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Landscape Dynamics in Protected Areas

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***Abstract*– National Park and protected areas have been identified to aid as a conservation reserve for many endemic flora and faunal species. In this regard, the government of India has designated a network of 700 Protected Areas (103 National Parks, 528 Wildlife Sanctuaries, 65 Conservation Reserves and 4 Community Reserves) to protect the biodiversity, while ensuring the sustenance of providing social, economic, and cultural and health benefits. The Western Ghats is one among 35 global biodiversity hotspots, spread across 8° to 22° N and 74° to 77° E, covers an area of 1, 60, 000 Km^2. Ecologically sensitive Western Ghats constitute <5% of India's geography and serve as carbon sink apart from providing water and food security to the peninsular India. Pivotal role in monsoon dynamics necessitates conservation and sustainable management to sustain water resources and also to minimise water conflicts. The main objective of the study is to assess the spatio-temporal changes of landscape in the National parks of Karnataka. Forests are getting degraded due to both anthropogenic (illegal encroachments, deforestation, invasion of exotic weeds, etc. coupled with unplanned developmental projects) and natural (forest fires, etc.) factors. For example, Biligiriranga Swamy Temple Wildlife Sanctuary (BRT) and Bandipur Wildlife Sanctuary have lost forest cover. Visualisation and simulation of landscape dynamics provided vital information for developing an appropriate conservation plans and implementation by involving local stake holders. The results will serve as a basis for framing the management plans in effective management of national parks and wildlife.**

Keywords*– *Western Ghats, National Parks, Biological Diversity, Land use Land cover, Modelling

INTRODUCTION

Forests are the vital ecosystems providing a wide array of ecosystem goods (food, fodder, fuel-wood, timber, manure, medicinal products, etc.) and services (carbon sequestration, etc.). Forests help in conservation of ecosystem, prevents erosions, maintain the quality and quantity of water, produces oxygen and reduces global warming [1]. Tropical forest covers only 12% of the total planet but is a home for more than half of the animal species and Earth's known plants [2]. Forest ecosystems are key components of the global carbon cycle which accounts for over 65% of the net primary production on land through photosynthesis [3]. Deforestation is one of the major driver of global warming and consequent changes in the climate [4]. This necessitates an understanding of land cover dynamics, which helps in evolving appropriate sustainable management strategies to mitigate climate change.

Land cover (LC) refers to the physical and biological features present on the surface of earth. Land use (LU) explains the land use features reflecting how a particular land is being used for human activities and associated economic functions. LULC analysis has become an important part of any research because of the incremental changes due to anthropogenic activities [4]. Insights of landscape dynamics through LULC change analyses help in understanding the ecosystem structural changes, fragmentation of forest, conversion of one land form into another, illegal encroachments, etc., which helps to manage ecosystems towards the conservation and sustainable use [5, 6, 7].

The availability of spatial data acquired at regular intervals through space borne sensors, with collateral data (the Survey of India topographic maps, vegetation maps) etc. through GIS (Geographical information system) and GPS (Global Positioning System) has helped in assessing the LULC dynamics [8]. Satellite based remote sensing provides continuous monitoring of area of interest and these data have been widely used in the studies related to forest dynamics as it helps in preparation of an effective management plan which is site specific by understanding the variations at that particular location. Remote sensing has done a lot of improvements in past years and thus, provides a high resolution datasets that provides us with a clear picture of the variation occurred [9, 10, 11]. Analysis of temporal variations can also be done by finding out the LULC for various years.

India is one of the twelve mega-diverse countries in the world with a variety of wildlife, flora and fauna. Karnataka state is blessed with some of the best,

magnificent and diverse forests in the country [12]. It has lush evergreen forests in Western Ghats while have scrub forest in the plains. The Western Ghats of India is a series of hills stretching over a distance of 1600 Km from north to south and is known for its biodiversity (one among the 35 global hotspots for biodiversity). It lies in western part of peninsular India and serves as a haven for various flora and fauna. The rich biodiversity embraced with high endemism is owed to humid tropical climate, geological and topographical and geographical isolation. It serves as an important watershed for entire peninsular India. Though the ecologically sensitive Western Ghats constitute <5% of India's geography but they serve as one of the biggest carbon sink apart from providing food and water security to the peninsular India. The Western Ghats are extremely important from the point of revenue generation, productivity, subsistence and employment potential. Over the past century, there have been various significant transformations in the Western Ghats due to both anthropogenic (illegal encroachments, mismanagement, invasion of exotic weeds, senseless unplanned developmental projects) and natural (forest fires, etc.) factors. The variation in land dynamics can easily be understood by LULC dynamics [13].

