Observation of cryosphere

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ICIMOD – an intergovernmental learning and knowledge sharing centre serving 8 member countries

- **Vision:** The mountain population of the greater Himalayas enjoys improved well-being in a sustainable global environment.

- **Mission:** To enable and facilitate the equitable and sustainable well-being of the people of the Hindu Kush-Himalayas by supporting sustainable mountain development through active regional cooperation.

ICIMOD aims to assist mountain people to understand climate changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues.
The HKH region is one of the most dynamic and complex mountain systems in the world. It contains the largest amount of snow, glacier and permafrost found outside the Polar Regions, including more than 50,000 square km of glacier cover. This vast accumulation of snow and glaciers acts as a natural water reserve, feeding ten major Asia river systems. The mountain system, stretching 3,500 km through some of the world’s wettest and driest environments, rising eight vertical kilometers through nearly every life zones existing on Earth, and at the geographical centre of the largest and densest concentration of humanity, is recognized as an extremely fragile environment vulnerable to global warming.
Develop and implement cryosphere monitoring activities at ICIMOD. Categorized into three main components:

1. Field-based snow and glacier monitoring
2. Field-based hydro-meteorological observations and monitoring
3. Remote sensing-based observations and monitoring

Activities under these three components ensure an interdisciplinary approach to developing comprehensive assessments of glacier water resources and future water availability scenarios.
The current status of benchmark glaciers and their response to climatic variations is assessed through:

- Monitoring the glacier mass balance and dynamics of benchmark glaciers
- Short-term glaciological measurement campaigns in the region
- Glacier mass balance and dynamics modelling
Field-based Snow and Glacier Monitoring

Photo: SR Joshi ICIMOD
Field-based hydro-meteorological observations and monitoring

Assessments of current and future water resources at the catchment and sub-basin scales are carried out through:

- Meteorological monitoring
- Short-term hydrological monitoring
- Glacio-hydrological and snow melt model development
- Modelling future changes in glacier meltwater contributions to overall discharge
Field-based hydro-meteorological observations and monitoring
Remote Sensing-based Snow and Glacier Monitoring

ICIMOD maintains a multi-level remote sensing based observation system for snow and glacier monitoring in basins and sub-basins, including:

- Mapping and monitoring of glaciers and glacial lakes using Landsat and other high resolution satellite images
- Snow cover monitoring using MODIS
- Using unmanned aerial vehicles (UAV) and high resolution stereopair satellite images to monitor glacier mass change
- Detailed investigations of glaciers in representative basins/sub-basins
MODIS receiving station in ICIMOD

Installing MODIS receiving station at ICIMOD

Receiving MODIS images since January 2013
Capacity Building

Capacity building features strongly within the Cryosphere Initiative and its activities, including:

- Support for a two year MSc programme in glaciology at Kathmandu University
- Scholarships for MSc and PhD students
- Short-term training courses and study tours
- Short-term personnel exchange and on-the-job training for professionals from the region
But the cryosphere in the HKH is changing....

Changes in the glaciers may have a significant impact on the quantity and timing of water availability. A comprehensive understanding of the extent and nature of changes in glaciers will support downstream hydrological planning and water resource management.
Fast retreating Gangapurna glacier at the northern slope of Annapurna Range, Manang Lake and Manang Village, Nepal
Glaciers in The Hindu Kush – Himalaya Region

The Himalaya alone have nearly 60,054 km² of snow and ice.
Glaciers are retreating fast
Most of glacial lakes in the region are formed/developing since last half century

1956
photograph of Imja glacier
(Photo: Fritz Muller; courtesy of Jack Ives)

2006
photograph of Imja glacier
(Photo: Giovanni Kappenberger courtesy of Alton C Byers)

Imja Glacier and formation of Imja glacial lake, Nepal – Repeat Photography
Need to monitor the glacier changes

Glaciers in Nepal [Draft ICIMOD (2009)]

2009 inventory 3577 glaciers 4154 sq.km.
2001 inventory 3252 glaciers 5324 sq.km.
Results: HKH region

