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# Mountain Knowledge Hub Initiative in the Hindu Kush-Himalayan Region

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## Abstract

Improving the livelihoods of the mountain communities and environmental conservation in the Hindu Kush-Himalayan (HKH) region have been the twin agenda of the International Centre for Integrated Mountain Development (ICIMOD). ICIMOD is a multidisciplinary center for research and training on integrated mountain development and the chief commodity that the centre deals with is information and knowledge on mountain development. Availability, accessibility and affordability of geo-information at multiple scales and the capacity to use modern analytical and decision support system tools are becoming useful means to investigate key components of mountain ecosystem issues facing today. Realizing the potential of geographic information (GI) for integrated mountain development, ICIMOD through its Mountain Environment and Natural Resources Information Systems (MENRIS) programme, has been promoting the GI science, technology and applications for the mountain areas.

Earth observation from space (remote sensing) is a valuable technological tool that provides long-term, consistent measurements of key variables (geo-information) for studying the conditions and trends of different ecosystems. Mountain areas have received special attention due to remoteness and vastly varying bio-physical, social and cultural conditions. ICIMOD is one of the first and foremost regional institutions in the region addressing towards mountain geographic information infrastructure (Mountain-GII) at the local, national and regional level for sustainable decision-making for integrated mountain development.

Through strategic partnerships with key regional/international agencies and together with national partners, MENRIS is making significant contributions towards capacity building; developing mountain thematic databases and delivering useful mountain-specific applications and decision support systems. The information and knowledge products thus generated through these systems are useful to development practitioners and policy-makers for planning and decision making. Mountain Knowledge Hub (GeoPortal) has been conceived and designed to create a common platform for effecting sharing and exchange of geo-information based knowledge resources through a distributed and decentralized network of partners in the region. Such a framework has proven to be a viable technological and institutional option for building mountain knowledge hub on key issues of concerns in the region such as bio-diversity conservation, water resources management, glacier and climate change, transboundary air pollution, disaster management, landuse planning and many more.

KEY WORDS: Geographic information, mountain environment, earth observation, decision support system, Mountain GeoPortal, Mountain Knowledge Hub

## 1. Introduction

Mountain areas cover a significant part of the world's surface with half of the world's people depending directly or indirectly on them. Mountains provide water, energy, minerals, and forest and agricultural products and are areas of recreation. They help in maintaining the climatic cycles and water balances. They also store the biological diversity necessary for the sustainability of human life. Mountain environments are essential to the survival of global ecosystems. However, mountain ecosystems are fragile and are susceptible to soil erosion, landslides, and loss of genetic diversity. Physical isolation has excluded the mountains and their populations from development, resulting in political and economic marginality.

The mountains and their ecosystems have constantly been gaining the attention of the world community. The linkages between environmental degradation in the mountain areas and its effects downstream are becoming ever more prominent. The importance of mountains as global life support systems has been duly recognized by the proclamation of the year 2002 as International Year of Mountains by the United Nations.

Among the world's mountain areas, Asia contains the largest, highest, and most populated mountain systems. The Hindu Kush-Himalayan region, stretching 3,500 km over eight countries, from Afghanistan in the west to Myanmar in the east, is home to more than 140 million people and affects the lives of three times as many in the plains and river basins below. The western parts of the region are dominated by arid and semi arid climate and the area is faced with problems water scarcity, deforestation, soil erosion and soil fertility. The central part is dominated by monsoon climate which results in flooding and landslides in the summer and water scarcity during the rest of the year. The eastern Himalaya faces heavy rainfall during monsoon causing floods and landslides. The area has dense forests and high biodiversity. The Tibetan and Qinghai platue have cold arid climate with very little rainfall. The climatic conditions vary greatly in the mountains with varying slopes and altitudes which change within very short distances. Most of the people in the region live in poverty and they depend on subsistence farming and forest resources for their livelihood. Extreme physical conditions, fragile ecosystems and high dependence of the people on natural resources make sustainable development of the mountains a big challenge.