Considering the ecological, biodiversity, geoclimatic importance several regions have been demarcated as eco sensitive areas for conservation of endemic flora. There are 14 major protected areas in central Western Ghats (Karnataka State). The current study analyses the temporal land cover variations in Talacauvery Wildlife Sanctuary, Bandipur Wildlife Sanctuary, BRT Tiger Reserve using temporal remote sensing data.

OBJECTIVE

Objectives of the current research are (i) to understand landscape dynamics in various National parks in southern Karnataka through temporal remote sensing data with cadastral maps and (ii) suggest appropriate conservation measures.

STUDY AREA

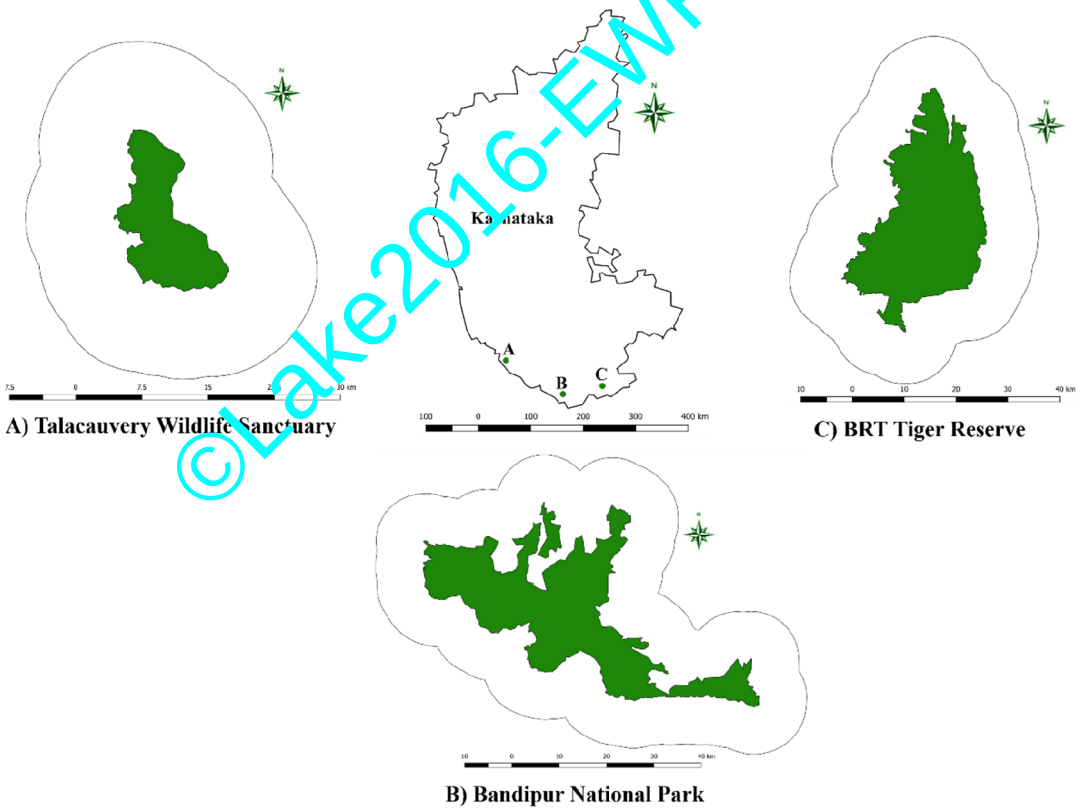
LULC dynamics analyses is carried out in the 3 protected areas – Talacauvery Wildlife Sanctuary, Bandipur National Park, and BRT Tiger Reserve in Southern Karnataka. Talacauvery Wildlife Sanctuary come in the Western Ghats region. Western Ghats is one among 35 global biodiversity hotspots and it lies in the western part of peninsular India in a series of hills stretching over a distance of 1,600 km from north to south and covering an area of about 1,60,000 sq.km. It harbours very rich flora and fauna and there are records of over 4,000 species of flowering plants with 38% endemics, 330 butterflies with 11% endemics, 156 reptiles with 62% endemics, 508 birds with 4% endemics, 120 mammals with 12% endemics, 289 fishes with 41% endemics and 135 amphibians with 75% endemics [5]. Karnataka has a total forest cover of 43356.45 Km^2 which is 22.60% of its total geographical area. Table 1 (A, B, C) provides all the information about the 3 protected areas.

