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LAND USE LAND COVER DYNAMICS OF NILGIRIS DISTRICT, INDIA INFERRED FROM SATELLITE IMAGERIES

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ABSTRACT

Land use Land cover changes are critical components in managing natural resources especially in hilly region as they trigger the erosion of soil and thus making the zone highly vulnerable to landslides. The Nilgiris district of Tamilnadu state in India is the first biosphere in Western Ghats region with rare species of flora and fauna and often suffered by frequent landslides. Therefore in this present study land use land cover dynamics of Nilgiri district has been studied from 1990 to 2010 using Satellite Remote Sensing Technique. The temporal changes of land use and land cover changes of Nilgiris district over the period of 1990 to 2010 were monitored using LISS I and LISS III of IRS 1A and IRS-P6 satellites. Land use dynamics were identified using Maximum likelihood classification under supervised classification technique. From the remote sensing study, it is found that during the study period of 1990 to 2010, area of dense forest increased by 27.17%, forest plantation area decreased by 54.64%. Conversion of forest plantation, Range land and open forest by agriculture and settlement leading to soil erosion and landslides. Tea plantation increased by 33.95% and agricultural area for plantation of vegetables increased rapidly to 217.56% in the mountain steep area. The accuracy of classification has been assessed by forming confusion matrix and evaluating kappa coefficient. The overall accuracy has been obtained as 83.7 and 89.48% for the years 1990 and 2010 respectively. The kappa coefficients were reported as 0.80 and 0.88 respectively for the years 1990 and 2010.

Keywords: Land Use Land Cover, Remote Sensing, Classification, Kappa Coefficients, Overall Accuracy

1. INTRODUCTION

Hill range ecosystems are consistently experiencing land use and land cover changes due to natural and manmade activities (Agarwal *et al*., 2002). Land use land cover changes are important in the context of bio-diversity, ecological stability and economic development of the regions (Jennifer *et al*., 2010; Ram and Kolarkar, 1993; Bisht and Kothyari, 2001). These changes have been affected by human activities with reference to the needs of society's cultural and physical needs throughout the world. Land use and land cover change has become more important for managing natural and monitoring environmental changes (Lambin *et al*., 2001). Land use dynamics influence the climatic change and the climate-related impacts such as Green house gas regulation, genetic and species diversity and biodiversity (Chase *et al*., 1999). Conversions of these Environmental factors are based on the land use land cover. Replacement of natural forest by settlement, agriculture is often occurring land conversion due to the human destruction of forest and associated with extensive use of land for agricultural production for livelihood systems. These

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changes affect the vulnerability of human and location to climatic and economic changes (Armentaras *et al*., 2003; Laurence, 1999; Noss, 2001; Turner *et al*., 1995; Mugagga *et al*., 2012; Vitousek, 1994). It is evident that the Global environmental changes are mainly due to land use land cover changes detection and is very useful inputs to decision makers for implementation of policy made at regional, natural and global levels for appropriate direction (Bilsborrow and Ogondo, 1992; Verburg *et al*., 1999). This study assess the land use land cover using LISS I and LISS III of IRS 1A and IRS-P6 satellite data for land use classification based on maximum likelihood classification. Numerous ground truth data were collected from the field for land cover changes between 1990 and 2010. The accuracy assessments by kappa coefficient using confusion matrix we also performed.

Natural hazards such as Landslides are triggered in the mountainous regions where hectic changes in land use and land cover. It is learned from the history that the causes of landslides are anthropogenic factors, conversion of natural forest to agricultural and settlement and coupling with intense rainfall induce landslides in the Nilgiris district which emphasis on land use land cover pattern changes.

1.1. Study Area

Nilgiris is one of the oldest mountain ranges, located at the tri-junction of Tamil Nadu, Kerala and Karnataka and it is a part of Western Ghats. Nilgiris is India's first biosphere and it has been declared as one of the 14 hotspots of the world because of its unique bio-diversity. Nilgiris is situated at an elevation of 900 to 2636m above Mean sea level. There are Eight Hydel power house in this district which increases the significance of the study area. The total area extends around 2593 km^2. The area lies between $11^0 8'$ N to $11^0 15'$N latitudes and $76^0 13'$E to $77^0 2'$E longitudes. The monthly average rainfall in this district is 94.20 mm. In the months of June, July, September, October and November, receives a rainfall that is more than the annual average rainfall. The district has the highest average number of rainy days with 7.3 days per month, mean maximum average temperature of 20.7°C, mean minimum average temperature of 9.6°C and mean relative humidity maximum of 76.9% and minimum of 75.8%. In the previous history, landslides were pre-dominantly occurred mostly in Kallar to Coonoor road stretch.

