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FUTURE PREDICTION OF LAND COVER IN DEVIKULAM TALUK, KERALA

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ABSTRACT
Land Cover of the Earth is undergoing significant transformation due to natural and human induced interventions. Information about land use change is very essential for planning, monitoring and management of natural resources. Prediction of natural and social causes of land cover change through spatially explicit models is made possible by GIS and other computer based techniques which can define and test relationships between environment and social variables using a combination of existing data, observations on the ground and the data from remote sensing. This study is proposed with an objective to inventory various land cover classes in Devikulam Taluk, Kerala. With the help of temporal data sets, the dynamics of the different land use classes in the study area has also been attempted. An attempt is made to correlate each land cover class for the Land Transformation Model (LTM) developed based upon Markov and Cellular Automata. Using the developed LTM, generation of the future scenario of land cover of the study area has been attempted. This information is expected to be useful for the assessment of land cover change and plan for better land management strategies after a review of the future trends in the land cover patterns. This study shows the extent of forest area which is degraded and converted to other land cover classes.

KEYWORDS: Degradation, multi criteria evaluation, Cellular automata, western ghat.

INTRODUCTION
The amount, the rate and the intensity of land use and land cover changes are very high in developing countries. The human impacts upon the land are still very great and increasing (Rao and Pant, 2001). Land use research has grown in importance with intensification of agriculture and pressure on habitats. There has also been a progressive increase in policy interest in land use change reflecting public concern (Bunce *et al*., 1998). An analysis of the nature and rates of environmental change over recent periods is essential for a proper understanding of origin of environmental problems at the grass root level. It is also necessary to allow formulation of accurate productive models of environmental change so as to avoid future encumbrances. In this respect, information on the existing land use/land cover pattern, its spatial distribution and changes in the land use pattern is a pre-requisite for planning, utilisation and formulation of policies and programmes for making any micro and macro-level developmental plan (Mathew, 2010). A problem common in development planning is the inadequacy of information on the current land cover and available resource base. Without accurate information, policymakers often fail to make decisions or make incorrect decisions. Sound decisions depend on accurate information, yet every country and especially low-income countries face severe competing demands for the financial and human commitments necessary to staff, information system equal to its policy-making requirements (Cummings, 1977). The frequent inadequacy of land cover information may be due to difficulties in accessing some regions because of limited or failed infrastructure or civil and military disturbances; lack of trained personnel, equipment, or funds to collect information properly; or rapid changes in the resource base not detectable by traditional data collection methods such as the high rates of deforestation in many areas of the world caused by increased population pressures (Haack, English, 1996). For well over a decade rapid forest loss stemming largely from increased industrial demand for timber, conversion of forest land to agricultural use besides growing rural and urban requirements for fuel and construction wood has been recognized as one of India's most serious environmental problems. It is only in recent years; however, the Indian government has acknowledged the failure of many of the forest policies pursued since Independence to resolve this problem. However, the government has been equally slow in recognizing the implications of forest decline for India's large (and growing) forest-dependent population (Jewitt, 1995). The Western Ghats has suffered rapid deforestation in the past few decades due to large-scale conversion of forests for fuel wood, roads, and plantations of tea and coffee *etc.* Rapidly occurring land-cover and land-use changes in the Western Ghats have serious implications for the biodiversity of the region. Both landscape changes as well as the distribution of biodiversity are phenomena with strong spatial correlates (Menon and Bawa, 1997). Due to its richness and vulnerability, the Western Ghats is among the world's biodiversity "hot spots" (Myers *et al.,* 2000). Recent developments in remote-sensing technology and Geographic Information Systems (GIS) allow the use of a landscape ecology and spatial analysis approach to the problem of deforestation and biodiversity conservation in the Western Ghats. The changes in land use and land cover have profound consequences for the biodiversity and economic well-being of the people. Although change in

the Western Ghats is occurring at a rapid pace, the exact magnitude and patterns of change are not well understood. Moreover, the drivers as well as consequences of change remain unexplored (Menon and Bawa, 1997).