Table 1: Data sheet of (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

National Park	Talacauvery Wildlife Sanctuary	Bandipur National Park	BRT Tiger Reserve
Notified under section of WPA, 1972 as (amended upto 2003) (Final Notification)	Section 26 A (b)	Section 35 (4)	Section 26 (A) (b)
Year of establishment	1994	2001	1994
Latitude	12° 17' 14" to 12° 26' 38" North	11° 35' 34" to 11° 55' 02" North	11° 43' to 12° 08' North
Longitude	75° 25' 23" to 75° 33' 15" East	76° 12' 17" to 76° 51' 32" East	77° 00' to 77° 16' East
Area	105.59 Sq. Km.	872.24 Sq. Km.	539.52 Sq. Km
District	Coorg	Mysore and Chamarajanagar	Chamarajanagar
Vegetation	Evergreen and Semi-evergreen forests, Shola grassland	East - stunted trees, interspersed with bushes and open grassy patches; Northwest - a gradual shift in the vegetation from open	Scrub, Deciduous, Riparian, Evergreen, Sholas to Grasslands

		dry deciduous forests to tropical mixed deciduous forests	
Flora	*Dipterocarpus indicus, Antiaris toxicaria, Kingiodendron pinnatum, Diospyrous ebenum, Alstonia scholaris, etc.*	*Shorea talura, Santalurn album (Sandal), Terminalia chebula, Anogeissus lati/olia, Chloroxylon swietenia, Acacia leucophloea,, etc.*	*Anogeissus latifolia, Dalbergia paniculata, Baswellia serrata, Commiphora caudate Acacia chundra, Diospyros melanoxylon, etc.*
Fauna	Tiger, Malabar, Nilgiri Marten, Elephant, Clawless Otter, Tiger, Lion tailed macaque, Slender loris, Travancore flying squirrel, etc.	Elephant, Tiger, Chital, Gaur, langur, Bonnet macaque, Sloth Bear, Muntjac, Quails, Partridges, stone curlew, bkuewing parakeet, etc.	Tiger, Elephants, Gaurs, Leopard, Butterflies, Sloth Bear, Flying squirrel, Sambhars, Chital, etc.
Rainfall	-	914 to 1270 mm	6000 mm

Figure 1: Study Area



Data

Table 2: Satellites and their resolutions used as input data

Satellite	Year	Resolution			
		Spatial	Spectral	Radiometric	Temporal
Landsat-1 (http://*earthexplorer.usgs.gov*)	1973	60m	RBV(3), MSS(4)	6 Bits	18 days
Landsat-5 (http://*earthexplorer.usgs.gov*)	1991	30m	MSS(4), TM(7)	8 Bits	16 days
IRS p6L4X (http://nrsc.gov.in)	2016	5m	LISS IV (3)	10 Bits	5 days

METHOD

1. Pre-processing – The remote sensing data for various National Parks across the Western Ghats were acquired for different time periods from Glovis, USGS earth explorer. The data collected were geo-referenced, geo-corrected, rectified and clipped pertaining for the study area. Geo-registration if the remote sensing data is done from Google earth using QGIS. A buffer region of 10 Km is considered as per the guideline by Karnataka Forest Department [14].

