashar valley, Lachen, North Sikkim: Lack of climate data at high altitudes

COMMUNITY PERCEPTIONS OF CLIMATE CHANGE

Local communities have been experiencing and responding to climate change for millennia. Thus the limited scientific data for present climate change can be supplemented by data based on local knowledge and observations. Ingty and Bawa (2012) have documented detailed observations on climatic changes and cascading impacts on biodiversity and the natural resource landscape of two agro-pastoral communities in the Lachen valley. These include weather-based indicators of climate change such as lesser snowfall, shifts in seasonal timing, erratic rainfall (less often but more intense), accelerated glacial melt, and water sources drying out. There have also been observations of biodiversity indicators such as species range shifts and altered phenology. They throw light on the profound impacts climate change has on the religious sentiments of the community as well. Furthermore, they have documented adaptation strategies of both individual agents and traditional institutions. Finally their study underlines the significance of a holistic approach whereby traditional community knowledge may complement the scientific data.

Poudyal (2012) in a lucid narrative discusses the “common man’s” day-to-day experience of changing climate and its cascading impacts. This engrossing chapter suggests the urgent need for a commitment to counter the impacts of climatic change,to avoid, as he puts it, heading“towards a precipice that may be of our making”.

Fig 2: Local communities have extensive knowledge about climatic variation.

The people of Sikkim clearly have considerable awareness of changes in climate parameters (Fig. 2). There is also evidence that people have already started to adapt to changes in climate. Nevertheless, considering the potential importance of local knowledge, more systematic work with good sample sizes and rigorous ethnographic approaches is needed to document the wealth of such knowledge. Moreover, we need to more rigorously separate impacts of climate change from impacts due to other changes in the environment or in society.

IMPACTS ON LIVESTOCK AND AGRICULTURE, WATER, AND BIODIVERSITY

Livestock and Agriculture: Sharma and Rai (2012) describe a number of changes at low, medium and high altitudes, primarily in response to reduced pasture lands, warming, and decrease in precipitation. Pastoralists at high altitudes move around less and have become sedentary. Productivity of several crops has decreased while crop diversification has increased. Senthil (2012) document changes in the quality of the milk from cattle: the amount of sour milk being gathered by milk cooperatives has increased; sourness presumably is being caused by the warm weather.

Changes in agrarian livelihoods are common place and are being driven by a number of environmental, social and economic factors. Attributing a particular change to change in climate requires surveys and empirical work to tease apart the various factors. Such work remains to be undertaken in Sikkim and in much of the Himalayas. Similarly, one has to be careful in the use of the term "adaptation". Humans adjust continually to changes, but not all adjustments constitute adaptation. Sharma and Rai (2012) emphasize that traditional ecological knowledge, agrobiodiversity, multiple land uses and diversification of livelihoods allow local communities to cope with changes, and will each play an important role in true adaptation to climate change. The state aspires to have fully organic agriculture by 2015, and should therefore reduce the area under high-yield crop varieties dependent on pesticides and synthetic fertilizers. Agricultural intensification reduces agro-biodiversity and ecosystem services.

Water: It can be expected that climate change will have several major impacts on water supplies. Glacial lakes, rivers, streams and springs could be all affected. Kumar and Prabhu (2012) show how due to rapid melting of certain glaciers, the area of high altitude lakes in Sikkim has increased significantly over the last 50 years. In many parts of the Himalayas, the number of such glacial lakes has also increased. Increases in water volume enhance the risk of glacial lake outburst floods (GLOFs).

Tambe et al. (2012) present indirect evidence for declines in spring water availability during the dry season, and suggest an approach to monitor spring water flows. There is a need for study regarding the impact of climate change on discharge rates of streams and rivers in Sikkim.

Clearly, systematic monitoring of water in the lakes, springs, streams and rivers of Sikkim is needed. Mahamuni and Kulkarni (2012) underline that without a proper understanding of aquifer dynamics, any study of groundwater remains incomplete. Kumar and Prabhu (2012) and Tambe et al. (2012) each propose protocols and approaches for monitoring glacial lakes and springs. The studies related to discharge rates of the river systems should also be given priority in Sikkim.

Fig 3: A species of Rhododendron in Lachung Valley, Sikkim.

Biodiversity: The extraordinary diversity of plants, animals and other organisms is perhaps the most significant environmental asset of Sikkim (Fig. 3).

