BACKGROUND DOCUMENT

Regional Capacity Building for Glacier Water Resource Assessments and Monitoring in the Hindu Kush Himalaya

Project supported by the Regional Environment, Science, Technology and Health Office for South Asia (REOSA)

Project implemented by the International Centre for Integrated Mountain Development (ICIMOD)

Introduction

In the Hindu Kush Himalayan (HKH) region, glaciers cover an area of nearly 60,000 km^2 (ICIMOD, 2011). Ten of the largest rivers in Asia are sourced in the Himalayas, and changes in glacier areas and volumes will have direct effects on streamflows in the region. However, there are few long-term monitoring sites in the HKH region, and even fewer dedicated research basins with a full suite of glaciological, climatological, and hydrological observations. As a result, the response of glaciers and streamflows in the region to climatic change is largely unknown. The proposed workshop aims to fill this knowledge gap in the long term by developing and strengthening the existing regional capacity for glacier water resources assessments and monitoring.

In the HKH region, the basic river basin hydrology can be broadly classified as one of three main types: 1) pluvial (rain dominated), 2) nival (snow-melt dominated), and 3) glacial (glacier-melt dominated). Compared with both pluvial and nival basins, glaciated basins tend to have more stable annual discharge volumes, as glaciers function as water reservoirs on annual to decadal timescales. For example, in warm, dry years, glacier melt supplements reduced streamflows. Conversely, in cold, wet years, glacier accumulation is stored for future release. As a result, studies from other regions have demonstrated that glacierized basins typically exhibit reduced streamflow variability (e.g. Fountain and Tangborn, 1985).

The reliability of discharge in glacierized basins can be critical for agriculture, hydroelectric power generation, and local water resources. With climate change however, the timing and magnitude of discharge in glacierized basins will be affected. Such changes may also be transient, depending on the current status of glaciers in the region. To quantify the effects of climate change on glacier contributions to streamflow, a comprehensive monitoring strategy is required to inform future modeling efforts. The monitoring strategy has three main components: observations of glacier mass balance, observations of basin hydrology and climatology, and observations of glacier area and volumetric change through remote sensing (Figure 1). Each component can exist in isolation, but a clear assessment of glacier water resources requires an interdisciplinary approach. Each of these components are discussed in greater detail below.

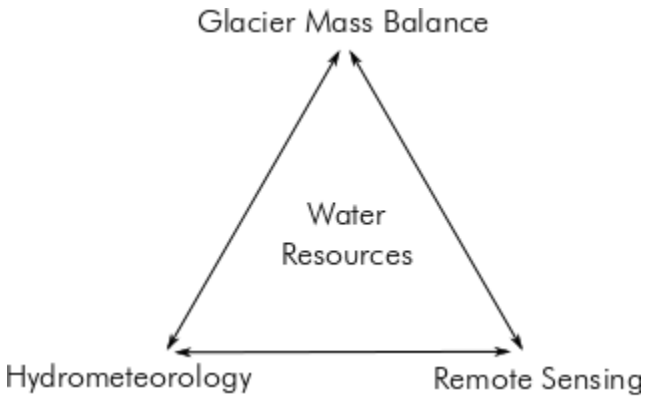

Figure 1. A strategy for comprehensive glacier water resource monitoring and assessments in the HKH region.

Glacier Mass Balance

Glacier mass balance represents the difference between mass gains (accumulation) and mass losses (ablation) for a glacier on an annual basis. Processes that contribute to glacier mass gain are, for example, snowfall, avalanching, and wind redistribution. Processes that contribute to glacier mass loss include surface melt and sublimation, wind redistribution, calving, and basal melting. Glacier mass balance (as opposed to glacier length change) is a direct and sensitive indicator of climate change, as it is depends on annual precipitation and temperature.

Traditionally, glacier mass balance observations are derived from field-based point measurements of accumulation and ablation at a series of locations on a glacier surface. These measurements can be extremely difficult to obtain in the Himalaya, given the altitude at which glaciers exist, the remote nature of the field work, and the inherent dangers of high-altitude glacier work and travel. A previous REOSA/US Embassy-funded workshop focused on glacier mass balance measurements in the HKH region, and a basic overview and demonstration of these techniques will be provided in the current workshop.

Hydrometeorology

To estimate both the sensitivity of glacier mass balance and the hydrologic response of glacierized basins to climate change, simultaneous observations of hydrology and meteorology are required. In remote mountainous regions, the deployment of automatic weather stations can provide critical information on vertical temperature gradients and the vertical and horizontal distribution of precipitation (Pellicciotti et al., 2012). These data are required not only for assessing glacier mass balance sensitivity, but also for providing inputs for glacier mass balance and hydrological models. Meteorological observations are also used to test downscaling routines, which enable regionally distributed modelling.

To evaluate glacier contributions to streamflow, observations of stream discharge are critical. Typically, discharge is estimated by converting continuous observations of stream height (or stage) into discharge. Simultaneous observations of stage height and discharge are used to construct a rating curve, which is used to convert the stream height into a discharge estimate. Methods for the observation of both stage and discharge vary depending on site characteristics, funding, and logistics.

