Conference and Workshop Report

ICIMOD

FOR MOUNTAINS AND PEOPLE

International Conference on the Cryosphere of the Hindu Kush Himalayas: State of the Knowledge

and

Workshop on Hindu Kush Himalayan Cryosphere Data Sharing Policy

14–18 May 2012, Kathmandu, Nepal

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

DEPARTMENT OF STATE UNITED STATES OF AMERICA

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

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the Governments of Afghanistan, Austria, Bangladesh, Bhutan, China, Germany, India, Myanmar, Nepal, Norway, Pakistan, Sweden, and Switzerland, and the International Fund for Agricultural Development (IFAD).

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Contents

Acronyms and Abbreviations

CMP	Cryosphere Monitoring Project
DHMS	Department of Hydro-Met Services, Bhutan
ELA	Equilibrium line altitude
ICIMOD	International Centre for Integrated Mountain Development
GCISC	Global Change Impact Studies Centre
GHOST	Global Hierarchical Observing Strategy
GLIMS	Global Land Ice Measurements from Space
GLOF	Glacial lake outburst flood
GTN-G	Global Terrestrial Network for Glaciers
HKH	Hindu Kush Himalayan region
ICSU	International Council for Science
masl	Metres above sea level
NSIDC	National Snow and Ice Data Center
RGI	Randolph Glacier Inventory
SIWI	Stockholm International Water Institute
TERI	The Energy and Resources Institute
WAPDA	Water and Power Development Authority, Pakistan
WGMS	World Glacier Monitoring Service

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Last but not least, the conference and workshop greatly benefited from the contributions of all the participants, which made the meetings a success. The invaluable contributions, deliberations, and knowledge gathered through the participation of distinguished scientists, researchers, and practitioners is of immense value and ICIMOD would like to acknowledge all of the participants.

Background

The Hindu Kush Himalayas (HKH) contain the world's largest volume of permanent ice and permafrost outside the polar regions. Changes in the reserves of ice and snow in the region have significant implications for the water resources of 10 major river basins in the HKH region, which provide life to more than 1.3 billion people. Long-term monitoring is needed to better understand the effects of climate change on the region's cryosphere, including its impact on water resources.

In general, cryospheric monitoring in the HKH region has been characterized by first impressions, micro studies, and fragmented and short-term measurement series. There has been growth in cryosphere monitoring research activities as the importance of the integral role of cryosphere monitoring in the assessment and management of the region's water resources is increasingly recognized. Against this backdrop, the International Centre for Integrated Mountain Development (ICIMOD) has been implementing the Cryosphere Monitoring Project (CMP) to contribute to improved knowledge and understanding on the cryosphere by analysing changes in the region's glaciers, snow, and glacio-hydrology in relation to the impacts of climate change on water resources management in the HKH region. Better coordination and concerted efforts between research organizations and institutions working in the region is also crucial to enhancing cryospheric knowledge and research in the region.

ICIMOD held a groundbreaking, three-day international conference on the Cryosphere of the Hindu Kush Himalayas: State of the Knowledge, followed by the two-day Hindu Kush Himalayan Cryosphere Data Sharing Policy Workshop. The conference and workshop were held at ICIMOD Headquarters in Kathmandu, Nepal, 14–18 May 2012. Ninety-six participants from 18 countries, including 15 participants from partners in regional member countries and top scholars and practitioners from across the globe, were brought together to discuss the most recent research on snow, glaciers, glacial hydrology, and capacity building in cryospheric research in the HKH. Supported by the Norwegian Ministry of Foreign Affairs and the United States Department of State, the two events made significant contributions to strengthening the exchange of knowledge, enhancing regional cooperation for cryosphere monitoring, promoting regional efforts to better understand the cryosphere, and formulating the initial framework for setting up a regional hub and clearing house for cryosphere data and information.

The enthusiasm for the Cryosphere Knowledge Hub is evident; the breadth of the task for its establishment is also clear. Establishing a regional Cryosphere Knowledge Hub as currently envisioned will require unprecedented levels of international and inter-sectoral cooperation, and a sophisticate, nuanced approach to gathering, storing, and sharing information. Uniquely positioned as a regional, inter-governmental, non-political cryosphere research organization in the HKH region, ICIMOD has the potential to create a meaningful central database to collect, catalogue, and disseminate crucial information. As the proceedings of this conference and workshop demonstrate, the scientific community is enthusiastic about the initiative. The nuances of creating a regional knowledge-sharing platform are complex, but its importance eclipses any roadblocks to its establishment.

The two-day workshop following the conference allowed groups of expert participants to gather and discuss the creation of the HKH Cryosphere Knowledge Hub. The groups discussed the practicalities under four themes:

- What type of data and information exists?
- Who has the data and information?
- What is an appropriate data sharing policy?
- What is the best data sharing mechanism?

Experts also provided input on the design framework of the knowledge hub and how data should be shared, taking into consideration the data requirements and constraints of international, regional, and local organizations in terms of content and format as well as political sensitivities when sharing data across borders.

International Conference on the Cryosphere of the Hindu Kush Himalayas: State of the Knowledge

Opening Session

In his opening address, Dr David Molden, Director General of ICIMOD, spoke on the conflicting stories being reported on the HKH cryosphere. He said that "only long-term studies of cryosphere can bring out the true picture, and this calls for the establishment of a cryosphere knowledge hub in the region". Camilla Røssaak, Minister Counsellor of the Royal Norwegian Embassy in Nepal, concurred that there is a need for increased knowledge, regular measurements, and more data for cryospheric research, as these are also useful for adaptation measures at all levels. Patricia Mahoney, Deputy Chief of Mission of the US Embassy in Nepal, noted that most research in the HKH has been piece-meal, and only a few glaciers have been studied over a long period of time. She called on the participants to "exchange knowledge, identify gaps, and strategize". Pradeep Mool, Coordinator of the Cryosphere Monitoring Project at ICIMOD, set the tone for the conference by flagging the need for long-term monitoring of HKH cryosphere and called for the establishment of a regional hub for cryosphere knowledge to enhance data sharing, capacity building, and networking at all levels to further cryosphere research in the region.

Global Cryosphere Monitoring

In this session, presenters gave an overview of the current global glacier monitoring regime, the gaps and overlaps in data sources, and the strengths and weaknesses of various methodologies and data sets.

Jeffrey S Kargel from the University of Arizona in the US made a presentation on global and regional remote sensing initiatives in the Hindu Kush Himalayas. He explained that because data has been organized by drainage basin/sub-basin rather than by international political borders, major remote sensing projects can be used to produce data on the 10 river basins in the HKH region. The National Snow and Ice Data Center (NSIDC), Global Land Ice Measurements from Space (GLIMS), and Randolph Glacier Inventory (RGI) programmes all have large data sets based on remote sensing. However, because of differences in the attributes used in each database, different results might be produced. For example, GLIMS and RGI images laid over one another appear to tell a different story about the same glacier, including how it has changed over time. As RGI was designed to fill a gap in the data acquired by the GLIMS programme, GLIMS data and RGI data actually complement each other. However, because RGI has a heterogeneous set of attributes and GLIMS has homogenous attributes, it will take some work to combine them effectively.

Koji Fujita of Nayoga University in Japan presented on spatially heterogeneous wastage of Himalayan glaciers and research that has attempted to address the gap in ground-based data in the discussion of the fate of Himalayan glaciers. Based on ground observations and mass balance studies, it was found that the Yala, Rikha Samba, and AX010 glaciers in the Nepal Himalayas have shown rapid wastage (negative mass balance) since the 1970s. To date, only 40 glaciers have been effectively monitored by the direct stake method. And despite advances in remote sensing technologies, this ground-based data remains important. Geodetic laser monitoring of changes in glacier height may be another effective field-based monitoring method. He also found that whereas changes in the glaciers of Nepal are temperature driven, in Tibet and the Karakoram Range, changes are mostly precipitation driven. In the Karakoram and Pamir ranges, the lower altitudinal boundary of the snow-covered area of the glacier, or equilibrium line altitude (ELA), is decreasing, possibly due to surging glaciers.

The third presentation argued that the role of glacial melt for the overall hydrology of Asia is less important than commonly assumed, that snow melt is a larger contributor to stream flow than glacial melt, and that the Indus and Amu Darya basins, both highly dependent on melt water, are extremely important to irrigation downstream. Walter

Immerzeel from the University of Utrech in the Netherlands demonstrated the enormous climatic variability in the region and vast differences in precipitation across the region – from as high as 11 m per year to as low as 200 mm per year – both of which have a large influence on how glaciers behave. Since 2009, there has been intense media attention to glacial melt and climate change. While it is true that glaciers have been retreating over time since the 1970s, regional anomalies exist – it all depends on the climate, topographic characteristics, and debris cover on individual glaciers.

There are still many scientific challenges and gaps that need to be filled, including a lack of observations, distribution of precipitation in mountain catchments, variability in cryospheric response to drivers of climate change, process understanding versus spatial scale, calibration and equifinality (geochemistry, isotopes), changes in monsoon strength resulting from climate change, and monsoon feedbacks. It is certain that siloed, single-country research will not deliver maximum results. The level of uncertainty is high and there are many factors affecting the accuracy of research in the region. One of the ways inconsistencies in data can be effectively mitigated and eroded is through increased data and knowledge sharing.

Cryosphere Monitoring in the HKH Region

Directing the discussion to the Hindu Kush Himalayas (HKH), this session focused on various monitoring and research activities currently underway in the region. Presenting scientists explained how geography, national interests, local capacity, and international political sensitivities come into play while conducting research in their respective countries.

Mohammad Naim Eqrar of Kabul University opened the session by presenting on the impacts of climate change on water resources in Afghanistan which, at a national level, could be seen as a water-rich country. He explained that this suggestion is misleading as high spatial variability at river basin and sub-basin levels gives a very different picture of the situation and even indicates that water scarcity already exists in the Northern Basin. Predictions show that river basins such as the Helmand and Harirod will pass below the scarcity threshold within a few decades if not years, while the Northern Basin will face absolute scarcity in the near future. Water productivity and efficiency of water use for food production will be important, as will improved dams and water storage facilities. As the majority of Afghan rivers are shared with several countries downstream, development projects should take the effects on neighbouring countries into account. As Afghan scientists lack reliable data and expertise, capacity building will be crucial to developing Afghanistan's strength as a regional participant and contributor.

Phuntsho Namgyel from the Department of Hydro-Met Services (DHMS) in Bhutan followed with an overview of cryosphere studies in Bhutan. Bhutan boasts 2,794 glacial lakes, of which 26 are regarded as potentially dangerous. About 70 per cent of the country's settlements are along river basins where the impacts of flooding are most devastating. With so many glacial lakes, glacial lake outburst floods (GLOFs) are a highly-feared natural disaster in Bhutan, with the 7 October 1994 GLOF resulting from the breach of Lugge Tsho still fresh in the nation's collective memory. The Department of Geology and Mines is involved in draining glacial lake water to mitigate GLOF-related hazards, and the DHMS intends to install monitoring stations upstream, including some to gather data on glacier mass balance in order to better understand Bhutan's glaciers. Toward that end, Bhutan is looking to partner with agencies working on related areas such as cryosphere research, GLOF mitigation, and early warning systems.

Lide Tian of the Institute of Tibetan Plateau Research of the Chinese Academy of Sciences in China explained that while many people south of the Himalayas worry about water availability, research has shown a significant increase in the water levels of inland lakes on the Tibetan Plateau. Loss of glacier depth has been observed in Kangwure and Naimona Nyi glaciers and many glaciers, including Naimona Nyi Glacier, the Dongkemadi Glacier, and glacier No. 12, have lost mass over the years. Differential GPS methodologies have proven useful in monitoring these changes: they are more precise, less sensitive to precipitation changes, and have a margin of error of only a few centimetres. However, more data is needed, including on glaciers at higher elevations and on larger glaciers, and significantly more data is needed regarding glacier accumulation zones. He also shed light on the Third Pole

Environment – a glacier monitoring network active in the Tibet Autonomous Region, Pakistan, Tajikistan, and Nepal (in Nepal, at Yala Glacier in particular).

