Harmonised Land Cover
Understanding natural resources dynamics

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Land cover is one of the most important and easily detectable indicators of changes in ecosystems. Land cover links social and physical environments, and changes in land cover can directly impact on biodiversity, and alter ecosystem services and livelihood support systems. Socioeconomic drivers can induce changes in land cover, disrupting the socio-cultural practices and institutions associated with managing natural resources and increasing the vulnerability of people to climate change. Analysis of land cover provides information about landscape patterns and their changes, which is useful in the assessment of human induced drivers and their impacts on the ecosystem. Therefore, land cover assessment and the monitoring of its dynamics are essential to the sustainable management of natural resources, environmental protection, and food security.

Typical land cover types in the mountain landscape

Need for harmonisation

As it has been recognised that information on land cover is a fundamental data layer, many efforts have been made in land cover mapping at global and national levels. Satellite images are the primary data source for both small and large-scale land cover mapping. The availability of satellite images at varying spatial scales and from different sensor types has greatly facilitated these efforts. However, differences in methodology and in the definition of land cover classes have produced land cover maps that are nice to look at, but that generate more ambiguity. Although comparison shows reasonable agreement among the land cover datasets at the global level in terms of total area and general spatial pattern, agreement is limited with regard to the spatial distribution of the individual classes. When we zoom into these global datasets at regional and national scales, the agreement is seen to be significantly decreased in many cases, and the differences in the definition of land cover classes become more prominent.

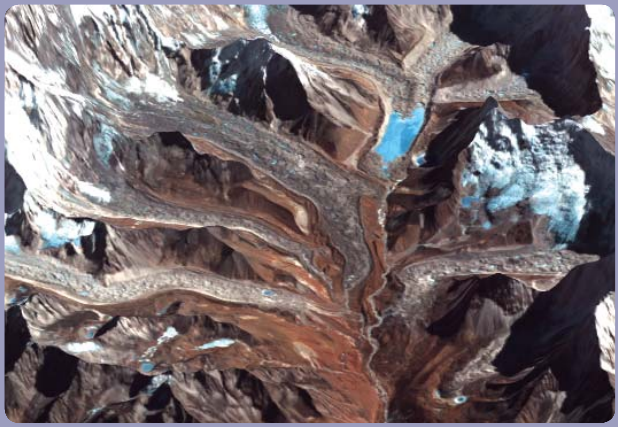
The definition of classes is one of the major issues with land cover databases. A study by the Food and Agriculture Organization of the United Nations/Global Land Cover Network (FAO/GLCN) identified more than 300 definitions of forest worldwide. The land cover classifications vary greatly from one country to another in terms of the definition of classes in addition to differences in spatial disaggregation and resolution. This variability creates challenges in the study of land cover dynamics, as the data available for different time slices are not sufficiently logically and spatially consistent for them to be compared scientifically. The heterogeneity of datasets limits their flexibility and efficiency in serving the multitude of potential applications.

With climate change and the need for homogeneous land cover data across the region for change analysis, the importance of harmonisation has become all the more evident. ICIMOD – which has been preparing land cover maps at national and sub-national (watershed) levels for many years, defining the classes to meet project requirements – collaborated with FAO/GLCN in the Regional Harmonization Programme (RHAP) to build a consensus at the regional level on the development of a harmonised and standardised system of land cover classification. A number of regional and national level workshops were organised involving developers and users of land cover data. Legends were discussed in the national context of each country and then defined using the Land Cover Classification System (LCCS) developed by FAO and the United Nations Development Programme (UNEP). In the LCCS, a land cover class is defined by a set of independent diagnostic attributes or classifiers, and the amount of detail in the description of a land cover feature is linked to the number of classifiers being used. The two-phase design, with the initial dichotomous phase and the modular-hierarchical phase, results in a land cover class defined by a Boolean formula showing each classifier used, a unique number for use in the geographic information systems (GIS), and a name, which can be the standard name as supplied or a user-defined name. The classifiers are categorised as pure land cover classifiers (life form, height, and so forth), environmental attributes (altitude, climate, landform, and so forth), and specific technical attributes (floristic aspect, crop type, and so forth). The process is further facilitated by the LCCS software, which is free and systematically guides users through the steps of defining the legend.