Modeling is an important tool for studying land-use change due to its ability to integrate measurements of changes in land-cover and the associated drivers (Lambin, *et al.,* 1999). CA Markov model in this study attempts to untangle the driving forces behind anthropogenic land use, including socio-economic and biophysical driving forces, resulting in the final prediction of land cover thematic map. As the impacts of land cover change on carbon dynamics, climate change, hydrology, and biodiversity have come up; modeling of this transformational force has become increasingly important. Given the wide variety of applications that rely on the availability of land cover projections , modeling approaches have originated from a variety of disciplines, including geography, landscape ecology, economics, biology, and others. Initial modeling was often isolated within each discipline, but multidisciplinary modeling frameworks were developed as land cover modellers began to integrate the socioeconomic and biophysical components of land cover change (Sohl and Sleeter, 2011).

STUDY AREA

Devikulam Taluk is located in the southern part of the Western Ghats, a region with pre-dominance of Shola forest ecosystem. Area Extends from 76°38'20" to 77°18'00" E longitude and 9°57'00" to 10°21'30" N latitude - 1800 km^2. It includes Kuttumpuzha, Kannan Devan Hills, Mannankadam, Marayoor, Mankulam, Keezhanthoor, Kanthalloor, Pallivasal, Kottakamboor, Vellathooval, Vattavada, Anaviratty, Kunjithanny (according to census of India 2001). A number of protected areas span in an around this region, including the Indira Gandhi Wildlife Sanctuary (987 km²), Eravikulam Wildlife Sanctuary (97 km²), Chinnar Wildlife Sanctuary (90 km²), Parambikulam Wildlife Sanctuary (274 km²) and several reserved forests. This region is also contiguous with reserved forests and protected areas further to the west and east. The highest peak in south India, Anaimudi 2,695 m is also a part of the range. A large proportion of this range has been set aside as protected and reserved forests due to its importance as a base for natural resources and also as the watershed of many major rivers and minor streams originating from these hills. A buffer of 10 km of the study area was taken for this study. The study area is depicted in figure- 1.

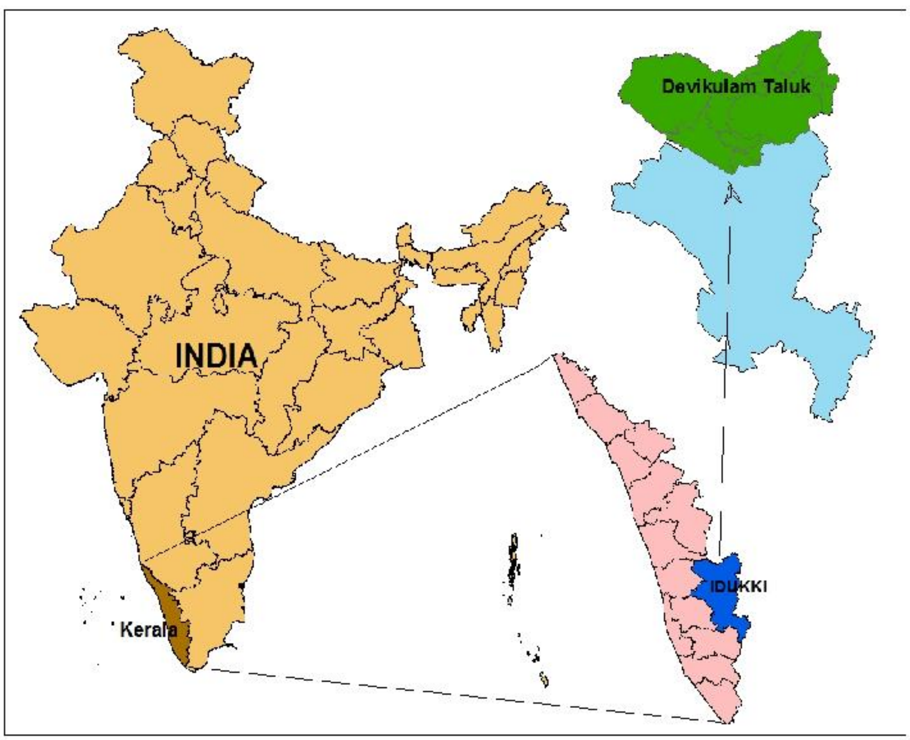


FIGURE 1: Study area.

METHODOLOGY

Cloud free data of IRS P6 LISS III satellite data of January 2000 and February 2011 covering path and row 100/66 was obtained from National Remote Sensing Agency, Hyderabad. IRS-P6 LISS-III with a spatial resolution of 24m and the spectral wavelength of four bands (B2 0.52 – 0.59, B3 0.62 – 0.68, B4 0.77 – 0.86 and B5 1.55 – 1.70µm) have been used in this study (figure 2). Prior to geometric correction satellite images were radiometrically corrected for subsequent analysis.