Demonstrating ongoing work in India, Bhanu Pratap Thakur of the Wadia Institute of Himalayan Geology in India presented the results of mass balance studies using the direct stake method at the debris-covered Chorabari Glacier and the clean Dokriani Glacier. Both showed negative mass balance between 2003 and 2009; however, Chorabari showed a greater mass balance value because it has a much bigger ablation area than Dokriani. Between 2003 and 2010, research has shown that the Dokriani Glacier retreated by 128 m and the Chorabari Glacier by 66 m, arguing that the retreat of a glacier snout may be an indicator of climate change.

Keshav P Sharma of the Department of Hydrology and Meteorology in Nepal outlined activities the department has undertaken, including a bathymetric survey of Imja and Gosaikunda lakes to assess their growth rate (area and volume); lowering of the lake level of Tsho Rolpa by 3 m as part of GLOF hazard mitigation; development of plans for the installation of an early warning system downstream of Tsho Rolpa using mobile/telephone technology; and work on Mera Glacier with Nagoya University, Japan, and the University of New Hampshire, US.

Most of the hydrological and precipitation monitoring stations currently operating in Nepal are in the hills and the plains. Less accessible areas above 4,000 masl are not adequately covered. The remoteness of villages and amount of funding needed for long trips to install and maintain monitoring equipment in rural areas limits cryospheric research, and maintaining the quality of the data these stations produce is difficult. As such, stations are set up where they can be most efficiently and economically maintained; they tend to be in tourist areas easily reached by commercial flights.

Discussing downstream trends, Htay Htay Than of the Department of Meteorology and Hydrology in Myanmar presented data indicative of climate change impacts in Myanmar. Since 1977, the onset of the monsoon has been later than normal, and since 1989, monsoon withdrawal has occurred earlier than normal. However, while the duration of the monsoon has decreased, the level of precipitation has not, resulting in an increase in the incidence of high-intensity rainfalls during the monsoon. Various river basins demonstrate increases and decreases in flow, indicating that different basins and their sources are affected differently by climate change.

Chaudhry Mustaq Ahmad of the Water and Power Development Authority in Pakistan shared key findings from cryospheric research in the Upper Indus Basin. There most of the glaciers are avalanche fed and a bulk of the precipitation occurs around 5,000 masl in the western Karakoram and 6,000 masl in the eastern Karakoram. He also explained how the soon-to-be established World Bank-funded glacial mountain research centre will collaborate with ICIMOD to:

- study climate change impacts on the cryosphere of the Upper Indus Basin;
- forecast long-term water availability;
- conduct glacier mass balance studies for five selected glaciers (yet to be selected) over the course of four years;
- map and monitor 50 Upper Indus Basin glaciers; and
- train in-country staff to use modern concepts and techniques in their research.

Pakistan currently has 20 monitoring stations between 2,200 and 4,800 masl, and this new project promises to produce more data and create more relevant information about the cryosphere of the Upper Indus Basin.

Summary of Day 1

The day's presentations threw into sharp relief the tremendous spatial variability across the HKH, which can make it difficult to collect accurate information about the region. In addition to grappling with high degrees of variability, varying methodologies between countries and projects forces the scientific community to deal with data sets that are difficult to integrate, resulting in a high degree of uncertainty associated with analysis and results. It was agreed that more work needs to be done to improve the analysis of error and uncertainty across methodologies.

In addition, it was clear from all the presenters that more quantitative data is needed. It is crucial to remember that sufficient data does not necessarily mean sufficient information. As research goes beyond glacier mapping to glacier dynamics, precise measurements are necessary to help reduce errors.

The presentations highlighted the need for increased focus on:

- high-altitude meteorological and climate data, including debris loads and ablation rates;
- discharge data and changes in seasonality;
- bringing data together to produce meaningful information;
- integration of field data with remote sensing studies and numerical modelling;
- integrating data across methodologies and disciplines;
- debris cover and implications for various data sets
- differentiation of snow dynamic from glacier dynamics(e.g. flow dynamics, thermal regime, glacier sensitivity);
- the Karakoram anomaly;
- information on glacier sensitivity and glacial dynamics;
- high elevation glaciers in order to understand mass balance changes on a regional scale (not just at low elevations);
- coordinated field studies; and
- regional capacity building.

Glacier Mapping and Research in the HKH Region

Karakoram and High Asia

Arguing for the establishment of a collaborative effort to assess the role of glaciers and seasonal snow cover in the hydrology of the mountains of High Asia, Richard Armstrong of the University of Colorado in the US opened the session by presenting combined data from the Brahmaputra, Ganges, Indus, Amu Darya, and Syr Darya river basins. The study aims to produce a realistic, accurate estimate of the future availability and vulnerability of water resources across these very large mountains. As the data sets available in each country differ, the research requires a high degree of flexibility and inclusiveness in its approach.

Wind action, the collapse of cornices resulting in avalanches, and the shifting of large quantities of snow can be hard to measure, but they all have significant impacts on glaciers in the Karakoram and have been neglected and understudied, argued Kenneth Hewitt from Wilfrid Laurier University in Canada. Avalanches and avalanche-fed glaciers are year-round phenomena that move masses of millions of cubic metres. As cryosphere research progresses, it will be important to develop knowledge on how ice falls relate to climate change. In what could be called 'known unknowns' in Himalayan glacier source zones, wind, avalanches, and ice falls dominate snow and ice transfers and decide the characteristics of ice, thermal dynamics, and debris. These factors must be considered in cryospheric research and modelling.

With regard to debris cover, Michael Bishop from the University of Nebraska at in the US Omaha elaborated on research that attempts to understand glacier-profile topographic characteristics by gathering data on glacier fluctuations, mass balance, glacier sensitivity, response patterns, and other controlling factors. The objective of this methodology, using digital elevation models and geomorphic parameters, is to capture relationships between glaciers and topography and multi-scale altitudinal variations to establish a comprehensive glacier assessment system. This study aims to produce information on multi-scale topographic influences, altitude variations, glacier classifications, and geomorphic characterization (debris cover, meltwater production, surface velocity fields, and glacier responses).

In his presentation comparing the characteristics of topographic glacier profiles for the assessment of glaciers in the Western Himalayas, Jack Shroder from the University of Nebraska at Omaha put a strong emphasis on the role of local partners in creating relevant, sensitive research and also highlighted the political problems that arise when concluding scientific research. Research and mapping of glaciers can have important human impacts. For example, an ice avalanche from the Siachen Glacier in the Karakoram Range killed 139 soldiers at the Gayani Army Camp in the Bilafond valley of Pakistan. The glacier, which was heavily-crevassed and partially collapsed with a great deal of moraine, had never been mapped.

Climate change is affecting the cryosphere of the HKH differently at different latitudes and altitudes. For example, while many glaciers in the region appear to be retreating, glaciers in the Karakoram Range have been advancing and surging. Nonetheless with all of this information, scientists have to look after the sensitivities in the host countries and try to stimulate better communication and data sharing with local scientists. When water discharge data is a state secret, it can be problematic. Part of the general solution is that we need more research, particularly by local scientists.

Pakistan

Sahibzad Khan of the Pakistan Meteorology Department opened the session by presenting research showing that the frequency of heat waves in northern Pakistan has been increasing over time along with the average temperature. Water availability appears to be declining as the nation's population continues to rise, worrying scientists and politicians alike. As monsoon rains become increasingly irregular, the inflow of water is becoming less reliable, and droughts are increasing in frequency. As a result, crop and livestock productivity is declining. As these changes occur, food production and security is a major concern for Pakistan. Scientists in Pakistan feel a need to extend the observation network to improve data collection.

Muhammad Zia ur Rahman Hashmi of Pakistan's Global Change Impact Studies Centre (GCISC) explained that 83 per cent of the total ice reserves in Pakistan are contained in three watersheds – Shyok, Shigar, and Hunza – and that 44.8 per cent of the Indus River is fed by glacier melt. While global monitoring over the last 100 years indicates that mountain glaciers in general are shrinking, there is widespread evidence of glacier expansion in the late 1990s in the central Karakoram. In the HKH region of Pakistan, most of the glaciers are retreating. But as Immerzeel et al. noted in a 2009 paper, it is also important to consider the possible effects of various potential outcomes: even if the glaciers vanish completely, the flow of the Indus River is only expected to decrease by about 15 per cent overall, and very little or no change is expected for the dry season. GCISC, working with various line agencies of the Pakistani government, will continue to monitor these changes.

Both Khan and Hasmi expressed concern in regard to the overall lack of data, technical capacity, and coordination in Pakistan – which could lead to a duplication of efforts. The lack of capacity means that Pakistani scientists and their data cannot contribute as substantively as they would like to the proposed Cryosphere Knowledge Hub.

India

Alagappan Ramanathan, of Jawaharlal Nehru University in New Delhi, gave an overview of winter accumulation and mass balance studies from the Chhota Shigri Glacier in Lahaul-Spiti, Himachal Pradesh, India. Approximately 14 per cent of the Indian Himalayas are covered by glacier ice, and another 30–40 per cent gets snow cover in the winter months. But there is limited data on winter accumulation. Much of this data gap can be attributed to problems of access – for example, when roads are blocked by snow and ice – which makes having consistent access to certain areas very difficult. Research has been able to determine that between 2003 and 2010, elevation and ice flow velocities slowly decreased in the ablation area of the monitored glaciers, leading to a 24–37 per cent reduction in ice fluxes. Data is showing that mass balance is strongly dependent on debris cover, exposure, and the shading effects of surrounding slopes.

Rajesh Kumar of Sharda University in New Delhi continued the discussion on the Indian Himalayas by focusing on climate change impacts. He reported that teams are also conducting meteorological observations, water level measurements, measurements of accumulation zones, and snout measurements. Results observed include overall negative balance of Gara Glacier, Gorang Glacier, Shaune Glacier, Naradu Glacier, and glaciers in the Suru valley; snout retreat of Gangotri Glacier; perennial rivers turning into seasonal rivers; lack of balance in the ecohydrological equilibrium; and less water availability for drinking and other human consumption.

The Energy and Resources Institute (TERI) in India operates the Glacier Research Programme – an integrated regional model to quantify the linkages and dynamic relationship between meteorological parameters, the rate of glacier melting, and meltwater discharge in order to make an assessment of runoffs in the high-altitude catchments of Himalayan rivers. TERI's Nathaniel Dkhar described the programme's three operational phases: establishment of glacier monitoring observatories and field laboratories, analysis of satellite data and field experiments for calculation of modelling constants, and the development of an integrated runoff model. This three-pronged (meteorological monitoring, glaciological monitoring, and hydrological monitoring) approach captures the dynamism of glacier melting. Ongoing monitoring of Kolahoi Glacier in Kashmir and East Rathong Glacier in the eastern Himalayas shows recression and decrease in glacier areas over the years.

For all of the projects based in India, access remains an issue. Extreme weather, washed out roads, and inaccessibility of certain glacial areas limits the scope of research. TERI has strategically partnered with local mountaineering organizations like the Himalayan Mountaineering Institute to improve coordinated access, but funding remains a limitation for reaching certain areas. Despite this limitation, coordinating with researchers working downstream can make data more relevant and useful.

