MONITORING FOREST RESOURCES USING REMOTE SENSING DATA

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ABSTRACT

Space borne remote sensing data has been used in Nepal for forest cover estimation as well as change detection. Detailed forest mapping particularly forest types classification is not satisfactory in the mountainous regions due to the rugged terrain, scattered forest patches, macro and micro climatic variation, seasonal variation in vegetation, selective felling of trees and agro-forestry practices. However in the plain areas (Terai region) the result is satisfactory. Recently countrywide forest types mapping was completed. Seven forest classes including shrub area were separated along with other land cover classes. Multi temporal remote sensing data has been analyzed to monitor the condition of forests of Sunsari district. Landsat TM data of 1991 and 1999 were used to find the change detection in forest areas.

1. INTRODUCTION

Satellite remote sensing data has been used in Nepal since past two decades in specified areas with limited application. Forestry sector is one of the main application areas where this technology has been using from the beginning. In Nepal forest resources is one of the main renewable natural resource. Until 2/3 decades back a statement “Green forest, Nepal's wealth” was so common that every primary school children were aware on the statement. As time changes, these days no one repeat this statement. That statement is removed from the curricula. This means depleting of forest resources is so rapid that, if present rate of deforestation (1.7%) continue there will be only 19 % of forest cover remained by 2020, which was 38 % in 1978, and 29 % in 1994. The share in national revenue from forestry sector is gradually decreasing.

Nepal’s forest land is gaining tremendous pressure from cultivation, new settlement, infrastructure development, fodder, fuelwood and timber collection. Realizing much more pressure on forest land, government of Nepal has been emphasizing on community forestry programme where local users are solely responsible to manage and utilize the forest resources. Forests are the bulk storage of greenhouse gases. Loss of forest land means releases of storage greenhouse gases. In Nepal, forestry and landuse change alone contribute about 85% of national account of greenhouse gases emission. Total CO_2 emission from landuse change and forestry sector in 1994 was about 8.1 million tones. Therefore forest cover monitoring is very important and essential not only to assess the impact of community forestry programme but also to set the programme and policy on bio-diversity conservation as well as environmental and ecological balance. Satellite remote sensing is one of the viable techniques to monitor the changing pattern of forest cover.

In spite of the tremendous use of the satellite data, there seems some limitation on use of the satellite data in Nepal’s perspective.

2. STATUS OF USE OF SATELLITE DATA IN FORESTRY SECTOR IN NEPAL

Satellite remote sensing technology opens both the opportunity and challenges in the forestry sector in Nepal. Satellite remote sensing data has been used to obtain the forest cover, forest cover change, and other forest statistics information combined with forest inventory data. Other application areas are wildlife habitat mapping, soil and watershed management and various researches. Loss of forest biomass is also linked with carbon dioxide emission. In Nepal, mostly used satellite data are Landsat TM, IRS, ADEOS, SPOT etc. Since, Nepal doesn't have own receiving station, to obtain the data, we should rely on the foreign receiving stations and satellite owners. Bangkok station only covers eastern Nepal whereas Indian receiving station covers the whole country.

Usually users want cloud free and shadow free data for the optimum use. But these two things cannot go together in the context of Nepal. Satellites are designed in such a way that, they cross the mapping frame in late morning (around 10 o'clock). At that time sun elevation is still low and high mountains still have long shadow particularly in winter season where there is more chance to get the cloud free data. The best season in Nepal, to get the cloud free data is the winter (November to February). This means there is more chance to get the cloud free data but with severe shadow. Satellites have the revisit cycle of about two weeks. Relying on the self experience at least one year time period is required to get the cloud free data of the whole country of a particularly satellite.

The importance of satellite data in Nepal is increasing. Users or researchers very often want to know existing situation of landuse/land cover of a particularly area. The simplest way to get the information is from the satellite data. But not all have the enough budgets to purchase the data or required systems to processes the data. In the context of Nepal, data holding organizations are providing value added product of satellite data to those interested users or researchers, although there is lack of clearly defined mechanism for data dissemination.

Satellite data are still very expensive. Developing country cannot allocate enough budgets to purchase the satellite data and the other cost. Government budget do not get the priority to purchase the data. Considering the Nepal's situation, satellite data have been purchased with the financial support of donor agency. Some countries that have own satellite have also provided the data free of cost for the research purposes. Considering these facts, the cost of data/information is beyond the bearable capacity for the general users or researchers. This limits the usability of the data in spite of the huge potentiality of the data itself.

