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# A Satellite Data Performed Quantification of Terrain Alterations in Cochin

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**Abstract:- Cochin known as commercial capital of Kerala, LNG terminal and International container terminal which occupying in the city makes it large commercial hub .Its having an increasing population is about 2.3 Million which is largest agglomeration in Kerala. A comprehensive understanding of the changes that occurring in Environment need to be estimate, prepare a sustainable plan for futuristic environment management. The LULC changes can be determine the potentiality of urbanization in the city. Remote Sensing platform based LULC study can classify the LULC change detection processes under the Arc GIS and ERDAS software with the application Survey of India Toposheets and LISS III images. The study reveals the urbanization potential of the city during the proposed time interval.**

***Keywords:-*** *LULC, Remote Sensing, LISSIII, USG SEarth Explorer, Vembanad KOL.*

## I. INTRODUCTION

Analysis of the nature and rates of environmental changes over recent decades, especially urban land use change analysis is essential for a proper understanding of why the present environmental problems have arisen[1].It is also imperative to formulate accurate productive models of environmental changes. 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, utilization and formulation of policies and programs for making any micro and macro-level developmental plan[2]. Land has been going through tremendous transformations due to sprawls in agriculturalisation, industrialization and urbanization. The changes in land use affect the ecosystem in terms of land cover, land quality and capability, weather and climate, carrying capacity of the land and in short the whole population and socio-economic determinants[3] .

Study of the land use changes of Cochin City is very pertinent in the context of the fast urbanization it is facing. Cochin is the commercial capital of Kerala as well as one of the principal seaports of our country. The population of this metropolis is about 2.5 million[7], making it the largest urban agglomeration and the second largest city in Kerala after the state capital. The population of the city is increasing very rapidly. Center for Population Studies, CUSAT predicted that population will reach 2.5 million within the next decade [7]. Government has started a number of development projects such as International container terminal, LNG Terminal etc. This will add to the already existing stress facing the Cochin city.

A major portion of the Vembanad kayal, which is a part of Vembanad-Kol Ramsar Wetland, is in Cochin City. The Vembanad-Kol Wetland System is the largest brackish, humid, tropical wetland ecosystem in the Southwest coast of India. It provides important habitat for several species of flora and fauna of which many are vulnerable. The wetland regularly supports 20,000 residential/migratory water birds, several prawn species, fishes and mangroves (WWF, 2002). Significant strands of mangrove vegetation are also found in the city. Also, this city has a wide area of Pokkali and aquaculture fields.

Land use change study using remote sensing data (satellite and aerial) and analysis using GIS has been done for both rural and urban areas. This method is very efficient for assessing the changes or degradation of a region [4]. Change detection involves the use of multi-date (time series) aerial photos or satellite imageries of the study area, from which land use maps can be generated by visual interpretation or digital image processing. GIS analysis will give the actual area of each and every land use classes and the areal extent of changes through the overlay operation.

In this study, we have mapped the existing land use pattern with the help of ArcGIS and ERDAS using LISS-III imageries. The land use changes occurred during the last decades is assessed from 1967 Toposheets. Based on these observations some proposals are made for management of the city area.

## II. MATERIALS AND METHODS

### *A. STUDY AREA*

The study area was selected according to the City Development Plan published by the Cochin Corporation in 2002. The selected city boundary lies between Coordinates 76°12'13.5" to 76°22'59.7" E longitudes and 9°51'54.5" to 10°4'55.2"N parallels, covers an area of about 344.8 $Km^2$ with a population of 2.5 million (based on 2011 Census) and a density of average of 35 persons / hectare [7].The Cochin city lying close to Arabian Sea and its connected with a large backwater system called Vembanad Lake. A large scale infrastructural development has been occupied in the core areas of the city .The broad scope of tourism in the city

became the reason for establishing a large network of Hotels and related infrastructures like Shopping Malls. The study area includes the Cochin Corporation, 3 municipalities and 12 panchayats as its administrations; it's listed in Table 1.

| | | |
|---|---|---|
| 1. Cochin Corporation Area | 7. Kadamakudy Panchayath | 13. Njarakkal Panchayath |
| 2. Kalamassery Municipal Area | 8. Mulavukadu Panchayath | 14. Kumbalam Panchayath |
| 3. Thripunithura Municipal Area | 9. Varapuzha Panchayath | 15. Kumbalangi Panchayath |
| 4. Thrikkakara Municipal Area | 10. Cheranalloor Panchayath | 16. Chellanam Panchayath |
| 5. Thiruvankulam Panchayath | 11. Eloor Panchayath | |
| 6. Maradu Panchayath | 12. Elamkunnapuzha Panchayath | |