Temporal variation of snow cover area (SCA) of HKH – 8 Days composite of 2005

January
Snow cover change from 2002 - 2010

Linear regression (trend) indicate decline of snow cover trend for last decade
Additional risks are created .......
The risk of GLOF has increased
A study carried out by ICIMOD and UNEP identified 3252 glaciers and 2,323 glacial lakes in Nepal. An analysis of the inventory data suggested that 20 of the glacial lakes in Nepal were potentially dangerous. Studies of these potentially dangerous lakes by a multi-disciplinary team of professionals are required and necessary implementation of appropriate mitigation measure(s) for potentially dangerous lakes should be carried out.

Potentially Dangerous Glacial Lakes of Nepal

- A = Nagma (Tamor)
- B = (?) (Tamor)
- C = Lower Barun (Arun)
- D = Lunding (Dudh Koshi)
- E = Imja (Dudh Koshi)
- F = Tam Pokhari (Dudh Koshi)
- G = Dudh Pokhari (Dudh Koshi)
- H = (?) (Dudh Koshi)
- I = (?) (Dudh Koshi)
- J = Hungu (Dudh Koshi)
- K = East Hungu 1 (Dudh Koshi)
- L = East Hungu 2 (Dudh Koshi)
- M = (?) (Dudh Koshi)
- N = West Chamjang (Dudh Koshi)
- O = Dig Tsho (Dudh Koshi)
- P = Tsho Rolpa (Tama Koshi)
- Q = (?) (Budhi Gandaki)
- R = Thulagi (Marsyangdi)
- S = (?) (Kali Gandaki)
- T = (?) (Kali Gandaki)

? No name
### Basins

<table>
<thead>
<tr>
<th>Basins</th>
<th>Number</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amu Darya</td>
<td>3,277</td>
<td>2,566</td>
</tr>
<tr>
<td>Indus</td>
<td>18,495</td>
<td>21,192</td>
</tr>
<tr>
<td>Ganga</td>
<td>7,963</td>
<td>9,011.53</td>
</tr>
<tr>
<td>Brahmaputra</td>
<td>11,497</td>
<td>14,019</td>
</tr>
<tr>
<td>Irrawaddy</td>
<td>133</td>
<td>35</td>
</tr>
<tr>
<td>Salween</td>
<td>2,113</td>
<td>1,351</td>
</tr>
<tr>
<td>Mekong</td>
<td>482</td>
<td>234</td>
</tr>
<tr>
<td>Yangtze</td>
<td>1,661</td>
<td>1,561</td>
</tr>
<tr>
<td>Yellow</td>
<td>189</td>
<td>137</td>
</tr>
<tr>
<td>Tarim</td>
<td>1,091</td>
<td>2,310</td>
</tr>
<tr>
<td>Interior</td>
<td>7,351</td>
<td>7,535</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>54,252</strong></td>
<td><strong>60,054</strong></td>
</tr>
</tbody>
</table>

The status of Glaciers in 2010 of the Hindu Kush Himalayan region.

**Total glaciers in HKH:**
- No: 54,252
- with area: 60,054 km²

**Glacier Cover in HKH:** 1.4%

**Glacier data online**
- [http://geoportal.icimod.org/](http://geoportal.icimod.org/)
- [http://glims.colorado.edu/glacierdata/](http://glims.colorado.edu/glacierdata/)
Decadal glacier change from 1980’s to 2010 of Nepal, Bhutan and some basins of Afghanistan, Pakistan and India

22% Glacier area loss

23% Glacier area loss

23% Glacier area loss

22% Glacier area loss
Focus on the development of the glacier area over decades, to understand future change and offer a possible evaluation of future water quantity and availability.
Decadal Glacier Change

Table: Change in glacier area in Imja valley of Dudh Koshi basin over three decades

