Land Cover Change Analysis with Special Reference to Forests and Paddy Wetlands of Neyyar and Karamana River Basins, Kerala, SW India Using GIS and Remote Sensing

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Abstract- Understanding the rate of land use changes in time and space and to find out the drivers behind this, is very useful in preparing the model for regional spatial pattern of the area and future prediction of implications of the changes for sustainable development, especially in a state like Kerala having low per capita land, high population density and limited resource availability. Owing to the population explosion and poor management of land use, the natural resources in the State are being degraded at alarming rate. The study is an attempt to derive useful information for the river basin management by analyzing land use/land cover change in the study area on a time scale. Since remote sensing data provides detailed and cost effective information with respect to spatial distribution of vegetation types and land use, the data of different periods were used for this study. Land use change with special reference to forests and paddy wetlands in Neyyar and Karamana river basins of Thiruvananthapuram district during the respective periods of 1905-2000 and 1968-2013 were analyzed through Survey of India toposheets and LISS imageries using Geographical Information System. The detailed analysis has revealed that the area under forests and paddy drastically decreased from 33% to 7% and 10% to 2% respectively. Encroachment and infrastructure development in the highlands are the root cause of deforestation in the study area. Expansion of built up areas by reclaiming the paddy wetlands, resulted in the drastic decrease in paddy wetland category.

Index Terms- Forest, Paddy wetlands, Land Use change, RS, GIS

I. INTRODUCTION

Global increase in population and the depletion of natural resources are driving extensive changes in land use that alter biodiversity patterns and ecosystem function and hence caused for the irreversible loss of the forests and wetlands (Aronson *et al*, 2010, Foley *et al*, 2005, Grimm *et al*, 2008 and McKinney, 2006). Currently, fresh water resources in several parts of the globe is facing severe crisis in availability due to unsustainable water use aggravated by the unpredictable and unforeseen changes in the climate realm triggered by deforestation. The climate change coupled with urbanization and rampant alterations in land use made most of the world's fresh water flow regimes under severe pressure and change. River banks and its associated landforms act as pioneer sites of human settlements and cradles of civilizations all over the world, and now they were among the foremost natural systems facing the ensuing pressures of development. Degradation of river basins consequent to resource depletion is one of the major environmental problems of Kerala that need immediate attention and corrective measures.

Forests and Wetlands referred to the respective 'lungs' and 'kidneys' of the landscapes, but are continuously exploited unscientifically in search of profits and means of subsistence. These ecosystems play a central role in functioning of the biosphere, provide various environmental services by regulating climate, hydrological and biogeochemical cycles and directly and indirectly contribute to socio-economic development. By acting as a sink for greenhouse gases, forests and wetlands help to mitigate the effects of climate change. However, through agriculture, urban and suburban development, much of the forest and wetland resources have been lost and with them many of the important functions that they provide also adversely affected. In Kerala State, the forest and wetland ecosystems have assaulted various adverse changes with growing demands, creating crisis in the environment. Studies done by Menon and Bawa (1998), Jha *et al* (2000) revealed that substantial conversions of forests take place in Kerala in the past were done for agricultural expansion, plantation development and for various other developmental activities.

Knowledge of extent of land utilization is essential for any land use planning to avoid any adverse consequences in future. Land Cover is an important input parameter for a number of agricultural, hydrological and ecological models, which constitute necessary tools for development, planning and management of natural resources

in the territory. Such planning also requires the knowledge of land diversions over a period of time. Analyzing spatio-temporal characteristics of land use is essential for understanding and assessing ecological consequence of development and thus helps for decision making process. Remote Sensing (RS) and GIS are powerful tools which have revolutionized our understanding of approach to the earth's resources and environment and their management (Long *et al*, 2007. Guler *et al,* 2007). Remote sensing data provides detailed and cost effective information with respect to spatial distribution of vegetation types and land use.