China

Shichang Kang from the Institute of Tibetan Plateau Research opened the session with a discussion of the recent dramatic thinning of glaciers on the Tibetan Plateau. Their research focuses on the Nam Co Basin, which covers an area of 20,000 sq.km. The conditions in the basin, he argued, are indicative of overall plateau trends because the area features immense environmental diversity: lakes, rivers, glaciers, snow, permafrost, alpine meadows, and wetlands. There, the annual temperature is increasing, annual precipitation is showing no trend, annual evaporation is increasing, and winter precipitation is increasing. The glacial area has shrunk by 28 per cent in the last 28 years, and the water level of inland lakes is increasing. Field work in the basin includes mass balance measurements, GPS surveys, and hydrological observation. Tritium measurements on the plateau have proven useful in measuring changes in ice reserves and glacier thinning.

Box 1: Titles of Poster Presentations

Eight posters from North America, Europe, and the HKH region were presented during the poster session. The poster along with the designers and their institutional affiliations are presented below.

Interactively-coupled simulations of alpine climate and glacier surface mass balance in the Karakoram
S. Emilt Collier[1, 2,] Thomas Molg[2] and Andrew B G Bush[1]
[1] Department of Earth and Atmospheric Science, University of Alberta; [2] Institute of Ecology, Technical Universitat Berlin, Berlin, Germany

Mapping and Monitoring of Snow Cover

Decadal Glacier Change in Bhutan Himalaya

Glaciers Mapping and Inventory of Nepal

International Centre for Integrated Mountain Development(ICIMOD)

Cryosphere Monitoring Project (CMP) in the Nepalese Himalayas
Dorothea Stumm[1], Pradeep K. Mool[1], Arun B. Shrestha[1], Sharad P. Joshi[1], Samjwal Bajracharya[1], Rijan B. Kayastha[2], Lochan P. Devkota[3], Om R. Bajracharya[4]
[1] International Centre for Integrated Mountain Development (ICIMOD); [2] Department of Environmental Science and Engineering, School of Sciences, Kathmandu University; [3]Central Department of Hydro-Meteorology, Tribhuvan University, Kathmandu, Nepal; [4] Department of Hydrology and Meteorology, Kathmandu, Nepal

Recent and future glacier dynamics and hydrological regime in the Upper Karakoram
Daniele Bocchiola[1], Boris Mosconi[2], Cristoph Mayer[3], Astrid Lambrecht[4] Andrea Soncini[1] Alberto Bianchi[1], Guglielmina Diolaiuti[2], Elisa Vuillermoz[5], Claudia Mihalcea[2], Carlo D'Agata[2], Claudio Smiraglia[2]
[1] Politecnico di Milano, DIIAR, CIMI, Italy; [2] Department of Earth Sciences, Universita di Milano; [3] Commission for Glaciology, Bavarian Academy of Sciences; [4] Institute of Meteorology and Geophysics, University of Innsbruck; [5] EV-K2-CNR Committee of Italy

Precipitation patterns in the Karakoram and Himalaya from observations and model simulation
E. Palazzi[1], A. Provenzale[1], J. von Hardenberg[1], E. Vuillermoz[2], G.P. Verza[2], P. Cristofanelli[3], and B. Adhikary[4]
[1] Institute of Atmospheric Sciences and Climate (ISAC)-CNR, Torino; [2] Ev-K2-CNR Committee, Bergeamo; [3,1] Institute of Atmospheric Sciences and Climate (SAC)-CNR, Bologna; [4,2] Ev-K2-CNR Committee, Kathmandu, Nepal

Impacts of Debris on Glacier Research: Priorities and relation to glacier-climate interactions on clean-ice glaciers
Lindsey Nicholson
Institute of Meteorology and Geophysics (IMGI), University of Innsbruck, Austria

Nepal

Rijan Bhakta Kayastha from Kathmandu University gave an overview of the glacier research and capacity development programmes currently underway in Nepal, including a glacier mass balance study using energy balance modelling and calculations on glacier AX010. Kathmandu University has offered an MSc on Research in Glaciology and will produce 20 graduates by the end of the five-year project period of the Cryosphere Monitoring Project. These graduates will have the skills to monitor the mass balance of glaciers and collaborate with ICIMOD and other organizations in hydro-meteorological studies and assessing changes in the cryosphere, and they will play crucial roles in the management of water resources and the assessment of water-induced disasters such as GLOFs.

Further contributing to the discussion of studying Nepal's cryosphere, Elisa Veuillermoz from the EV-K2-CNR Committee of Italy, presented ongoing research from Changri Nup Glacier in the Khumbu valley of Nepal aimed at understanding atmospheric dynamics and ongoing climate variations. In 2010, an automated station was installed at 5,700 masl in an effort to understand climatic variability. Currently there is no measurement of snow depth, but that will be added to this station soon, as should radiance balance measurements. The studies carried out so far include the calculation of albedo on the glacier surface using incoming and outgoing short-wave radiation and the latent heat of vaporization; effects of black carbon deposition on snow ice surface and floating in air, especially the frequency of acute pollution occurring during the pre-monsoon season and linkages between black carbon and ice and snow melt; estimation of melting in 2011; and the effects of black carbon on ablation, including ablation modelling. Future activities are planned to improve surface energy balance, measure ice ablation (melting plus sublimation), and to model stream flows from glaciers.

Summary of Day 2

The ongoing research in the Nam Co Basin encouragingly demonstrates that good research is possible at very high altitudes, although it may require some creativity like the use of Tritium level measurements. It is also promising to see the development of the local capacity for glacier research through the introduction of an advanced degree programme in glaciology at one of the Nepal's premiere universities, Kathmandu University. During the group discussion, participants were enthusiastic of the promise that such developments show for the future of glaciology in the HKH region.

Regarding future research, participants voiced cautions and concerns including the following points:

- Most of the research to date has focused on relatively small glaciers. The strategic development of research, monitoring, and modelling should seriously consider the question of scale and representativeness in glaciers.
- Collaboration is crucial; duplication drains resources. ICIMOD as a hub can help cut down on this.
- Integrating data sets is important in order to make information useful.
- Can Kathmandu University provide courses for students from the region at reasonable rates?
- Find a balance in research between benchmark glaciers, which are good for studying climate trends, and glaciers where other parameters are more important to learn about new processes.
- For complicated glaciers, projects need to reduce expectations for immediate data and focus on the long term. Expectations for outputs should not be so high as to prevent scientists from tackling difficult glaciers.
- Systematic approaches that are universally applicable to different levels of complexity are required for more consistent, repeatable results.
- Scientists have a lot of power to reduce public misinformation: when talking about glacial retreat to the media and the public, scientists have to emphasize regional variations.
- Similarly, scientists must publicly express that glacial retreat will not necessarily cause huge changes in water resources.
- Whether working in science or policy, professionals working on the cryosphere must help decision makers take action amidst uncertainty. There has to be consistent efforts to bridge the gap between science and policy.

Glacier and Snow Monitoring and Glacio-hydrological Modelling

This session focused on factors inducing changes in the glacier and snow regimes in the HKH region and beyond, including the extent of inter-temporal and spatial changes. It also dealt with the contributions of snow and glacier melt to runoff as well as related issues such as uncertainties, errors, knowledge gaps, and methodological and modelling issues.

Opening the session, Michael Zemp, Director of the World Glacier Monitoring Service (WGMS), described the dearth of long-term data on glacial change in HKH region. The available data for target region includes Austrian mapping from 1970, Finnmap in 1990, SRTM3 DEM in 1999, ASTER GDEM from 2000–2010, ASTER from 2003, and Landsat from 2000. Using a differentiation of the various sources gives a decent picture of glacial change over time. But this is an example of a quick solution that should not necessarily be trusted. Geodetic volume change assessments can bridge the data gap in the HKH region. Corresponding analysis of map and satellite data must come with sound uncertainty assessments. Recent discussions have focused on researchers using the same data and producing different results. Systematic errors can be extreme and contribute to this. To combat this, it's important to find stable terrain.

Francesca Pellicciotti from the Swiss Federal Institute of Technoogy-Zurich (ETH Zurich) presented on glacio-hydrological modelling in the Langtang Basin of Nepal. For this study, researchers used four main types of measurements: air temperature along the valley; precipitation along the valley; understanding meteorological and melt variability over a debris-covered glacier via ablation measurements; and the hydro-geochemistry and isotopes for characterization of water sources and runoff components. To gather accurate, meaningful data, parameters need not be taken from literature but rather specifically selected and designed for the site. A multi-variable, multi-step approach allows researchers to calibrate different sets of parameters against observations of different types in a step-wise approach. To this end, this research in the Langtang Basin is a pilot study which intends to combine observation and sophisticated modelling to reduce some of the uncertainties cryosphere scientists face in their work. Some of the initial observations recorded include: temperature and precipitation variation with elevation; detachment of the tongue of the Lirung Glacer from the accumulation zone; and the effects of wind (katabatic wind) on temperature variability over debris-covered glaciers.

For a perspective from outside the region, Miriam Jackson from the Norwegian Water Resources and Energy Directorate described ongoing glacier monitoring in Norway. Ninety-eight per cent of the electricity in Norway comes from hydropower. Because Norwegian glaciers play such a crucial role in hydropower production, data was needed from a very early stage in hydropower development, and the government and private companies had a vested interest in researching them, therefore it was well-funded from the start. There are primarily two types of glaciers found in Norway: plateau/icecap glaciers and cirque/valley glaciers. Currently 42 glaciers have been measured and 15 are currently being monitored; only six glaciers have been measured consistently for more than 50 years. Results show fairly constant retreat for all glaciers. Although maritime glaciers, including the Nigardebreen Glacier, experienced growth in the 1990s, they have retreated since then.

In discussing field evidence and modelling approaches for determining the water balance of Batura Glacier, Matthias Winiger of the University of Bonn in Germany argued that the number of uncertainties in glacier research is growing. There are many contradictions in the data, and scientists are observing many different situations on the same glacier. His research demonstrated a water balance model of Batura Glacier, a complex system in the western Himalayas, which took many factors into account – drifting snow, avalanches, precipitation, evaporation, ablation, black carbon, debris cover, seasonal snow cover, and runoff. He also called for enhanced coordination of field studies on the same glacier, the integration of scales (regional and global scale, data quality, vertical gradients/processes), and flagged the importance of comparative field work.

Drawing on data from the Water and Power Development Authority of Pakistan's (WAPDA) network of 20 high-altitude stations in the ablation zone of the upper Indus Basin for the period 1991–1995, Daniyal Hashmey of WAPDA explained how the stations in Pakistan collect hourly data for parameters including temperature, precipitation, humidity, solar radiation, water, and wind. The results vary across the stations. Snow melt flow trends do not necessarily correspond with rising trends in sensible heat; however, falling trends in glacier melt flow correspond with falling sensible heat, implying reduced ablation and stability of glaciers. It is clear that the project needs more data over a longer period of time to make any reliable determinations.

To bring the session to a close, Mats Erikkson of the Stockholm International Water Institute (SIWI) presented on strategies to bridge the gap between science and policy in the field of water and climate change. Currently, the field has two types of research: highly academic studies and highly applied studies. There needs to be a streamlined flow from generating knowledge to influencing change agents to making a difference for the poor as well as for other groups such as industry and the general public. There is a need to package research findings for an appropriate target group, whether it is for the scientific community, decision makers, policy makers, the general public, or the media. By appropriately packaging data, SIWI was able to influence the UNFCCC in taking water from being a 'sector' to a 'resource', linking it to human rights. But work still remains to be done.

ICIMOD Initiatives

Over the years ICIMOD has developed an inventory of glaciers and glacial lakes in the HKH region and is now monitoring geophysical parameters like the extent of the glacial area, snow cover, and debris cover on a large scale in order to understand the extent of associated changes over the years. With the Cryosphere Monitoring Project, ICIMOD is also making forays into new territories such glacier mass balance measurement studies and modelling to better understand glacier dynamics.