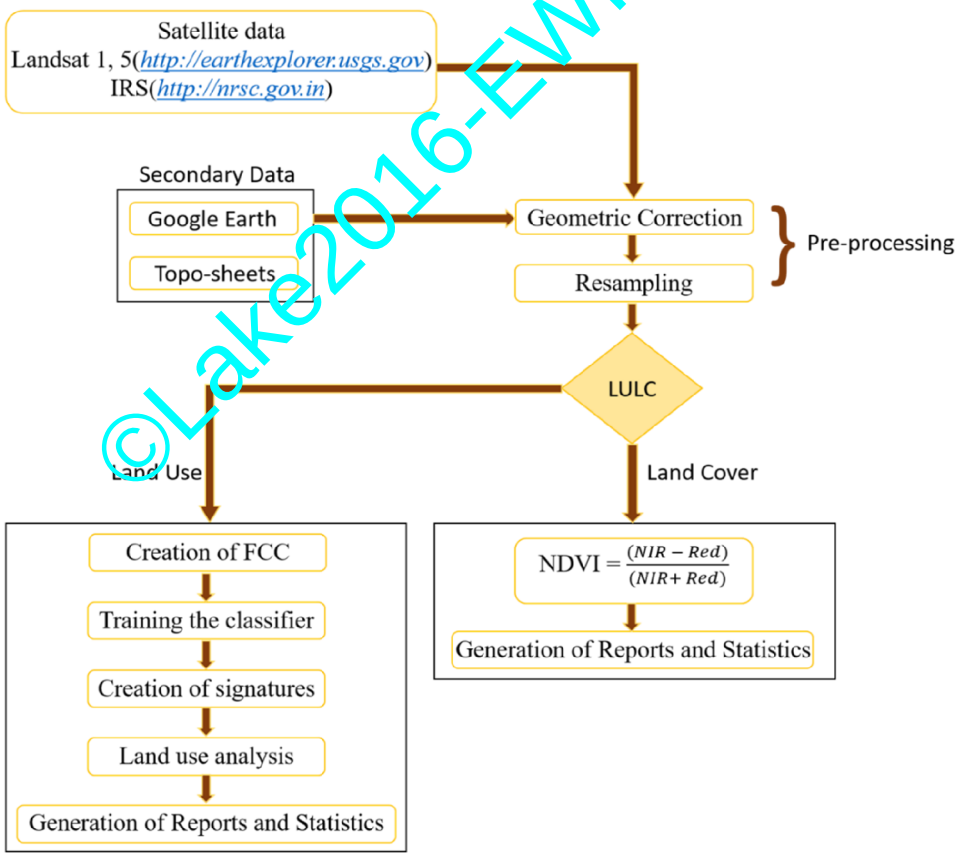


Figure 2: Methodology

2. Land Cover Analysis – This is done to understand the variation occurring in vegetation cover over the years. Normalized difference vegetation index was found appropriate and was used to find the vegetation cover. Its value ranges from -1 to +1. Very low values of NDVI (less than -0.1) indicates open areas, rocks, urban built up. Zero value indicates water body. Moderate value (0.1 to 0.3) represents sparse vegetation and high values (0.4 to 0.8) represents dense vegetation. As we approach NDVI = 1 the vegetation cover can be called to become more and more dense [14].
3. Land use analysis – This method involves:
   a. Creation of False color composite (FCC) which is formed by assigning Blue band = Green Band data, Green band = Red band data, Red Band = Near Infrared data.
   b. Training polygons are selected which corresponds to heterogeneous patches on the FCC. The training polygons should be distributed uniformly across the image and should cover atleast 15% of the total area. These polygons are taken by overlaying the FCC on google earth.
   c. These signatures are assigned to various classes and classification is done.

Land use analysis was carried out by using supervised classification – maximum likelihood classification algorithm. Remote sensing data was classified using signatures which were created from the training polygons that includes all the land use type detailed in table 3. Mean and covariance are calculated by maximum likelihood estimator [14].
Then Maximum likelihood classifier is used to classify the image using the signatures created. This method (MLC) is considered as one of the most superior methods providing classification on the basis of probability density function. The land use was understood by using the temporal data via GRASS (Open source software). The signatures were collected by overlaying FCC on Google earth through QGIS.