## 2. Persistence knowledge gap

Current understanding of mountain ecosystem and it services is still very limited. The sporadic bursts of attention given to mountain areas have generally been a post-disaster phenomenon. Systematic attention to these problems is a very recent phenomenon, and it is extremely limited in extent and coverage. There are large gaps in understanding issues specific to mountain environment and its intricate linkages with socio-cultural aspects. The per-

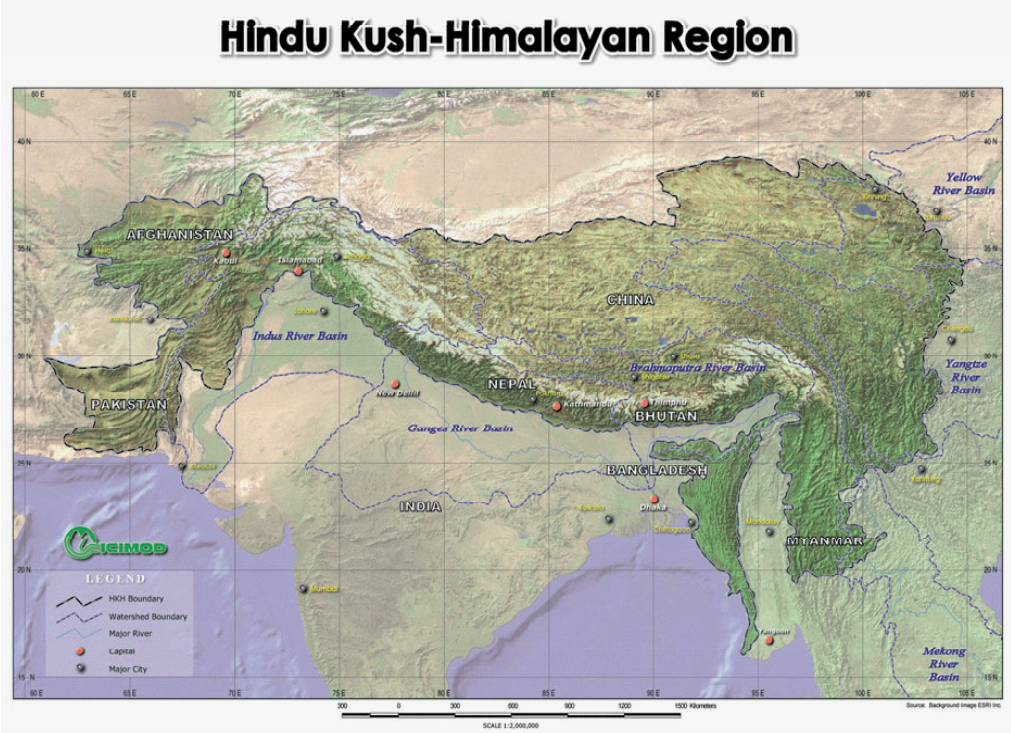


**Figure 1:** Hindu Kush-Himalayan Region.

sistent knowledge gaps in understanding and delivery of sustainable mountain development were identified as an area of major concern by UNCED Agenda 21, Chapter 13.

Sustainable development in mountain areas requires access to data, information, knowledge and understanding about the natural resources and environment with respect to its physical conditions including socio-economic dimensions. Following Rio summit in 1992, the mountain regions have been constantly gaining the attention of the world community for their contribution towards important ecosystem services for life support. Furthermore, the WSSD in 2002, with its emphasis in implementing in Agenda 21 and IYM-BGMS 2002, highlighted the need to promote the use of information and knowledge to support sustainable development.

## 3. Role of Geo-information in sustainable mountain development

Neglect of mountain areas in the major developmental efforts has resulted in a general lack of understanding of the natural and human processes affecting these mountains. The few development interventions that were designed were often of sectoral nature that addressed the symptoms more than the causes of the problems and largely ignored the opportunities for development that the mountains of the HKH provide.

Lack of information and appropriate means to present and disseminate this information has often been the cause for the absence of an integrated approach. To enable sustainable decision-making, there needs to be a realistic assessment of natural resources and socio-economic conditions. There is a strong need for the systematic generation of data that covers both the current situation and provides insight to the changes over time. Spatial information is critical for this purpose. The availability of consistent thematic databases at different levels of detail (e.g. local, national, regional) will help to improve the ability to investigate key components of the Himalayan environment. The significance of geographic information has been well recognized in the scientific circles both at the national and regional levels.