The land use change is significant due to various physical and socio-economic factors and the land use pattern of an area is directly related with the level of techno-economic advancement, nature and degree of civilization of its inhabitants (Whyte, 1961).Land use changes in any region are mainly related either with the external forces and the pressure built up within the system. The spatio-temporal changes in land use in the river basin have a direct influence on its hydrological realm **a**nd affect in many ways such as change in total run off, flooding in low lying areas etc. (Wilk and Hughes, 2002). The National Forest Policy (1988) envisage bringing one-third of the geographical area of the country under forest cover to maintain ecological balance and environmental stability. The forest cover of India has been estimated to be 637 Km^2 and 19.39% of the geographic area of the country (Mahajan and Panwar, 2005). Followed by forests, agriculture is the most dominant land use in India. Deforestation and conversion of water logged wetlands into built-up area affect the water retention capacity of soils of the river basins (Nikhil and Azeez, 2010). High rates of wetland conversions were mostly occurred by the push of population growth resulted in the reclamation of these ecosystems for various developmental activities (Turner *et al,* 1993).The present study deals with land use mapping with special reference to degradation of forest and paddy wetlands in Neyyar and Karamana river basins of Kerala State using remote sensing data, topographical maps, and ground truth studies applying GIS and Remote Sensing techniques .It is an attempt to derive useful information for the river basin management by analyzing land use/land cover in the study area spatially and temporally.

II. STUDY AREA

The information on land- use and land-cover patterns, their spatial distribution and changes over time-scale are the pre-requisite for making development plans. The present study area falls under the catchment areas of Neyyar and Karamana rivers in Thiruvananthapuram district, Kerala State, SW India, comprising the highland, midland and

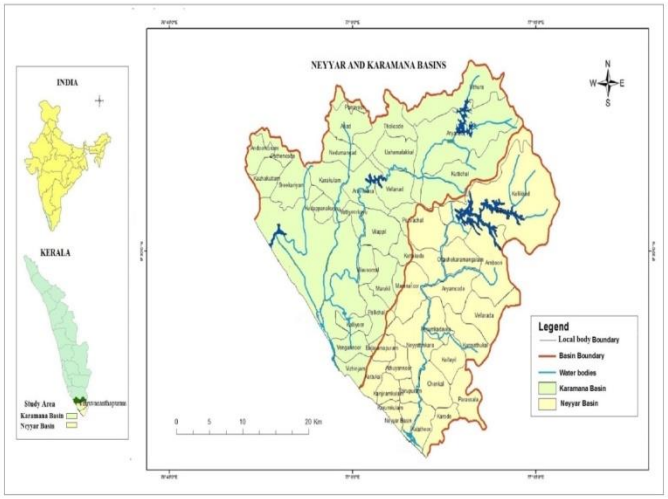

Fig.1 Location map of the study area

lowland regions with different terrain conditions. The Neyyar and Karamana river basins lies between 8^0 15' to 8^0 45' North latitudes and $76^0$50' to 77^0 20' East longitudes, and occupy a total area of 1199 sq.km (Fig.1). The Neyyar river originates from Agasthya hills of Western Ghats at an elevation of about 1860 m above msl and flows in to the Arabian Sea. The total watershed area of this river is 497 Sq.Km. The general elevation ranges from 750 m in the upper region, 60 m in the middle region to less than 2 m in the lower region.The Karamana river originates from

Chemmunji mottai (Nedumangad hills) of Western Ghats at an elevation of about 1717 m above msl and flowing about 66 Km and merges into the Arabian Sea near Thiruvallom. The total basin area of this river is 702 Sq.Km.

III. MATERIALS AND METHODS

The study uses two sets of data which includes topographical maps (SoI) and remote sensing (IRS) imageries. Terrain data sets were prepared from IRS LISS P6 111 (2013) images based on geology, geomorphology, drainage network, drainage density, slope, relative relief, soil thickness, land-use and rainfall. Land use maps of forested lands of 1905 (1:63360), 1968 (1:50000) and 1980 (1:25000) were extracted from the *Survey of India (*SoI*)* toposheets and the data regarding natural forest cover of the study area (2000) were traced out from IRS P6 LISS-11 images.

Areal distributions of paddy fields were traced out from the SoI toposheets (1968), imageries of IRS LISS-11 and IRS LISS-111 of 1989 and 2013 respectively. All the maps were digitized following uniform scale and overlaid in GIS platform (Arc GIS 10.1).

Prepared the land-use maps and overlay operations were conducted for the detailed analysis of the variation in areal extension of forests and paddy fields over the years. The land use/land cover information is obtained by map to map comparison, since it gives complete details of land use/land cover change detection.