Table 3: Land use classes

S No.	Land use class	Land uses included in the class
1	Evergreen Forest	Evergreen forest, Semi-Evergreen forest
2	Deciduous Forest	Moist Deciduous forest, Dry Deciduous forest
3	Scrub Forest	Scrubs and grasses, Grasslands
4	Forest Plantation	Plantations done across the forest by forest department
5	Horticulture	Plantation on agricultural lands
6	Agriculture	Current sown, fallow agricultural land
7	Water bodies	Lakes, reservoirs, ponds
8	Urban	Residential area
9	Open Area	Rock, Queries, Abandoned mining sites, open area

RESULTS AND DISCUSSIONS

Land cover analyses of Talacauvery Wildlife Sanctuary (TWS), Bandipur National Park (BNP) and BRT Tiger Reserve (BRTTR) for 1973, 1991 and 2016 are as shown in Figure 3 (A, B) and Figure 4 (A, B) shows the proportion of vegetation cover. In TWS, the vegetation cover is increased by 0.45 %. In BNP, the vegetation cover is declined by 7.01 % since 1973. While in case of BRTTR, vegetation cover is declined by 1.67 %. The decrement is more significant in the transition 1973-1991 when compared to the transition period 1991-2016. Figure 5 (A, B) shows the land cover analyses of BNP and BRTTR with 10 Km buffer region and Figure 6 (A, B) shows the proportion of vegetation for the protected areas with 10 Km buffer region. In case of TWS the vegetation cover has increased by 0.5% due to increased horticulture practices. While taking the case of BNP with 10 Km buffer, the vegetation cover has dwindled by 5.61 % and 5.55 % during 1973-1991 and 1991-2016 respectively and in case of BRTTR, there is a slight decline in the vegetation cover during 1973-1991, the transition period 1991-2016 does not show much changes in vegetation cover due to increased horticultural activities.

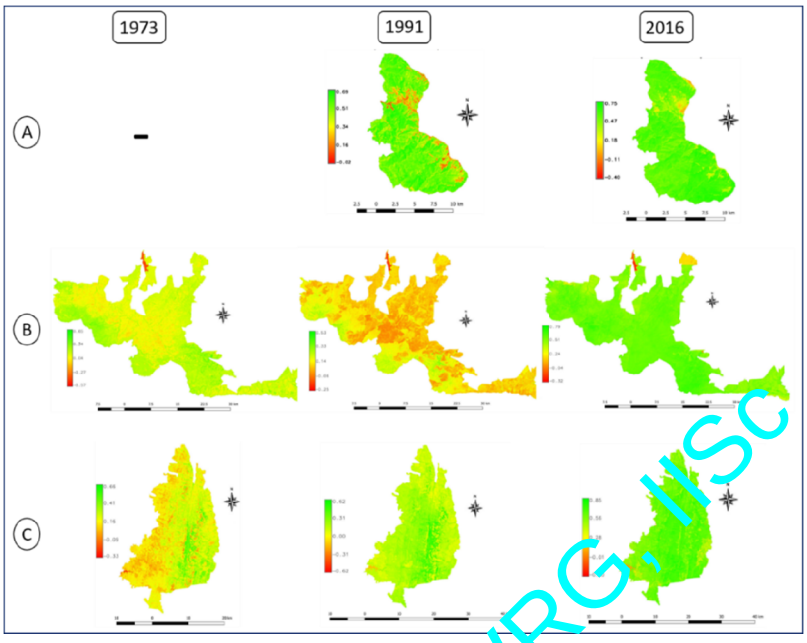


Figure 2: Land Cover Analysis of (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

Figure 3: Land Cover Analysis of (A) Talacauvery Wildlife Sanctuary, (B) Bandipur Wildlife Sanctuary, (C) BRT Tiger Reserve