Remote Sensing

Remote sensing provides a powerful tool that can be used to generate regional information on glaciological, hydrological, and meteorological conditions. For example, glacier area and volume changes can be estimated from repeat satellite imagery and digital elevation models (DEMs). Estimates of glacier mass change obtained from field-based measurements should be compared with estimates of mass change derived from digital elevation models collected from spaceborne sensors over longer periods of time. Remotely-sensed snow cover data can also provide information on the timing and magnitude of snow-melt runoff, and on important glaciological parameters such as the equilibrium line altitude.

Remote sensing studies are invaluable for developing baseline glacier inventories, such as the HKH inventory established by ICIMOD. Remote sensing studies also link point scale surface observations with regional-scale data. For assessments of glacier water resources, such linkages are key to effective monitoring in data-scarce regions.

Project Objectives and Outcomes

The primary objective of the workshop is to build the regional capacity for monitoring glacier water resources in the Himalaya, and to provide a forum for cross-border and interdisciplinary exchanges. The workshop will specifically engage with early-career geoscientists, researchers and professionals in the region to help build a long-term regional commitment to glacio-hydrological monitoring and international cooperation. Specifically, the workshop seeks to:

1. provide participants a synthesis of current understanding on glaciers and glacier hydrology in the Himalaya
2. inform regional members on the monitoring strategies and the importance of a multi-disciplinary approach for the assessment of glacier water resources
3. strengthen regional cooperation and data sharing to develop sound scientific datasets that cross the HKH region

As regional cooperation and collaboration will be key to the development of comprehensive regional datasets, the workshop will bring together professionals and early-career researchers from HKH member countries. Through discussions with world-renowned researchers, hands-on activities, and an intensive two week field visit to the Langtang Valley, the workshop will foster regional partnerships that will hopefully translate to long-term international cooperation.

Project Implementation

To fulfill the project objectives, three activities will be organized. These activities include a classroom-based “Workshop on the Assessment of Glacier Water Resources”, “Regional Field Training Course on Glacier Water Resources”and “Regional Data Sharing Workshop”. A proposed implementation timeline for these activities are shown in Table 1, and described in greater detail below. The workshop on glacier water resource assessments will precede the training programme, and a list of potentially participating institutions is given in the next section.

Activity 1: Workshop on the Assessment and Monitoring of Glacier Water Resources

The proposed workshop will build on the success of the 2012 “International Conference on the Cryosphere of the Hindu Kush Himalayas: State of the Knowledge”and Regional Glacier Mass Balance Training”, which was funded by the US Embassy and the Royal Norwegian Embassy (RNE) in Kathmandu. The conference brought together ninety-six participants from 18 countries, and provided an important baseline understanding of the current status of glaciers and glacier hydrology in the HKH region. The

2014 workshop will be conducted with participants from regional institutions, and citizens of the region who are pursuing post-graduate degrees at accredited universities anywhere in the world. The workshop will feature four days of lectures, discussions and problem-based learning with international experts, as well as ICIMOD researchers and visiting scientists.

Topics covered will include an updated assessment of scientific knowledge related to glaciers, glacier hydrology, and climate change in the region, the development and challenges of multi-disciplinary observation networks, and on future research directions. Workshop participants will also be given the opportunity to present a description of their current research, and on the status of the glaciohydrological monitoring networks in their region.

Activity 2: Regional Field Training Course

To emphasize the importance of field work and the collection of quality scientific data, workshop participants will join ICIMOD researchers on a two-week field trip to Yala Glacier in Langtang National Park. As part of the Royal Norwegian Embassy-funded Cryosphere Monitoring Project (CMP), Langtang Valley and Yala Glacier are sites of meteorological, hydrological, and glacier mass balance observations. Workshop participants will gain practical field experience and assist in (1) discharge measurements, (2) weather station maintenance, (3) mass balance measurements, and (4) the installation of an on-glacier meteorological station. Workshop participants will gain an appreciation of the physical nature of glaciological fieldwork.

Prior to departure for the field, a high-altitude medical specialist will provide instruction on health issues associated with working at high altitudes, and basic mountaineering skills (harnesses, crampons, ropes) will be demonstrated by a certified guide. A full discussion of the risks associated with high-mountain field work will be provided, and all participants will be required to sign a waiver that demonstrates their knowledge and acceptance of the risks involved.

In the field, training participants will follow the standard trekking route to Kyanging village in the Langtang Valley. Days for acclimatization will be taken here before proceeding to Yala Glacier, at an elevation of 5300 m. The group will camp at Yala for three to four days, and assist in the field programme established as part of the CMP. A certified mountain guide will accompany all groups on the glacier, and the use of a rope and harness will be mandatory on the snow-covered glacier.

Workshop and Training Calendar

The proposed dates for the workshops and field training are as follows:

- 21 – 25 April: training workshop, health and safety training, and equipment organization
- 28 April – 12 May: field expedition in Langtang Valley