Geographic Information Systems (GIS) and Remote Sensing or often referred to as the geo-information technology (Geo-IT) has an immense scope for a wide range of applications in natural resources and environmental management. Geo-IT can play a prominent role in mountain development and environmental management in several areas.

GIS and RS based tools have the ability to integrate large volumes of diverse spatial and non-spatial data from numerous sources at various scales. Although the data usually have a spatial component, standard database capabilities remain within GIS. Data can therefore be stored, retrieved, edited, administered and shared following the same rules as a regular database. Visualization of data is another important asset of GIS. With relative ease maps, reports and graphs can be generated. Maps provide an overview which can not be attained by text only and are very important to support decision making. This is especially true for mountain areas, which are by definition characterized by high spatial heterogeneity.

Besides the databases and visualization characteristics, a GIS has spatial modeling capabilities. It enables the combinations of spatial themes by defining relationships between them to answer specific questions. “What if” type of scenarios can be simulated to evaluate the effect of several environmental options or use as spatial decision support system. Crop suitability mapping for example could use spatial data on climate, morphology and soil. A specific crop will grow well in a range of climatic, morphologic and soil conditions. It can be spatially evaluated where these conditions are met and changes in one of the variables can easily be assessed on its effect on crop suitability.

Remote Sensing is a very valuable data acquisition tool in mountain areas, which are often inaccessible and remote. Mountain areas are difficult to reach and field work is difficult and expensive. Using satellites it is possible to detect the spectral behavior of the surface of the earth. Each object on the earth has a specific spectral behavior and Remote Sensing can be used to derive these characteristics through image interpretation and build datasets which in its turn can be integrated using GIS.

## 4. Geographic information initiatives at ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) has been working as the only international organization with a focus on improved livelihood and sustainable ecosystem management in the Hindu-Kush Himalaya. Through its Mountain Environment and Natural Resources Information System (MENRIS) program, ICIMOD has been focusing on GIS capacity building and networking of the national institutions in the region to promote the development of geographic information, its sharing and effective use in the region since early 1990.

The approach MENRIS has taken to contribute to sustainable mountain development using Geo-IT is based on the framework as shown in figure below. The framework is based on networks of national and regional partners and strategic alliances beyond the region. The left column shows the transformation of data into information which is used in different applications to support decision making. The right column shows the processes and outputs

at each level. The acquisition of data and integration of information applied to specific applications will generate knowledge bases. The knowledge bases used for decision making will eventually contribute to sustainable development.

