Linking Geodata with Biodiversity Information in the Himalayas

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A workshop convened by the Global Mountain Biodiversity Assessment of DIVERSITAS and ICIMOD

The inventory and assessment of biodiversity resources have become essential for policy-making and management strategies as well as for developing and testing scientific hypotheses. There is an increasing need to compile mountain biodiversity databases and to make them available on-line. At the forefront of this work is an initiative lead by the Global Mountain Biodiversity Assessment of DIVERSITAS in cooperation with the Global Biodiversity Information Facility (GBIF). The aim of the workshop is to highlight the usefulness of geo-referenced biodiversity data for the integrated analysis and spatial visualization of biodiversity information in relation to climate, land use, physiography and other important parameters. The workshop will bring together national partners from the HKH region to explore the possibility of hosting a regional platform for mountain biodiversity data from the Hindu Kush-Himalayas. Ideally, such a platform would provide easy and open access to Himalayan biodiversity data and metadata, and make it available for wider dissemination both regionally as well as to the global change research community. The portal gateways under discussion include the GBIF/GMBA Mountain Biodiversity Portal and the ICIMOD Mountain Geo-Portal.

Report prepared by Dr Eva Spehn and Mr Basanta Shrestha

Introduction

It is estimated that about twelve per cent of the world's population live in the mountains. Fifty per cent of the world's population depends on goods and services provided by these mountains. While mountains cover one fifth of the terrestrial land area outside the Polar Regions, the alpine life zone alone (above the treeline) makes up only three per cent of the Earth's surface, but contains at least ten thousand or four per cent of all vascular plant species. This disproportionate richness in species is important for slope stability and key ecosystem services in the mountains. Mountain biodiversity is of prime conservation value, as mountains host half of all thirty-four global biodiversity hotspots.

The compression of thermal life zones and the fragmentation of the landscape into a multitude of microhabitats in the mountains, each inhabited by a suite of species, result in hotspots of biological diversity. Biological diversity is considered essential for the persistent functioning and integrity of mountain ecosystems, and this dependency is likely to increase as environmental conditions change. Steep terrain and the mountain climate together with severe land-use pressure cause mountain ecosystems to rank among the most endangered landscapes in the world (Agenda 21, Chapter 13 of the Rio Protocol).

Making an inventory and assessing mountain biodiversity are essential to improve understanding of, developing management strategies and conservation interventions for, and for predicting and testing scientific hypotheses related to the mountain environment. This has not been the case, however, especially in the context of the Himalayas due to the lack of data in the region. Hence the need for accessible, quality information on ecosystem dynamics in the Himalayas, both at species and ecosystem levels, for informed decision-making.

Given these challenges, the International Centre for Integrated Mountain Development (ICIMOD) together with the Global Mountain Biodiversity Assessment (GMBA) jointly organised a pre-conference workshop on 'Linking Geodata

with Biodiversity Information in the Himalayas' at ICIMOD's Headquarters in Kathmandu from the 15th to the 16th of November 2008. The aim of the workshop was to facilitate deliberations on ways of improving biodiversity databases at regional and national levels; the need for standardisation and harmonisation of data for exchange; and ways of facilitating easy and open access to geo-coded biodiversity information. The workshop was organised as a precursor to the International Mountain Biodiversity Conference and representatives from ICIMOD's regional member countries, Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan, attended.

Aims and Objectives

The aim of the workshop was to show the benefits of geo-referenced biodiversity data, for integrated analysis and spatial visualization of biodiversity information in relation to climate, land use, physiography and other important parameters. The workshop aimed to bring together national partners from the HKH region to explore the possibilities of hosting a regional platform for mountain biodiversity information for the Hindu Kush-Himalayas.

The workshop deliberated on the available tools to facilitate the exchange of biodiversity and geoinformation worldwide e.g. GBIF, WMO/GTS and WorldClim. The workshop also aimed to introduce ICIMOD's initiatives on geo-information applications for biodiversity database development and sharing. The ultimate aim is to provide easy and open access to biodiversity information on the Himalayas via GBIF/GMBA Mountain Biodiversity Portal and the Mountain Geo-Portal of ICIMOD and to develop a framework and partnerships for standardized biodiversity databases and for their dissemination through standard metadata systems to the wider regional and global change research community.

