Banko Janakari

A Journal of Forestry Information for Nepal

National Land Cover Monitoring System for Nepal

The progress of a country depends on how it is using modern technology in monitoring and management of its resources. Earth observation science and machine learning algorithm are one of the most fascinating modern technologies used for monitoring of natural resources and their management planning. These technologies acquire information on different phenomena on earth without making physical interaction with the ground. Such information enables us to construct meaningful evidence for decision making regarding management of natural resources on earth.

Nepal has a long history of preparing national land cover maps, especially forest cover map for national reporting and providing baseline information for decision making. The first attempt of forest cover mapping was made during the forest inventory in 1960, whereas the first detailed land system mapping was carried out in 1986 by the Land Resource Mapping Project (LRMP) using aerial photographs. Similarly, the Department of Survey of the Government of Nepal has published a topographical map of Nepal based on aerial photographs. In addition, the Department of Forest Research and Survey developed a forest cover map of Nepal in 2010. The Forest Research and Training Centre (FRTC) is now implementing the Ecosystem and Forest Type Mapping Program, which aims at developing updated maps of forest types and ecosystems in Nepal. One of the drawbacks of our mapping efforts is that none of the land cover products are comparable due to inconsistencies in the baseline data, i.e. satellite imagery, methodologies, and classification systems used for mapping.

As party to the United Nations Framework Convention on Climate Change (UNFCCC), Nepal needs to prepare the Land Use and Land Cover (LULC) information as per the guidelines of the Intergovernmental Panel on Climate Change (IPCC) to estimate GHG emissions/removals. The comparable periodic or annual land cover maps provide information on land cover changes that is required for international reporting and informing national, provincial and local level policies related to land use, including forest management and GHG emission reduction plans.

In this context, the FRTC, in collaboration with ICIMOD, has recently developed a National Land Cover Monitoring System (NLCMS) that gives accurate annual land cover information of Nepal between 2000 and 2019. Mapping and monitoring land cover using satellite data is highly challenging, especially in high mountain areas, due to shadows and inaccessibility for field data collection. However, this challenge was overcome using the Landsat 4–5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+)

and Landsat 8 Operational Land Imager (OLI) sensor satellite, launched by NASA. The annual land cover maps have been generated using primitive approach. Notably, Landsat data is available free of cost.

Since July 1972, satellites in the Landsat program have been imaging our planet's landmasses at a particularly useful scale that shows us both natural and artificial changes. Landsat is the only satellite system that has recorded Earth's land–surface conditions for over four decades. It is a surprise that users can find much more historical Landsat data than ever before in the Landsat archive at the U.S. Geological Survey's Earth Resources Observation and Science Center.

Besides, all the Landsat images can be analyzed using Google Earth Engine (GEE) applying the machine learning algorithm following various Landsat specific processing methods. Specifically, there are methods to compute at–sensor radiance, top–of–atmosphere (TOA) reflectance, surface reflectance (SR), cloud score and cloud–free composites. With the support of the SERVIR–HKH, FRTC was able to generate national–level land cover maps for Nepal without massive downloads of Landsat images, and an online land cover application system has been prepared.

Land cover results show that the primary land cover in the country is forest, followed by cropland and grassland. These three classes cover about 80% of the country's area. The results show that forests covered 40.01% of the total area of Nepal in 2000, 41.15% in 2010, and 41.72% in 2019, whereas Other Wooded Land (OWL) covered 3.57% in 2000 and 3.62% in 2019. The Foreshores and OWL together covered 45.34% of the total area of Nepal in 2019. Data show that agricultural land is decreasing.

Quality assured reference data is vital for the NLCMS development. Reference data are collected from the field. Additional reference data are collected using Collect Earth Online (CEO) software. Through free–of–cost cloud–based software, the CEO enables users to access satellite imagery to efficiently collect up–to–date data about their environment, monitor landscape changes over time, and use data to implement and enforce conservation policy. An intuitive, web–based interface enables multiple users, including students and members of the public institutions, to contribute to image analysis and data collection.

The capacity building, sustainability, information sharing and technology exchange were considered while developing the NLCMS. Therefore, the system was co–developed by the FRTC in collaboration with ICIMOD and international experts through the SERVIR–HKH programme. National stakeholders were engaged to define the land cover classification systems to ensure widespread use of the product. The algorithm was implemented in GEE using python and a few scripts to make the system consistent and transparent for any land cover analyst. The use of GEE helped to analyze a large number of Landsat satellite images for Nepal without downloading them. The NLCMS is expected to be useful for monitoring land–based resources continuously in future.

Raja Ram Aryal
Assistant Remote Sensing Officer
Forest Research and Training Centre