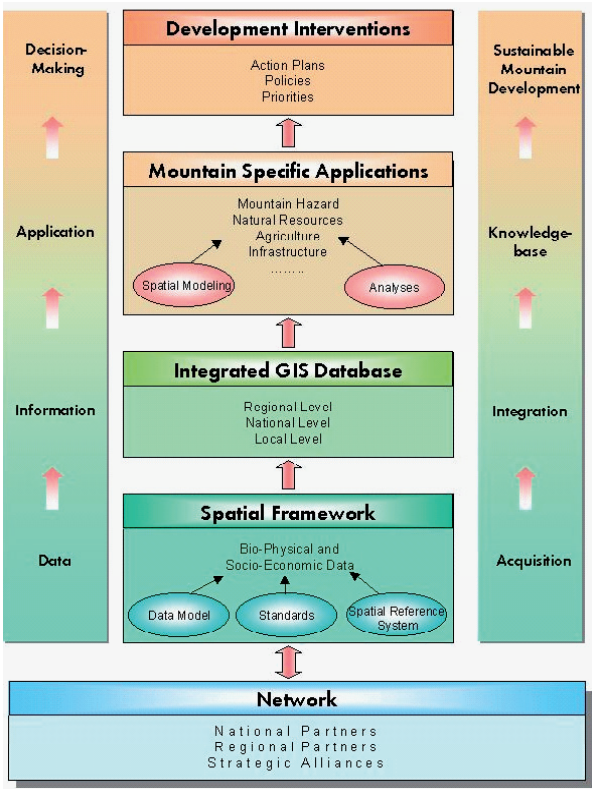


**Figure 2:** Sustainable Mountain Developing using Geo-IT.

The middle column shows the components at different levels of utilization of Geo-IT and the approach of MENRIS. At the basic level, it emphasizes on a Spatial Framework for data acquisition and processing. Data models, standards and spatial reference systems are important building blocks for development of bio-physical and socioeconomic data. The next level is the integrated databases at local, national and regional levels. These integrated databases are used for mountain specific applications such as mountain hazards assessment, natural resources management and agricultural planning. These applications will use spatial modeling techniques and analytical and visualization tools for better representation and understanding of the mountain issues. The results of the applications will provide necessary support for policy and action plan formulation which will lead to development interventions in the priority areas.

ICIMOD has been working under this framework with programs focusing into four strategic components – capacity building and networking, GIS data management, applications and decision support systems, and resource centre and clearinghouse.

Developing human resources in the field of GIS and Remote Sensing has been a major focus since the inception of MENRIS. A number of training courses suitable for different audiences such as policy makers, managers and professionals have been developed. These courses have been regularly conducted in the member countries of ICIMOD. Besides the courses on GIS and Remote Sensing in general, various courses on thematic applications have been developed. ICIMOD has worked with various universities in the region to integrate GIS and Remote Sensing in academic courses.

The GIS data management component focuses on data acquisition and management in different fields of application. The development of land cover databases, the establishment of the regional hydrological data centre and the creation of an image catalogue with Remote Sensing imagery of the region are some examples.

Application of geo-information to solve real world problems is of course the ultimate goal of the program. ICIMOD is involved in numerous projects in partnership with national institutions where geo-information technology is applied.

The resource centre or clearinghouse function is a very important component of the program to disseminate data, information and knowledge resources. The Mountain Knowledge Hub (GeopPortal) has been developed to provide a common platform or gateway for users and providers to share interactive maps, data, metadata and applications through the internet.

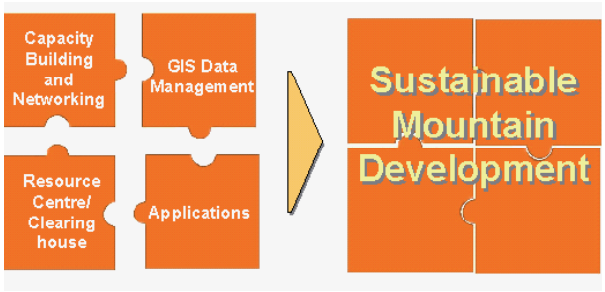


**Figure 3:** Sustainable Mountain Development.

## 5. Mountain knowledge hub initiative

The advent of internet technology has revolutionized the concept of networking and information sharing. Internet provides huge potential for effective and efficient ways of obtaining, using and sharing information. Internet is now part of daily life and the information era is in full progress now. These developments have not left the GIS community untouched and many of the software developments are now focused on internet mapping technology. Recent development has leveraged publication

of geographic data through the internet. Centrally stored data and applications and dissemination through the web by open internet protocols are now the common standard. The numbers of web GIS applications have grown tremendously over the last years.

ICIMOD has been on the forefront of these developments in the Hindu-Kush Himalayas. A mountain knowledge hub framework was developed to share, learn, exchange and discover geo-based information with a particular focus on earth observation derived information using industry standards in GIS and internet technology through a distributed and decentralized network of partner institutions of ICIMOD regional member countries. Such a framework is aimed to:

- Integrate mountain information and knowledge resources using Geo-ICT tools, methods and technologies;
- Develop and establish mountain information and knowledge hub for key thematic areas of mountain ecosystem; and
- Promote the use of mountain information and knowledge hub for integrated mountain development to the wider communities.