Opening Session

Dr Andreas Schild, Director General of ICIMOD, welcomed the participants and emphasised the importance of geo-coded information for understanding the rapid environmental changes taking place in mountain ecosystems. He highlighted the central role that ICIMOD had been playing in the mountain agenda and the significant contributions it could make to promotion of regional approaches and a methodology for filling the data gaps in the Himalayas as the only mountain-specific, research based organisation working in the Hindu Kush-Himalayan (HKH) region at the regional level. In this context, he also added the important role that the Mountain Environment and Natural Resources' Information System (MENRIS) division of ICIMOD could play to bridge the data gap on biodiversity in the HKH region.

In his remarks at the opening session, Professor Christian Körner, Chair of the Global Mountain Biodiversity Programme, stressed the biophysical characteristics of the mountains which are endowed with immense biodiversity. He said that the information about locations is not only fundamental for understanding biodiversity but also helps us to explore the evolutionary processes of species. So, a 'corporate' community was needed to make information on mountain biodiversity available to a wider scientific community and to policy-makers.

The pre-conference was fortunate to have Professors Bruno Messerli and Yuri Badenkov present as observers. Professor Christian Körner, Dr Eva Spehn, Dr Falk Huettmann, and Dr Bernhard Wolf Dickoré from GMBA and Mr Basanta Shrestha, Mr Birendra Bajracharya, and Mr Sudip Pradhan from ICIMOD gave presentations to the workshop. Mr Basanta Shrestha, division head of MENRIS, presented ICIMOD's programme and activities on geographical information systems and remote sensing (GIS-RS) acted as moderator while Mr Paribesh Pradhan was the rapporteur.

GMBA Presentations

Introduction to the GMBA Global Biodiversity Information Facility (GBIF) project on geo-referenced databases on mountain biodiversity

Dr Eva Spehn, Executive Secretary, GMBA, Institute of Botany, University of Basel gave this presentation. Dr Spehn explained that the Global Mountain Biodiversity Assessment (GMBA) was inaugurated under the patronage of DIVERSITAS at the 1st International Conference on Mountain Biodiversity in Rigi-Kaltbad, Switzerland in September 2000 and is supported by the Swiss National Science Foundation (since 2004) and DIVERSITAS.

GMBA is a cross-cutting network of DIVERSITAS embracing issues of their four core projects bioGENESIS, bioDISCOVERY, ecoSERVICES, and bioSUSTAINABILITY. GMBA primarily aims to provide a scientific basis for the conservation and sustainable use of mountain diversity by encouraging and synthesising often hidden and fragmented results of research on high elevation organismic diversity, its regional and global patterns, its cross- and intercontinental comparisons, and its causes and functions. In other words, it aims to document and synthesise knowledge on the biological richness of the mountains of the world and the changes this richness is undergoing as a result of direct and indirect human influences. GMBA also investigates the mechanisms that create and maintain mountain biodiversity and the functional consequences in both pristine and inhabited high-elevation terrains. It also helps to stimulate new research activities with a comparative emphasis and give a 'corporate' identity to the global scientific community involved in work in mountain biodiversity. In this way, GMBA also helps to create a platform to communicate findings and engage in dialogues with national and international policy forums.

To identify mountain biodiversity, how it is changing and why, GMBA has initiated a project on geo-referenced electronic biodiversity databases on mountain organisms, in cooperation with the Global Biodiversity Information Facility (GBIF). Georeferenced biodiversity data will allow the combination of ecologically relevant information with biodiversity patterns and so facilitate the modelling of species distributions (niche models) and ecosystem boundaries, opening a new field of research (Körner et al 2007). GBIF has a mission to make the world's primary data on biodiversity freely and universally available via the Internet. More than 150 million single records of organisms are currently available at the GBIF data portal (http://data.gbif.org) GMBA will develop a thematic Mountain Portal in 2009, which will help to select mountain relevant data from GBIF. Thematic biodiversity portals like the Ocean Bio-Geographic Information System (OBIS) for sea organisms or the Mammal Networked Information System (MaNIS) are role models for the GMBA Mountain Portal.

There is an urgent need to increase the amount and quality of geo-referenced data on mountain biodiversity available online, especially for the Himalayas. There is also a need to develop a quality set for mountain specific data, such as precise georeferences, or additional altitude information.

Beyond data mining: The evolutionary and ecological usefulness of electronic biodiversity data in combination with geo-physical information systems

In his keynote lecture presentation, Professor Christian Körner, Institute of Botany, University of Basel, explained the importance of understanding biodiversity to understand the evolution of different organisms. He said that evolution is a process that requires time and space. Mountains restrict both, space (as area decreases with altitude) and time (as the length of the growing season also decreases with altitude) and are therefore great places to study evolution. Since mountains are present at all latitudes, they represent nicely replicated study objects for evolution and biodiversity.