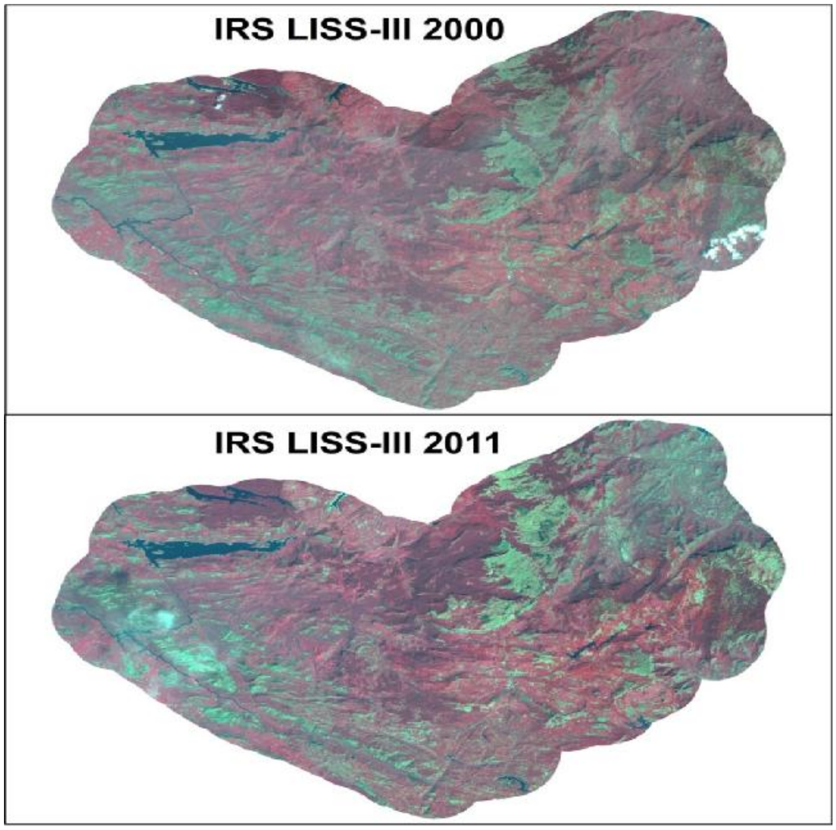


FIGURE 2: False Colour Composite (FCC) LISS -III Images

The land cover type maps of 2000 and 2010 were characterized using hybrid approach of both supervised classification technique using the maximum likelihood algorithm and then visually corrected on the basis of spectral signatures. A 10 fold classification scheme based of the major land cover types of the area was considered which include Built up, Cropland, Open and Dense Forest, Forest Plantation, Tea Plantation, Scrubland, Grasslands, Barren or rocky areas and water body. The classified land cover map was validated by ground verification. Road network was delineated with the help of IRS LISS-IV image of 2005 with a spatial resolution of 5m and toposheets of the study area. The digitally classified maps of the year 2000 and 2011 are shown in fugure -3 and 4.

