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Geographic Information Systems and Remote-sensing Technologies for Mountain Development

Geographic Information Systems (GIS) and Remote-sensing (RS) technologies are essential tools that facilitate the spatial decision-making process. These tools are being used extensively but there are hurdles in the implementation of these technologies, especially in the Hindu Kush-Himalayan region. This paper discusses these constraints, including the role of ICIMOD in disseminating these tools throughout the region.

The Context

Because of rapidly growing populations and a dwindling resource base, sustainable development involves greater and conflicting demands on available resources. Decision-makers need to monitor and analyse the changing resource bases of specific ecosystems in order to make informed choices. Modern Information Technologies, such as GIS and RS, can facilitate efforts in this direction.

The diversity, marginality, and strategic importance of mountains, together with vastly different rates of change in different components of their physical, biological, and societal systems, present greater challenges for the use of GIS and RS. In contrast to the widespread use of GIS in other areas, the use of the technology has been relatively limited in mountain environments. However, in recent years, growing concern over the environmental degradation of mountain ecosystems and the need for a valid information base upon which we can base sustainable development decisions, emphasised the utility of GIS and RS technologies.

GIS and RS are being used increasingly as tools to assist in resource inventory and the integration of data and as a mechanism for analysis, modelling, and forecasting to support decision-making.

However, the use of GIS and RS in the mountains requires special considerations. These are based on the particular characteristics of mountain environments and our understanding about how mountain systems work. GIS and RS softwares are gradually being modified to addres these special conditions of mountain areas.

Potential Application Areas in Mountain Environments

- *Terrain analysis*
- *Snow-cover analysis*
- *Mountain hazard mapping*
- *Watershed management*
- *Accessibility Analysis*

GIS and Remote-sensing Technologies

Remote-sensing and GIS technologies are proving to be efficient tools that enable decision-makers to address problems of environment and development in an integrated manner. GIS integrates biophysical and socioeconomic data and can be

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http://www.south-asia.com/icimod.htm

Comments are Welcome

Box 1: Analysis of livestock and feed situation using GIS in the middle mountains, Nepal

Planning techniques, such as GIS, can be used to collate the available information and carry out an area-based and problem-oriented analysis. GIS has the potential of using wide-ranging applications to solve specific development problems by using different sets of indicators (see Box 1).

ICIMOD conducted a case study in Kabhre Palanchowk district in the Central Development Region of Nepal to demonstrate the use of GIS for improved livestock planning. The case study assessed different subjects; viz., population, natural resources, and infrastructure; to present an overview of the district. In addition, feed supply, feed requirements, and livestock carrying capacity were also analysed along with the locations of livestock services.

The GIS software, ARC/INFO, was used to establish the database on the basis of an IBM compatible PC platform for data input and digitising. Geographic analysis was conducted on an IBM RISC System/6000 and on a UNIX Operation System. The global universal transfer mercator (UTM) was used for map projection.

