

Information series on geographical information and remote sensing systems in mountain environments

Geographical information and remote sensing systems play a special role in the Hindu Kush-Himalayan region in support of informed decision making. This series of information sheets presents information on basic technologies, approaches, and applications related to geographical information and remote sensing, and used or developed by ICIMOD, as a background for understanding for policy makers, development workers, and others.

Forests provide many goods and services. They provide economic and social benefits such as employment and income from timber, fuelwood, and non-timber products including fodder and food (berries, mushrooms, nuts, fruit), and protection of sites of cultural value. They also play a vital role in the conservation of ecosystems. Forests maintain water quality and regulate water flow, and they can prevent or reduce the severity of floods, avalanches, erosion, and drought. They are the world's most important carbon sinks, storing more carbon than the oil reserves. Forests continuously remove carbon from the atmosphere through photosynthesis, a process which converts atmospheric carbon to organic matter. However, deforestation is now returning this stored carbon to the atmosphere at an estimated rate of 5.9 gigatonnes CO₂ per year.

Improved knowledge on the extent of forests and on any changes taking place is important for evaluating many of the multiple roles of forests. Accurate information on the changing status of forest carbon stocks is especially important in order to address issues of deforestation and introduce measures to reduce or reverse forest loss. This means being able to estimate the amount of biomass in the forest.

Remote sensing for REDD

Above-ground biomass estimation for carbon stock

Remote sensing and above-ground biomass

Different approaches have been used to estimate the above-ground biomass in forests, including field measurements, remote sensing, and modelling based on the use of geographic information systems (GIS). Given the amount of forests and their often remote location, comprehensive field measurements are likely to be impractical. Thus during recent decades, approaches using remote-sensing data have become increasingly popular. According to the Good Practice Guidance published by the Intergovernmental Panel on Climate Change (IPCC) in 2003, remote-sensing methods are very suitable for independent verification of carbon pool estimates of above-ground biomass in relation to land use, land-use changes, and forestry. However, ground-based data collection is also necessary.

Estimation of forest biomass in three watersheds in Nepal

Estimation by ground measurements

An ICIMOD project trained local forest users to carry out ground-based measurements that would be acceptable for use in assessments under programmes for reducing emissions from deforestation and forest degradation (REDD). ICIMOD selected community-managed forests in three watersheds in

Nepal, one each in the mountain district of Dolakha, the hill district of Gorkha, and the Terai district of Chitwan. A participatory GIS approach was used to delineate the boundaries of the community forest areas. Members of the forest user groups collected data such as tree diameter at breast height (DBH), crown diameter, tree height, geographic coordinates, and slope aspect.

At the same time, the project aimed to develop a methodology to verify these carbon stock measurements using remote sensing. The project emphasised capacity building of user groups and national stakeholders.

Estimation and mapping using remote sensing

High-resolution GeoEye-1 (0.5 m) satellite images were acquired for the biomass estimation and mapping. A differential global positioning system (DGPS) was used to assess the positional accuracy of the satellite imagery. Land cover classification was carried out in the three watersheds using object-based image analysis (OBIA). The land cover maps were used in planning and to identify sample plots for the field measurements.

The methodology for calculating carbon stock baselines from the remote sensing images was developed in close coordination with the International Institute for Geo-information Science and Earth Observation (ITC-Netherlands). First, crown projection areas (CPA) for individual trees were extracted from the high-resolution satellite images. Then biomass and carbon stock were calculated for individual trees using a general regression equation derived for moist tropical forests. These data were used to derive linear regression models for CPA to biomass and CPA to carbon stock. These models can be used to estimate and map biomass and carbon stock through satellite images.

Conclusion and way forward

Scientifically robust estimates are needed for monitoring, reporting, and verification for implementation of REDD-plus projects. The methodology described here is concerned

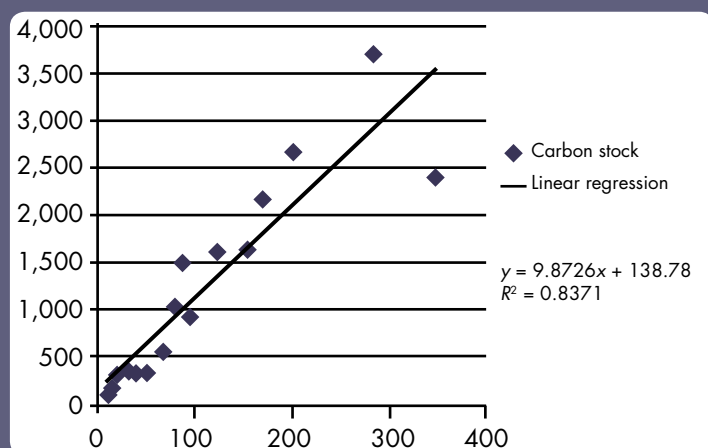


with accurate local-level carbon estimates that can be used as a basis for REDD calculations for small forests, especially those managed by communities. The method needs to be further refined for different tree and forest types and different conditions. Although intermittent field verification will always be necessary as an ongoing measure of quality control, the method offers a way of estimating carbon stocks and verifying estimated change on a forest scale, even in remote and poorly accessible areas.

New technology such as airborne laser scanning (LiDAR) has recently been introduced in Nepal for more accurate and quantitative measurement of three-dimensional forest attributes. The national forest resources assessment (FRA-Nepal) has included the two pilot watersheds studied in the present initiative in their survey, which will enable these new techniques to be used to further refine the remote sensing based methodology.

The Department of Forests of the Government of Nepal has also prepared forest carbon measurement guidelines to bring uniformity to measurements and supporting mechanisms for carbon trading. The guidelines include both field-based and remote sensing based approaches, and will help to institutionalise these methodologies further in the national context.

Relationship between crown projection area and carbon stock using a linear regression equation



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