Mountains host half of all 34 global biodiversity hotspots, therefore, data on mountain biodiversity is crucial for any kind of future research, analysis, hypothesis and prediction.

Georeferences provide mainly latitudinal and longitudinal information. However, in the case of mountains, information on altitude is crucial additional information; since, in very rugged terrain, a slight error in latitude or longitude changes altitude significantly. The great variation in regional spatial extent of mountain environments and duration of time supportive of life processes offers test conditions for evolutionary theories, but the quality of the data needs to fit the purpose of the study.

Description and definition of the subject is the first step in any scientific study. So, there should be a discourse on defining the subject of the data itself. For example: the term 'mountain' is itself vague for the purpose of developing any mountain biodiversity database. There is no standard and globally accepted definition of what constitutes a 'mountain' and what is 'alpine'. Definitions are often insufficient since not every land areas above 300 m elevation can be called either a mountain or alpine. Therefore, there is a need for a bioclimatic definition rather than 'per meter' definition of a mountain. The parameter of such a bioclimatic definition should include: minimum mean ruggedness (e.g. Δ >200 m per 30"); the altitudinal tree limit as it correlates with the seasonal mean temperature of 6.6 ± 0.8 °C worldwide; and the mean temperature (the upper limit of higher plant life correlates with a minimum period of 30 days with a mean temperature above 0°C).

Apart from understanding the geographical matrix in such a bioclimatic definition, there should also be detailed information on where these land area categories are, how steep they are to make a mountain, how big the remaining areas are in various latitudes and how much time per year the regional climate offers to higher plant life.

For pragmatic reasons, GMBA has defined the montane belt by its ruggedness (>200m across neighbouring 30" pixels and minimum elevation >300 m) and a climatic tree line algorithm.

The treeline ecology and a global climate and topography database have helped significantly in development of a thermal envelope of plant life in the mountains, across latitudes and altitudes. Altitude related phenomena of biodiversity and evolution are distilled by linking climate and topography.

In this way, Körner's main hypothesis stated that time and space provide the major explanation of global diversity, where disturbance and habitat diversity (geodiversity) are more regional (azonal) drivers and physiological constraints operate at boundaries and are generally overvalued.

The challenges to this hypothesis, however, include linking biodiversity data with 'space-for-life' data and 'time-for-life' data, combining the two, distilling global trends from 'noisy' regional trends, and testing biodiversity ratios across organismic groups and climates.

Open access to biodiversity data and the GMBA/GBIF mountain biodiversity web portal

Dr Falk Huettmann of EWHALE laboratory, Biology and Wildlife Department, Institute of Arctic Biology, University of Alaska, discussed the GBIF web portal on mountain biodiversity. He introduced the concept of mega science, i.e. science projects which involve many scientists and institutions working on a common, often interdisciplinary goal. He gave as examples the International Polar Year (IPY), NCBI genbank, Ocean Biogeographic Information System (OBIS), Census of Marine Life, ITIS, NEON, GEOSS, FishBase, LTER, Group on Earth Observations, Mammal Networked Information System (MaNIS), Global Biodiversity Information Facility (GBIF) and Global Mountain Biodiversity Assessment (GMBA). Mega Science projects are huge, interdisciplinary research projects funded by institutions such as the International Council for Science (ICSU), WMO (UN), Organisation for Economic Cooperation and Development (OECD), the National Academies, ICSU CODATA, National Institutes of Health, National Science Foundation or the Environmental Protection Agency in United States. Mega science projects are centred around components of Data Information Service (DIS) with functionalities like open access, free raw data, spatial and temporal data, and metadata in ISO (International Organisation for Standardisation) format. The services also include public ownership of data, professional credit for data publication, and explicit use and sharing of data.

The Global Biodiversity Information Facility (GBIF) is such a mega science project, making biodiversity data from many different sources such as natural history museums collections' available online. GMBA is working on a thematic mountain portal using GBIF data, with the primary goal to harvest the internet and public biodiversity data sources relevant for mountains and additional databases such as the Flora Tibetica collection of B. Dickoré (next talk). Some of the key issues in this mountain portal project have been the definition of 'mountain' itself, along with getting a tree line formula, aspects of specific slope and building queries related with altitude.