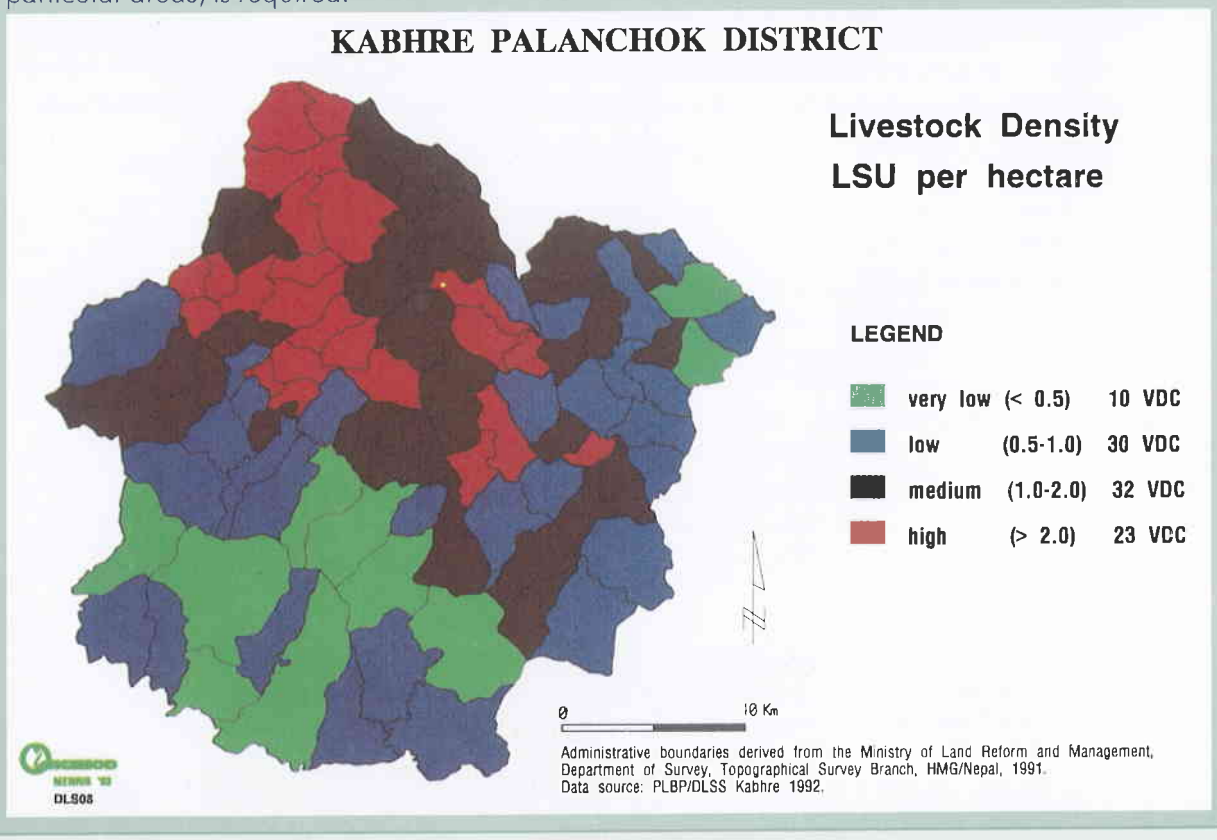
Results

Analysis: The analysis of the feed situation showed that there is an overall feed deficit of about 50 per cent in the district and that the northwestern and eastern Village Development Committees are most affected.

Prognosis: Efforts should be made to reduce the district's livestock population and to increase their productivity by using different management options.

Analysis: Almost all livestock service centres are located in areas where livestock density is a major problem. Despite the mountainous terrain, farmers have access to livestock service centres within two hours in most of the critical areas.

Prognosis: An infrastructure for extension services has been established, but an integrated approach that can bring varied knowledge and skills to the farmers, on the basis of the specific conditions of particular areas, is required.



used to develop alternative strategies for decision-makers to address complex and highly multi-dimentional problems. Contrary to the conventional approach, these tools enable the compilation of multi-sectoral spatial data and their presentation in a reasonably understandable map format.

With the advent of modern satellites, considerable data on the Hindu Kush-Himalayan (HKH) region's natural resources are now available. Satellite data are essential for monitoring the dynamically-changing resource base. Advances in satellite image processing and computer analysis have made it possible to evolve a realistic, accurate, and uniform database to facilitate the decision-making process.

The recent breakthroughs in information technology and advanced GIS/RS research are providing new ways of facilitating strategic planning for environmental and development issues.

Hurdles in the Use of GIS and RS

Despite technological advancement of GIS and RS, their dramatic declining costs, and improved 'user-friendly' software, the potential benefits of GIS have not been fully exploited. The use of GIS and RS must involve awareness of the limitations of not only the available data but also the understanding of environmental processes and the technology in use. Given such awareness, these technologies can prove valuable for descriptive, analytical, and evaluative purposes. In the HKH region, it is not always the technological hurdles that prevent successful GIS implementation but other limiting factors, e.g., data access and exchange, data standardisation, deficient institutional frameworks, complex topography, and lack of trained manpower.

Data Access

Yet another limiting factor to implementing GIS is the lack of appropriate and accurate base maps to serve as a basic input to GIS. Unnecessary restrictions limit their use. The policy in this respect should be rational, keeping in mind the pace in modern trends, without compromising the specific needs of individual countries.

Data Standards

One of the key issues facing GIS usage today is the absence of acceptable standards in the region. GIS can only benefit if accuracy and accessibility of information are standardised. Beyond the technical aspect of data sharing and compatibility issues, there is also a need for institutional arrangements, both within the individual countries and within the region, to facilitate mutual sharing of data. The ultimate goal should be to develop national and regional GIS capabilities with appropriate networks interlinking them.

Three-dimensional GIS Issues

The current GIS technology is basically two dimensional, and there is difficulty in modelling the truly three-dimensional aspects of mountain regions. The other issues related to mountain environments are those of geographic and economic marginalisation, as well as difficult access.

