ARCP2008-16NMY-Shrestha

1. Project Title

Impacts of Global Change on the Dynamics of Snow, Glaciers and Runoff over the Himalayan Mountains and Their Consequences for Highland and Downstream Regions

2. Detailed Proposal

Introduction

Himalaya is the third largest store house of frozen water on earth, after the Arctic/Greenland and Antarctic regions, is crucial for the billions of people inhabiting the mountain slopes and valleys and plains in the south. Without snow melt, the rivers flowing down from the Himalaya would remain dry for the greater part of the year, thereby cutting off the livelihoods of farmers and resulting in massive food shortage.

The Himalayan ranges are the regions of the globe where recent climate change is most evident, consistent with the notion that high-elevation mountain ranges that extend into the mid- to near the top of troposphere will experience greater warming.

The snow and ice accumulation determine a large part of surface hydrology in the Himalayan Rivers and changes in hydrology and water availability are expected to be significantly large when surface air temperatures rise in the high mountains and the mountain basins. The hydrological cycle of the region is complicated by the Asian monsoons, but there is little doubt that melting glaciers provide a key source of water for the region in the summer months.

However due to ruggedness of the Himalayan terrain and inaccessibility of its higher regions, there is a great paucity of adequate scientific data leading to uncertainty and knowledge gap in understanding the dynamics of accumulation and depletion of snow and glacier of the Himalayan region in the context of climate change and the resulting change in the hydrology of the region.

In order to address such uncertainties, 'what if' types of analysis are sought. Various hydrological models in conjunction with climate models can fulfil such tasks efficiently.

However, General Circulation Models (GCMs) because of their coarse resolutions cannot very accurately provide the climate prediction in the Himalayas wherein the topography is highly complex. Therefore, high resolution regional climate models (e. g. PRECIS, RegCM) will be used for the simulation of the climatic variables. Similarly, use of multi-temporal remote sensing data is inevitable for assessing climatic conditions as well as snow and glacier coverage on the ungauged and inaccessible Himalayan terrain. To assess the impact of climate change on utilization of water resources and subsequent livelihood of the people, a distributed/semi-distributed hydrological modelling of basins is essential. Most of such models take into account of only precipitation and snowmelt as input to the system. Therefore a model like ITGG 2.0, AGETA model, other relevant energy budget model which are capable of estimating glacier melt in the Himalayan region under different conditions is required

Objectives

Against this backdrop proposed research will attempt to addresses fresh water related key issues pertaining to future climate change in the Himalaya, which is of high scientific interest but also of primary socio-economic relevance for the region. For this purpose, the proposed project would attempt to meet the following objectives:

- To assess the dynamics of snow and glacier of the Himalayan region in response to the climate change (APN science agenda, Item 1 - climate)
- To assess the flow regime of major river system of the region through comprehensive distributed hydrological models with snow and glacier melt component. The sensitivities of the people's livelihood both in highland and lowland and their linkages and transboundary cooperation for sustainable development will be assessed under projected hydrological regimes (APN science agenda, Item 4 - use of resources and pathways for sustainable development).
- To provide science based information to implement adaptation and mitigation strategies for dealing with the impacts and consequences of climate change on the Himalayan ecosystem services in terms of water resource (APN science agenda, Item 5 - cross cutting and science- policy linkages).