1.2. Data Acquisition and Preparation

LISS I and LISS III data were used to determine Land use land cover with a classification procedure. Geometric correction was preformed over the both of the images. In order to study the long term variation of land use land cover changes in the study area 1990 IRS-1A imagery (Path 26, Row60 with spatial resolution of 72.5 m) and 2010 IRS-P6 imagery (Path 099, Row 65, with shift 25% with spatial resolution of 23.5m) have been used. The month acquisition of both images were (24th Jan 1990 and 6th Feb 2010) kept almost same to get maximum accurate land use land cover dynamics with Four Spectral bands of Blue, Green, Red and IR. Survey of India (SOI) topo sheets of the year 1972 of 1:50,000, 1:25,000 scales were used to generate base layers of boundaries, water bodies, forest area and built up area. Numerous field data were collected with a handheld GPS Leica G5+. Google Earth data (http:earthgoogle.com) were used for the validation of pre and post classification results.

2. MATERIALS AND METHODS

2.1. Maximum Likelihood Classification

The Maximum likelihood classification is the most common supervised classification method used in remote sensing data of digital image classification (Richards, 1999; Strahler, 1980; Conese and Maselli, 1992; Ediriwickrema and Khorram, 1997; Bayarsaikhan *et al*., 2009). This classification type has become popular and assumes that the statistics for each class in each band are normally distributed and calculate the probability that a given pixel belongs to a specific class. Each pixel is assigned to the class that has the highest probability threshold. If the highest probability is smaller than a threshold specified, the pixel remain unclassified. Maximum likelihood classification performed according to discriminant functions for each pixel in the image Equation (1):

$$g_i(x) = \ln P(w_i) - \frac{1}{2}\ln\left|\Sigma_i\right| - \frac{1}{2}(x - m_i)^t \sum_i^{-1}(x - m_i) \quad (1)$$

Where:
gi(x) = Discriminant functions
$P(w_i)$ = Prior probabilities

$|\Sigma_i|$ = Covariance matrix of data in class w_i

2.2. Accuracy Assessment of Land Covers Classification

In this study, the most commonly used accuracy assessments such as over all accuracy; user's accuracy; producer's accuracy and a kappa co-efficient were adopted in order to get better classification results. Accuracy assessments were obtained from the confusion matrix which shows the classification result by comparing with ground truth information of land use land cover data. The overall accuracy of the classification was determined based on ground truth region of interest. Region of Interest were divided in to two groups, one is for classification procedure and another one is for accuracy Assessment. Confusion matrix reports the overall accuracy, user's accuracy, producer's accuracy and a kappa co-efficient. The kappa co-efficient (Equation 2) suggested by (Jenson, 1986; Congalton, 1991; Stadelmann *et al*., 1994; Foody, 2002; Skidmore, 2002; Choen, 1960; Lillesand and Keifer, 1972; Lunetta *et al*., 2002; 2004; Shao and Wu, 2008) was used in the accuracy equation of this study:

$$k = \frac{N\sum_k X_{kk} - \sum_k X_{k\Sigma} X_{\Sigma k}}{N^2 - \sum_k X_{k\Sigma} X_{\Sigma k}} \qquad (2)$$

Where:

$\sum_k X_{kk}$ = Sum of the confusion matrix diagonals

$\sum_k X_{k\Sigma}\ X_{\Sigma k}$ = sum of the ground truth pixels in a class time the sum of the classified pixels in that class summed over all classes

N = Total Number of pixels in all the ground truth classes

3. RESULTS

3.1. Land use Land Cover Classes

Considering the study area and having prior knowledge of its land use pattern, the following land form classes have been identified and furnished in **Table 1**. Based on these classes scheme with maximum likelihood classification technique, two supervised classification images were prepared for the study area of the year 1990 and 2010.

4. DISCUSSION

4.1. Change Detection

The classified images of long term land use and land cover dynamics for the years 1990 and 2010 has been given in **Fig. 1 and 2** respectively. The results of this change detection study reveals that the requirement of land for the developmental activities has been increased significantly which support human livelihood needs such as orchard, tea plantation, agricultural area (vegetation) and water bodies. Built-up area had increased from 152.65 km^2 to 156.75 km^2 from 1990 to 2010, which recorded an increase of 2.68% during the study period due to social and other economic reasons.