Much of Sikkim's unique biodiversity is found in the alpine and sub-alpine areas. Telwala (2012) and Chettri et al. (2012) document responses of alpine plants in other parts of the world to climate change. Acharya and

Chettri (2012) provide evidences for climate change impacts on four important faunal groups namely birds, reptiles, amphibians and butterflies. These include adaptations such as range shifts, altered breeding mechanisms and skewed sex ratios. Furthermore an increasing trend of warming resulting in numerous cascading impacts of climate change threatens numerous faunal species to the brink of extinction. Long term monitoring the paper underlines that long term monitoring programs would be essential to have a better understanding on the complex impacts of climate change.

Kumar (2012), in an elegant study, models future habitats for Rhododendron and shows how these habitats may shrink under climate change scenarios. Climate change may also have indirect impacts on biodiversity, as for example, by increasing the incidence of forest fires. Sharma et al. (2012) illustrate an approach to monitoring forest fires. Modeling might be necessary to predict future risk areas and potential biodiversity responses to fire.

Limitations of modeling however are shown by the paper by Ravindranath et al. (2012). Based on downscaling of global models, they conclude that "the projections for the forest sector of Sikkim show that the biodiversity-rich districts of Sikkim are not likely to be impacted by climate change by 2030s and 2080s**."** However, much evidence points to significant changes already underway in biodiversity-rich areas of Sikkim. It seems most likely that the pace of such changes will accelerate further during the next few decades.

Clearly there is no substitute for ground-based observations. The results of the models are as good as the inputs the models receive. Ground based observations should provide the basis for testing a range of hypothesis and indicate the type of data that needs to be collected through rigorously tested hypotheses. As shown by Kumar (2012), niche-modeling provides another avenue to assess the potential for species to shift and the habitats that might (or might not) be available for range alterations. Among the most urgent priorities for research are general models for the spread of new diseases, pests and invasive species.

VULNERABILITY TO CLIMATE CHANGE

Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as *"the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes"* (IPCC 2001). Barua et al. (2012) point out that poverty and vulnerability are intrinsically linked, since the poor usually have limited resources or assets to cope with climatic changes.

Two papers in this volume use different approaches to assess regional vulnerabilities. Barua et al. (2012) use a multidimensional thematic framework, the "Multidimensional Poverty Assessment Tool." Tambe et al. (2012) use a rapid assessment method using available government-sourced datasets and primary information collected from village consultations. These data are grouped into three broad categories, namely exposure (climate data), sensitivity (elevation, dependency on farming) and adaptive capacity (social, economic and environmental data) as indicators of climate change vulnerability. Barua et al. (2012) assessed vulnerability to water resource scarcity in two wards in a rain-shadow area of the Southern district of Sikkim. As seen by stakeholders in this region, the challenges posed by climate change are not limited to water scarcity but include a list of other needs for building community resilience to climate change. The paper touches upon numerous positive interventions by the Rural Management and Development Department (RM&DD) of the Government of Sikkim (e.g. rainwater harvesting (RWH) to collect the rainwater and increase the supply of water for domestic use during water scarcity periods). The paper points out that livelihood diversification will be an important element of reducing vulnerability.

The results of Tambe et al. (2012) suggest varying levels of vulnerability based on a combination of three indicators. Even though villages like Karzi-Mangnam were subject to moderate exposure they showed high vulnerability due to high sensitivity and low adaptive capacity, suggesting that interventions need diverse sectoral profiles and need to be area-specific. Similarly Barua et al. (2012) suggest that RM&DD should plan interventions at the village level rather than the block level, since social and economic profiles, and hence vulnerability, vary across villages. The approach used by Tambe et al. (2012) can also be greatly enhanced if different indicators are weighted differently.

Several studies have shown that the Himalayas are warming faster than the global average (Shrestha et al. 1999; Liu and Chen 2000; Dimri and Dash 2012; Shrestha, Gautam and Bawa 2012). Climate change impacts in the region could be devastating. Clearly, more accurate data on weather, landslides and GLOF potentials are required to reliably assess vulnerability.