<table>
<thead>
<tr>
<th>SN</th>
<th>Data Year</th>
<th>Glacier Number</th>
<th>Glacier Area (Km²)</th>
<th>Glacier Area (%)</th>
<th>Elevation (m asl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2010</td>
<td>24</td>
<td>45.91</td>
<td>31.67</td>
<td>8018</td>
</tr>
<tr>
<td>2</td>
<td>2000</td>
<td>21</td>
<td>51.93</td>
<td>35.83</td>
<td>8329</td>
</tr>
<tr>
<td>3</td>
<td>1992</td>
<td>21</td>
<td>53.74</td>
<td>37.08</td>
<td>8329</td>
</tr>
<tr>
<td>4</td>
<td>1979</td>
<td>20</td>
<td>63.22</td>
<td>43.62</td>
<td>8427</td>
</tr>
</tbody>
</table>
Over 60% of the total glacier area of the HKH is located in the elevation range 5000 – 6000 masl. The glaciers below 5700 masl are particularly sensitive to climate change unless they are covered by thick debris (Bajracharya et al., 2014). The Indus, Ganges and Brahmaputra basins have 79%, 60% and 77% of their total glacier area, respectively, below this critical elevation. CI glaciers at low altitude and small glaciers are the most sensitive glaciers to climate change in the HKH region.
### Important of cryosphere

<table>
<thead>
<tr>
<th>Basin</th>
<th>Annual precipitation (mm)</th>
<th>Glacierized area (%)</th>
<th>Annual runoff (mm)</th>
<th>Contribution to total runoff (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Glacier melt</td>
</tr>
<tr>
<td>Upper Indus</td>
<td>346</td>
<td>4.9</td>
<td>574</td>
<td>40.6</td>
</tr>
<tr>
<td>Upper Ganges</td>
<td>900</td>
<td>5.4</td>
<td>1088</td>
<td>11.5</td>
</tr>
<tr>
<td>Upper Brahmaputra</td>
<td>573</td>
<td>3.1</td>
<td>691</td>
<td>15.9</td>
</tr>
<tr>
<td>Upper Salween</td>
<td>595</td>
<td>1.3</td>
<td>480</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Average contribution of glacier melt (A), snow melt (B), glacier and snow melt combined (C) to total flow during and the average discharge at different stages in major streams in the model domain (all panels) during 1998-2007.

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**Table:**

- **Basin:** Names of the river basins.
- **Annual precipitation (mm):** Annual precipitation in millimeters.
- **Glacierized area (%):** Percentage of glacierized area.
- **Annual runoff (mm):** Annual runoff in millimeters.
- **Contribution to total runoff (%):** Percentage contribution to total runoff from glacier melt, snow melt, rainfall-runoff, and base flow.
The snow and glacier meltwater plays a pivotal role in the water supply for those river basins that are arid downstream, in particular where there are large irrigation systems that depend on upstream water resources. Changes in the glaciers may have a significant impact on the quantity and timing of water availability. A comprehensive understanding of the extent and nature of changes in glaciers will support downstream hydrological planning and water resource management.
The Regional Cryosphere Knowledge Hub is a collaborative effort to share and disseminate cryosphere-related data by:

- Providing a web-based interactive portal for dissemination and visualization of cryosphere data

- Regular publication of quarterly e-bulletin on the cryosphere activities of ICIMOD and its regional member countries

- Organizing conferences, seminars, and workshops

- Providing a platform for regional knowledge sharing events
In the end

Although uncertainties about the rate and magnitude of climate change and potential impacts prevail, it is generally agreed that climate change is gradually and powerfully changing the cryosphere, ecological and socio-economic landscape in the HKH region, particularly in relation to water, with significant implications for mountain communities and livelihoods, as well as downstream users, including women.

It is estimated that around 1.3 billion people live in the river basins draining the HKH. Here, more than 20% live below the poverty line, amounting to around 260 million people. Therefore, climate change impact on the HKH region is particularly severe due to the large concentration of people dependent on climate-sensitive livelihoods such as agriculture.
Thank you

Regional Stakeholder Consultation on Climate Services for the Third Pole Region
Jaipur, Rajasthan, India
9-11 March 2016