IV. RESULTS AND DISCUSSION

Forest is a renewable resource and contributes substantially towards economic development and they play a major role in enhancing the total quality of the environment. According to various related reports on deforestation in India, the large-scale alterations of forested lands happened after the independence interms with that almost all types of landforms were undergone the phase “development”. During this phase, the term conservation of ecosystems and species was practically unheard and the natural areas particularly the forests and wetlands experienced wide spread conversions and modification (www.iipsenvis.nic.in). Menon and Bawa (1998) reported an annual decrease of 0.57% forest cover in Western Ghats region during 1920 to 1990. Prasad *et al* (1998) estimated a decline of ~ 0.90% of natural forest cover in Kerala annually during the period 1961 to 1988. Thus, wide scale alterations of natural landuse happened in lowlands, midlands and highland areas of the State.

The terrain system of Neyyar and Karamana basins extends from Western Ghats to the Arabian coast cutting across all major physiographic divisions identified in the State. The terrain condition has been influenced by three main processes namely, marine/estuarine, fluvial and denudational. Based on slope characteristics and morphogenetic attributes, 5 terrain units inclusive of water bodies, have been identified. While, the coastal plains host three natural wetland systems (Veli lake, Akkulam lake and Panathura k*ayal*), the highlands contain three important man made water bodies – the Neyyar, Peppara and Aruvikkara reservoirs. Landform controlled by marine/estuarine processes cover about 26% of the study area. Coastal plain exhibit evidences of paleo-sand ridges/strand lines. Between Kovalam and Vizhinjam, pocket beaches are well developed and are known for its tourism potential. Another feature is that the floodplains could not be marked as continuous phenomena along the rivers under study. Field investigation indicates that the rivers are incising (cutting down) its own floodplains. Neyyar and Karamana rivers are not joining the sea through the parallel running backwater system, instead form distributaries and merges with the Arabian Sea. Emergence of marine terraces can also be marked in close examination. Meanders in midland and highland regions are believed to be structurally controlled. Gently undulating terrain covers the maximum area. Alternate valleys/basins and hills characterize this unit. Altitudinally, this unit lies below 100 m contour. Although this unit has been grouped under denudational category, the area often exhibits gradational features as well. Infact, rolling nature is due to alternate valleys and denudational low hills.

The Agasthya*malai* is the important peak in the river basins. Parts of highly undulating terrain, mountain land as well as hilly terrain are highly susceptible to erosion. Isolated hills are structurally controlled in nature.Fig.2 shows the different terrain groups in the study area. Secondary data on existing terrain nature/conditions were listed in Table 1.

The present study indicated that the density of virgin forests in the Western Ghats, which is known for its rich biodiversity, has been decreasing over the years. The forest ecosystem of the study area once known for its plethora of plant and animal species is now subjected to drastic deterioration consequent to unscientific and improper exploitation for various resources.Fig.3 shows the trend of deforestation in Neyyar and Karamana basins during the period 1905 to 2000. Table 2 shows the extent of forests in Neyyar and Karamana river basins during different periods.