PLANNING FOR CLIMATE CHANGE

We strongly urge that the expected adverse effects of global climate change be confronted by multifaceted, comprehensive approaches at the policy level, including local, regional and global strategies. The United Nations Framework Convention on Climate Change (UNFCCC) highlights two fundamental response strategies: mitigation and adaptation. "*While mitigation seeks to limit climate change by reducing the emissions of GHG (greenhouse gases) and by enhancing 'sink' opportunities, adaptation aims to alleviate the adverse impact through a wide-range of system-specific actions"* (Fussel and Klein 2002).

The four papers discussed in the following section argue for adaptation and mitigation strategies to tackle the looming dangers of climate change. Bhattacharya et al. (2012) bring to light the impacts on weather and consequent vulnerabilities in water resources, agriculture, livestock and dairy industry, biodiversity, forests, wildlife, and environment. They further suggest adaptation strategies for each area they defined as vulnerable. Tambe and Arrawatia (2012) describe the numerous initiatives, both planned and ongoing, of the Government of Sikkim. These include interventions to stabilise water resources, afforestation and conservation, vulnerability assessments and consequent capacity building and diversification of livelihoods to improve adaptive capacities.

Bhagwat et al. (2012) underline the potential for using the State's extant institutional frameworks to participate in global efforts to establish market mechanisms to support reductions in forest loss and degradation. The authors estimate that after a grazing ban was declared in Barsey Rhododendron Sanctuary, carbon stocks increased by about 585 thousand tonnes. While such mechanisms may hold immense potential,we must also be careful of the significant downsides plaguing market approaches to natural resource custodianship. As Lawlor et al. (2010) point out, "REDD+ programmes pose risks to the livelihoods and customary land claims of indigenous peoples and other rural populations". If forest carbon comes to be treated as any other international market commodity—and in the absence of the strongest of safeguards—producers will be able to derive only marginal benefits from their participation.

A Framework for the Future

The available evidence strongly indicates that, as in other regions of the Himalayas, climate in Sikkim is changing rapidly and that more changes are ahead. Importantly, climate will act in concert with other ongoing changes, such as those in land use patterns. The papers in this volume show that climate change is likely to have profound effects on biodiversity, human health, local livelihoods, agriculture and water availability. The Eastern Himalayas as a whole is inherently prone to geological disasters such as earthquakes and landslides. Climate change may exacerbate these risks.

Thus the state must prepare itself to cope with climate change. Tambe and Arrawatia (2012) list a number of initiatives in the state to cope with climate change. Some are linked with climate change mitigation or adaptation, while others have only a tenuous connection. We suggest that the state should further strengthen its ongoing efforts by undertaking a comprehensive and systematic project for climate change adaptation and mitigation (Fig.4).