Institutional Issues

One of the major issues facing the region is lack of awareness, among decision-makers and planners, that the GIS technology is no longer a luxury, but rather an essential tool for management of natural resources and environmental problems and all decisions concerned with the use of space. This awareness should be increased. Surprisingly, awareness among user groups in the region concerning the potential benefits of GIS technology is lacking due to the distance and remotness of user groups.

Lack of coordination amongst institutions, deficient institutional frameworks, and lack of financial support are some of the main problems facing the implementation of GIS.

Box 2: Land Cover Assessment and Monitoring in Pakistan Using Remote Sensing Technologies

Together with UNEP's Environment Assessment Programme for Asia and the Pacific, ICIMOD carried out a macro-scale land cover assessment and monitoring exercise in Pakistan in 1996. Despite the limited resources and time frame, as many parameters as possible have been taken into account. Some of the data are as old as 10 years and facilitate the comparison of old and new data and might be helpful in ascertaining the physical changes occurring in land-use patterns.

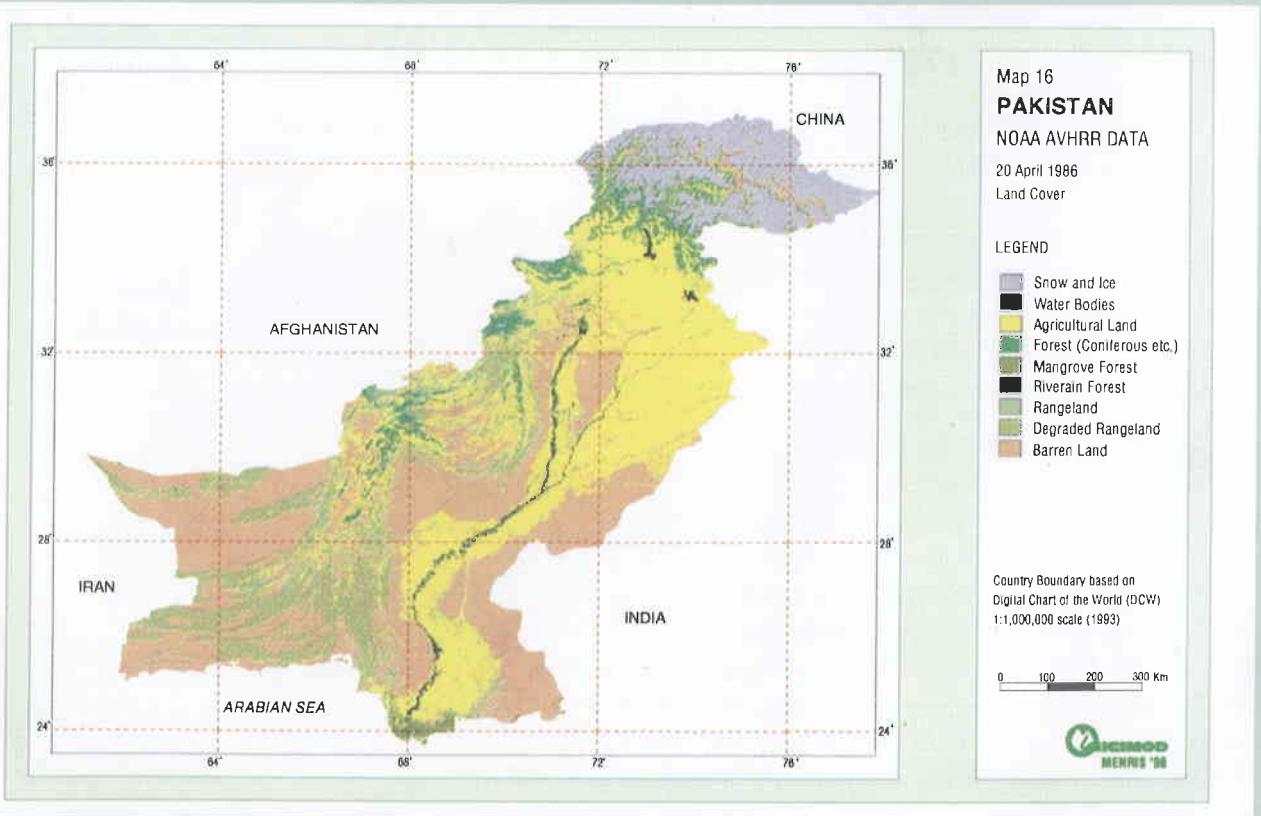
The source of information used in this report is digital data derived from the NOAA AVHRR LAC format node, with a 1.1 km spatial resolution acquired during ascending node (13:30 LST).