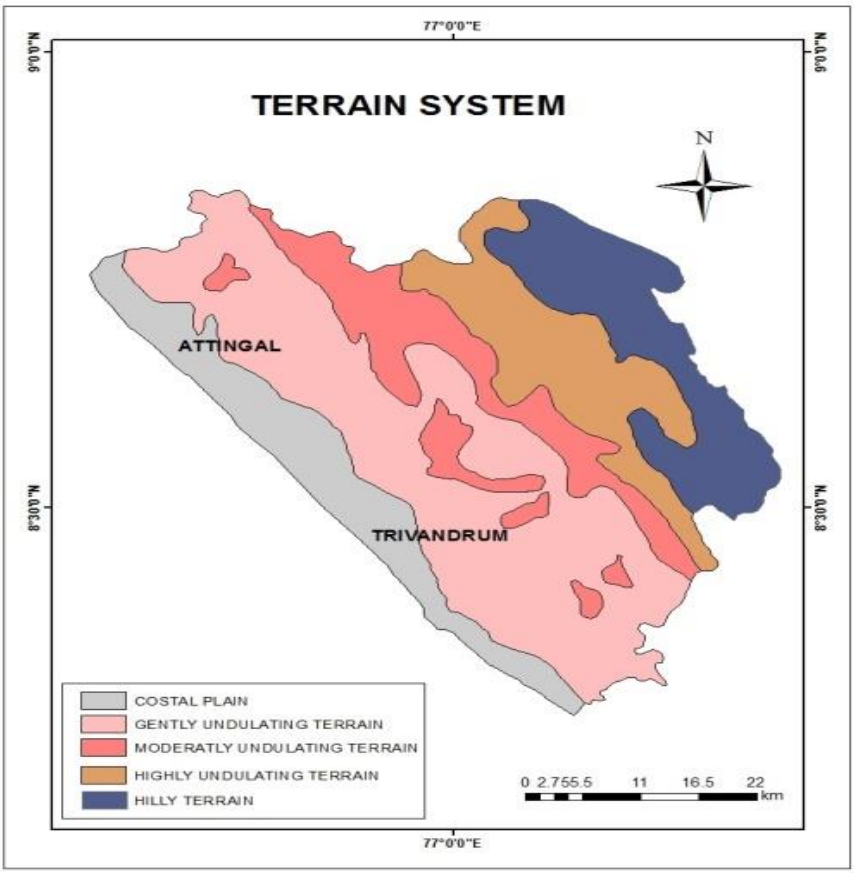

Fig.2 Different terrain groups in the study area (Area shown in Sq.Km)

Table 1 Terrain system of Neyyar and Karamana river basins (Area shown in Sq. Km)

Sl. No	Parameters	Neyyar		Karamana		Total (Neyyar + Karamana)	
		Area	Percentage	Area	Percentage	Area	Percentage
1	Mountains and hilly terrain	80.40	16.18	48.90	6.97	129.30	10.78
2	Highly undulating terrain	38.72	7.79	118.07	16.82	156.79	13.08
3	Moderately undulating terrain	59.09	11.89	111.26	15.85	170.35	14.21
4	Gently undulating terrain	281.0	56.66	291.12	41.47	572.15	47.72
5	Coastal plain	37.76	7.6	132.65	18.90	170.41	14.21

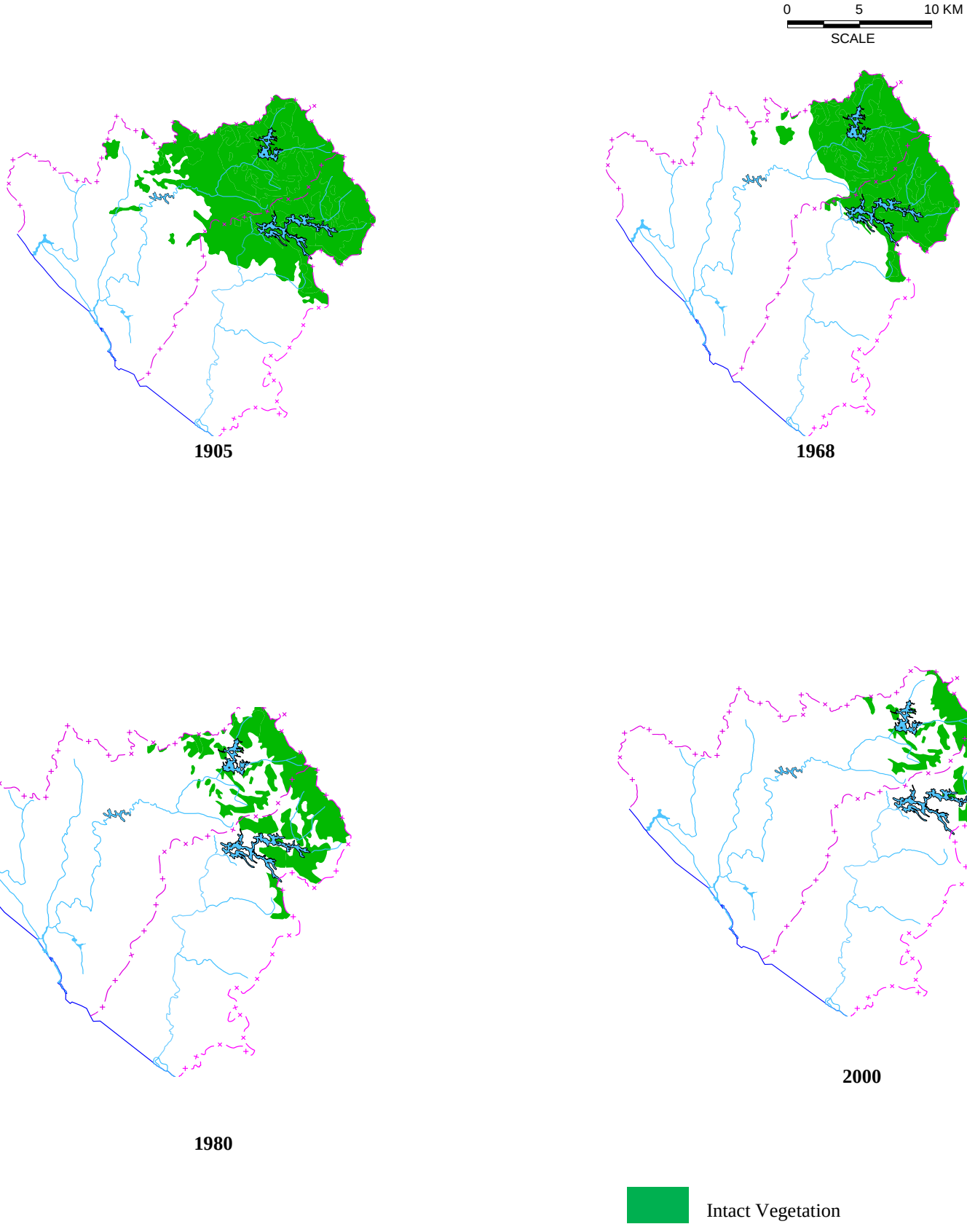
0
5
10 KM
SCALE
1905
1968
1980
2000
Intact Vegetation