## 6. Approach and methodology

Geo-ICTs are considered to have a central role in achieving a successful transition from traditional (sectoral) environment and natural resources management to integrated (holistic) approach to development because of their integrative quality (linking bio-physical and socio-economic information) and their location-based property (addressing relationships among places at local, national, regional and global levels). Geo-ICT provides multi-disciplinary tools that allow integration and collaboration among many sectors and support wide spectrum of thematic areas of ICIMOD's mission. The basic approach for a mountain environmental knowledge hub is to set up a technological and institutional framework for integrating mountain geo-information and knowledge resources of important mountain ecosystem and its services. Such a framework envision to derive knowledge from the host of different information resources and providing a means of natural and seamless access to information and knowledge to the Users with 3-D visualization capability that are eye-catching (intuitive) to policy-decision makers and easily understood by the common people. Different parameters of mountain ecosystem and its services will be considered in different thematic areas namely: air, water, land and bio-diversity. Many of these themes are interrelated and organizing information themes in a common geographic platform would also allow viewing and analyzing relationships between or among the themes.

## 7. Thematic knowledgebase

ICIMOD has adopted a strategic approach to assist its regional member countries in capturing the opportunities provided by the GI and related technologies for organized information networking and improved decision making. Many applications covering diverse ranges of applications and decision support systems suitable for mountain areas have been developed at the local, national and regional levels contributed to develop thematic knowlegdebase in major issues of concerns in mountain development. Some of the key areas of thematic applications and knowledgebase are mentioned briefly as below:

### 7.1. Glaciers and Glacial Lake Outburst Flood (GLOF)

Rapid accumulation of water in glacial lakes, particularly in those adjacent to receding glaciers, can lead to a sudden breaching of the unstable 'dam' behind which they have formed. The resultant discharges of huge amounts of water and debris – a glacial lake outburst flood or GLOF – often have catastrophic effects downstream. Remote Sensing has been used to identify lakes that could pose a potential threat in Nepal, Bhutan, and several basins in India, Pakistan and China. GIS databases with detailed data on various parameters of glaciers and glacial lakes have been developed which can be used as a baseline for climate change studies.

### 7.2. Agricultural systems

ICIMOD started the project "Methodologies for assessing sustainable agricultural systems in the Hindu-Kush-Himalayan region (HKH) - an eco-regional framework" in 1999. The project resulted in a set of GIS based methodologies, databases and software that can facilitate the sharing, retrieval and analysis of useful information on the HKH region. Ultimately these tools can be used by decision makers to identify agricultural "islands of success" and extrapolate those to similar agro-ecological areas throughout the region.

### 7.3. Socioeconomic studies

Mapping the status of development is another field ICIMOD has been involved in over the last years. For Nepal a methodology was designed to map and publish a wide variety of indicators of development such as infant mortality rates, nutrition, health, income, literacy, etc. on district level. It was the first study in its kinds and the results were very much appreciated, especially by decision makers working in development. Repeated studies using the same methodology and data from census of different years have shown trends of different indicators and their

spatial pattern over time which are very helpful in policy making. Mapping of socioeconomic indicators are also being carried out in Chittagong Hill Tracts of Bangladesh, Himachal Pradesh of India, and Bhutan.

### 7.4. Land use and land cover mapping

Land use and land cover information are the basic requirement of all studies on natural resources. ICIMOD has been working on deriving land cover and land use maps at different scales which are suitable for various applications. Satellite images of different resolutions, e.g, IRS WiFs (180 m), Landsat TM (30m), IRS LISS4 (5m), IKONOS (4m and 1m) are used to prepare land cover maps at regional, national and local scales.

### 7.5. Urban applications

The urban applications have been focused on database development and analysis of trend of urbanization. The "Kathmandu Valley GIS – Bridging the Data Gaps", completed in 1999 was the first application in Nepal which generated extensive databases of Kathmandu valley and made the digital databases accessible to general users. This initiative created awareness among the GIS data users and providers for the need of data sharing.

Another urban application was "GIS for Municipal Planning – a case study from Kirtipur Municipality". The study also generated GIS databases at 1:4000 scale along with the orthophoto of the area which are very useful for the planners. The study also showed the development trend and status of infrastructure as well as the potential areas of growth.