To open the session, ICIMOD's Samjwal Bajracharya, presented an inventory of glaciers, both clean and debris covered, in the HKH region, including the 10 river basins of Amu Darya, Tarim, Yellow River, Yangtze, Indus, Ganges, Brahmaputra, Irawaddy, Salween, and Mekong. There are more than 54,252 glaciers in the region spread over a combined area of 60,054 sq.km (1.4 per cent of the total area of the HKH). Overall, glacial areas have been decreasing drastically. Glacier area was 3.6 per cent of the total area of Nepal in 2001; in 2010 it had reduced to 2.9 per cent. The glacial area of Bhutan decreased by 22 percent between 1982 and 2010. Conducting this inventory, ICIMOD has learned that access to the highest quality of satellite images is necessary for regular monitoring and that the rapid melting of glaciers necessitates a more rapid methodology for the monitoring of glaciers. Future activities planned include the identification of hotspot glaciers for regular monitoring, implementation of a quick methodology for glacier monitoring in the eastern Himalayas, and dissemination of all glacier-related databases once the institutional intellectual property rights and data sharing policy is in place.

ICIMOD's Deo Raj Gurung reiterated the central messages from the 2009 Earth Observation Symposium held at ICIMOD: there is a lack of cryosphere information; access to cryosphere data is difficult; there is a need for coordination to facilitate data access in the region; and ICIMOD needs to start officially functioning as a hub fro cryosphere knowledge to move toward addressing these issues. The Moderate Resolution Imaging Spectroradiometer (MODIS) is currently the de facto standard for monitoring geophysical parameters of snow on a large scale. ICIMOD has created an online snow cover data portal which shows the results of studies carried out in 10 river basins and 92 sub-basins in the HKH. The snow cover change for 2002-2011 showed a declining trend for the whole HKH region; a declining trend in the winter (although not statistically significant) and declining trends in the summer and spring; and maximum snow cover between January and February for the whole Indus Basin. More analysis is needed on snow cover mapping and monitoring in the HKH. As other researchers have argued, snow melt and its dynamics could be more important than glacier melt in many cases, but the public and some scientific research overlooks snow melt and combines the two.

Dorothea Stumm and Sharad Joshi presented ICIMOD's glacier mass balance measurement initiative, arguing that it is an excellent indicator of climate change with implications for water availability, therefore integral to ICIMOD's research. ICIMOD is employing GHOST (Global Hierarchical Observing Strategy), which consists of five tiers:

- large scale, long term monitoring;
- extensive, process-oriented mass balance measurements (higher spatial and temporal resolution);
- simple mass balance measurements – regional focus (lower spatial and temporal resolution);
- glacier length, volume, and mass changes by remote sensing; and

Box 2: Regional Training on Glacier Mass Balance on Yala Glacier in Langtang Valley in Nepal
26 April–12 May 2012

One component of the Cryosphere Monitoring Project is building the capacity of partners in regional member countries to monitor and assess glaciers, snow, and glacio-hydrology as well as promote a common methodology for glacier mass balance monitoring.

Toward this end, ICIMOD organized a training programme for about 15 participants from Afghanistan, Bhutan, China, India, Nepal, and Pakistan. In addition, one participant each from the US and Japan joined the training programme.

For the first three days, training on the theoretical aspects of glacier mass balance measurements, mountain safety, and health risks was conducted in Kathmandu. The team left for the Langtang valley 29 April and reached the Yala Glacier base camp 5 May. Over the next three days, the team carried out glacier mass balance measurements on Yala Glacier at 5,100 masl, using the direct stake method. The training involved site selection and mass balance measurement.

- glacier inventories.

To date, ICIMOD's glacier study initiative has focused primarily on simple mass balance measurements and glacier length, volume, and mass changes, but it is moving into more extensive mass balance measurements.

The Cryosphere Monitoring Project has five components:
- in-situ glacier monitoring;
- assessment of current and future water resources;
- glacier and snow monitoring by remote sensing;
- a regional cryosphere knowledge hub; and
- local and regional capacity building (see Box 2).

The expected results include measurements of the mass balance of clean glaciers in Yala (extensive mass balance study) and Rikha Samba (simple mass balance study); data on the general state of glaciers; better understanding of glacier processes of the debris-covered Lirung Glacier; more knowledge of the links to weather and climate; and input data for modelling.

Closing Plenary Session

Dr Eklabya Sharma, Director of Programme Operations at ICIMOD, moderated a plenary discussion on the current status, trends, uncertainties/gaps, future directions, and possibilities for collaboration. The results are summarized below.

Status and Trends

- Enormous differences exist between glacier types and in glacier dynamics. Before beginning a study, there is a need to define the questions to be answered so that we can go deeper into the study.
- Cryosphere research in the HKH has come a long way and ICIMOD has more knowledge now than in 2007. There is now an inventory of glaciers and glacial lakes. Information on the delineation of glaciers and debris cover is available. Mass-balance studies are picking up with results varying in different parts of the Himalayas. The research is moving in the proper direction.
- China is ahead in terms of cryosphere research and monitoring. In India, there is a burgeoning interest in cryosphere, a glaciology institute has been created, the GB Pant Institute of Himalayan Environment and

Development will have a cell on glaciology, and various climatic centres and universities are waking up to new possibilities. Cryosphere curricula are under development to generate interest – what is lacking is job prospects and future opportunities. In Pakistan, there is going to be a research and monitoring centre at WAPDA. As changes in cryosphere affect people living downstream and development imperatives, HKH countries must understand the need for regional cooperation and transboundary research.

- ICIMOD will make cryosphere a Regional Programme in its next Medium Term Action Plan. Capacity building is a primary focus of the Cryosphere Monitoring Project.
- The region needs to give top priority to the field of glacio-hydrology. There is need to build capacity beyond glacier mass balance measurement.
- How to interpret GRACE gravity data is yet to be determined. To separate storage of ice and loss of ice in the ablation requires airborne missions above the glaciers, which calls for an unprecedented degree of international cooperation.
- More training is needed for young people in measuring mass balance and changes in the glacial terminus and training is needed for data modellers on using GRACE data and how to address data gaps.
- Many river basins are dependent on meltwater from the cryosphere. When linked to poor and marginalized people, cryosphere research becomes very important. We need to focus on small glaciers, as these are the most important glaciers serving millions of people.

Data and Knowledge Gaps/Uncertainties

- There are two fundamental uncertainties: inherent uncertainty in the system and uncertainty coming from different mindsets (different actors involved, different perspectives, which questions are being asked).
- In Sikkim, India, part of the Kangchenjunga Landscape, there is a local belief that there are more than 70 hidden lakes covered by Zemu Glacier. Local culture and beliefs should also be captured.
- Mores studies are needed on permafrost (the extent of permafrost in the HKH, amount of ice stored in permafrost, future projections, how much water has been released, and associated hazards) as well as differences in the contributions to runoff from glacial melt, snow melt, rainfall, and permafrost.
- Hydrology is important to understand soil moisture and evapo-transpiration. There is vegetation up to 4,000 masl in the Himalayas. To understand the hydrological balance in the Himalayas, the role of hydrological losses and vegetation needs to be understood.
- The study of rock glaciers is very hard to undertake, although they are an important source of water for Kabul, Afghanistan.

Future Direction

- ICIMOD should identify key pilot sites, including communities directly dependent on the cryosphere for water, and establish a series of such sites around the region for long-term monitoring.
- There must be more coordination between global, regional, national, and local initiatives, sharing of roles and responsibilities, and an attempt to prevent some institutions from monopolizing research.
- The five tiers of GHOST show that there is no one size fits all solution. We should gradually and strategically move up the tiers as we gain experience and capacity.

Dr Sharma also collected feedback from participants to ensure that the key points were taken from the conference (see Box 3).

Concluding Session

After the presentations, participants discussed the uncertainties that remain in scientific research on the cryosphere and the importance of collaboration to erode these uncertainties, fill knowledge gaps, and produce useful, relevant information. An individual researcher's horizon is often rather short – there is immense pressure to produce results and often limited resources for outreach and the development of effective communication plans.

Box 3: Messages from the participants

The academic community of Afghanistan needs support. Students need MS and PhD scholarships.
Mohammad Naim Eqrar, Kabul University, Afghanistan

It would have been interesting if the term 'glacial lake' had been included in the conference. For eastern Himalayan countries like Bhutan, GLOF-related issues are very important but these were missing from presentations and discussions.
Karma, Department of Geology and Mines, Bhutan

The Third Pole Environment work group can collaborate with ICIMOD as equal partners in areas such as glacier monitoring and exchanging knowledge.
Shichang Kang, Institute of Tibetan Plateau, China

Glacier retreat and its impact on water resources are of interest to India. The cryosphere group should work toward generating higher quality hydromet data in the Himalayan cryosphere for water discharge and security in lean periods, for vulnerability assessment, and for eco-sustainability.
Alagappan Ramanathan, Jawaharlal Nehru University, India

We should collaborate with our regional member countries, not just for information but also for technology transfer and capacity building.
Htay Htay Than, Department of Hydrology and Meteorology, Myanmar

Kathmandu University is ready to collaborate with regional countries and international partners to enhance research on the cryosphere in the Himalayan region.
Rijan Kayastha, Kathmandu University, Nepal

Snow and glacial processes are as important as atmospheric processes for Bangladesh. Also downstream impacts of changes in cryosphere are just as important as sea level rise and storm surges for Bangladesh. Bangladesh is very much interested in links between downstream impacts and changes in the cryosphere.
Fazlul Bari, Planning Commission, Bangladesh

It is encouraging to see students working on glaciers. Better coordination is important for cryosphere research and monitoring.
Koji Fujita, Nagoya University, Japan

Institutional capacity building is necessary and important.
Sahibzad Khan, Pakistan Meteorology Department

Externally imposed methodologies and technologies for the study of the HKH glaciers alone will not cut it. Creative and innovative approaches are even more important. We need to study people and glaciers in their cultural and ecological context as well. There is a huge store of knowledge in the HKH not framed in modern terms, so it helps to investigate glaciers through people and history.
Kenneth Hewitt, Wilfried Laurier University, Canada

There are many uncertainties but we also know a lot of things. We and our politicians need to act now: take decisions under uncertainties.
Mats Eriksson, Stockholm International Water Institute, Sweden

We should link and differentiate processes and methods, open our institutional box, go to the fields and meet and interact with the people.
Matthias Winiger, University of Bonn, Germany

With regard to climate change impacts on cryosphere, one size does not fit all. The recurrent theme has been how complicated and heterogeneous glacier change is. There are lots of unknowns and uncertainties but also many things we do know, so we can take on the climate change deniers. The signal might not be as large and integrated over the region as we thought but if we take what we know valley-by-valley then what we know is truly enormous.
Jeffrey Kargel, University of Arizona, US

The Hindu Kush Himalayan region is getting lots of attention and researchers are also interested. The cryosphere group needs to share data and information with the research community.
Michael Bishop, University of Nebraska at Omaha, US

Capacity building training in Yala Glacier was male-dominated. Women need to be considered in glacier mass balance studies, with a nod to gender equity.
Miriam Jackson, Norwegian Water Resources and Energy Directorate, Norway

ICIMOD is doing very good work and we hope to stay engaged with ICIMOD.
Jay Pal Shrestha, US Embassy, Nepal

ICIMOD would like to serve as a regional Cryosphere Knowledge Hub.
Pradeep Mool, ICIMOD

There remain many scientific challenges and uncertainties in the future of glaciology. Lack of observations in mass balance, runoff, precipitation, and temperature leaves significant gaps. Other gaps and uncertainties include the distribution of precipitation (and temperature) in mountain catchments; variability in cryospheric responses (black carbon, debris); process understanding versus spatial scale; calibration and equifinality (geochemistry, isotopes); changes in monsoon strength under climate change; and monsoon feedbacks.