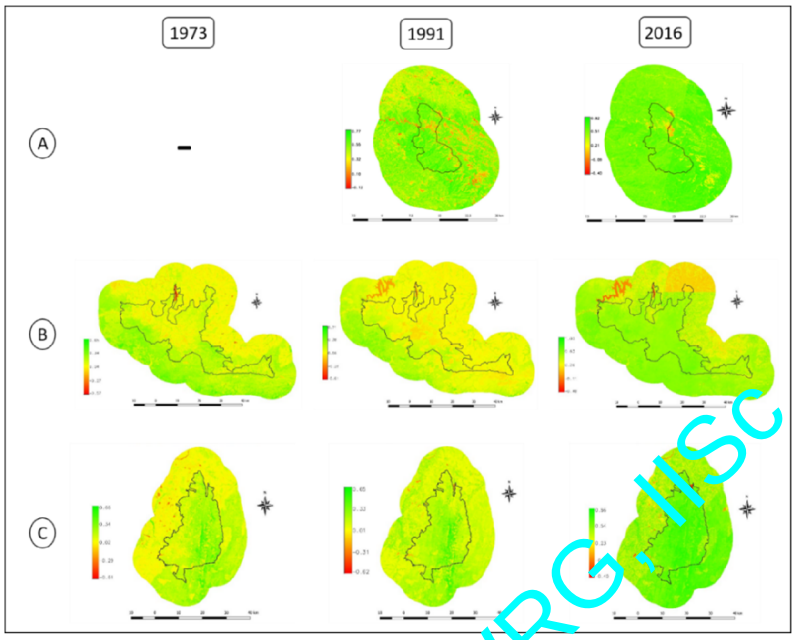


Figure 4: Land cover analysis with 10 Km buffer for (A) Talacauvery Wildlife Sanctuary, (B) Bandipur Natonal Park, (C) BRT Tiger Reserve

Figure 5: Land Cover Analysis with 10 Km buffer for (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

To get better insight, land use analysis was performed using maximum likelihood classifier. Figure 7 (A, B, C) and Table 4(A, B, C) shows the land use analyses of Talacauvery Wildlife Sanctuary, Bandipur National Park, BRT Tiger Reserve. In case of Talacauvery Wildlife Sanctuary, there is not much change because of high altitude. There are various villages inside the wildlife sanctuary but due to less population there is not much interference. In Bandipur National park, temporal analyses shows that there is decline in deciduous forest by 15.19% and the same has been converted into scrub forest, human habitations with enhanced agriculture activities. Regeneration of forest is hampered because of grazing. Frequent forest fire and infestation of weed on large scale signifies poor forest management. In case of BRT, there is a decline in evergreen and deciduous forest cover and a sharp increase in scrub forest due to increased deforestation activities. This deforestation is also due to increased encroachment within the boundary of the tiger reserve. Figure 8 (A, B, C) and Table 5 (A, B, C) shows the land use analysis for the protected areas with 10 Km buffer. In TWS there is an increase in horticultural activities as a result of high coffee and rubber plantation due to heavy rainfall in the region. The existing agricultural crops were converted into commercial crops to generate higher revenue. The area at the periphery of the sanctuary has seen conversion of deciduous forest into commercial crops and rubber plantation. The temporal analyses of BNP shows a reduction of 18.71% of deciduous forest and transformation of the same into scrub forest. Due to construction of dams, there is a slight increase in water bodies. In case of BRTTR, the evergreen and deciduous forest have shown less variations from 1973-1991, while shows a high reduction in 1991-2016. The scrub forest has increased significantly and shows that there is a transformation of evergreen and deciduous forest to scrub forest. There was an increase in agricultural activities which has declined again due to increase in horticultural practices. Another cause of degradation of forest is due to increase in the population.