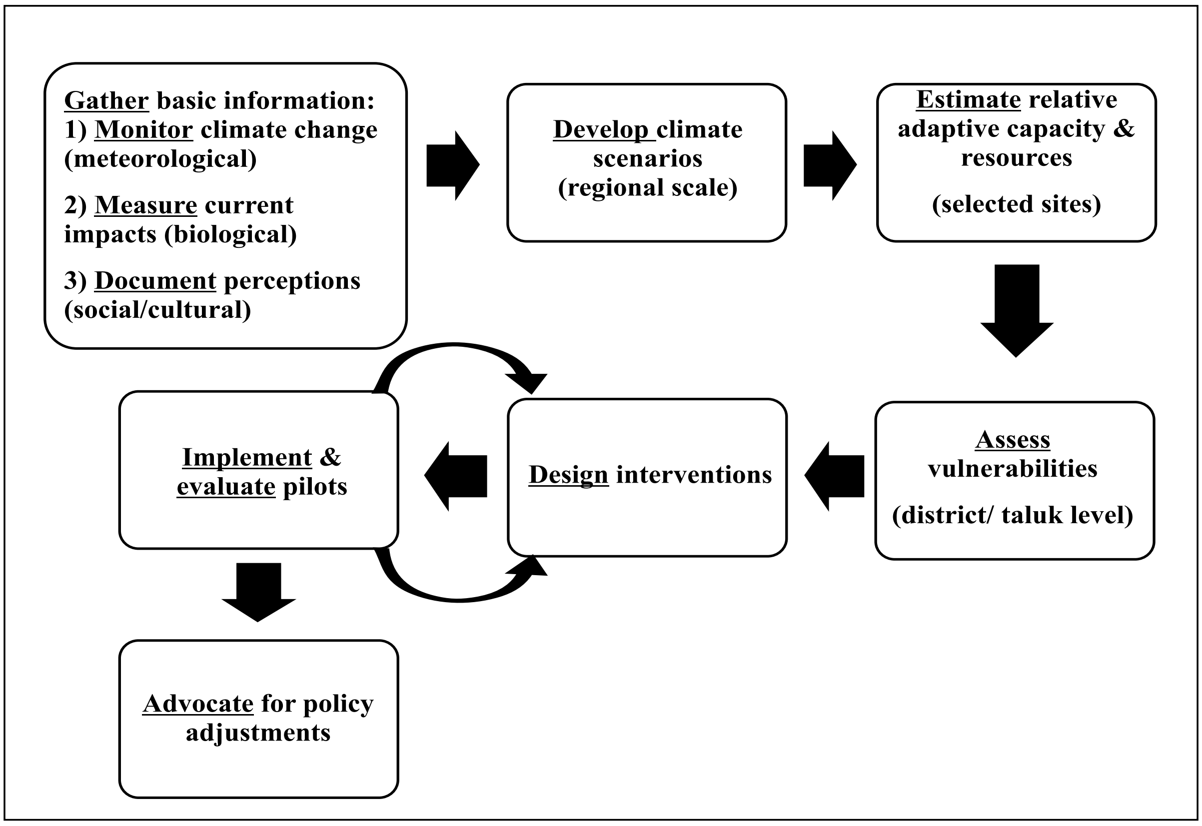

Fig 4: A framework for the future

The state should consider setting up of a state-wide inter-departmental authority for climate change adaptation and mitigation, with representation from the departments dealing with land, agriculture, forests, water, energy, meteorology and finance. The proposed authority should have a scientific panel and a steering committee including representatives of business, civil society, and academia. The following elements are integral to such a programme on mission mode:

1. *Monitor Climate Change and Impacts*. A series of weather stations are needed along the full altitudinal gradient to track changes in temperature, precipitation, glaciers and GLOFs, springs and rivers. In parallel, selected sites should be monitored for changes in phenology, shifts in species distributions, spread of new species and pathogens, agriculture and livelihoods.

2. *Develop Climate Change Scenarios*. Taking into account all available data that can be assembled now, including perceptions of local communities about climate change, the proposed authority could develop scenarios and models for climate change without necessarily waiting for the results of monitoring. Downscaling of global models of climate change is a major challenge but would constitute a critical advance in the development of realistic scenarios. Participation of various stakeholders is also key to scenario development. Scenarios and models would need to be continuously updated as new data from monitoring become available.

3. *Vulnerability Assessments*. Based on the above two points, vulnerable geographical regions and human populations should be identified. Vulnerability assessments will also highlight at-risk natural resources (such as water and biodiversity) and sectors (e.g. agricultural and energy development). Participatory approaches must be integral elements of vulnerability assessments.

4. *Design and Implement Interventions*. Given our findings and those of national and international bodies, we must expect that interventions at multiple scales will be required to cope successfully with climate change in this area. Interventions will be required in agriculture, human health, biodiversity, and natural resources. Participation of stakeholders in all stages from planning to implementation would be a key component of interventions.

5. *Evaluate Interventions*. Following principles of adaptive management, periodic evaluation of intervention outcomes must be undertaken. Interventions should be designed with explicit feedback loops to register signals for the need to adapt or modify interventions as social and environmental conditions change.

Ongoing learning from each of the five steps above should provide the basis for necessary policy changes in such critical sectors as energy, agriculture and natural resources.

Second, the state must build adequate capacity in research and action for climate change. Again, a framework for building capacity is needed at all levels, not only for research and academic centers but also for various government departments and civil society. An interdepartmental authority for climate change can play a critical role in designing a capacity building programme.

Third, mitigation must be an important component of any comprehensive climate change programme. The state must calculate its carbon footprint by gathering data on carbon emissions and carbon sequestration. Data on emissions from both urban and rural sector will be required. Policies should be put in place to reduce emissions and to further develop and measure carbon sequestration potential especially through natural forests. Carbon footprint data could become an important factor in aligning state polices with national and international frameworks to reduce emissions, and in benefiting from the various incentives for reductions currently under development. States taking a proactive stance toward climate change response planning will be best placed to benefit from such incentives as they emerge.

We hope that the papers in this volume will prompt to consider the framework proposed to cope with climate change.

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