From the classification it is learnt that, water bodies had increased from 19.49 km^2 in 1990 to 68.84 km^2 in 2010, which recorded an increase of 49.35km^2 (253.21%) for this period. In Nilgiris district, dense forest was 479.01 km^2 in 2010, a considerable increase of 27.17% as compared to 1990. Compared to other land cover types Forest plantation area decreased rapidly from 421.88 km^2 to 191.35 km^2 (7.38%) for the period 1990 to 2010. Orchard area increased from 157.67 km^2 (6.08%) to 241.57 km^2 (9.32%) which is about 53.21% of a total area of Nilgiris.

Table 1. Land use land cover classification types defined in this study

S. No.	Class	Descriptions
1.	Built up land	Areas populated with residential, commercial and industrial
2.	Dense forest	Land cover of canopy density of 70% and above
3.	Forest plantation	Artificially established forest distinguish from natural forest by the tree being Planted in straight lines
4.	Orchards	Area cover with fruit trees
5.	Range land	Natural landscape in the form of grass land, shrub lands
6.	Open forest (Shoals)	Area cover of canopy density between 10% to 40%
7.	Tea plantation	Area cover with tea plants
8.	Vegetables	Area planted with vegetable plants
9.	Water bodies	River, Lakes, ponds and Reservoirs