Participants highlighted key messages from the day's proceedings, which included the following:

- The message must now be: The world cannot survive without water, and cannot survive without mountain regions because they have water.
- In order for data to be meaningful, it must be collected over a 30-year period, otherwise it is susceptible to being attributed to weather fluctuations or spikes.
- Working together, especially when researchers work on the same glacier, is crucial. Different data types, different types of stations, and different financial sources prevent scientists from working together all of the time, but a greater effort must be made.
- Researchers working in the same areas or regions should at least consider comparing station setups so it is known what else is out there and what data to expect down the road.
- For information about the cryosphere to remain relevant and have an impact, researchers need to leave the boxes they work in and be willing to cross thematic, spatial, temporal, and methodological boundaries.

In closing the three-day conference, Dr David Molden said there is still much that needs to be done. He also stressed the importance of capacity building. He said that ICIMOD looks forward to playing a larger role in capacity building and training, and, using links with policy makers in the region and on the international level, ICIMOD will also work to promote data and knowledge sharing. Acting as the Cryosphere Knowledge Hub, ICIMOD intends to work more closely with regional member countries and get more involved with different activities in the region such as the Third Pole Environment. It wants to be a storehouse of cryosphere data and information in the region for use by scientists, locals, and governments, and it wants to follow international standards as much as possible.

Dr Eklabya Sharma noted the impacts that changes in the cryosphere are having on people downstream. Many of the drivers of these changes are not well understood. He said it is the responsibility of ICIMOD, its eight regional member countries, and the international community to address the myriad issues facing the region and its cryosphere, and to work together for the creation of the Cryosphere Knowledge Hub.

Workshop on Hindu Kush Himalayan Cryosphere Data Sharing Policy

Creating the HKH Cryosphere Knowledge Hub

At the HKH Cryosphere Data Sharing Policy Workshop, experts discussed the initial ideas for setting up a regional Cryosphere Knowledge Hub under one of ICIMOD's programmes. As a regional intergovernmental learning and knowledge sharing centre, ICIMOD is well placed to share data and information among scientists, practitioners, policy makers, and communities as well as contribute to reducing scientific uncertainty. It will take an unprecedented degree of international cooperation to realize the task being taken on, but its development is also of unprecedented importance to the international community.

ICIMOD envisions the regional Cryosphere Knowledge Hub as a platform to strengthen the exchange or sharing of data and knowledge, to enhance the cooperation in cryosphere monitoring, and to promote regional efforts to better understand the cryosphere of the region. It aims to be a 'hub of activity' for storage, analysis, sharing and dissemination of data and knowledge for relevant operational service and research institutions in the region and beyond according to regionally and internationally agreed upon standards.

There is no question that sharing knowledge is essential. There are many formidable institutions designed to facilitate the sharing of information within and across borders, and there is growing interest in the HKH region in terms of research. This interest is coupled with the hope that there are linkages between information generation and development, and ways to positively affect the livelihoods of people in the region.

Continuous and consistent research and monitoring of glaciers is essential to prevent the emergence of data gaps in the vast field of glaciology. Using the same satellite images of the same region, scientists sometimes get different results. There is a need for better training, and even if a scientist's work is mostly focused on satellite research, they should visit glaciers to understand on the ground what they are seeing on the screen.

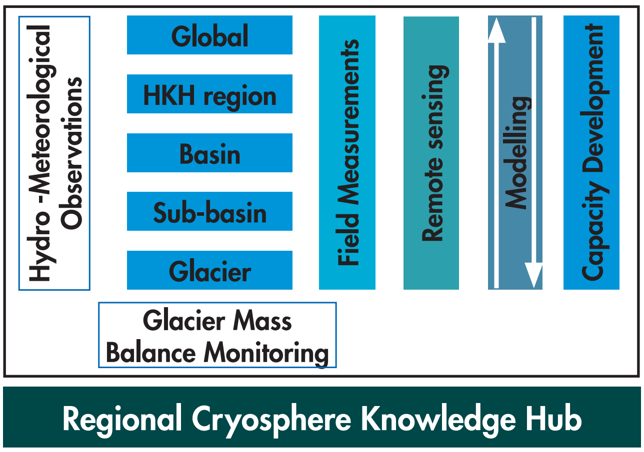
The Cryosphere Knowledge Hub should strive to:
- expand capacity building within each country;
- encourage sharing data in standardized, usable formats;
- encourage the use of scientific research for the benefit of people living in the region; and
- work with donors to make research relate to, enhance, and improve work with poor and marginalized people whose livelihoods are affected by changes in the cryosphere.

Uncertainties and mitigation

There are two main types of uncertainties in cryosphere studies: intrinsic uncertainties in the systems researchers are dealing with – moving from alpine to Himalayan areas, for example – and uncertainties that come from applying perspectives across regions.

To mitigate and lessen uncertainties, cryosphere researchers must:
- use methodologies that allow distinction between: glacial melt, snow melt, rainfall, and permafrost;
- develop studies that include considerations of soil absorption, evaporation, and transpiration from the canopy; and

Figure 1: Elements of the Cryosphere Knowledge Hub



- try to include interpretations of vegetation and hydrological losses in data sets.

Possibilities for collaboration

There is no doubt that data must be shared across borders – mountains cross boundaries, floods cross boundaries. As Dr David Molden remarked, although ICIMOD has to remain technical and scientific and stay out of politics, it has a stated objective to foster regional collaboration. If handled with sensitivity, technical data can lead to apolitical sharing.

Some strategies for negotiating these political sensitivities include:
- discussions of flora and fauna moving across borders as an entry-point to a broader discussion;
- identifying pilot sites with certain characteristics then applying information to other pilot sites with similar characteristics across the region; and
- fostering strategic relationships between remote sensing methods and ground-based research to build a meaningful body of knowledge about the region, not just individual countries.

There are models for sharing data already in place. The experience and value of each demonstrates the complexity of establishing and maintaining information hubs and portals. Some examples the group discussed include the following:

- **Global Terrestrial Network for Glaciers (GTN-G)** acts under the auspices of FAO ICSU,UNEP, UNESCO and WMO as an umbrella for existing and operational monitoring services on glaciers and facilitates the exchange of information and addresses issues like data access and availability and the standardization of measurement methods.
- **GLIMS/WGMS/NSIDC** runs a network to which national correspondents can contribute knowledge. The kinds of studies conducted through this network are only possible when you have established a data centre that makes sure data is compiled in a standard form and available for free in the long-term.

As Michael Zemp stated, regardless of its technical format, the creation of a regional data hub needs to take into consideration its responsibility to:
- foster cooperation between national, regional, and local data providers;
- adopt a fair and coherent international data policy;
- adopt international formats and standards;
- ensure data reporting to international data centres including a clear data citation and versioning strategy; and
- become a member of the International Council for Science (ICSU) World Data System in order to gain legitimacy.

Key issues Regarding the HKH Cryosphere Knowledge Hub

In some regions, data is available from the past 100 years, while others have only three years of data available. Scientific knowledge is characterized by reproducibility and transparency in the data used to produce research findings. If regional politics prevent the sharing of the data behind research findings, the quality and accuracy of the scientific knowledge the region produces can be questioned. Strategies for sharing data in ways that are less politically sensitive need to be explored.

The Cryosphere Knowledge Hub will improve cryosphere research in the region through the following contributions:
- Sharing what studies are being undertaken in order to know what data to expect down the road
- Recommendations for basic research guidelines to guide researchers in their project design
- Funding agencies should hold projects/programmes/researchers accountable for sharing data
- Recommendations to researchers on how to budget for the storage and dissemination of data and information, including submission to the hub. The more methodologies and data types that are created and implemented, the more resources it will require on the back end for archiving and publishing
- Reminding researchers that 'low quality' data is not useless and should still be submitted

- Valuing metadata, which gives a snapshot of data but not raw numbers. Nothing can happen if data sets are unknown; moreover, it could be a less politically-sensitive way to establish a regional body of knowledge
- Long-term records of the HKH (careful tracing of scientific expeditions, archives, bibliographies, old photographs, etc.)
- Data policy tenets guided by the tenets of the GTN-G policy (e.g., high quality, long-term, standardized data; one-year retention period for researchers; public domain for non-commercial use; and acknowledgement of the hub in all published materials)
- Value additions through stories and analyses
- ICIMOD's own institutional paper on intellectual property rights and data sharing policy

Summary of Group Sessions

Type of data/information

This group conducted an audit survey of the types of information about the cryosphere available and discussed the information and data needed in cryosphere research and development. It also discussed what type of data standardization is needed to move toward uniformity in terms of use and sharing in the region. There is a vast range of data related to the cryosphere available – from glacier measurements to downstream hydrological data – and it will be important for the hub to take into account the breadth of information relevant to its mission.

The group also discussed the inclusion of socioeconomic data and the need for data standardization in order to operate efficiently and effectively. Full text of this group's information audit can be found in Annex 3.

Who has the data/information?

This group conducted an institutional mapping exercise to determine the range and types of information sources that exist in the region. The group identified four main cryosphere data sets that are available, 21 institutions in the region with available cryosphere data and the potential to produce more; 10 institutions currently collecting hydrology, meteorology, mass balance, hydro chemistry, and snow monitoring data; 15 international monitoring organizations and institutions; 23 relevant government institutions in the region; and six 'scientific community' organizations with relevant data and sufficient capacity. A full listing of the organizations can be found in Annex 3.

Data sharing policy

This group discussed how to develop the proper data sharing policy for the hub including issues on the level of accessibility, general issues concerning cryosphere data, the challenges of being a data hub, and the terms and conditions for participating in the hub.

In terms of accessibility, it is recommended that metadata for all studies archived at the hub be made available despite political sensitivities. Even if only part of the data is exposed, it can help in modelling similar studies. ICIMOD will want to include a wide range of data including ICIMOD-created data, data from national partners, and information from international data sets; however, ICIMOD is not in the position to influence other countries' data sharing policies.

Participants discussed the importance of creating a reasonable embargo period on data sharing. One year was identified as ideal; however, given the career constraints of individual researchers (i.e., the pressure to publish), it was agreed that a two-year period with the option, exercised by the individual researcher, to reduce it to a one-year period be made available. Regardless, it should be clear that the researchers own their data and the hub is simply a coordinating body.

Regarding technical aspects of operating the hub, the group stressed that ICIMOD must consider:

- a user-friendly interface for submitting data, including data that is incomplete or doesn't exactly match a certain standard or format;
- proper data back-up given Kathmandu's earthquake-prone position; and

- substantial financing for archiving, including vast amounts of data and a constant need to update archival methods so older information remains accessible.

The established terms and conditions and citation standards should take intellectual property laws into consideration. They should also ensure that the hub receives appropriate attention for its role in collecting, coordinating, and disseminating data. Full text of these recommendations can be found in Annex 3.

Dissemination mechanism

This group came up with a series of guidelines to ensure the design of the hub is user friendly. The group felt strongly that the user interface should be made accessible via the internet and designed in a way that made the hub's information relevant to a wide range of consumers. This included suggestions to have a map tool to locate information about the region, a mechanism for handling information requests, and a plan for sustainability and low bandwidth accessibility.

The group also stressed that data tracking, before and after the addition of data to the hub, be part of the hub's functionality. It must clearly acknowledge the original source of data, and ask users about the end use of the data as a requirement before allowing data to be downloaded. This will ensure sustained enthusiasm in the knowledge hub because it both acknowledges the originators of the information, and allows tracking of the data's path. Full text of the group's recommendations can be found in Annex 3.