Table 1-: Administrative Divisions

*B. Methodolgy*

Toposheets were procured from Survey of India. LISS - III Images of Path-99 Row -66 with 60% shift along-track were procured from NRSC. Georectified toposheets Nos. 58B4, 58B8, 58C1, 58C5 were mosaiced to make a base map using ERDAS IMAGINE software with 'Polyconic' projection and 'Everest, as spheroid. Georectified LISSIII imagery was used as the base map with image to image georectification method using ERDAS IMAGINE.USGS Earth Explorer imagery data utilized for the preparation of 2019 LULC Map. The study area was demarcated according to the city developmental plan. The land use map was made using visual interpretation and onscreen digitization using ArcGIS 9.3 software. Paddy, Aquaculture Paddy cum fish culture area have mapped with help of extensive ground survey. The land use changes during 1967- 2019 were assessed. Maps were prepared by image interpretation, delineation and digitization process of LULC classes[5].Supervised classification of the data, maximum likelihood classification were adopted and change detection carried with integration of Arc GIS and ERDAS [6]. Road map of the city was also prepared and analyzed to observe the changes.

## III. RESULT AND DISCUSSION

*A. Land Use land Cover Change*

The total extent of the study area has increased from 341.505 $Km^2$ to 344.816 $Km^2$, which was due to increase of land area in Puthuvypin due to silting. Each land use changes are discussed below.Land Use land cover Maps given in Fig 2 and Fig 3.

Highly inhabited area or urban area has increased by great extent 17.5 $Km^2$ to 68.4 $Km^2$, almost a 235% increase. It indicates that the city is expanding very rapidly. If proper management is not done, it will lead to pollution, solid waste and transportation problems and scarcity for land. Extent of highly inhabited areas has expanded in the southern part of the city starting from Fort Kochi to Edakochi, in Central area of city starting from Cochin backwaters to Edappally & Ernakulam High court to Thevara.A small patch of urban area developed in Thripunithura.The urbanization has influenced on the other land use changes**.**Detailed data gven in Table - 2and Fig 1..

*B.* Wetland coverage has very high significance in the environmental health and Land use[8] of Cochin City – the total wetland area appears to have shrunk from 158.064 $Km^2$ to 114.27 $Km^2$ during the selected study period Details of wetland changes are given in the Table-3

*C.* Highly inhabited area or urban area has increased by great extent 17.5 Km2 to 68.4 Km2, almost a 235% increase. It indicates that the city is expanding very rapidly. If proper management is not done, it will lead to pollution, solid waste and transportation problems and scarcity for land. Extent of highly inhabited areas has expanded in the southern part of the city starting from Fort Kochi to Edakochi, in Central area of city starting from Cochin backwaters to Edappally & Ernakulam High court to Thevara. A small patch of urban area developed in Thripunithura.The urbanization has influenced on the other land use changes.

Estuary including Cochin backwaters decreased from 70.43 Km2 to 58.39 Km2, nearly a 17% decrease. From the overlay analysis we observed that 6.73 Km2 were reclaimed as land area and 4.51 Km2 reclaimed as paddy and aquaculture fields. Reclamation mainly happened around Cochin Corporation due the developmental activities. A Major part was lost by reclamation for modification of Marine Drive. Considerable area is lost due to the Construction of Goshree Bridges. A big patch of estuary attached with the Vallarpadam Island was lost due to the silt deposited by the Port Trust during deepening of the ship channel. This area is now being used for the International Container Terminal. Paddy fields, mainly valley fills / flood plains were situated in the inland Eastern areas of Cochin City. In 1967 almost 30.1 Km2 areas were used for paddy cultivation. Only 5.69 Km2 areas of the flood plain used for paddy remains in the study area now it is mapped as Seasonally flooded area but only very small extent of area is now used for cultivation. Almost 24.41 Km2 changed to Mixed land use and Highly populated area.