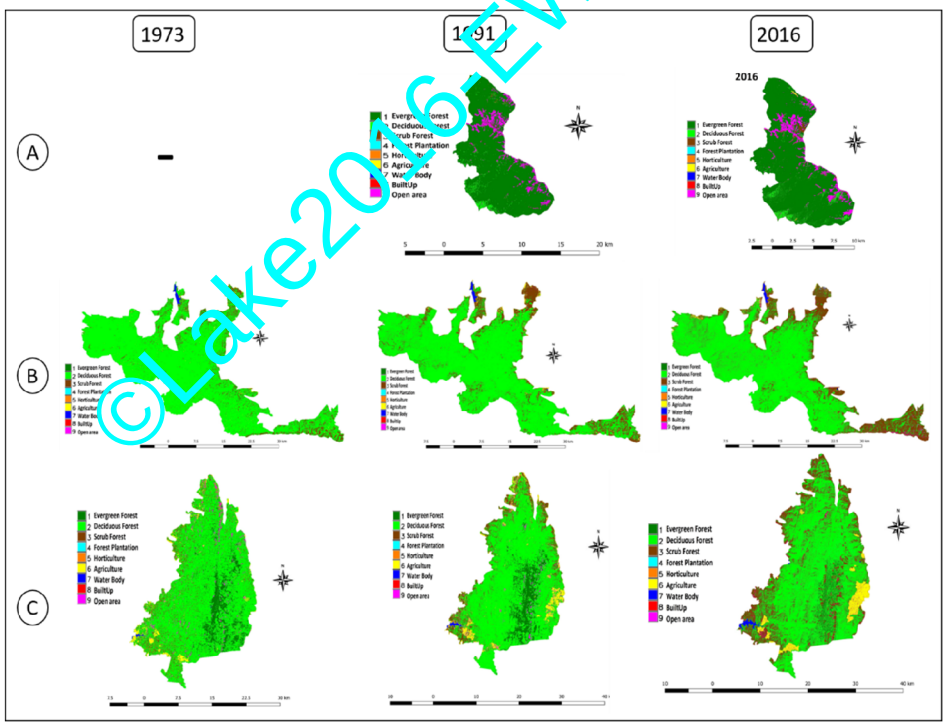


Figure 7: Land Use Analysis for (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

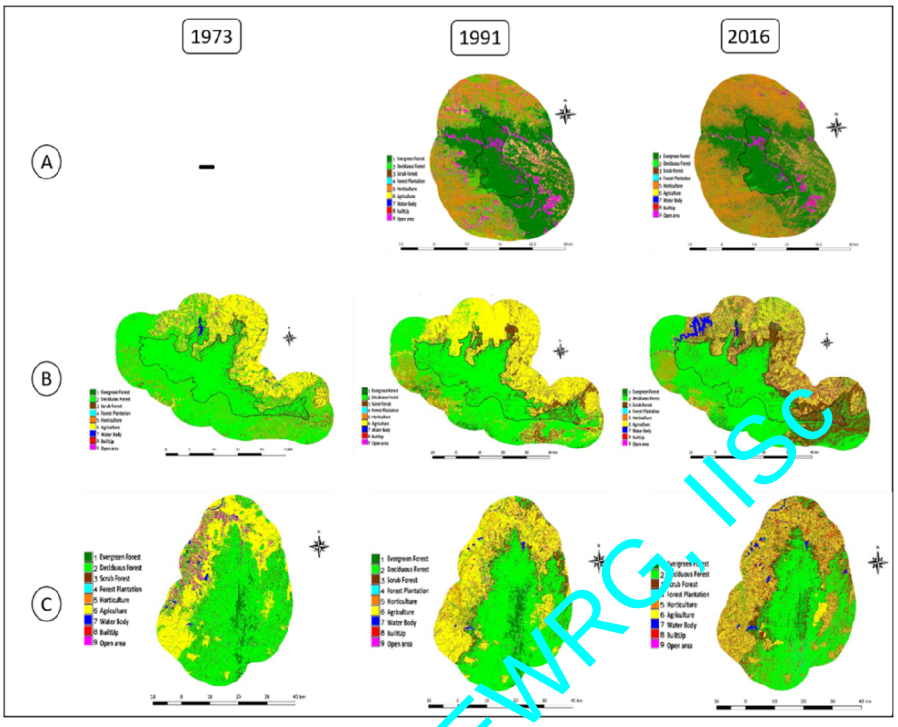


Figure 8: Land Use Analysis with 10 Km Buffer for (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