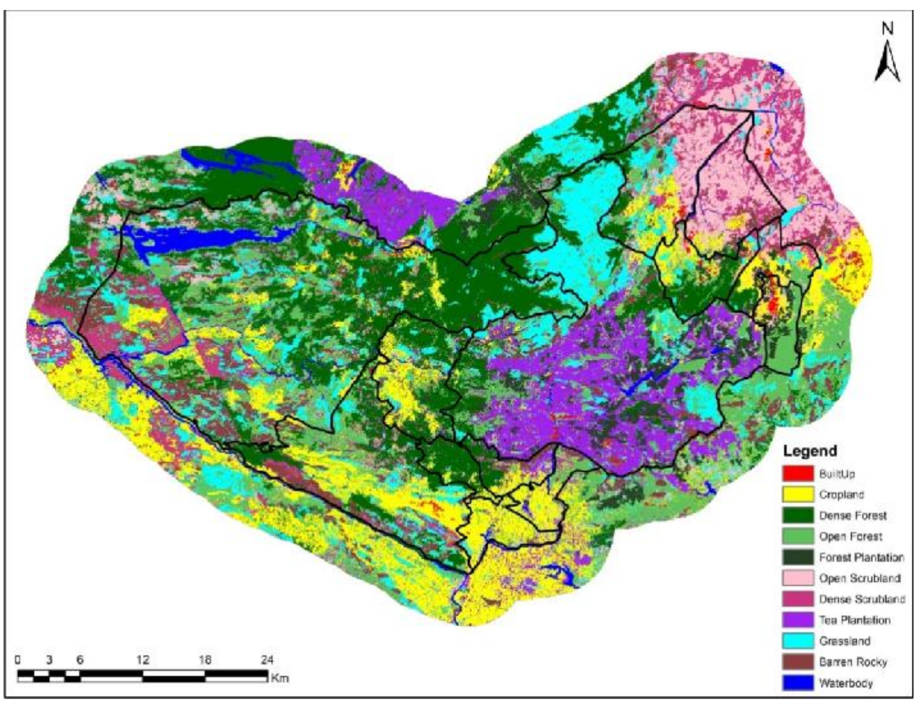


FIGURE 3: Digitally classified map of 2000

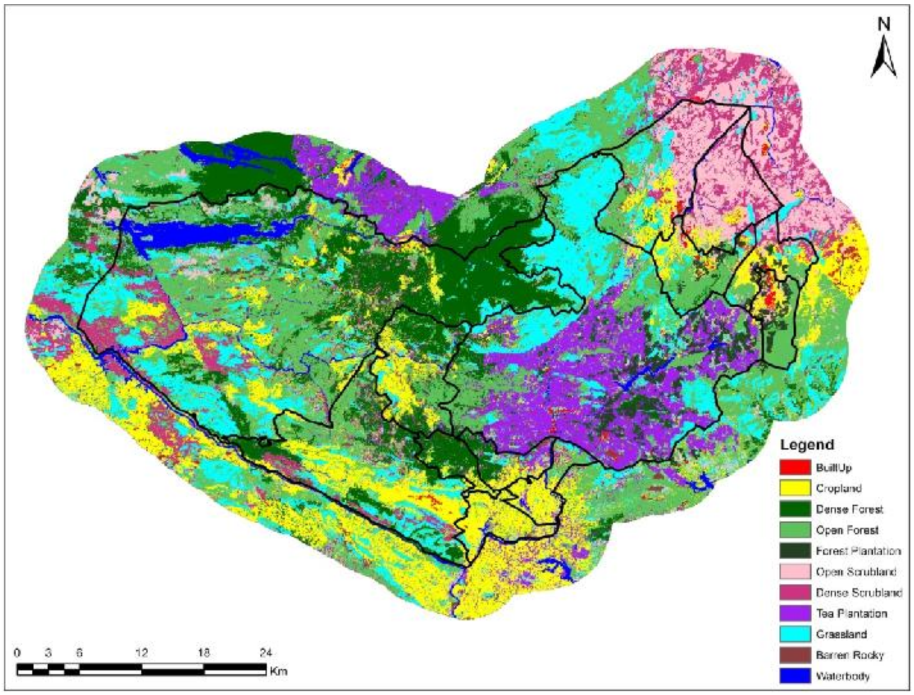
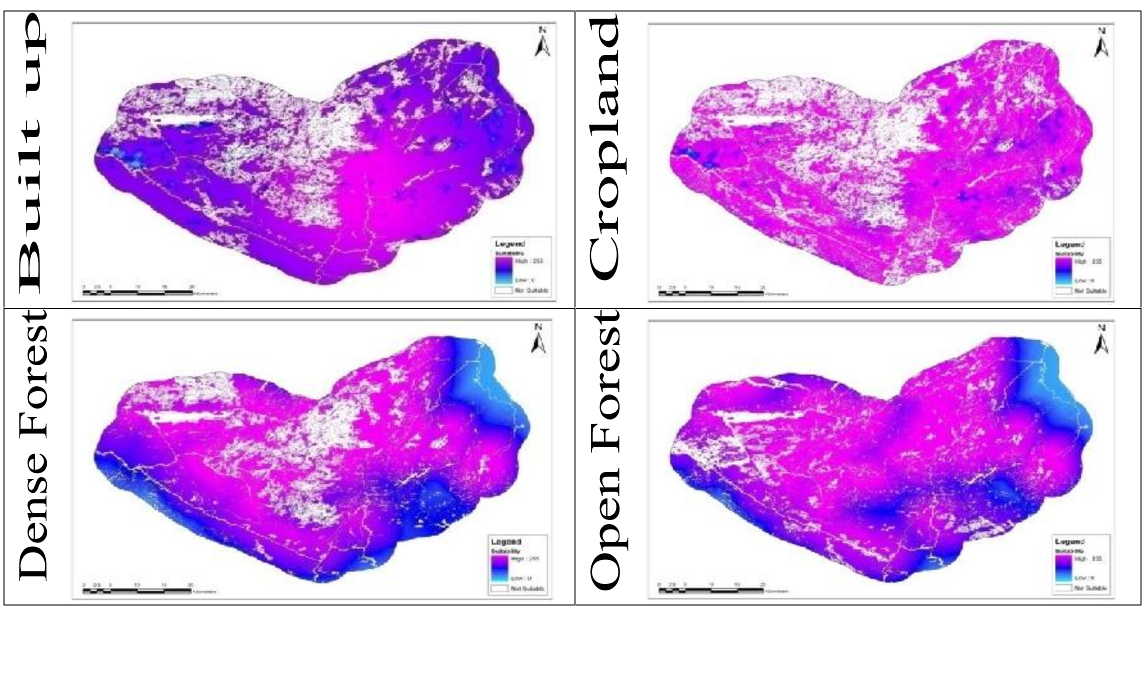