Way Forward: Establishing the HKH Cryosphere Knowledge Hub at ICIMOD

ICIMOD is taking the lead in setting up a long-term regional Cryosphere Knowledge Hub. The input received at this workshop will be useful in the establishment of mechanisms for exchanging data and programmatic information. The science community will share information and knowledge across borders not only with each other but also with other users such as local communities and governments.

The workshop was encouraging on many fronts. The region is seeing genuine capacity building – perhaps best exemplified by the Kathmandu University MSc programme – which is encouraging for the future of cryosphere studies and undergirds the importance of establishing a central knowledge hub for use by future generations of scientists.

Although some countries in the region may not have much data to contribute at this point, a well-designed knowledge hub can act as an incentive to conduct research, create data sets, and submit them to the regional hub. It will foster greater cooperation as well as a professional culture of scientific rigour and will serve as a hub for the region's cryosphere and socioeconomic data that is built on a network of trust and collaboration.

Cryosphere research is important for a wide range of sectors, including the private sector. Many different actors have an interest in the water supply, in risk management, and in predicting future weather patterns. A centralized regional knowledge hub at ICIMOD will allow for broad engagement with all sectors – academic, government, humanitarian, and private – and create opportunities for new sources of funding for research and new ways to put cryosphere knowledge to use.

The discussions that took place during this workshop will influence the architecture of the Cryosphere Knowledge Hub (see Figure 1), which will hopefully change the landscape of HKH cryosphere knowledge for current and future scientists, practitioners, and residents of the region.

Annexes

Annex 1: Conference and Workshop Programmes

International Conference on Cryosphere of the Hindu Kush Himalayas: State of the Knowledge, 14–16 May 2012, Kathmandu, Nepal

14 May 2012

Opening session		
Chairperson: **Professor** Hua Ouyang **Emcee**: Naina Shakya		
Time	**Agenda**	
08:15	Pickup at Hotel Himalaya	
09:00-09:30	Registration	Sarita Joshi and Rekha Rasaily, ICIMOD
09:30-09:45	Welcome address	Dr David Molden, Director General, ICIMOD
09:45-10:00	Opening remarks	Ms Camilla Røssaak, Minister Counsellor, Royal Norwegian Embassy, Kathmandu, Nepal
10:00-10:15	Opening remarks	Ms Patricia A. Mahoney, Deputy Chief of Mission US Embassy, Nepal
10:15-10:35	Cryosphere monitoring in the HKH region	Pradeep Mool, IWHM, ICIMOD
10:35-10:50	Remarks by the Chairperson	Prof Hua Ouyang, IWHM, ICIMOD
10:50-11:00	Announcements	
11:00-11:30	Group photograph followed by tea/coffee break	
Session I: Global cryosphere monitoring		
Chairperson: Michael P Bishop **Rapporteur**: Jack Shroder		
11:30-11:50	Global and HKH regional satellite remote sensing initiatives and some results	Jeffrey S. Kargel, NASA, GLIMS, NSIDC
11:50-12:10	Spatially heterogeneous wastage of Himalayan glaciers	Koji Fujita and Takayuki Nuimura
12:10-12:30	Climate change impacts on Asia's water towers: What do we know?	Walter W. Immerzeel
12:30-13:30	Lunch break	
Session II: Cryosphere monitoring in the HKH Region		
Chairperson: Koji Fujita **Rapporteur**: Shichang Kang		
13:30-13:50	Climate change impact on the water resources of Afghanistan	Naim Eqrar
13:50-14:10	Cryosphere studies in the Department of Hydro-Met Services, Bhutan	Phuntsho Namgyel
14:10-14:30	Direct measured glacier ice loss in recent years on the Tibetan Plateau, China	China: Tian Lide
14:30-14:50	Mass Balance Study of Himalayan Glaciers at Wadia Institute of Himalayan Geology	India: Bhanu Pratap
14:50-15:10	Monitoring the Cryosphere of Nepal: Challenges and Opportunities	Nepal: Keshav P Sharma
15:10-15:30	Climate Trends and Water Flow Condition in Northern Myanmar	Myanmar: Htay Htay Than

15:30-16:00	Tea/coffee break	
16:00-16:20	Initiatives by WAPDA in research and monitoring of Upper Indus basin Cryosphere	Pakistan: Chaudhry Mustaq Ahmad
16:20-17:00	Discussion on the outcomes of the day	
18:30	Reception dinner at Hotel Soaltee Crowne Plaza	All participants and other invited guests

15 May 2012

Session III: Glacier mapping and research in the HKH region (Karakoram and High Asia)		
Chairperson: Chaudhry Mustaq Ahmad **Rapporteur**: Alagappan Ramanathan		
Time	**Agenda**	
09:00-09:20	Establishing a Collaborative Effort to Assess the Role of Glaciers and Seasonal Snow Cover in the Hydrology of the Mountains of High Asia	R. Armstrong, A. Barrett, M.J. Brodzik, F. Fetterer, S.J.S. Khalsa, A. Racoviteanu, B. Raup, M. Williams; Univ. of Colorado
09:20-09:40	Himalayan Dimensions of Glacier Response to Climate with Karakoram Examples	Kenneth Hewitt, Wilfried Laurier Univ.
09:40-10:00	Remote Sensing and Geomorphometric Analysis for Characterizing Debris-Covered Glaciers in the Himalaya	Bishop, M.P., Shroder, Jr., J.F., and Burgett, A., University of Nebraska at Omaha
10:00-10:20	Comparison of Glacier-Profile Topographic Characteristics for Assessment of Glaciers in the Western Himalaya	Jack Shroder, Michael Bishop, Angela Burgett, University of Nebraska at Omaha

Session IV: Glacier mapping and research in the HKH region (Pakistan)		
Chairperson: Kenneth Hewitt **Rapporteur**: Shichang Kang		
10:20-10:40	Observed Climate Change in Pakistan	Sahibzad Khan, PMD, Pakistan
10:40-11:00	Cryosphere Studies in Pakistan: Global Change Impact Studies Centre (GCISC) research efforts	Muhammad Zia ur Rahman Hashmi, GCISC, Pakistan
11:00-11:30	Tea/coffee break	
Poster presentation session		
Chairperson: Dorothea Stumm		
11:30-12:00	Two minutes introduction of each poster presentation	

Session V: Glacier mapping and research in the HKH region (India)		
Chairperson: Miriam Jackson **Rapporteur**: Rijan B. Kayastha		
12:00-12:20	Winter accumulation and annual mass balance status of glaciers in Lahaul-Spiti, Himachal Pradesh	Alagappan Ramanathan, JNU
12:20-12:40	Retreating mountain glaciers and climate change	Rajesh Kumar, SU
12:40-13:00	Glacier research in TERI	Nathanial Dkhar, TERI
13:00-14:00	Lunch break	

Session VI: Glacier mapping and research in the HKH region (China and Nepal)		
Chairperson: Dr. Richard Armstrong **Rapporteur**: Rajesh Kumar		
14:00-14:20	Recent dramatic thinning on the Tibetan Plateau Glaciers	Shichang Kang, ITP
14:20-14:40	Glacier research and Capacity development in Nepal	Rijan B. Kayastha, KU

14:40-15:00	Studying Himalayan glaciers to understand atmospheric dynamics and ongoing climate variations. Data and findings from the Changri Nup Glacier (Nepal Himalaya)	E. Vuillermoz
15:00-15:30	Discussion on the outcomes of the day	
15:30-16:00	Tea/coffee break	

16 May 2012

Session VII: Glacier and snow monitoring and glacio-hydrological modelling		
Chairperson: Jeffrey S. Kargel **Rapporteur**: Nathaniel Dkhar		
Time	**Agenda**	
09:00-09:20	First results and challenges of a geodetic volume change assessment of selected glaciers in the Langtang, Nepal	Michael Zemp, J. Lindenmann, Tobias Bolch and Dorothea Stumm
09:20-09:40	Glacio-hydrological modelling in the Langtang basin	Francesca Pellicciotti, ETH
09:40-10:00	Glacier mass balance monitoring in Norway	Miriam Jackson, NVE
10:00-10:20	Indus River: Water Balance - Field evidence and modeling approaches	Matthias Winiger, University of Bonn
10:20-10:40	Anomalous hydrologic behavior of UIB especially during 1995 - 2009 period	Daniyal Hashmey, WAPDA, Pakistan
10:40-11:00	Bridging Science and Policy in the field of Water and Climate – SIWI (Stockholm International Water Institute) experiences	Mats Eriksson, SIWI
11:00-11:30	Tea/coffee break	

Closing session		
Chairperson: Eklabya Sharma		
14:00-15:30	Brain Storming Session on: Current status; Trends; Uncertainties/gaps; Future Directions and Possibility of Collaborations	All participants are encouraged to discuss
15:30-15:45	Closing Remarks	David Molden, DG, ICIMOD
15:45-16:00	Chairperson's concluding remarks	Eklabya Sharma, DPO, ICIMOD
	Announcements	

Workshop on Hindu Kush Himalayan Cryosphere Data Sharing Policy; 17 - 18 April 2012, Kathmandu, Nepal

17 May 2012

Plenary session: Introductory session		
Chairperson: Eklabya Sharma		
09:30-09:45	Opening of the workshop and remarks	David Molden, DG, ICIMOD
09:45-10:05	Views on internationally coordinated glacier monitoring on data sharing policy issues	Michael Zemp, WGMS
10:05-10:25	Cryosphere data sharing issues and the regional cryosphere knowledge hub	Pradeep Mool
10:25-11:00	Plenary discussion on key issues of crysophere knowledge hub and data sharing	All participants are encouraged to discuss
11:00-11:30	Tea/coffee break	

Breakout Session		
Chairperson: Jeff Kargel		
11:30-13:00	Formation of working groups and discussion	(4 Groups)
13:00-14:00	Lunch break	
14:00-15:30	Group work and discussion. (contd.)	
15:30-16:00	Tea/coffee break	
16:00-16:50	Group work and discussion (contd.)	
16:50-17:00	Announcements	

18 May 2012

Plenary Session: Group work presentations		
Chairperson: Mats Eriksson		
Time	**Agenda**	
09:30-11:00	Group presentations and plenary discussion	Group leaders
11:00-11:30	Tea/coffee break	

Plenary: Concluding session		
Chairperson: Hua Ouyang		
11:30-13:00	Conclusion of the workshop for sharing and dissemination of cryospheric data and information through crysophere knowledge hub and the way forward	All participants are encouraged to discuss
	Chairperson's concluding remarks	
13:00-14:00	Lunch	

Annex 2: List of Participants

Participants of the International Conference on the Hindu Kush Himalays: State of the Knowledge and the Workshop on Hindu Kush Himalayan Cryosphere Data Sharing Policy, Kathmandu, Nepal, 14–18 May 2012