Understanding land cover changes over decades

Land cover change study is one of the most common applications of remote sensing. The emerging issues of climate change have made these studies all the more important. It is through the study of historic and recent

Figure 1: **Imja glacier as seen in a Corona image of 15 December 1962 and as ASTER image of 1 February 2006**

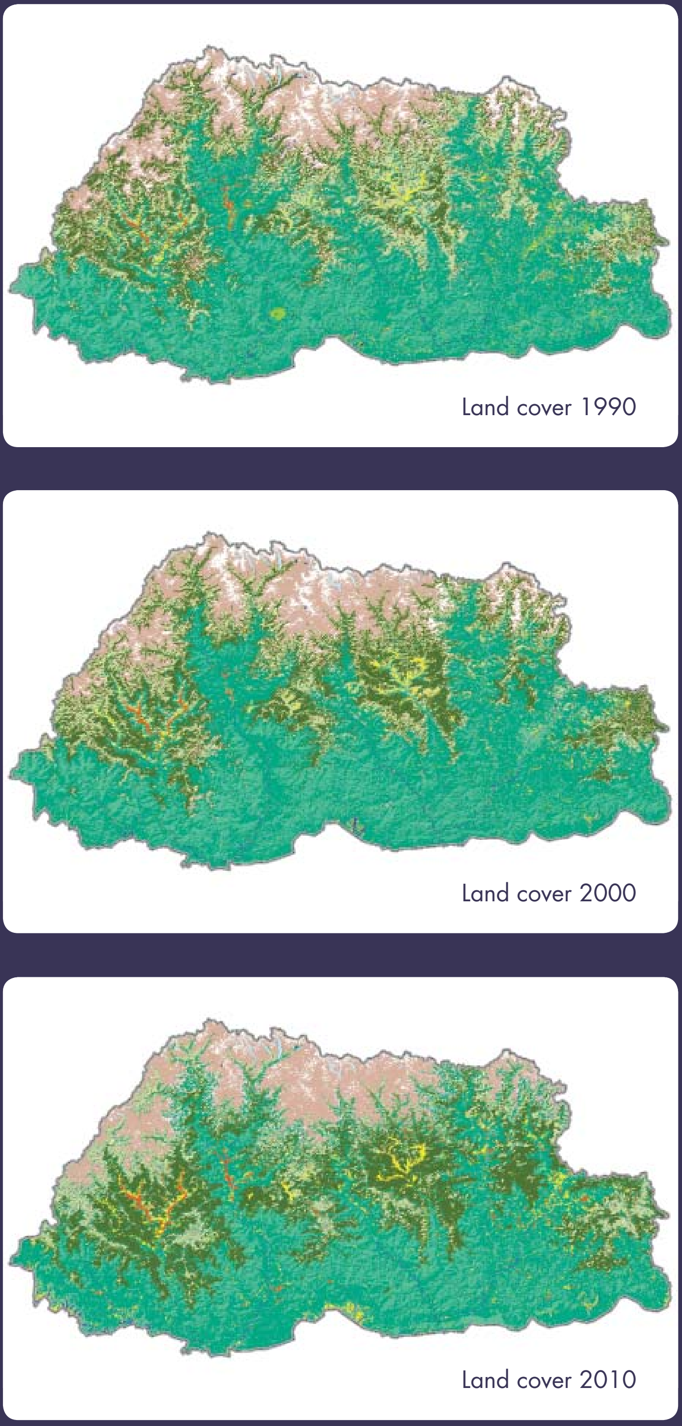


satellite data that the retreat of glaciers in the Himalayas was revealed (Figure1). While the changes in the cryosphere show the natural impact of climate change, the changes in vegetation and other land cover at lower altitudes reflect changes because of anthropogenic processes. To understand the overall changes in the Hindu Kush-Himalayas (HKH) over the past decades, ICIMOD initiated the development of land cover data for 1990, 2000, and 2010 using uniform data, legends, and methodology across the countries of the HKH (see Figure 2 for an example). LandSat™ images were classified using knowledge classifiers and object based image analysis. Data from previous field studies were used for ground-truthing. Partnerships with national institutions have been a key strategy, and professionals from these institutions with extensive field experience were involved in the classification process. These data will provide spatially explicit insights into the changes that are taking place and help in identifying the key location-specific drivers. Such information will be very useful in investigating socio-cultural and institutional issues and coming up with better policies for climate change adaptation.

Dissemination of land cover data

The investment in developing time series land cover data is justified by their potential use in a multitude of applications. However, making these data available to a variety of users, from researchers to managers and decision makers at all levels, is vital. ICIMOD has been working under SERVIR-Himalaya, an initiative supported by the United States Agency for International Development (USAID) and the National Aeronautics and Space Administration (NASA), to develop web-based tools to provide access to these data in a meaningful and user friendly way. Under this initiative, land cover data for different dates with change maps and statistics in charts and tables will be accessible by district or protected area for intuitive visualisation. Easy access to such information will encourage wider use and the integration of land cover change information into diverse studies related to climate change and adaptations.

Figure 2: **Land cover map of Bhutan at three points in time**



Conclusion

Land use and land cover is evolving as a fundamental source of information for the study of ecosystems. The availability of uniform time series data on land cover over the last two decades will be a great asset for understanding the dynamics and underlying drivers for change. Initiatives for harmonisation and uniform methodology have helped in generating awareness and building consensus among different stakeholders, who will be the ultimate beneficiaries of this information base. A more important step is to make these data easily accessible to all. This will facilitate wide use and provide opportunities to obtain feedback from users for the refinement of the data. These initiatives can be considered as fundamental steps towards creating a better information infrastructure for climate action.