The X, Y, and Z variables of biodiversity data currently available have been defined as latitude, longitude and species. Since altitude is an important factor for mountain research, as discussed in earlier presentations, to resolve the altitude problem is to provide X, Y, Z1 and Z2 variables online, with each variable representing latitude, longitude, species and altitude respectively. This problem has already been addressed in GBIF, so altitude was included in the search menu of the GBIF portal, and those data which provide the information can be extracted. This has helped the users to make a three dimensional searches.

The presenter gave insights into the technical aspects of the project such as databases, standardisation of data, interoperability issues and so forth. Apart from these, issues such as internet science, investment into knowledge, data mining, modelling and adaptive management, data creation and re-use, metadata, (online) data delivery, visualisation, analysis, and policy were also discussed.

GMBA pilot project: Flora Tibetica – A distributed database for the Vascular Plants of the Tibetan Plateau, Hindu-Kush, Pamir, Karakoram, Kunlun Shan, Himalayas, Hengduan Shan

Bernhard Dickoré of the Albrecht-von-Haller Institute of Plant Sciences, University of Göttingen, spoke about Flora Tibetica, a GMBA pilot project. He said Flora Tibetica is a distributed database on the vascular plants of the Tibetan Plateau, Hindu Kush, Pamir, Karakoram, Kunlun Shan, Himalayas, and Hengduan Shan. The presenter covered the background and history of 'Flora Tibetica'. The data structure was discussed along with tools, hypothesis, and evaluations of the project described in categories such as taxonomy, phylogeny, evolution, altitudinal zonation, and diversity of vegetation. The conclusion and outlook of the project were also discussed.

Flora Tibetica has 164,990 records in a distributed database out of which 144,618 are geo-referenced specimen records, 140,594 records are identified to species, and 82,757 records are seen or verified specimens.

The speaker concluded by stating that high-resolution spatial data of Tibetan and Himalayan flora are very crucial and these spatial data should reflect biogeography for 50 Mega-annum (Ma) and should be suggestive of large-scale glaciation and recent radiation. The presentation also concluded by discussing the need to place the 'Flora Tibetica' database online and feed it into the GBIF node. It also highlighted the need to work to fill the data gaps, improve taxonomy, geo-referencing, and links.

ICIMOD-MENRIS Presentations

Decision support tools and approaches to protected area management

Birendra Bajracharya,GIS Specialist, Mountain Environment and Natural Resources' Information System (MENRIS),International Centre for Integrated Mountain Development (ICIMOD) was the speaker on decision-support tools and approaches to protected area management.

He stated that decision makers today need to be able to find good solutions to increasingly complex socioecological systems. The complexity of making coherent, integrated, and interdependent decisions for ecosystem management demands sound scientific analysis based on reliable data and information. The tools used must be able to anticipate responses and feedback mechanisms on multiple temporal and spatial scales, accounting for biophysical, social, and economic considerations. Over the past decade or so, "interactive computer-based systems that help decision makers use data and models to solve unstructured problems" or decision support systems (DSS) have been developed with different forms and capabilities to facilitate this process. DSS have evolved as multi-component systems that include combinations of simulation modelling, optimisation techniques, geographical information systems (GIS), and associated databases and user interface components. The tools included in many systems developed as DSS are significantly wide-ranging in their levels of sophistication - from simple tools for integration of data and visualisation to extensive and complex integrated analytical tools and methods for modelling and simulation.

In the context of the HKH region, the development of DSS should be considered as part of a systemic process which invariably will become a platform for participatory consultations and analyses, resulting in improved understanding of the problems and tradeoffs of possible alternatives, as well as a framework for monitoring socioecological dynamics. The DSS should evolve over time and should address the process of decision-making and include the flexibility to review and change assumptions. The generic DSS framework is presented below in a diagram.

DSS for Protected Area Management – The HKKH Partnership Initiative

ICIMOD has been associated with the HKKH Partnership Initiative as an executing partner together with the International Union for the Conservation of Nature (IUCN), Everest,K2, and Council of National Research (Ev-K2-CNR), and Cooperazione e Sviluppo(Cooperation and Development) (CESVI). The project was developed in the framework of priorities defined in the World Symposium on Sustainable Development(WSSD)2002 draft plan of implementation and considers the recommendations made for achieving successful implementation of the priorities identified in Agenda 21 and funded by the Government of Italy's Directorate General's Guidelines for Developing a Cooperative System (DGCS).The activities are focused on three national parks of the Hindu Kush-Karakoram-Himalayan (HKKH) Mountain Complex: the Sagarmatha National Park (SNP) in Nepal, the Central Karakoram National Park (CKNP) in Pakistan, and the Quomolongma Nature Preserve (QNP) in Tibet Autonomous Region of China.