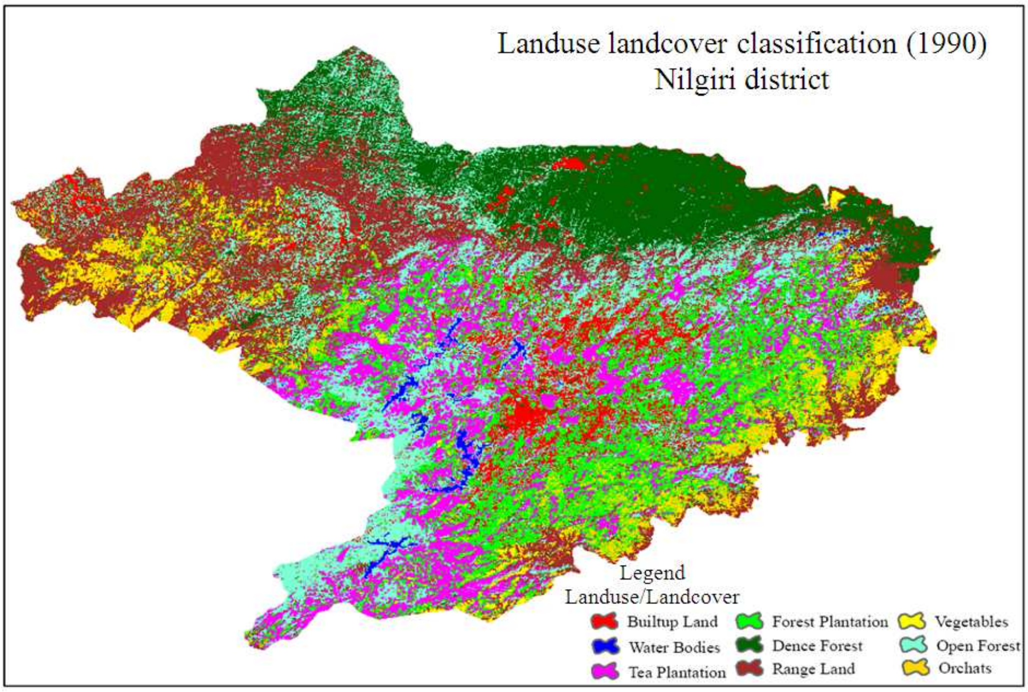

Fig. 1. LULC Classification Image of the year 1990

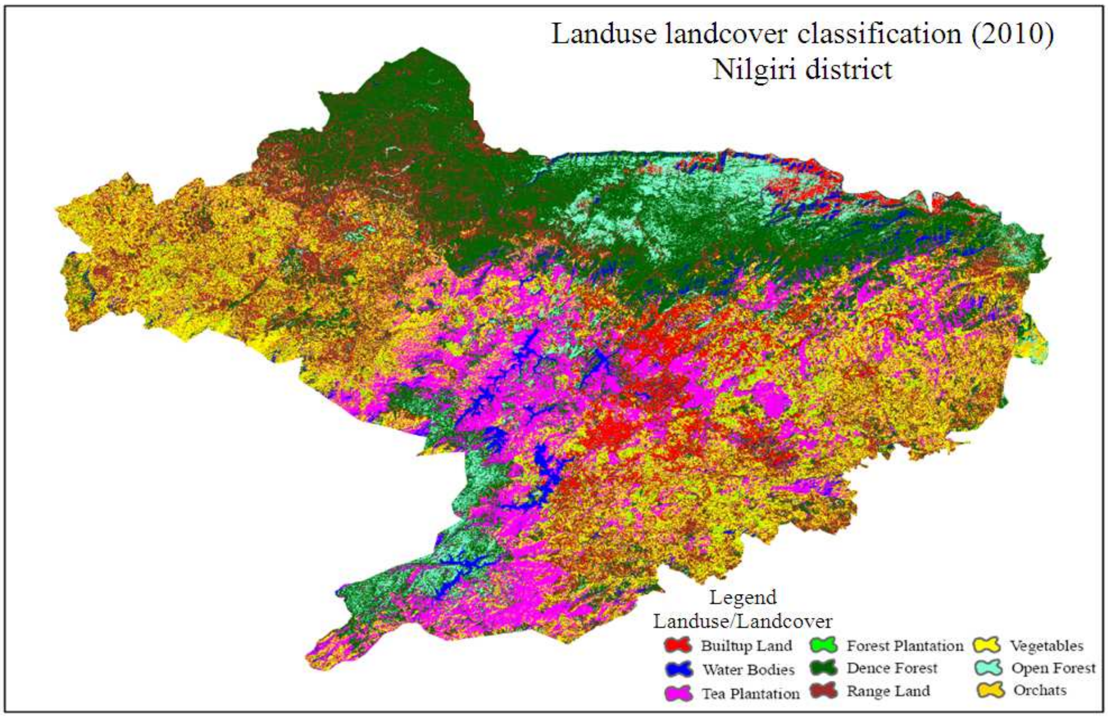

Fig. 2. LULC Classification Image of the year 2010

Fig. 3. Comparison of the land use land cover classes of 1990 and 2010 by percentage of study area

Table 2. Comparison of Producer's accuracies and user's accuracies for the year 1990 and 2010

Class name	1990 Producer's accuracy (%)	1990 User's accuracy (%)	2010 Producer's accuracy (%)	2010 User's accuracy (%)
Water bodies	69.12	82.82	100.00	100.00
Tea plantation	90.72	78.02	82.34	77.79
Range Land	79.07	88.21	90.47	94.67
Vegetation	91.97	77.76	81.21	81.21
Dense forest	81.78	85.90	85.27	85.27
Orchard	72.56	80.08	76.60	94.40
Forest plantation	89.44	89.44	95.97	99.47
Built-up Land	81.37	76.38	88.59	82.33
Open forest (Shoals)	88.86	78.08	100.00	87.87
Overall classification accuracy	83.74		89.48	

Decreasing trend also observed in the case of range land as it had reduced from 607.34 km^2 to 499.82 km^2, a reduction of 17.70%. Open forest area decreased by 31.38% from 1990 to 2010. Area under vegetable cultivation increased from 62.68 km^2 to 199.05 km^2 during the study period. This is due to the increased demand of vegetation every year for human needs. The comparison of land use dynamics of the years 1990 and 2010 is given in **Fig. 3**.

4.2. Accuracy Assessment of Classification

Accuracy assessment has been carried out by comparing the classified images with ground truth region of interest by conducting field reconnaissance. The land cover found in the field is compared to that mapped in the classified image for the same location by means of confusion matrix. The total number of pixels comprised of all the land use classes selected per image was 13770 and 13233 for the years 1990 and 2010, respectively. Then, producer accuracy and user accuracy were determined for each classes and the same is tabulated in **Table 2**. The overall accuracy was estimated relatively high, showing the values of 83.74% and 89.48% for the years 1990 and 2010.

5. CONCLUSION

In this study, land use land cover dynamics of the Nilgiris District for a span of 20 years (1990 to 2010) has been determined with the help of satellite imageries. From this study, is evident that the man-made activities such as agriculture; Tea plantation; built-up area had shown a considerable increase which shows the interruption in the natural eco system. This will enable the study area vulnerable to the natural phenomenon like soil erosion and mass land slip and requires effective and intensified land management system. As many factors which influences the classification of satellite imagery into land use land cover maps and the acceptability of classified imagery purely depends on overall accuracy of the confusion matrix formed out of ground truth region of interest. As the overall accuracy level achieved in this classification study were 83.74% and 89.48 for the years 1990 and 2010 authenticate the acceptable level of accuracy. As a conclusion, for regional level land use land cover analysis, remote sensing tool can be effectively used with support of ground truth to acceptable level of accuracy.

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