### 7.6. Biodiversity conservation and management

Due to high variability in altitude and climate within short distances, mountains are rich in biodiversity. Conservation of biodiversity and management of protected areas is one of the major concerns in the region. ICIMOD has been working on identification of biodiversity corridors between protected areas in the eastern Himalayas and developing conservation strategies. GIS and RS have been extensively used to identify corridor areas, study changes in vegetation coverage and habitat analysis.

In another project, ICIMOD is working on developing a decision support system for integrated monitoring of natural resources towards sustainable development and environmental conservation, mainly for the protected area management in three national parks of Nepal, Pakistan and China.

All of above applications and others have been able to generate geo-coded information and knowledge resources that can use used for informed decision-making. The information and knowledge base have been integrated within the framework of the mountain knowledge hub initiative. The section below describes briefly the contents of the knowledge hub.

## 8. Mountain knowledge hub contents

Major Focus of the knowledge hub are:

Capacity Building and Networking: This component focuses on enhancing and strengthening the capacities of institutions in utilizing geographic information, and applying spatial tools and techniques to support planning and decision-making. MENRIS has been implementing this primarily through regional/national training courses, provision of new software and tools, exchange of scientists, and technical backstopping to partner organisations.

Mountain Databases, Tools and Methods: One of the core functions of ICIMOD is to work as a facilitator for sharing data, information and knowledge on mountain ecosystem and its services. Limited availability and accessibility of geo-information and affordable tools and methods are the major problems faced by the mountain region. This section focuses on addressing the problem by developing innovative GIS/RS tools and methods for data identification, collection, archiving, accessing, visualization, and analysis of mountain resources and serves as clearing-house mechanism for disseminating geo-information and knowledge resources for mountain areas.

Thematic Applications and Decision Support System: The diversity, marginality, and strategic importance of mountains, together with vastly different rates of change in their physical, biological and societal systems present challenges for applying geo-information and related technologies. This component focuses on thematic application and DSS on key mountain issues.

Major Contents of the knowledge hub are:

- Cataloguing System: In partnership with FAO, data, metadata, images, maps and aerial photograph, catalogues are made available through the Geo-Network.
- Training and Education: MENRIS provides mountain focused training courses in applying geospatial tools in more than 12 different thematic areas. GIS for Beginners, E-learning system and Computer Based Training on application of Geo-informatics for Sustainable Mountain Development are made available.
- Thematic Application and Decision Support System (DSS): More than 12 different areas of applications and decision support systems have been developed in partnership with different national and international partners.
- Dynamic Mapping System: The Portal features interac-

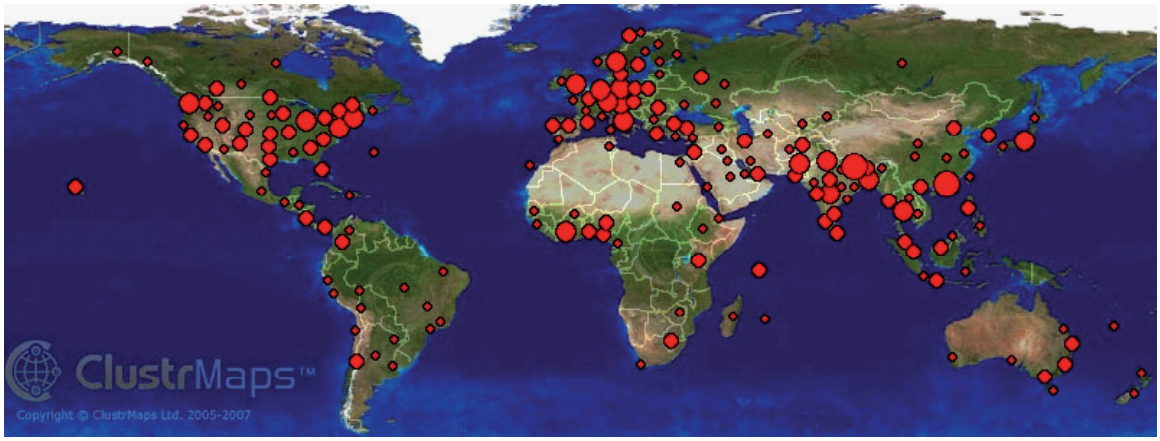


**Figure 4:** Distribution of User of Mountain Knowledge Hub Portal.

tive map services linking to the ICIMOD's map server using ARCIMS, Google Earth Application as well as in open source environment.