Work Plan

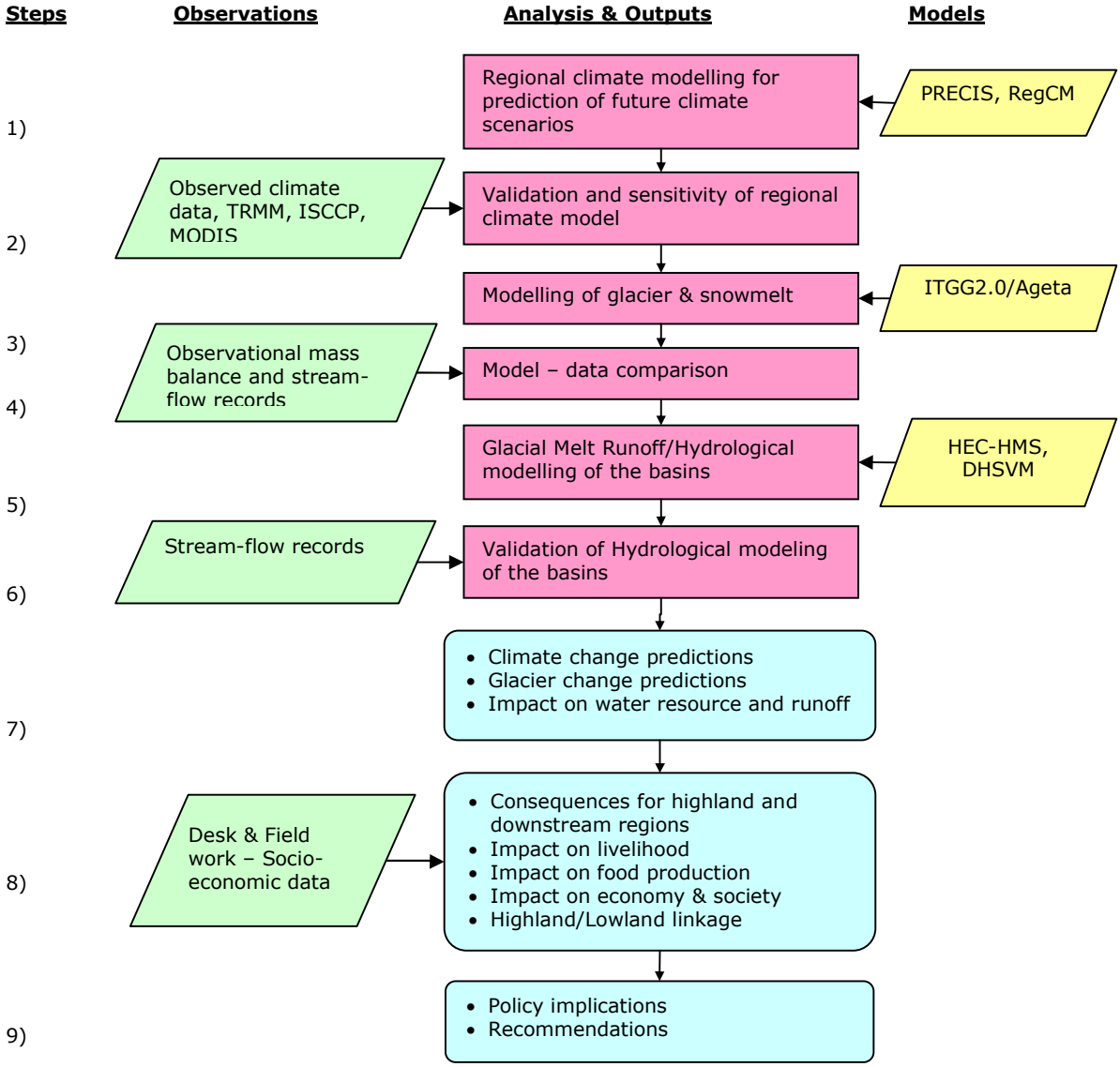
Work plan of the Proposed Project will carry out the following activities:

1. Simulation of required climate variables for the selected regions by using PRECIS and RegCM.
2. Assessment of dynamics of accumulation and depletion of snow and glacier of the Himalayan region by using field data, satellite imagery (Landsat, IRS, ASTER, MODIS etc), and energy budget model (for example the one developed by Fukushima, Y. et al., 1997; ITGG 2.0 etc.).
3. Validation of the results by using field data/the data from TRMM, TOVS, ISSP, MODIS etc.
4. Projections of snow and glacier mass balance using energy budget model with the developed climate change scenarios