Family name	Given Name	Institution	Country
Eqrar	Mohammad Naim	Kabul University	Afghanistan
Safi	Abdul Ghias	Kabul University	Afghanistan
Bhuiyan	Salim	Flood Forecasting and Warning Centre, Bangladesh Water Development Board	Bangladesh
Namgyel	Phuntsho	Chief of Planning, Coordination and Research Division, Department of Hydro-Met Services	Bhutan
	Karma	Department of Geology and Mines	Bhutan
Sharma	Pashupati	Executive Engineer, Hydrology Division, Department of Hydro-Met Services	Bhutan
Tian	Lide	Institute of Tibetan Plateau Research, CAS	China
Kang	Shichang	Institute of Tibetan Plateau Research, CAS	China
Lizong	Wu	Cold and Arid Region Environmental and Engineering Research Institute, CAS	China
Dkhar	Nathanial	The Energy and Resources Institute	India
Kumar	Rajesh	SET, Sharda University	India
Ramanathan	Alagappan	Jawaharlal Nehru University	India
Singh	Virendra Bahadur	Jawaharlal Nehru University	India
Thakur	Bhanu Pratap	Wadia Institute of Himalayan Geology	India
Than	Htay Htay	Department of Hydrology and Meteorology	Myanmar
Ahmad	Chaudry Mushtaq	Water and Power Development Authority of Pakistan	Pakistan
Hashmey	Daniyal	Water and Power Development Authority of Pakistan	Pakistan
Khan	Sahibzad	Regional Meteorological Centre, Pakistan Meteorology Department	Pakistan
Hashmi	M. Zia ur Rahman	Global Change Impact Studies Centre	Pakistan
Khan	Bilal Hussain	Water and Power Development Authority of Pakistan	Pakistan
Rana	Adnan Shafiq	Pakistan Meteorological Department	Pakistan
Fujita	Koji	Nagoya University	Japan
Hewitt	Kenneth	Cold Regions Research Centre, Wilfried Laurier University	Canada
Kargel	Jeffrey S	Department of Hydrology and Water Resources, University of Arizona	USA
Zemp	Michael	World Glacier Monitoring Services	Switzerland
Jackson	Miriam	Norwegian Water Resources and Energy Directorate	Norway
Winiger	Matthias	Vice Chancellor, University of Bonn	Germany
Eriksson	Mats	Programme Director, Stockholm International Water Institute	Sweden
Joshi	Anuja	Stockholm International Water Institute	Sweden
Pellicciotti	Francesca	Swiss Federal Institute of Technology Zurich	Switzerland
Ragettli	Silvan	Swiss Federal Institute of Technology Zurich	Switzerland
Petersen	Lene	Swiss Federal Institute of Technology Zurich	Switzerland
Schauwecker	Simone	Swiss Federal Institute of Technology Zurich	Switzerland
Juszak	Inge	Swiss Federal Institute of Technology Zurich	Switzerland

Family name	Given Name	Institution	Country
Immerzeel	Walter	Future Water, University of Utrecht	The Netherlands
Murakami	Kosei	Nagoya University	Japan
Nicholson	Lindsey	Centre for Climate and Cryosphere Institute of Meteorology and Geophysics, Universität Innsbruck	Austria
Sadiq	Aftab	School of Civil & Environmental Engineering, National University of Sciences & Technology	Pakistan
Sadiq	Ismail	Centre for Advanced Research in Engineering	Pakistan
Shroder	John (Jack)	University of Nebraska at Omaha	USA
Bishop	Michael P	University of Nebraska at Omaha	USA
Armstrong	Richard	CIRES/NSIDC, University of Colorado	USA
Williams	Mark	INSTAAR, University of Colorado	USA
Wilson	Alana	University of Colorado	USA
Emily	Collier	PhD Candidate, Chair of Climatology, TU Berlin	Canada
Bocchiola	Daniele	Ev-K2-CNR	Italy
van Dijk	Thaiënne	Deltares	The Netherlands
Adhikary	Bhupesh	Ev-K2-CNR	Nepal
Kayastha	Rijan Bhakta	Assistant Professor and Coordinator HiCCDRC, Kathmandu University	Nepal
Devkota	Lochan Prasad	Head of Department, Central Department of Hydrology and Meteorology, Tribhuvan University	Nepal
Sharma	Keshav Prasad	Director General, Department of Hydrology and Meteorology	Nepal
Bajracharya	Om Ratna	Joint Secretary, Department of Hydrology and Meteorology	Nepal
Rajkarnikar	Gautam Raj	Department of Hydrology and Meteorology	Nepal
Bista	Narayan Kumar	Assistant Hydrologist, Department of Hydrology and Meteorology	Nepal
Budhathoki	Kamal Prakesh	Department of Hydrology and Meteorology	Nepal
Adhikari	Tirtha Raj	Central Department of Hydrology and Meteorology Tribhuvan University	Nepal
Lacoul	Sriranjan	Division Chief – Joint Secretary, Water Resources Division/ WECS	Nepal
Koirala	Shishir	Senior Divisional Engineer, Water Resources Division/WECS	Nepal
Maskey	Pravin Raj	Department of Irrigation	Nepal
Bhusal	Jagat Kumar	President, Society of Hydrologists and Meteorologists–Nepal	Nepal
Joshi	Saroj Dhoj	Real Time Solutions Pvt. Ltd	Nepal
Rajbhandari	Rupak	Department of Meteorology, TC/TU	Nepal
Shrestha	Kedar Lal	Institute for Development and Innovation	Nepal
Lamsal	Damodar	Kathmandu University	Nepal
Rai	Sundar	Kathmandu University	Nepal
Bhattarai	Bikas Chandra	MS Glaciology student from Kathmandu University	Nepal
Shahi	Sonika	MS Glaciology student from Kathmandu University	Nepal
Baral	Prashant	MS Glaciology student from Kathmandu University	Nepal
Pradhananga	Niraj Shankar	MS Glaciology student from Kathmandu University	Nepal
Regmi	Dhananjay	Society for Ecological Restoration Nepal	Nepal
Shrestha	Suraj	Tribhuvan University, Kirtipur Campus (to be officially nominated from TU)	Nepal
Parajuli	Binod	Department of Hydrology and Meteorology (to be officially nominated from DHM)	Nepal

Family Name	Given Name	Institution
Vognild	Inge Harald	First Secretary, Royal Norwegian Embassy, Kathmandu, Nepal
Hall	Tracy A	Director, Regional Environmental Office for South Asia, US Embassy, Kathmandu
Shrestha	Jay Pal	Regional Environmental Affairs Specialist, Regional Environment Office for South Asia, US Embassy States of America, Kathmandu, Nepal
Singh	Deepak	Environment Officer, ADB, Kathmandu

ICIMOD Participants

Family Name	Given Name
Molden	David
Karki	Madhav
Sharma	Eklabya
Ouyang	Hua
Mool	Pradeep
Shrestha	Arun
Stumm	Dorothea
Shrestha	Rajendra
Joshi	Sharad
Shrestha	Basanta
Bajracharya	Samjwal
Gurung	Deo Raj
Panday	Arnico
Sherchan	Ujol
Bajracharya	Sagar
Shrestha	Finu
Maharjan	Sudan
Sharma	Aseem
Shrestha	Krisha

Participants in the regional training on Glacier Mass Balance on Yala Glacier in Langtang Valley in Nepal, 26 May–12 April 2012

Name	Institute	Country
Abdul Ghias Safi	Hydrometeorology Department, Faculty of Geo-sciences, University of Kabul	Afghanistan
Pashupati Sharma	Department of Hydro-Met Services (DHMS)	Bhutan
Karma Toeb	Department of Geology and Mines (DGM)	Bhutan
Wu Lizong	Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI)	China
Nathanial Dkhar	The Energy and Water Resource Institute (TERI)	India
Bhanu Pratap Thakur	Centre for Glaciology, Wadia Institute of Himalayan Geology (WIHG)	India
Virendra Bahadur Singh	School of Environmental Sciences, Jawaharlal Nehru University (JNU)	India
Bilal Hussain Khan	Water and Power Development Authority (WAPDA)	Pakistan
Adnan Shafiq Rana	Pakistan Meteorological Department (PMD)	Pakistan
Suraj Shrestha	Central Department of Hydro-Meteorology, Tribhuvan University (TU)	Nepal
Binod Parajuli	Department of Hydrology and Meteorology (DHM)	Nepal
Sonika Shahi	MS Glaciology student at Kathmandu University	Nepal
Prashant Baral	MS Glaciology student at Kathmandu University	Nepal
Niraj Shankar Pradhananga	MS Glaciology student at Kathmandu University	Nepal
Bikas Chandra Bhattarai	MS Glaciology student at Kathmandu University	Nepal
Alana Wilson	University of Colorado	USA
Kosei Murakami	Nagoya University	Japan

Annex 3: Workshop notes

I. Types of data/information

Data/information available;

- Remote sensing data (subset of global data set)
- Satellite images (high to low resolution images and historical archive)
- GPS control data for verification
- Transparent sharing policy reduces the cost of high resolution images
- Topographic maps (printed and digital)
- Aerial photographs
- Still photographs and video clips
- LIDAR Data

Cryosphere Data:

- Glaciers
- Perennial snow and seasonal snow
- Permafrost
- Glacial lakes

Glaciers

- Outline – length and areal extent
- Depth
- Clean and debris
- Slope
- Aspect
- Volume
- Ice reserve\water content
- Mass balance (ELA)
- Hypsometry
- Elevation
- Morphological type
- Dynamics
- Feeding mechanisms
- Snout fluctuation

Snow

- Snow cover area (seasonal)
- Snow depth
- Snow water equivalent (density)
- Albedo
- Genesis (avalanche)
- Fresh/old
- Black carbon

Permafrost

- Areal extent
- Liquid water content
- Depth (active layer thickness)
- Water content/type
- Temperature profile
- Seasonal frozen ground

Glacial lakes and GLOFs

- Field data (point or distributed data)
- Weather data (spatial)
- Length of data
- Time step
- Real time/archive

Priority data needed

- Basic
- Meteorological
  - Temperature (maximum and minimum)
  - Precipitation (solid and liquid, snowfall)
  - Solar radiation (incoming and outgoing, long wave and short wave)
  - Wind
  - Relative humidity
- Hydrological
  - Discharges
  - Gauge heights (level)
  - Quality
  - Turbidity/sediments
  - Area/velocity
  - Catchment map
  - Flood and drought frequency
  - Flood levels (water slope, bed materials)
  - Ground water/subsurface water
  - Evaporation/evapo-transpiration
- Goals/objective/stakeholders
  - Water resources
  - Socioeconomic data
    - population
    - land
    - structure
    - geomorphology
    - land use
- Seismic
  - Seismic maps
- Standardization of data
  - Follow WMO and USGS
  - Accuracy/precision
  - Uncertainty

II. Who has the data/information?

- List of institutions/organizations,
- Data standardization

Data/information generating and sharing institutions
- Organizations/institutions related to cryosphere in RMCs
- International monitoring organizations/institutions
- Scientific community both regional researchers and international researchers
- Government and policy institutions

Cryosphere data sets available

Afghanistan
- Ministry of Water and Power

Bhutan
- Department of Hydro Met-Services
- Hydrological division
- Meteorological division

China
- CAREERI, Chinese Academy of Sciences
- Third Pole Environment Project – has data on long-term observation of cryospheric regions, mass balance, hydrology, and snow cover in the Himalayas, Karakoram, and Hindu Kush mountains
- Institute of Tibetan Plateau Region, Chinese Academy of Sciences

India
- Jawaharlal Nehru University is producing hydrological data at the School of Environmental Sciences

Myanmar
- Department of Meteorology and Hydrology– collection of hydrological and meteorological data

Nepal
- Department of Hydrology and Meteorology – has hydrological, meteorological and hydro-chemistry data
- Kathmandu University
- Tribhuvan University

Pakistan
- Water and Power Development Authority (WAPDA)
- Hydrology and Water Management Department, WAPDA – responsible for the collection, storage, and dissemination of data

Hydrological, meteorological, snow and ice and glacier
- Pakistan Meteorological Department – collect climatic data from automated weather stations on glaciers
- Space and Upper Atmosphere Research Commission – satellite images about glaciers

Hydrology, meterology, mass balance, hydro chemistry, snow monitoring
- Indian Space Research Organization
- WADIA Institute (Institute of Himalayan Geology) _ Mass balance and meteorological data
- GSI – Geological Survey of India (mass balance data and overall data but not accessible)
- Institute of Himalayan Geology
- Birla Institute of Technology-
- Sharda University- Mass balance data
- IIT Roorkee and SAC, ISRO, Ahmedabad – Satellite data
- IIT Bombay–Remote sensing
- IMD (meteorological and climate data)