The main objective of this initiative is to consolidate institutional capacity for systemic planning and ecosystem management in the Hindu Kush-Karakoram-Himalayan (HKKH) region. As a multi-scale initiative, the project worked together with local, national, and regional stakeholders on capacity building and developing decision support tools (DSTs) for ecosystem management on different temporal and spatial scales. The project activities support the exchange of data, knowledge, and experiences across the region and the development of a management-oriented research framework. Based on this research framework, a number of social and ecological processes have been analysed and modelled using a system dynamics' approach. Computer-based software tools are being developed to support the decision-making process by facilitating integrated analysis and modelling on a common GIS platform.

ICIMOD has been involved in the project to provide overall technical inputs and expertise related to the application of GIS, RS, and information and communication technologies (ICT) to systemic natural resource management and monitoring, and integration of relevant knowledge, data, and models useful for developing and setting up DST application for ecosystem management in the context of selected protected areas sites.

Decision support toolbox (DST): design and development

The project is developing a Decision Support Toolbox (DST) through a participative and adaptive approach to support ecosystem management processes. The DST is conceived of as a collection of both hard and soft system methodologies and provides a set of generic tools to address the needs of stakeholders and support them in the decision-making process for ecosystem management in selected protected areas. The soft system and participatory tools of DST include scenario planning, participatory 3D modelling, and so on. The computer-based tools are designed and developed in a modular fashion keeping in mind users at different levels, and they which can be used independently or in an integrated fashion as a decision support system. The software component of DST is developed progressively, starting with simple application modules such as visualising and querying geographic layers, environmental and socioeconomic data, and gradually integrating modelling and analytical components to support systemic planning and decision making.

The software is designed in four distinctive modules which can be used collectively or independently as per the decision-making needs of the end users and the protected area to be managed. The first module is a 'Knowledge Base' which contains spatial and bibliographic metadata. This is an offline version of the project's 'Knowledge Base' for users without Internet connections; and it can be synchronised with the online version. The second module, 'Spatial Analysis', provides basic GIS tools for visualisation and analysis of spatial information. The third module, 'Scenario Analysis' provides tools for viewing qualitative models and running quantitative models built in Simile (an external software for modelling System Dynamics). Tools have been developed for inputs to the model from spatial layers and for writing the outputs back to spatial layers. This important development was carried out by ICIMOD by adding a spatial component to modelling of system dynamics. The fourth module, Decision Analysis, provides tools for multi-criteria analysis of various management options and resulting performance indicators to identify the most desirable decisions. The modules on System Analysis and Decision Analysis have been developed to run in an ArcGIS environment for those users who have access to it. The DST in the ArcGIS environment will be provided with additional customised tools with spatial models for habitat analysis and land-cover change analysis.

Regional knowledge hub for biodiversity information for the HKH region

Basanta Shrestha, Division Head, Mountain Environment and Natural Resources' Information System (MENRIS), International Centre for Integrated Mountain Development (ICIMOD) introduced ICIMOD by saying that it is a regional mountain learning and enabling centre devoted to sustainable mountain development in the HKH region and information and knowledge are its prime commodities.

Mountains possess typical geographical settings that give rise to diverse physical, cultural, and socio-ecological conditions these are the most dominant factors influencing sustainable mountain development. Addressing the needs of sustainable development in mountain areas demands special attention because of remoteness, widely varying socioecological conditions, and distinct spatial and temporal characteristics. He said unprecedented growth of geo-information and earth observation technologies and emergence of geographic information science now provide a viable institutional and technological framework to support informed decision-making by integrating many

disciplines. Integrated and innovative solutions based on modern decision-support tools and methods are considered crucial elements to improve scientific understanding, support policy decisions, and devise appropriate development interventions. ICIMOD is one of the first and foremost regional institutions promoting geo-based solutions (tools, technologies, and methodologies) for sustainable development in the region, and geo-based solutions have been the trademark of ICIMOD. It is an internationally recognised resource centre for geo-information and earth observation applications. ICIMOD pursues its goal through innovation and customisation of international knowledge, capacity building and by upscaling, and development of mountain–specific applications and decision-support systems: it acts as a clearing-house mechanism within ICIMOD and among agencies involved in sustainable mountain development.