In Nepal, most of the terrain is more or less hilly. With low sun elevation angle, topography causes a lot of variation and shadows. There are several methods to reduce the topography effect in the satellite image. Normalisation is one of them. The basic idea of the method is that original radiation values of the image are corrected. After successful correction, the image represents radiation values of the image taken when the sun is in nadir. In the method, a Digital Elevation Model is needed. At present there is lack of good DEM covering the country. However, Survey Department has produced digital contour data in topographic sheet wise. But creating DEM from these contours will be another major task considering time and money.

Nepal forest land is scattered throughout the country in varying scale. Due to the rugged terrain, steep mountain, agro-forestry practice causes erroneous classification of land cover classes. In the hilly area of the country, farmers conserve or plant fodder or other beneficial trees species in their farm land so that separation of different types of vegetation is particularly challenging. Shrub land is very much confused with farm trees or other vegetation. Nepal's almost all forest area is natural forest. This means there is heterogeneity in forest distribution. Small forest patches scattered everywhere in rugged terrain makes difficult to separate forest, shrub and farm trees or crops correctly. Some natural vegetation is seasonal. In the high mountain areas some plants grow after snow melting. These areas are very remote and very difficult to collect training samples, which are needed for image classification. Road networks are almost lacking in high mountains areas. Therefore, image classification also needs knowledge of seasonal variation of natural as well as cultivated vegetation.

3. FOREST TYPES CLASSIFICATION USING SATELLITE DATA

Although there are some problems areas, forest types mapping of the country was completed recently from the cooperation of Japan Forest Technical Association (JAFTA). Altogether 12 landuse/land cover classes are separated out of which 6 classes are from forest. Shrub area is classified separately (Figure 1).

Landsat TM and IRS 1D satellite data are used to classify the forest types. The Data were acquired from 1998/1999. Limited field samples were collected from those areas where road and air services are available. Altitude information is also included to separate the high altitude forest types with the low altitude forest types after classification. Field knowledge is also included to separate mixed classification. Besides the forest types other land cover classes are classified satisfactory. More refinement is still needed to improve the map. The map is useful in terms of aerial distribution of different forest types. Table 1 shows the different forest types and other land cover classes.

Land Covers Classes	Area (sq km)	Percentage
Shorea robusta (sal) forest	6025.2	4.1
Tropical Mixed Hardwood	7154.2	4.9
Lower/Upper Mixed Hardwood	19323.4	13.1
Chir Pine	8129.0	5.5
Blue Pine	5517.3	3.7
Fir/Hemlock	8805.3	6.0
Shrub/Grass	12822.0	8.7
Agriculture Land/Grass	40582.1	27.6
Trees	1032.9	0.7
Water bodies	645.8	0.4
Bare land	16826.5	11.4
Snow	19734.3	13.4
No Data	582.9	0.4
Total	147181	100

Table 1: Areas of Different Forest Types and Land Cover Classes in 1999 (with limited field verification)

4. A CASE STUDY OF SUNSARI DISTRICT

Sunsari district is one of the densely populated districts situated in the south-eastern part of the country. Total area covered by the district is 1257 sq. km. and total population is 625,633 according to 2001 population census. During the decade of 1991 to 2001, the population growth rate per annum in the district is about 3.5 %, which is, much more than the national average (2.1%). In-migration in the district from the nearby hilly district is the main cause of the population growth. The district is divided into 3 municipalities and 49 Village Development Committees as the lowest administrative unit. High population growth rate directly influences the existing forest resources in the district. The district has the comparatively good shape of forest compare to the other nearby district but this is also deteriorating very rapidly. Major dominant species in this district is shorea robusta, which is also a highly demanded hardwood species.

A case study was recently completed to see the changes in the forest area in the district. Multi temporal satellite data were used to see the changes. Thematic Mapper data of 17 December 1991 and 10 March 1999 were used in this study. False colour composite images of 1991 and 1999 are showing in the figure 2a and 2b respectively.