5. Validation of runoff from snow and glacier melt as outputs from energy budget model
6. Development of comprehensive distributed hydrological models (HEC-HMS, DHSVM, UBC etc) for the selected basins.
7. Simulation and evaluation of temporal and spatial distribution of flow under climate change scenarios.
8. Conduction of desk and field study to find the sensitivities of the people's livelihood, economy and society in both highland and lowland under changed hydrological regime.
9. Assessment of policy implications of the consequences of the changed hydrological regime for highland and downstream regions.
10. Production and publication of a 'technical report' for scientific community and another 'report' for dissemination among the policy/decision makers.
11. Publications of papers based on research results in peer reviewed international journals.
12. Conduction of workshop and seminar to consult, communicate results to end users, stakeholders and policy makers together with experts from other relevant Institutions and regions like Southeast Asia invited to share their knowledge and experience.

Research Framework

The research framework of the Project is conceptualized as in the figure below:



Relationship to the APN's Second Strategic Plan (2005-2010)

Science Agenda

The proposed study will create a better understanding of both mechanisms and consequences related to the disappearance of Himalayan glaciers using hydro meteorological data and application of knowledge based numerical models and remote sensing and GIS techniques. This increased knowledge on how fast and how far glaciers will recede and how much this will affect future runoff and water availability from the Himalaya will have a significant and **broad impact** on local economies and populations. Likewise, the enhanced knowledge will also elucidate various potential hazards as well as possible mitigation and adaptation measures for combating such hazards.

Policy Agenda

The proposed study intends to link the scientific results to the policy processes. The study is believed to provide science based information about how future climate change will affect glaciological and hydrological systems in the Himalaya. These scientific findings will be crucial for identifying and implementing adaptation and mitigation strategies for the sustainable development of the regions. We believe that the proposed methodology and the procedures adapted in the study will be capable of transferring the scientific knowledge to the policy processes.

Institutional Agenda

The proposed study involves the participation of the four member countries (China, India, Nepal and Pakistan) sharing the Himalayan region. The institutions of each member countries actively involved in generating and delivering scientific information of Himalayan environment system will be representing the member countries. The contributions of these institutions will be synthesized to produce the regional scenario of the impact of climate change on people through its effect on snow and glaciers. The available resources from these institutions such as data, infrastructure and the expertise will be mobilized in kind as leverage of support to APN's mission. The study will make an effort to strengthen the inter government network by promoting the participation of policy/decision makers and implementing agencies on consultative and dissemination workshop.

3. Regional Collaboration

Following collaborators will be involved in the proposed Project:

China:	The Institute for Tibetan Plateau Research
India:	The G. B. Pant Institute of Himalayan Environment & Development; and The IIT Roorkee
Nepal:	The Institute for Development and Innovation; The Department of Hydrology and Meteorology, GoN; and The Institute of Engineering, The Central Department of Geography, TU
Pakistan:	The Global Change Impact Studies Centre (GCISC)

4. Capacity Building for Global Change Research

The proposed project will be an initiative to apply the state of the art technology in an integrated approach for assessing the impact of global change on snow and glaciers, and its socio-economic consequences on a regional scale by involving the participation of the said countries.

The study is believed to strengthen the capacity of the institutions in the application of state of art technology, as well as by data and skill/knowledge sharing. The study would promote interaction and network with the partner countries and worldwide community of global change research as well.

Not only the findings but the methodology and procedures adapted in the study will a valuable input and asset to global change research and policy makers at the end.

5. Scientific Contribution of each Participating Country

Nepal, being the proponent of the project has drafted a proposal developed by doing regular interaction with partner countries though personal and electronic correspondence. The objectives, research design, methodology and procedures of the proposed project have been finalised with consent of partner countries and in accordance with their institutional ability. Data type, models, RS and GIS technique and the research framework used in the study have been identified and consented with interaction with country coordinators and principal researchers.

Respective institution of participating countries will be responsible for collecting data, running models, field study and reporting the country studies. However, meteorological and the hydrological data, and remote sensing data and others at ones disposal would be shared with other collaborator(s).