Mr Shrestha pointed that biodiversity is one of key resources in the Himalayas and there are many issues left to address with regard to biodiversity information.

- The need for spatial and temporal aspects of biodiversity information
- The need for standardisation and harmonisation of biodiversity information
- The need for an integrated platform to combine biodiversity information with other socioeconomic and biophysical parameters
- The need to strengthen regional and national capacities and networking
- The need for an innovative and systematic approach to customise international experience and knowledge for mountain-specific situations.

The speaker described the MENRIS programme and its activities over the last several years and suggested how ICIMOD could be a regional knowledge hub in the Himalayas by working closely with national partners and international agencies. Such a knowledge hub would entail a four-pronged approach by:

- strengthening the capacities of national partners and providing a network for biodiversity information in ICIMOD member countries;
- customising data harmonisation and standardisation adhering to international practices and disseminating to national partners;
- working on a pilot project on geo-referenced biodiversity information in ICIMOD member countries; and
- establishing a web-based platform to build, share, and disseminate biodiversity information from the Himalayas.

Mr Shrestha also illustrated the principles of data sharing with an example of the conservation commons to promote open access to information. He then outlined the topics for group discussions and deliberations.

Demonstrations

ICIMOD and GMBA gave live demonstrations of portals relevant to the work of workshop participants.

- Mountain GeoPortal htt[://menris.icimod.net
- Nepal Biodiversity Portal http://www.biodiversityofnepal.org
- GBIF Web Portal http://data.gbif.org

Group work and plenary discussions

Group work took place after the end of this two-day presentation to devise a way forward for linking geo-data with biodiversity information in the Himalayas. Participants and resource persons were divided into three working groups of 8 to 10 people. Each group was given a separate question to address. Brief accounts of the group sessions are given below.

Group 1: How to design a GBMA-ICIMOD mountain biodiversity portal?

Step 1- Identify the potential users of the mountain biodiversity portal.

Step 2 - Search criteria or query features in the database could be in terms of names of species, collectors and contributors, according to location and time, protected areas, administrative units, altitude, country or region, life zones, and so on.

Step 3 - The database could be compatible with those of the following organisations: GMBA, GBIF, Global Earth Observation Systems (GEOSS), IUCN, Ramsar Sites, Important Bird Areas(IBA), WWF, United Nations Environment Programme(UNEP),Critical Ecosystem Partnership Fund(CEPF), Food and Agriculture Organization(FAO), WESCOM(a software corporation),National Geographic, and others.

Step 4 – There should be s metadata system in a uniform format and adhering to ISO standards. The metadata should be on a local or public server and be accessible globally.

Step 5 - The goal of the portal should be to provide the most recent, time-referenced data.

Step 6 - Pilot studies to upscale the Mountain Biodiverstiy Portal that this workshop envisions will be essential. Hence, the group proposed that ICIMOD establish a Biodiversity of Nepal portal in collaboration with IUCN and the Department of National Parks and Wildlife Conservation (DNPWC). The group also suggested that 500 records of information on species could be added to make it a GBIF-GMBA standard pilot project.
The group also discussed the need for a regional hub for the GBIF-GMBA portal. It was agreed that, in the case of the HKH region, ICIMOD should take the lead as the regional hub for the GBIF-GMBA portal.

Step 7 - The participants discussed the technical requirements for such an initiative. Hardware and software requirements include servers and the Digital Imagining Information Resource's(DIGIR)/ Biodiversity Information Standards Access Protocol(TAPIR), personal computers (PCs), Linux operating system, File Transfer Protocol(FTP) services, Microsoft's web application framework(ASP.NET), Java, database management system(MySQL), object relational database management system (PostGreSQL), Excel, Microsoft(MS) Access, Apache, Map Server, Arc Geographical Information Systems (ArcGIS) Server, University of Minnesota's (UMN's) Map Server, Arch Internet Map Server (ArcIMS), and so on.

Step 8 - The web services and facilities that the portal should deliver would be a web map service (WMS), a web feature service (WFS), Google Earth, data downloading and mining facilities for predictive modelling, adding and merging other data sources (National Aeronautics and Space Administration [NASA] and Topography dataset), and linking with GenBank, Species 2000 and Bar Code of Life.

Step 8 - The need for data policy, embargo, and a white paper were also discussed. GBIF has a data policy, and GMBA has a data policy which is more mountains specific.