Fig.2 Temporal changes of Forests in Karamana and Neyyar basins

Year	Neyyar Basin (area:497 Sq.Km)		Karamana Basin (area:702 Sq.Km)		Neyyar and Karamana Basins(area:1199Sq.Km)	
	Area(Sq.Km)	%age	Area(Sq.Km)	%age	Area(Sq.Km)	%age
1905	170.0	34	222.05	31.6	392.05	32.7
1968	112.5	22.5	131.71	18.8	244.21	20.4
1980	68.5	13.7	99.3	14.1	167.8	13.9
2000	51.02	10.2	41.05	6	92.0	7.7

Table 2 Extent of forest area in Neyyar and Karamana basins at different periods

In 1905, area under natural vegetation in the two basins was estimated as 32.7% (Neyyar=34%, Karamana=31.6%). This has come down to 22.5% in Neyyar basin and 18.8% in Karamana basin by 1968. In 1980, it was again diminished into 13.7% and 14.1% respectively in the basins. In 2000, the forested areas were 10.2% and 6% in the respective basins and extent were about 51 Sq.Km in Neyyar basin and 41 Sq.Km in Karamana basin. It was observed that about 76 % of natural forest cover has been lost in Neyyar and Karamana basins during a time span of 95 years.Previous studies made in the forested areas support their findings.Ramesh *et al* (1997) found that the in Agastyamalai region of Neyyar basin; the annual rate of deforestation was 0.33 % during the time interval from 1920 to 1990. Jha *et al* (2000) estimated changes in forest cover between 1973 to 1995 in Western Ghats and reported a loss of 25.6% forest cover over 22 years. Studies by George and Chattopadhyay (2001) revealed that extensive conversion of forestlands to plantations, iinfrastructure development such as roads, hydroelectric and irrigation projects, and other institutional amenities led to deforestation in Kerala.The encroachment of local people residing nearby areas and planters also aggravated the rate of destruction of forests in the study area (Krishnakumar,2002). This can be attributed to increase in plantations and agricultural areas in the highland regions. The construction of Peppara dam (Karamana river) and Neyyar dam (Neyyar river) also imposed destruction of the forest wealth. Studies show that the Neyyar and Peppara reservoirs are considerably silted up due to the decrease in vegetative cover in its provenance zone (Suresh Babu *et al*,2000). However, if proper afforestation programme has not taken up in the degraded area, the problem will remain unsolved, affecting the net freshwater availability and normal climatic conditions.

Table 3 Extent of paddy wetlands in Neyyar and Karamana basins (total area: 1199Sq.Km) at different periods