The satellite images were classified into different land cover classes (Figure 3a and 3b) and image differencing is applied to obtain the change detection (Figure 4). Table 2 shows the major land cover areas for the years 1991 and 1999 and the differences. It revealed that, between this period forest land is still decreasing at the rate of 0.8 % per year.

Land Cover	Areas in 1991 (ha)	Areas in 1999	Change
Water body	2,384	3,249	865
Forest land	20,911	19,608	-1,303
Bare land	5,982	7,263	1,281
Grass	3,392	3,012	-380
Agriculture/other land	93,688	93,224	-464

Table 2: Major Land Cover areas and the change from 1991 to 1999

However, there is heavy pressure on the natural forest (government managed forest), but there are also significant areas of private plantation, which is appeared in the false colour composite images. Dalbergia sissoo is the main plantation species in the farmland, road and canal side plantation. Realizing the importance of community support to protect the forest resource, government of Nepal has also extended community forestry programme in the Terai districts. Present policy in the community forestry programme is that fringe area of forest near by the settlement is being handed to the local users as the community forestry programme. From the field observation, it is learned that since the past few years back community people are taking sole responsibility to manage, protect and utilize the forest resources. But there is still illegal tree felling and smuggling from those areas, which is outside the community forestry programme. Unemployment, accessible forest area, political disturbances, and lack of awareness are the main causes of the forest area depletion.

5. CONCLUSION

Remote sensing technology is very useful for the mountainous countries like Nepal, where there is lack of road networks and difficult terrain condition. Land cover information can be easily detected by analyzing the remotely sensed data. In forestry sector, there are also problems areas due to the severe shadow, topography, and vegetation composition. Applying detailed digital elevation model can minimize the problem areas.

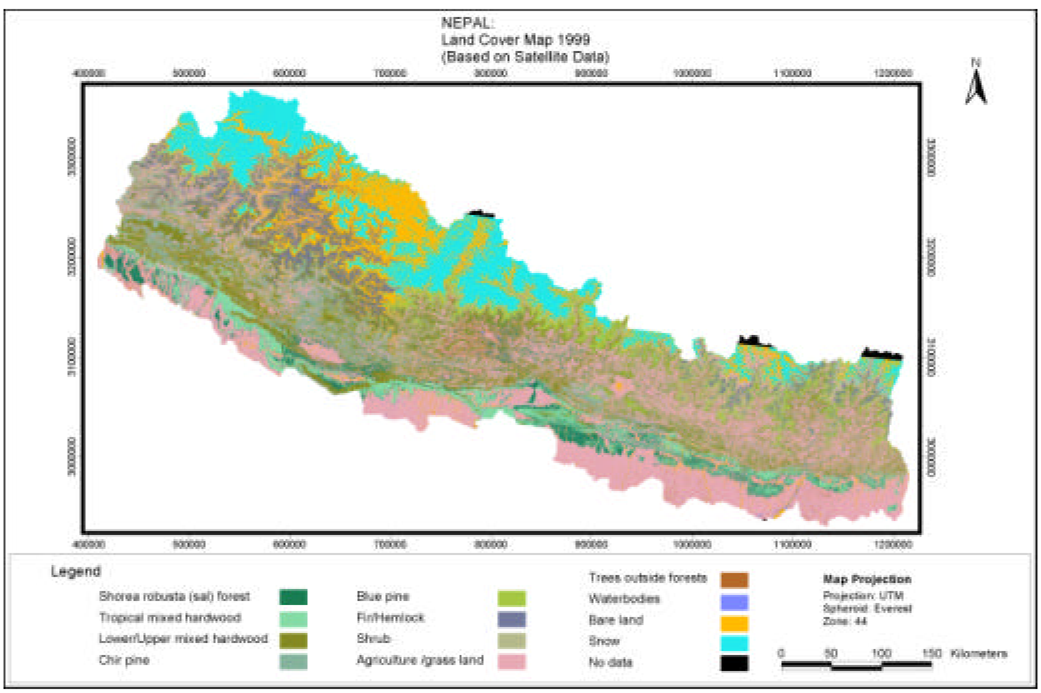

Figure 1: Forest Types and Land Cover Map of Nepal

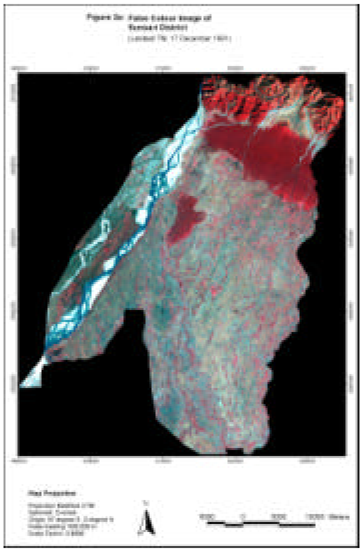

Figure 2a: False Colour Image of Sunsari (1991)