FIGURE 4. Digitally classified map of 2011

The temporal data *i.e.* the transition probability matrix and the transition area matrix were obtained as a result of Markov analysis, which is further used in the CA Markov model available in IDRISI Taiga. Markovian analysis - Transition probability matrix determines the probability for a pixel to change from one land cover class to every other class from time period 1 to time period 2. Transition area matrix determines the number of pixels which are expected to change from one class to every other land cover class from time period 1 to time period 2.

Suitability maps were generated using the multi-criteria evaluation technique wherein a combination of a set of criteria (factor and constraint) is done to achieve a single composite basis for a decision according to a specific objective. The buffer maps of each category from pixel value of 1(least likely to change) to 255 (most likely to change) were generated to form the factors for the multi-criteria evaluation. The Boolean map with values 0 and 1 form the constraint map. Each factor maps was assigned weight using the rank sum method to generate the suitability maps. For example buffer maps of built up, road, cropland, plantation, barren or rocky areas, grassland, scrubland and inverse of slope were used as factors with weights in decreasing order respectively and boolean map of water body, dense forest, slope >60% were used as the constraint, to generate a suitability map of built up class. Similarly suitability maps were generated for each land cover class (Figure - 5).



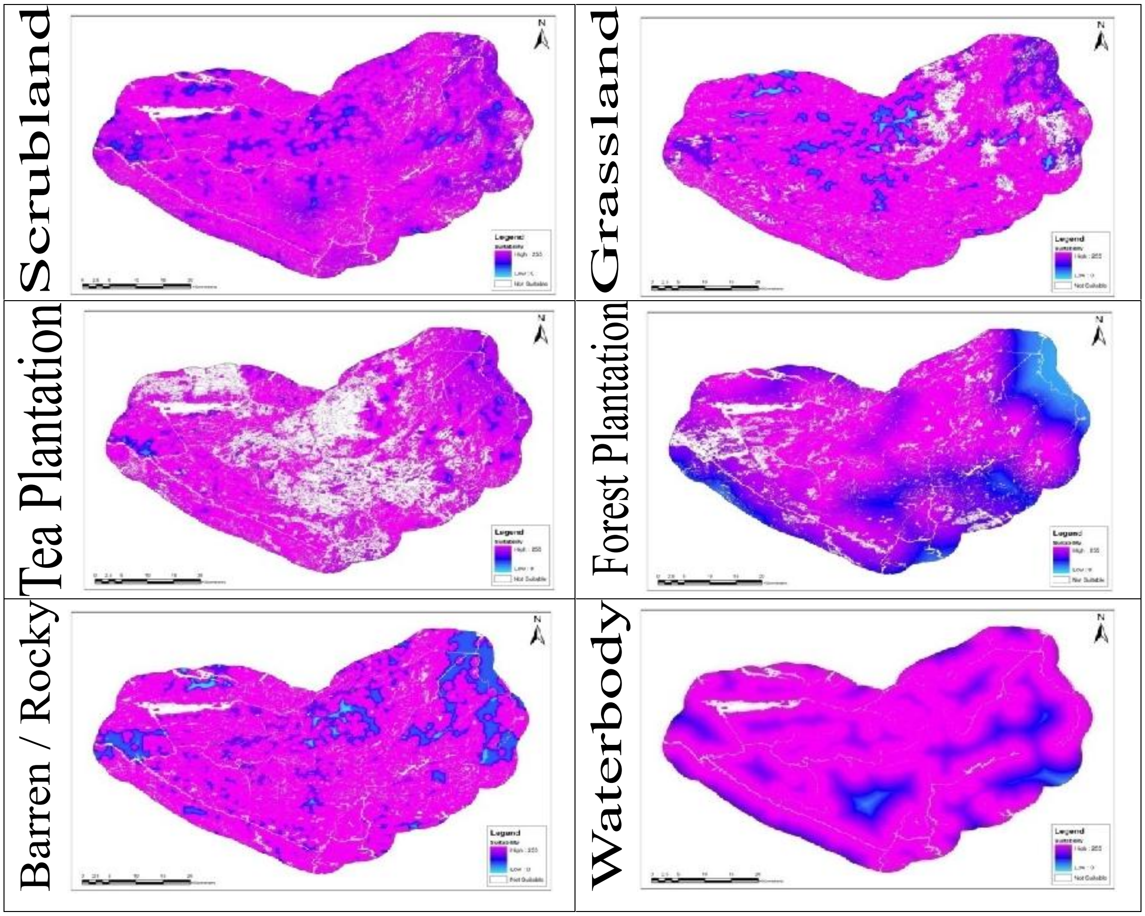


FIGURE 5: The suitability maps generated using Multi Criteria Evaluation technique.

The maps for each land cover class were compiled together and run in the CA Markov mode and the final projected land cover map of 2022 was generated.

RESULT & DISCUSSION

A trend of degradation of forest areas can be observed by this study. Rapid colonization results in conversion of forest to agricultural land and built up areas. Map of 2022 generated using CA Markov analysis, is given below as figure 6.

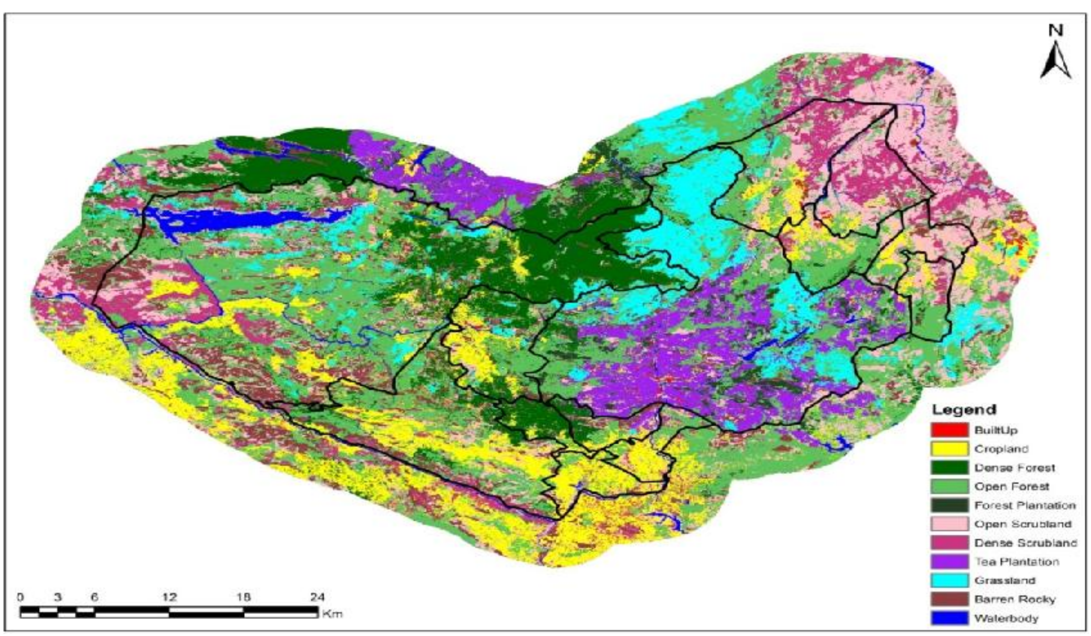


FIGURE 6. Projected map for 2022.