- Thematic Portals: A number of thematic portals on key mountain issues such as water quality, biodiversity, census indicators etc. have been developed in partnership with international and regional agencies.
- Space Technology Application for Mountain Areas: In partnership with ESA, this component provides information related to remote sensing application for sustainable development of mountain areas.
- UNEP-GRID Collaboration: As a GRID Center, the MENRIS programme has been implementing various collaborative activities in partnership with UNEP in key national and regional environmental issues
- MENRIS Networks: There is a comprehensive list of the MENRIS Network information available such as Focal and partners agencies, University network partners and Alumni network.
- Other Resources: An archive of related publications, reports, papers and e-bulletins covering events and activities on a quarterly basis can be accessed through the portal. A discussion forum, glossary of related useful sites, data downloads and the facilities for users to submit their maps, metadata, applications and news are important features of the Portal.

## 9. Conclusions

Mountains have very distinct spatial and temporal expressions and many of our planning and decision making processes in these areas are often influenced by geographic information. Given the dynamic character of the natural resources that undergo quick changes in the mountain region, there is constant need to update the information and review the dynamic linkages. Mountain Knowledge hub framework provides a unifying framework for integrating many different kinds of information for better understanding of mountain ecosystem and supports its functioning and management. Moreover, many problems we face in the region are transboundary in nature and using such a technology and a framework can promote regional cooperation among the participating member countries.

In the recent past, GIS and related technologies have improved the capabilities of handling geographic information, and they have made it necessary for different stakeholders to re-examine their roles with respect to the use and supply of such information. The information products through GIS base decision support systems are useful to indicate alternative strategies to mountain development practitioners and policy-decision makers and such a framework has proven to be a viable technological and institutional option for sustainable mountain development. ICIMOD, with its institutional foundation and active network of national partners and key GIS organizations around the world thus established so far, can leapfrog national efforts in the HKH region to attain higher stages of sustainable development using mountain knowledge hub framework.

## References

RHIND, D., 1997: Framework for the World. Ed. Cambridge.

SHRESTHA, B. and BAJRACHARYA, B., 2004: Regional Spatial Data Infrastructure (RSDI) in the Hindu-Kush Himalayan, February 2004, GSDI, Bangalore.

BITTER, P. and SHRESTHA B., 1999: Regional Geographic Information Infrastructure in the Hindu Kush – Himalayan Region, ICIMOD's Perspective.

BAHAIRE, T. and ELLIOT-WHITE, N, 1999: The Application of GIS in Sustainable Tourism Planning: A Review. Journal of Sustainable Tourism.

HEYWOOD, D.I., PRICE, M.F. and PETCH, J.R., 1994: Mountain Environment and GIS London: Taylor and Francis.

FALCONER A., FORESMAN J., SHRESTHA B., BAJRACHARYA B. and PRADHAN, S., 2002: A system for Survival - UNEP 2004, GIS and Sustainable Development, ESRI Press, USA.

GSDI, 2001: Developing Spatial Data Infrastructures: The SDI Cookbook, Nebert, D. D. (ed.) Version 1.1.

GROOT, R. and GEORGIADOU, Y., 2001: Advancing the concept of National Geospatial Data Infrastructure: Reflections on the "bottom line", Map India.

RHIND, D., 2001: Lessons learned from local, national and global spatial data infrastructures, Map India.

ESRI, 2002: What is the g.net Architecture?, ArcNews, Spring 2002.

DEPARTMENT OF SCIENCE AND TECHNOLOGY, Government of India, 2001: National Spatial Data Infrastructure (NSDI) Strategy and Action Plan. Task Force on NSDI, Dept. of Science and Technology, Govt. of India.

SURVEY DEPARTMENT, 1998: National Mapping, Issues and Strategies. Western Nepal Topographic Mapping. Project, Survey Department, Nepal.

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