Step 9 - The project should have a timeline and business mode: whether it should be a short-term or long-term initiative should be discussed and finalised.

Group 2: How to promote geo-referenced data on biodiversity?

The participants in this discussion group discussed the need for accessible data with linkages to other databases on national and global scales to promote geo-referenced biodiversity data. During the discussion, questions such as 'promotion to whom?' were raised. For promotion of geo-referenced biodiversity data, the participants of this group highlighted a number of key points.

Adoption of standards
There are three elements to be considered in adopting standards according to the group participants. They are standard methods such as Darwin Core, information elements like species, taxonomy, geographical coordinates; metadata; and the responsibility of providing a mechanism to control the quality of the data.

Metadata
The participants argued that there should be a standard format for metadata to facilitate linkages with the original databases in the HKH region. Like Darwin Core, a new common method for mountain-specific situations should be developed for the HKH region to enable linkages with regional and global initiatives.

Geo-referencing tools
Geo-referencing tools such as BioGeomancer should have a high-resolution data capacity and should be adopted by regional institutions.

Mountain-specific situation
Geo-referenced biodiversity data should have information that caters to mountain-specific needs. These should include mountain-specific needs or attributes, GIS layers, bioclimatic zones, aspects, slope, canopy cover, land use, and social structure – vertical dimension, glaciers, permafrost, and so forth.

Capacity building
To standardise and harmonise databases using an interoperable metadata system, there should be capacity building initiatives as well. These capacity-building programmes should be done to match local data with the standards of international data.

Linkages with regional and global initiatives
All the points mentioned above should match regional and global initiatives. One question that was constantly asked about this group's presentation was about Darwin Core, whether it is an ISO standard that should be followed or adapted in this context. To this, Dr Eva Spehn replied that the Darwin Core format was recommended, and that, although Darwin Core is an open source and perfect in this case, a customised version is needed to harmonise it with historical data for practical purposes: otherwise, it would be too tedious a task to change those data.

Group 3: How to improve the biodiversity database on the HKH region?

The participants in this group had a brainstorming session to discuss ways of improving the biodiversity database in the HKH region. Firstly, the status and assessment of mountain biodiversity were discussed and participants presented the names of the databases available in their respective countries. These included Eflora of Nepal, Flora Tibetica, Flora of China, Bhutan Flora, Myanmar Flora, Flora of Pakistan, Flora of India, Flora of Bangladesh, and Afghanistan (Flora Iranica). Nakul Chettri from ICIMOD commented that the information on fauna and lower plant groups is fragmentary in all of the eight countries of the HKH region and it was very difficult to compile these studies. MENRIS and the Environmental Change and Ecosystem Services (ECES) of ICIMOD both agreed to provide more information on the 3,500 flora and 200 fauna available on the current portal by mid 2009.

As a complementary approach to inclusive partnership, the participants also gave the names of key institutions and stakeholders in their respective countries. These are listed below.

Afghanistan
- Ministry of Agriculture, Irrigation and Animals (MoAIA)
- National Environment Protection Agency (NEPA)
- Provincial Area Development Ministry (PADM)
- Provincial Agricultural Department (PAD)
- Provincial Environment Department (PED)
- Kabul University
- Afghanistan Academy of Sciences (AAS)

Bangladesh

Flora:
- Bangladesh National Herbarium
- Bangladesh Forest Research Institute
- Department of Botany, Dhaka University

Fauna:
- National Museum Natural History Section
- Zoology Department, Dhaka UniversityZoology Department, Chittagong University
- Marine Science Institute, Chittagong University

Management:
- Department of Forests
- Asiatic Society of Bangladesh
- IUCN Bangladesh Country Office
- Department of Fisheries

Bangladesh Fisheries Research Institute
Bangladesh Agricultural Research Council
Bangladesh Agricultural Research Institute
Arannayak Foundation

Bhutan
National Biodiversity Centre (NBC)
Department of Forest, Nature Conservation Division

China
Kunming Institute of Botany
Chinese Academy of Sciences (CAS)
Tibetan Plateau Research Institute
Xinjiang Institute of Ecology and Geography
Tibetan Academy of Agriculture Sciences (TAAS)

India
Botanical Survey of India
Zoological Survey of India
Wildlife Institute of India
Indian Council for Forestry, Research and Education
GB Pant Institute of Himalayan Research and Development