Results

Six major biomass types encompassing a variety of ecosystems could be recognised for Pakistan, including the northern Areas (see Table). Varying degrees of disturbances, imbalances, and degradation dominate most of the forest areas. Subsistance agriculture, fuelwood collection, and grazing practices seem to be the dominant features of degradation, both quantitatively and qualitatively. Land area under snow and ice, water bodies, and wastelands are some other features derived from NOAA imagery.

Land-use Categories in Pakistan

Land-use Category	Area	Percentage
Snow and Ice	8,563	10.4
Agriculture	25,184	30.7
Rangelands	8,867	10.8
Rangelands: degraded	7,843	9.6
Coniferous, Scrub and other Forests	2,730	3.3
Riverine Forests including non-forest vegetation	1,801	2.2
Coastal Mangrove Forests	556	0.7
Water Bodies	93	0.1
Wastelands including Deserts	26,394	32.2
Total	82,031	100.0



Training and Placement Issues

GIS is still a novel tool in many organisations. There is a lack of trained manpower to take on GIS responsibilities. One issue often encountered in the region is the non-utilisation of the skills acquired during training, owing to inappropriate placement of personnel on return from training and the absence of an appropriate infrastructure to support further study or work. Also, the universities have not yet introduced GIS/RS courses into the curricula.

Along with the active participation of partner institutions and their willingness and ability to adopt GIS/RS technologies for planning processes, a clear paradigm shift at the institutional and policy levels is a must for the successful implementation of GIS in the region.

The Need

Today, it is widely accepted that the introduction of information technology, in general, and GIS, in particular, can offer opportunities for improved decision-making and lead to more effective and less wasteful administration. The success or failure of GIS implementation are mainly attributed to an organisation's inherent receptivity and ability to sustain the development of innovations such as GIS.

Our experience shows that there are several factors (listed below) that can be attributed to the success of GIS implementation which are indigenous as well as exogenous.

- Training and awareness for all levels of users: decision-makers, professionals, and technical personnel
- Close collaboration between data users and data providers: hardware/software vendors, national survey departments, national and regional data holders, etc
- Capacity-building and institutional strengthening through training, provision of hardware/software, collaborative case studies' development, and database compilation and development
- Simple applications producing information fundamental to the work of potential users
- Awareness of and vision to adopt modern technologies
- User-directed implementation involving the participation and commitment of all the stakeholders in the project
- A large measure of stability in the organisation and its personnel or, alternatively, a collective ability to cope with change

A stronger and active network is required to serve as a mechanism to bridge the gap between users, end-users, and data providers.

For many organisations, successful GIS implementation may remain an impossible dream unless far greater consideration is given to the organisational and human dimensions. Although implementation is recognised as the sole responsibility of the participating organisations, ICIMOD can play a catalytic role in this respect by focussing on its two mandatory functions: training and advisory services.

ICIMOD's Role

In the process of implementing an integrated approach to development and environmental management in mountain areas, ICIMOD, through its Mountain Environment and Natural Resourses' Information Service (MENRIS), serves as a resource centre for the HKH Region for the study and application of GIS and Remote-sensing technologies (see boxes 1 and 2 for examples). Its close contacts and collaboration with research institutions, space agencies, and vendors have fostered the establishment of nodal agencies in its participating Regional Member Countries as part of a GIS/RS network to serve this vast region of immense diversity.

The network encourages dialogue between professionals working in the HKH Region on a common, compatible integrated GIS platform. Sharing public domain data and information on analytical problems is encouraged, thus bridging the data gap. A regional mechanism has been sought for pooling resources, expertise, and facilities for and work on common problems in the HKH region for the mutual benefit of participating regional member countries through a network of collaborative institutions using a decentralised approach.

MENRIS promotes GIS/RS technologies to facilitate improved decision-making through the provision of a spatial framework in the HKH region. More specifically, MENRIS focusses on capacity building, institutional strengthening, and information exchange and dissemination.

The **partnership initiative** is designed to extend the functional capabilities of national institutions by developing mutually-supportive relationships. These relationships focussed initially on training and dissemination of GIS/RS. Ultimately, MENRIS seeks to develop a robust, productive GIS/RS environment to attain the common goals of an accurate information base which can then be used for management and monitoring of the natural resource base and the environment in the region and, in the long run, fully integrate with the national and local planning and monitoring process.

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MENRIS
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Further Readings

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Established in 1983, ICIMOD is dedicated to the cause of poverty alleviation and environmental conservation in the Hindu Kush-Himalayan range of Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. ICIMOD is a focal point for documentation and information exchange, training, applied research, and demonstration on a wide range of issues affecting mountain people.

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