Principal investigator (Proponent) and the country coordinator as well as some expert personals will make a regional synthesis from the country studies for each year and for the entire project at the end.

The principal investigator will organise and the workshops and meetings. The country coordinators will liaison and supervise those workshops and meetings in their respective country.

Regular interactions between the researchers through electronic media and periodic meetings will be carried out for mutual consultations and for ensuring that the set targets and the project objectives are met.

6. Policy-relevancy and Sustainable Development Issues

The proposed project is believed to provide science based information about the impact of future climate change on glaciological and hydrological systems in the Himalaya. The project would elucidate the attendant natural hazards and sensitivities of sustainable development. This information will be crucial for designing future adaptation and mitigation strategies to reduce the risk of global change. Similarly, any foreseeable positive impact of the global change detected in the study would be beneficial for framing future development policies.

The key stakeholders and policy makers of the host country will be invited in the initial and the year end meetings for the dissemination and review of the project findings. The reports will be put in websites to ensure access of the greater community of policy makers.

Poverty, food security and energy are the major issues of the sustainable development of the countries belonging to Himalayan region. The impact of snow and glacier dynamics on the flow regime and thereby its implication of fresh water availability for ensuring food security and energy sufficiency and health and sanitation and thus reducing poverty are pertinent research issues of the proposed project.

7. Relationship between Global Change Research Programmes and Networks

The proposed project will work in close partnership with organisations involved in similar research activities like ICIMOD, MAIRS, MRI, American Cordillera Transect (ACT) etc so that the project would be able to deliver the best possible results by maximising available resources. The project will also be in close contact with other organisations like START, DIVERSITAS, IGBP, IHDP, and WCRP, CLIMAG, CLIC etc.

8. Related Research Work

The frozen water in the Himalaya is crucial for the people inhabiting the mountain slopes and valleys and the plains. The ice mass over this mountainous region is the third largest on earth, after the Arctic/Greenland and Antarctic regions. Without snow melt, the rivers flowing down from the Himalaya would remain dry for the greater part of the year, thereby cutting off the livelihoods of farmers and resulting in massive food shortage. Barnett et al, 2005 in a global assessment of the impact of global warming on snow dominated regions indicates that the Hindu Kush Himalaya area is perhaps the most critical area, where vanishing glaciers will negatively affect water supply in the next few decades because of the region's huge population.

The recently published fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC 2007) concludes that warming of the global climate system is unequivocal, as is now evident from …… widespread melting of snow and ice, …….. The report concludes that the average global temperature is very likely to increase between 1.8ºC and 4.0ºC by the year 2100. Warming is expected to be greatest over land and at most high northern latitudes, snow cover are projected to contract …….

The Himalayan ranges are the regions of the globe where recent climate change is most evident, consistent with the notion that high-elevation mountain ranges that extend into the mid- to near the top of troposphere will experience greater warming. As a result glaciers are receding throughout the Himalayan, with potentially severe consequences for the availability, in particular during dry period, of drinking water, and water for irrigation, industries and hydropower production for the billions living in the downstream areas (Shrestha 2006). The hydrological cycle of the region is complicated by the Asian monsoons, but there is little doubt that melting glaciers provide a key source of water for the region in the summer months.

Despite its relevance, few studies have been conducted on the hydrological effects of climate change at basin scale in the Himalayas. Some modelling exercises on effects of climate change on runoff from glacierized tropical catchments are going on for the Andes (Juen, I. 2007). Similarly such exercises on a few catchments of Himalayan river basins (Singh, P. and Bengtsson, L. 2005; Thayyan et al 2007; etc)) have been reported. Regional differences in response of flow in glacier-fed Himalayan rivers to climatic warming has been reported using statistics model (Rees and Collins 2006) . Hydrological effects of climate change at basin scale in the Himalayas based on deterministic models and their consequences for the highland and downstream regions are however still missing.

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