Year	Total area of Paddy wetlands in the basins (Sq.Km)	%age
1968	115.98	9.8

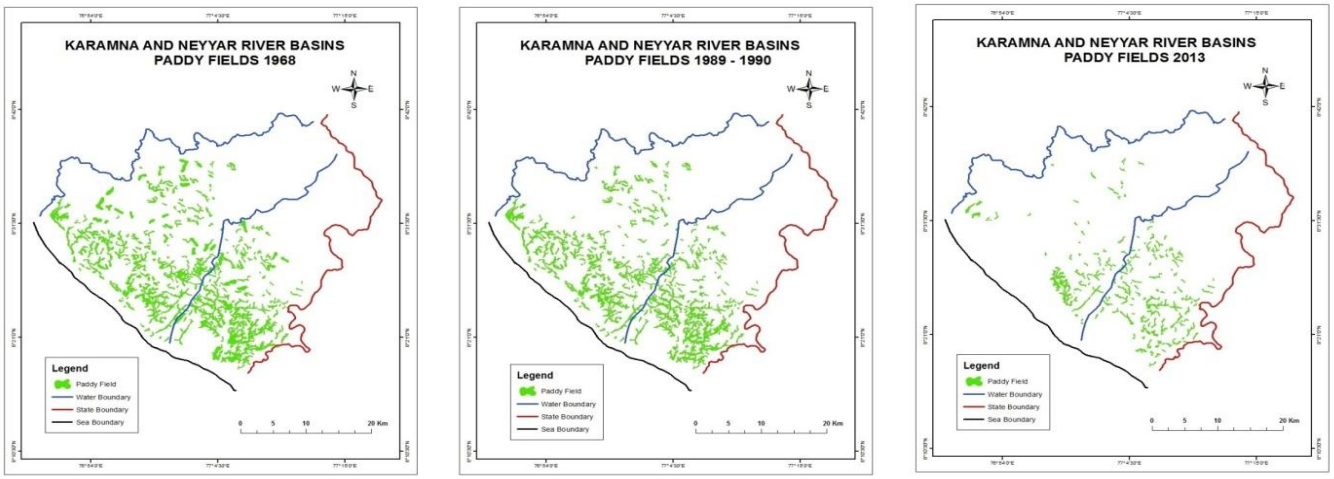

Fig.4 Temporal changes of Paddy Wetlands in Neyyar and Karamana basins

As per the studies of Nair (1994 &1998), substantial part of money received in the form of remittance in Kerala has been invested for building constructions over the years. The exponential increase in the number of households created the utilization of all available lands including paddy lands by filling and reclamation. Further, a considerable portion of the farmers sold their land, since paddy cultivation becomes a non-profitable avocation. Chattopadhyay (1991) reported a decline of paddy wetland area in Thiruvananthapuram city from 9.6% (1976) to 5% (1991). Paddy lands in several areas of Thiruvananthapuram district were reclaimed disregarding its environmental significance. According to Sindhu and Divya (2011), built-up area in Thiruvananthapuram City was only 13.93 km^2 in 1967, and it increased to 59.87 km^2 in 2008. On the other hand, paddy area reduced from 25.8 $km^2$to 1.52 km^2 during 1967 to 2008, Even though, the Government of Kerala has enacted law (Kerala Paddy Lands - Wetlands Conservation Act, 2008) against the reclamation of paddy lands, the land reclamation activities are continuing regularly at several places in the basins to meet the ever increasing human requirements and thus adversely affecting the ecological balance. Hence stringent measures have to be taken for controlling the reclamation activities for the sustainable development.

V. CONCLUSION

As per the transformation of socio-economic set up and variations in environmental conditions, the highly dynamic land use system also affected by various changes and leading to environmental degradation issues. Degradation of natural resources is one of the major issues in a state like Kerala, which has brought about indelible and irreparable land use and ecological changes, leading to impairment of its vital functions. In the present study, spatial and temporal changes of forests (1905-2000) and paddy wetlands (1968-2013) in Neyyar and Karamana basins of Thiruvananthapuram district, Kerala State were quantified using Geographical Information System (GIS) and Remote sensing (RS) techniques. Drastic depletion of forests and wetland areas in the river basins have been noticed during the study periods as stated above with the supportive data generated. Land use changes in any region are mainly related either with the external forces and the pressure built up within the system. As part of urbanization, Thiruvananthapuram district

has witnessed reclamation of paddy wetlands in extreme.Hence for this assessment, Neyyar and Karamana basins were taken together for the spatio-temporal changes. Population increase, encroachment, agricultural expansion, construction of dams and other infrastructural developments are the major factors influenced for the land use/land cover changes in Neyyar and Karamana basins of the state. Expansion of built up areas as part of urbanization have been noted as the main reason for the drastic changes in paddy land conversion. With the advancement of remote sensing techniques and supporting system like GIS, we can have better understanding of the land use/ land cover change dynamics similar to this, and such data can be used as decision supportive data for future planning and development.

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