From the statistics it can be noted that a conversion of open forest to other land cover classes is the highest. A decrease in area from 68876 Ha in 2000 to the projected 2022 is significant. The increase in the area under plantation and cropland is also very high, which is about 37309 Ha and 35128 Ha respectively. There is an increase of 1790 Ha of built up area from 2000 to 2022, indicating rapid urbanization in relatively fragile areas.

Also, the area from open forest category is mostly converted to Plantation or cropland, from which a portion is carved out as built up area. In the case of the scrubland, there is an increase in area to 5509 Ha between 2000 to 2011 whereas there is a decrease from 2011 to the projected 2022. This is due to the suitability maps and the transition area matrix and transition probability matrix generated, where the probability of scrubland changing to cropland or plantation appears very high. There is a slight increase in barren or rocky areas of around 887 Ha from 2000 to projected 2022. The statistical output of each land cover class is also given in the table 1.

TABLE:1. Land cover Types of 2000, 2011 and predicted 2022 (Area in Ha)

Sl. No.	Land Use / Land Cover Classes	LISS – III (2000)	LISS - III (2011)	Projected (2022)	% Change in land cover from 2000 to 2022
1	Built Up	103.02	941.80	1892.74	0.62
2	Cropland	27401.00	59080.17	62529.22	12.25
3	Dense Forest	50173.00	45542.23	41253.94	-3.11
4	Open Forest	100170.98	33462.29	28954.10	-24.02
5	Plantation	38809.00	70985.01	76118.30	13.01
6	Grassland	30161.00	29871.57	30488.32	0.11
7	Scrubland	18318.00	23826.91	20583.63	0.79
8	BarrenRocky	14982.38	14067.64	15869.47	0.31
9	Waterbody	8916.38	8916.38	9004.28	0.03
Total		286694	286694	286694	

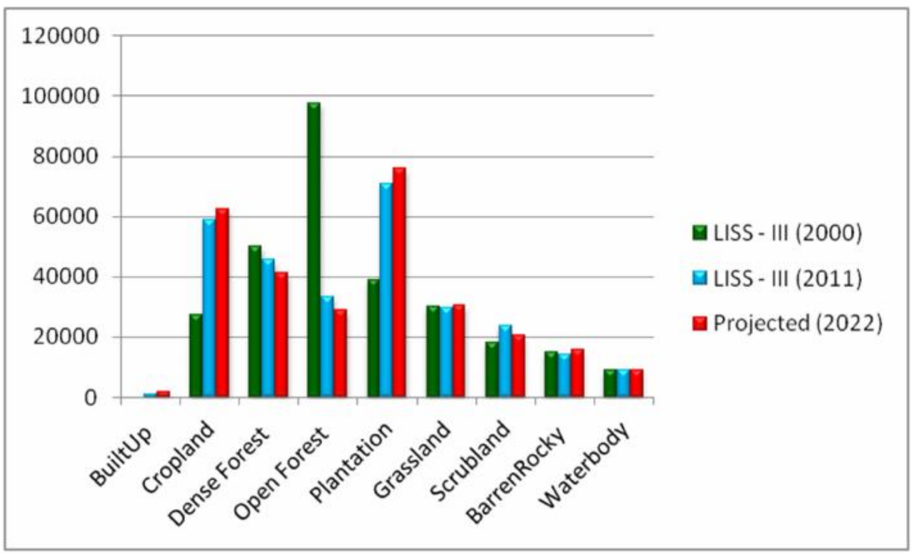


FIGURE 7: Graph showing the comparison of land cover classes over the three time periods

Validation of the projected land-use and land cover status for 2022 although is an important task, it could be ideally validated at a later stage after the emergence of the situation as on that date (Houet and Moy, 2006).

CONCLUSION

Western ghat is one among the world's hotspots and should be conserved for the maintaining the overall balance of the ecosystem. Degradation of forest is happening in many areas of Western Ghats. The conversion of forest lands and protected ecosystem to other land cover classes such as cropland and plantation are not expected to be stopped until strict regulatory measures are imposed by the government to ensure full stoppage of such anthropogenic activities. This study shows the extent of forest area which has already been degraded and converted to other land cover classes. In case the same trend continues till 2022 many drastic changes can be expected. This study therefore highlights necessity for formulating policies and regulations to curb future degradation of forest.

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