International monitoring organizations and institutions
- USGS
- WMO
- JICA
- FAO
- NASA
- DFID
- NOAA
- IPCC
- ASTER- MODIS, ALOS, HJ-2
- ICIMOD
- WGMS
- NSIDC
- UNEP
- CIFIPRA, IRD, France
- IAHS

Government Institutions and Policy Institutions

Afghanistan
- Ministry of Water and Power
- Ministry of Irrigation
- ANDEMA – Afghan National Disaster and Environmental Management Authority

Bangladesh
- Bangladesh Meteorological Department
- Ministry of Defense
- Bangladesh Water Development Board (Water level, Sediment)
- Ministry of Water Resources
- Land use Agro-ecological Data
  - Soil agriculture - Ministry of Agriculture
  - Remote sensing- Ministry of Defence
  - Water Resources Planning Organization under Ministry of Water Resources
  - BARC (Bangladesh Agriculture Research Center) – Agriculture database

Bhutan
- Ministry of Economic Affairs

China
- Ministry of Science and Technology
- Submission of all data to ministry and provides data policy
- National Science Foundation of China
- Chinese Academy of Sciences

India
- Ministry of Forest and Environment
- Department of Science and Technology
- Ministry of Earth Sciences

Myanmar
- Ministry of Transport

Nepal
- Ministry of Environment
- Planning Commission
- Ministry of Finance

Pakistan
- Ministry of Climate Change
- Planning Commission
- Ministry of Water and Power

Scientific Communities
- ICIMOD
- ASIAN-CLIC (Climate and Cryosphere)
- International Association of Cryospheric Science – IUGG
- High Asian Cryosphere (HAC)
- SAARC – Meteorological wing (SMRC- NWRD)
- FLEX – Spanish organization

III. Data Sharing Policy

Types of data
- Metadata
  - Should be in some standard format like GLIMS/ NSIDC
  - Can include full/partial data
  - Metadata is one possible partial solution for data availability across borders.
  - metadata is available, it can help with modeling and simulating studies
- Types of data
  - ICIMOD-created data
  - National partner data
  - International data
- ICIMOD cannot give a policy to national partners about how to share the data; individual countries have their own policies. The ICIMOD policy of data collection must be framed in consideration of country policies.
- Partial Data – It would be useful to have a repository for miscellaneous data – e.g. Project information (proposal), unpublished models
- Photographs from individuals from ground or plane. (Some repositories do already exist)
  - Labeling photos with dates and locations may be labor-intensive.
  - Google can be useful for uploading photos etc. but may not be trustworthy as then you don't have control over it.
- Derived climate products, masters theses (soft copy of thesis is enough). Would ICIMOD also archive such products?
- Partial Data could be a partial solution as a country may share data with one country but not with another.
  - Can include snapshot of data with its information of availability for sharing.
  - Viewing of .pdf or low resolution data should be possible – then scientists can see data, and even cite it, but can't manipulate database
- Full Data – GLIMS/NSIDC are good examples of data sharing platforms
  - Needs to be publicly/freely accessible (see GLIMS data-sharing policy)
  - When data can be obtained (after proprietary period or not, period may be negotiable)
  - Owner of data – originator of data is owner during proprietary period. A person can't be forced to submit data. Data belongs to institution.
- Results and model output: sharing through publication

What is a reasonable limit for proprietary period?
- 2 years is probably optimal.
- 1 year is ideal, but difficult sometimes, e.g. when writing book or chapter. People may have option to waive proprietary period or shorten it.
- ICIMOD will be the coordinator of the data and ownership should be with the data originator

Issues concerning cryospheric data
- Snow cover data is very complicated – it's necessary to measure grain size, seasonality, snow to ice transition, thickness of snow
- Permafrost distribution
- Distribution of mean annual temp below freezing point – all very important but it comes from different kinds of sources of information.

Challenges
- Hardware facility level for data storage for ICIMOD needs to be sufficient.

- Automated back-up is ideal. Regular back-ups are very important for an archival centre.
- An automated system ideal for data delivery, rather than a person who has to sit there and send out data.
- Media type needs to be updated as format keeps changing (e.g. magnetic tapes, CDs, DVDs). A useful archive implies preservation, including re-recording data.
- Amount of data is a challenge – terabytes of data.
- Organisations responsible for archives need to have budget for database maintenance.
- Necessary to have contact information for person who delivers data – name, e-mail, phone number. This needs to be updated if that person moves to another institution.
- Need good web developers. Their job includes providing ID and password to contributors. It must be easy for someone to update information (but hard for hackers).
- At least one person responsibility should be public interface withcontributors. (A problem with GLIMS is that this activity has been slimly funded, present level is 10% of a full-time position).
- It is hard to share certain types of data (e.g. hydrological). Nobody will share data at policy level; need thematic area. It may be easier if data are linked to programme, e.g. hazard assessment, agriculture etc. When the aim is disaster reduction, food production/security etc then the needs of a community need to be linked to the requirement to share data.
- ICIMOD promoting itself as data hub may not work; could be easier if needs of different themes were linked to a cause.
- Many bilateral agreements exist but don't necessarily function – hydrological data is extremely sensitive,
- To convince the national policy makers with the benefits of data sharing especially in case of natural disasters so save the life and property – Food security, Biodiversity research can be addressed
- This is how ICIMOD can negotiate. As a center of trusted knowledge hub, it can provide this service. It can help facilitate communication and build trust when info is valuable.
- An existing data gap is of permafrost data for India – this needs to be filled.
- In terms of cost and ease, electronic delivery of data is easiest for data dissemination (annual report).
- People won't upload data/photos to a repository if they don't think that data they will be saved.
- Quality of data – The methodology should be explained.

Terms and Conditions

- Concerning project data and Intellectual Property rights: ICIMOD should be custodian of data only, not owner. This policy has existed previously at ICIMOD for hydro-meteorological data. ICIMOD should try to encourage data-sharing (by countries, institutions), and get them to see the benefits.
- ICIMOD can facilitate (by having well-lubricated lines of communication) timely access to data. Send initial request to ICIMOD, then they route communication to Other country, and data pertinent to that example is then delivered (although if need is urgent, direct channels should also be tried.
- A Memorandum of Understanding is probably not necessary, but we need at least a Culture of Understanding. ICIMOD can be a great trust-builder as a neutral institution.
- Aster is freely available (under certain limitations) although from a – Japanese instrument on an American spacecraft. Commercial outfits (e.g. GOI) expect to be paid, and their policy needs to be abided by.
- We can help nurture a culture where image sharing is encouraged. A specific example regarding image data is the problem in getting data from different country's satellite, although should be available even on cost basis.
- Loss of data is a problem, especially raw field data. USGS has an official policy that field notebooks belong to the government.
- How to cite data set – (Note – data won't be cited unless available).

Citation

- WGMS is a good example.
- An additional possibility is citing one example of an annual report (e.g. Norwegian glacier report). Should be searchable – it would be useful if possible to search publications on e.g. Langtang glacier (in WGMS?).
- An annual report for ICIMOD about the state of data/knowledge would be useful.
- Information on citing should be at home page of portal (or other obvious place).
- How to acknowledge in paper - USGS has a category of publication called open-file report. This could be a unique and useful opportunity to save data that aren't peer-reviewed, and have some way of citing it.

IV. Dissemination mechanism

- Provide not only data/information but also added services
- Important issue is: Feasibility – what can be done next month, nice things to complement with what the community already has
- Important to map: where to get data from, and also categories target groups (scientific community, national partners, tourists)
- Define: what is the main chain that needs to be set up?
- Mechanism to handle data/information requests - Help Desk (knowledge brokering, so to speak), FAQs (need to be continuous and regularly updated, otherwise it will harm the reputation of the web portal)
- ICIMOD: data and database work is pretty ad-hoc, needs to be systematized, so Regional Information System intends to systematize that, in the new strategy "climate change and cryosphere" is one of the six regional programs
- Lots of data in the region but not shared widely – in ICIMOD's satellite rainfall estimation project, raw data cannot be shared but results/knowledge products that used those data can be
- Niche areas: cross-boundary cryosphere data for scientists , also hazards and risks for national agencies and local communities
- Regional cryosphere knowledge hub could be conceived of as a Global Cryosphere Watch customized to the HKH region
- Potential users? Hundreds of visitors to the HKH, mountaineers, science expeditions, they would be interested to know about avalanches and snowfall (could part of weather services related to cryosphere?)
- Other products – webcam (check snowline, recent snowfall, wind situation, debris or clean ice glacier, etc.), weather forecasts, glacier photos as these would help drive traffic (as they are attractive to both public and scientists)
- Knowledge products could be tailored to the international audience and also the region (for example, water availability information and its seasonality are important for farmers in Pakistan, for instance, but currently there are no/little web resources addressing this important issue)
- Branding is important – if data are coming from Pakistan for instance, they have to be properly credited. The whole system will run if it becomes 'high visibility' – so branding important. If we get to that point, then it works, and also attracts funding.
- What are the niches? High altitude AWS data, DHMs in regional countries make real or near real time data available
- ICIMOD-led HYCOs project uses real time info for flood forecasts/outlooks – similar system is needed for cryosphere;
- As the baseline to the data policy, it is important to make "highly visible" where data came from (source should be mentioned at very high level) , then it becomes easy to resolve data policy issues (such as how to credit/cite/terms of use); Protocol about usage of data – this kind of information has to be upfront
- Content management system – be able to update – even scientists can update, workflow for content management at ICIMOD involves author/editor/publisher.
- Start out with easy/simple data formats – ASCII, XML, etc. – same data format as used for data submission
- Recommendation: Go through ICIMOD's cryosphere components , what it already has, what would be nice to add on,
- Archiving function of Cryosphere Knowledge Hub, repository, Archival data should be made directly downloadable,
- When data requests come in, ask the user: "what are you using data for?" Inquire specifically what he/she is looking for and for what purpose, the thing is more than 50% of people requesting data end up getting different data than what they were originally looking for
- Upload raw data – what gets published is monthly/yearly values. Provide summaries (web services) -> yearly/quarterly summaries
- Website design and presentation of data are important
- Dissemination channel: cell phones, local radios

Design an architecture of database/knowledge hub in a way that after 5 years or 6 it is still sustainable/functional – so it should be also be low-tech /low bandwidth

What is available now?

- MODIS projects (snow cover), in-situ snow measurements, public awareness (e.g. snow photographs)
- Inventory of glaciers and glacial lakes, glacier thickness information, rock glaciers (recognize this although not feasible)
- If mass balance information is available, upload it somewhere (including photos for comparison)
- Hazards: avalanches, snow profiles (types of snow), (In USA, they mapped every avalanche paths), SASE (for Indian army, do forecasting for villages)
- Inventory of events (GLOFs, surges, glacial lakes, avalanches, avalanches)
- Permafrost? Maps showing continuous/discontinuous, changing permafrost, changes in volume, mass, area, ground temperature (Chinese bore holes up to 100 meters)

What would be nice to have/add on?

- Lake and river ice, if lake is big enough, satellite images of that possible
- Permafrost and freeze/thaw (ground temperature).
- High Altitude Automatic Weather stations
- Melt water, high altitude runoff
- Restrict to high elevation stations
- Weather related information related to cryosphere should be high elevation (above 3500m)

Others

- Nice to have map-based browser
- Menu of data
- Menu of resources (e.g. bibliography of all publications in HKH)
- Main components of web portal : interactive map interface, data for downloads, resources, (also data catalogue, so we know what is in there)
- ISO standards for metadata information. Metadata info – be able to download and view/use in your own system

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