Table 4: Land Use Analysis for (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

Class	Talacauvery Wildlife Sanctuary		Bandipur National Park			BRT Tiger Reserve		
	% Cover							
	1991	2016	1973	1991	2016	1973	1991	2016
Evergreen Forest	86.77	85.55	0.2	0.37	0.02	11.5	10.68	4.33
Deciduous Forest	3.27	3.77	90.04	84.15	74.85	74.79	72.36	65.27
Scrub Forest	1.24	1.97	8.51	13.81	23.11	7.33	9.93	22.43
Forest Plantation	0	0	0	0	0.07	0	0	1.17
Horticulture	0	0.12	0	0	0.01	1.13	0.18	0.41
Agriculture	0	0.09	0.85	1.23	0.82	2.80	5.13	4.10
Water Bodies	0	0	0.39	0.38	0.38	0.18	0.3	0.56
Built Up	0.03	0	0	0.02	0.06	0	0.03	0.76
Open Area	8.68	8.51	0.01	0.05	0.69	2.27	1.4	0.97

Table 5: Land Use Analysis with 10 Km Buffer for (A) Talacauvery Wildlife Sanctuary, (B) Bandipur National Park, (C) BRT Tiger Reserve

Class	Talacauvery Wildlife Sanctuary		Bandipur National Park			BRT Tiger Reserve		
	% Cover							
	1991	2016	1973	1991	2016	1973	1991	2016
Evergreen Forest	44.21	44.04	0.60	1.69	0.89	5.45	5.16	1.74
Deciduous Forest	13.25	7.64	61.69	47.53	47.30	52.08	45.47	39.03
Scrub Forest	0.45	1.75	6.87	11.54	25.58	7.86	12.57	22.66
Forest Plantation	0	0	0	0	0.13	0	0	1.15
Horticulture	25.14	38.48	4.35	3.38	2.90	1.34	2.99	5.97
Agriculture	5.99	2.30	25.23	35.07	17.77	27.74	30.76	21.91
Water Bodies	0	0	0.43	1.34	1.36	0.62	0.53	1.37
Built Up	0.08	0.67	0	0.78	1.08	0	0.57	2.35
Open Area	10.89	5.12	0.83	0.42	2.99	4.91	1.95	3.82

CONCLUSION

The landscape dynamics of the protected areas in south Karnataka has been done. Land Use/ Land Cover studies were done for 1973, 1991 and 2016. The study shows that even though there has been declaration of protected areas, there is still degradation going on. Results shows that in Bandipur National Park and BRT Tiger reserve there is decrease in dense forest (Deciduous and Evergreen) by 15.37% and 16.69% respectively and this has been converted into sparse forest (Scrub forest. Talacauvery wildlife sanctuary being at high altitude, being a part of Western Ghats is less degraded when compared to other protected areas considered in the study. There is a reduction in evergreen forest by 1.22% which has been converted to deciduous and scrub forest. When considering the buffer region Bandipur National Park has reduction in deciduous forest by 14.39% and BRT Tiger Reserve has degradation in dense forest by 16.76% which has converted into scrub forest. On the other hand Talacauvery Wildlife Sanctuary has a reduction of 5.61% in deciduous forest. One major change observed in buffer region of TWS was increment in horticulture activities by 13.34% which is due to high altitude and high rainfall in the region.

Major factors which influence the degradation are increase in population, over-grazing within the wildlife sanctuary, forest fires (natural or anthropogenic), deforestation activities to increase commercial plantations, smuggling of timber and fuel-wood, increased encroachment, increased poaching activities, etc. Some of the steps which can be taken are practising afforestation activities (plantation of native species), keeping a strict management and regular visits to the field to stop the smuggling and encroachment activities, construction of animal corridors where human-animal conflicts have increased, rehabilitation of people living in protected areas. Other practices to be followed are construction of water bodies within the sanctuary and rejuvenation of old water bodies and putting a ban on poaching activities.

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