Myanmar
Ministry of Forestry (MoF)
Department of Agricultural Research (DAR)
Department of Botany, Ministry of Education
Department of Zoology, Ministry of Education

Nepal
Ministry of Forest and Soil Conservation
Department of Natural Park and Wildlife Conservation (DNPWC)
Department of Forest
Natural History Museum
Department of Plant Resources

Pakistan
Ministry of Environment
Provincial Wildlife Departments
Provincial Forest Departments
Natural Herbarium, National Agriculture Research Council
Pakistan Forest Institute
Pakistan Agriculture Research Council
Natural History Museum
IUCN Pakistan
WWF Pakistan
Himalayan Wildlife Foundation

Other Institutions
Edinburgh Botanical Garden
Natural History Museum, London
Natural (National) History Museum, Vienna
Munich Botanische Staatssammlung
Kew Botanical Gardens

To improve the biodiversity databases in the HKH region, participants also stressed the need for base maps providing information about the vegetation types, digitisation of information on herbarium and museum specimens along with land-use maps, local-level information, recent data set integration, designing formats for future surveys, and so forth. Participants also discussed the possibility of having a national- or regional-level networking mechanism like Mountain Forum for the global mountain community. One more question raised by participants from the other groups was how GBIF was dealing with biodiversity. GBIF representatives explained that GBIF was more focused on the biodiversity aspect than on the economic aspect which is directly linked to agriculture. Also in the case of agrobiodiversity, other issues such as rights and patents arose which raised a different set of issues entirely.

Recommendations

Participants from all eight regional member countries of the HKH region made some important recommendations and supported the suggestion that ICIMOD act as a regional knowledge hub for biodiversity information in the Himalayas. The recommendations made were as follows.

- It is recommended that ICIMOD become a regional node of GBIF and that a memorandum of understanding (MoU) or some kind of letter of agreement with GBIF be signed to this effect. To this effect, GMBA will provide the necessary guidance and information for ICIMOD.
- ICIMOD shall facilitate or encourage key national partners in regional member countries (RMCs) to become national nodes for GBIF. ICIMOD and GMBA will promote a common methodology and databases with regard to geo-coded biodiversity information.
- ICIMOD and GMBA shall work together with national partners towards standardisation and harmonisation of information on biodiversity in the Himalayas. It is suggested that Darwin Core - an international, standardised metadata system on biodiversity be used by ICIMOD and its partners.
- ICIMOD and GMBA will try to promote capacity-building initiatives by organising a workshop cum training programme for national partners in RMCs on geo-referencing biodiversity information.
- Together with national partners, ICIMOD and GMBA will also develop concept proposals-initiatives to promote open access to biodiversity information in the Himalayas.

Annex 1 Programme

November 15th, Saturday

14:00	Opening	
14:10	Introduction to the GMBA/GBIF project on datamining of georeferenced mountain biodiversity databases	Eva Spehn, GMBA, Institute of Botany, University of Basel
14:30	Exploring the evolution and ecology of mountain biodiversity by linking organismic data bases with geophysical information systems	Christian Körner, Institute of Botany, University of Basel
15:30	Open Access to biodiversity data and the GMBA/GBIF mountain biodiversity webportal	Falk Huettmann, EWHALE lab- Biology and Wildlife Dept., Institute of Arctic Biology
17:00	GMBA pilot project: Flora Tibetica	Bernhard Dickoré Albrecht-v.-Haller Institute of Plant Sciences, University of Göttingen,

November 16th, Sunday

09:00	Decision support tools for protected area management	Birendra Bajracharya, GIS Specialist, MENRIS, ICIMOD
09:20	Regional knowledge Hub for biodiversity information for the HKH region	Basanta Shrestha, Division Head, MENRIS, ICIMOD
09:45	Demonstrations - Mountain Geo-Portal - Nepal Biodiversity Portal - GBIF web portal	Sudip Pradhan, DSS Programmer / ICIMOD Eva Spehn, GMBA,
10:30	Tea break	
11:00	Group work on common goals of GMBA and ICIMOD: 1) how to improve biodiversity database in the Himalaya 2) how to use goe-referenced biodiversity data for better management decisions 3) how to design the GMBA data portal / Mountain Geoportal on mountain biodiversity	
12:00	Group Presentations (I, II and III)	
12:30	Discussion and Closing	
13:30	Lunch	

Annex 2 List of Participants

Linking Geodata with Biodiversity Information in the Himalayas

15-16 November 2008

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