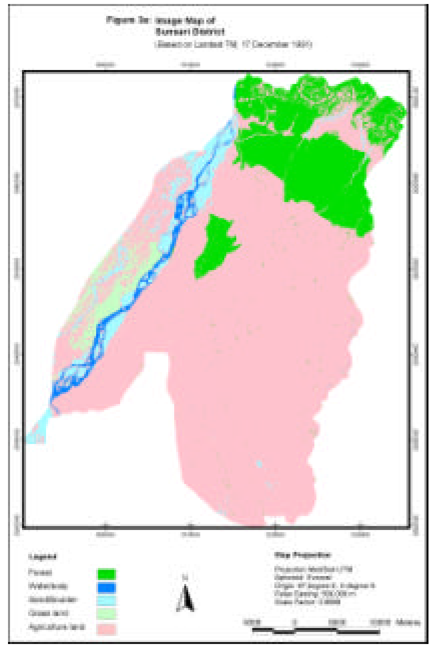

Figure 3a: Land Cover map of 1991

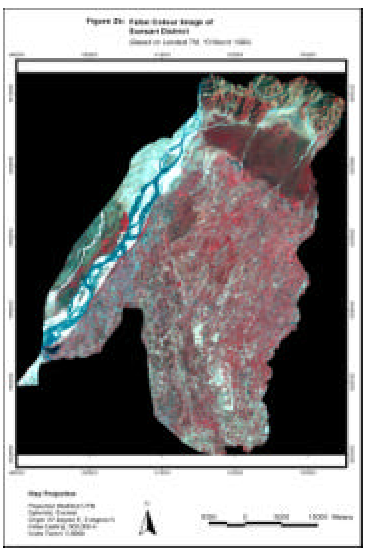

Figure 2b: False Colour Image of Sunsari (1999)

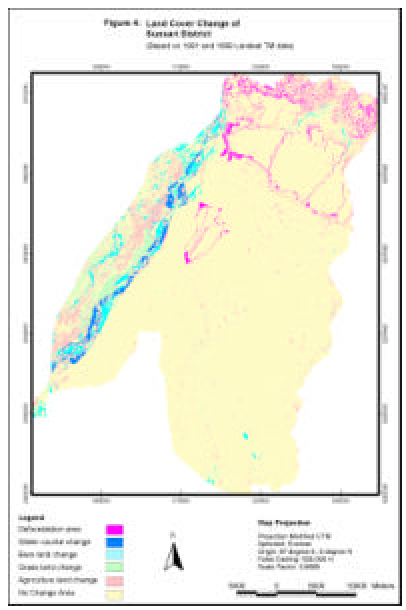

Figure 4: Deforestation and Land Cover Change from 1991 to 1999

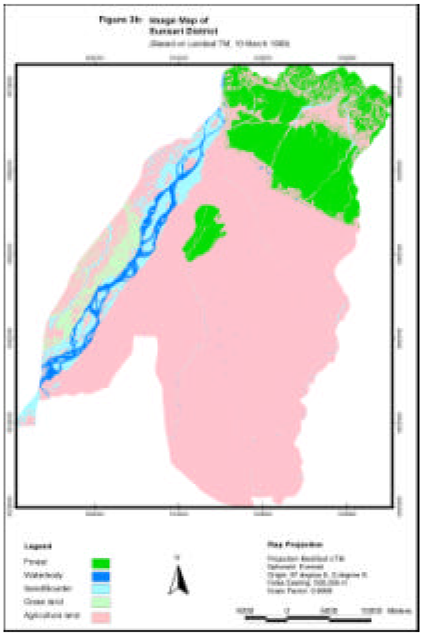

Figure 3b: Land Cover Map of 1999

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