Three decades earlier, Pokkali culture or paddy cum fish culture were distributed all over the study area. Paddy cum Fish culture in the city area has drastically decreased from 42.08 Km2 to 8.05 Km2(80% reduction).Now only in northern islands Pizhala, Kadamakuddy, Varapuza and Elamkunnapuza, as well as a patch of area in southern part of the city - Kanddakadavu and Maruvakad area is used for paddy cum fish culture. Paddy cum fish culture is changed to other land uses. 9.99 Km2of area(23.7%) of Paddy cum fish culture is changed to Land area(Mixed Land Use). All most

all the area of Aquaculture ponds in the study area were paddy cum fish culture in 1967, but now very small amount area using for paddy cum fish culture. 25.63Km2 area is presently under aquaculture. Considerable amount of River (about 23%) has been lost around the study area during this period; from 5.47 Km2 to 4.22 Km2. Reduction may be due to the encroachment of riversides

Seasonallyflooded area Fallow wetland only flooded in Monsoon season. It has increased from 5.69 $Km^2$ to 8.95 $Km^2$(57%). It is mainly contributed by paddy cultivated area. Water logged area increased from 1.30 $Km^2$ to 3.8 $Km^2$(192%) which is mainly contributed by paddy cum fish culture. Muddy area almost vanished which has reclaimed to the land area.

Beaches have decreased from 0.78 $Km^2$ to 0.44 $Km^2$(21%). The decrease may due to natural processes and disaster. This reduction mainly happened in Chellanam to Fort Kochi seashores. Sandy areas in Fort Kochi are almost completely lost. A large extent of beach increased was added in the Puthuvypin area, which has been acquired for LNG Terminal Project.

*D. Changes in Road*

Area occupied by roads has increased from 2.77$Km^2$ to 3.96 $Km^2$ and that by railways has increased from 1.6 1$Km^2$ to 1.99 $Km^2$, which is due to the development of rail tracks and stations. In this urban land use change study only the area of important roads were considered. From this data alone the extent of road and related infrastructure changes could not be assessed. So the roads have been mapped as line features with the help of Google earth images(Fig-4). Even though the Urban area increased to 235% , It is found that total bituminized roads have increased from 349.3 Km to 480.3 Km, almost by 131km (37%). But it is extremely inadequate considering the population increase during this period compared with other cities in India.

One (NH-47) National Highway increased to three (NH-17, NH-47, and NH-49) during this period. Length of the National highway increased from 24.3 km to 42.9 km(76%). Also, NH-47 was re-rooted through a new road away from thickly populated area. A large area has been converted for the container Road which connecting the International container terminal.Comparison of the Road devlopemnt given in Fig-5.

| LULC Class | 1967 | | 2019 | |
|---|---|---|---|---|
| | *Area km²* | *%* | *Area km²* | *%* |
| Highly Inhabited Area | 17.5 | 5.12 | 68.4 | 19.84 |
| Mixed Land Use | 158.84 | 46.48 | 160.31 | 46.5 |
| Estuary | 70.43 | 20.61 | 58.39 | 16.94 |
| Paddy cum fish culture | 42.08 | 12.31 | 8.05 | 2.33 |
| Paddy | 30.01 | 8.82 | 0 | 0 |
| Aquaculture | 1.8 | 0.53 | 25.63 | 7.44 |
| River | 5.46 | 1.59 | 4.22 | 1.23 |
| Seasonally flooded area | 5.69 | 1.66 | 8.95 | 2.59 |
| Water logged | 1.3 | 0.38 | 3.8 | 1.11 |
| Vegetated wetland | 1.10 | 0.32 | 1.14 | 0.33 |
| Connecting canals | 0.86 | 0.25 | 0.88 | 0.26 |
| Muddy area | 2.18 | 0.64 | 0 | 0 |
| Rail | 1.61 | 0.47 | 1.99 | 0.57 |
| Road | 2.77 | 0.81 | 2.96 | 0.86 |

Table 2-: Land Use Land Cover Change 1967-2019

| 1967 | | 2019 | |
|---|---|---|---|
| *Land use* | *Area Km²* | *Land use* | *Area Km²* |
| Estuary | 70.43 | Estuary | 58.39 |
| Paddy cum fish culture | 42.08 | Paddy cum fish culture | 8.05 |
| Paddy | 30.1 | Paddy | 0 |
| Aquaculture | 1.8 | Aquaculture | 26.83 |
| Seasonally flooded area | 5.69 | Seasonally flooded area | 8.95 |
| Water logged | 1.30 | Water logged | 3.8 |
| Vegetated wetland | 1.1 | Vegetated wetland | 1.14 |
| River | 5.47 | River | 4.22 |
| Muddy area | 2.19 | Muddy area | 0 |
| Connecting canals | 0.86 | Connecting canals | 0.88 |
| | | Mangrove | 2.01 |
| Total | 158.11 | | 114.27 |

Table 3-: Total Wetland Changes

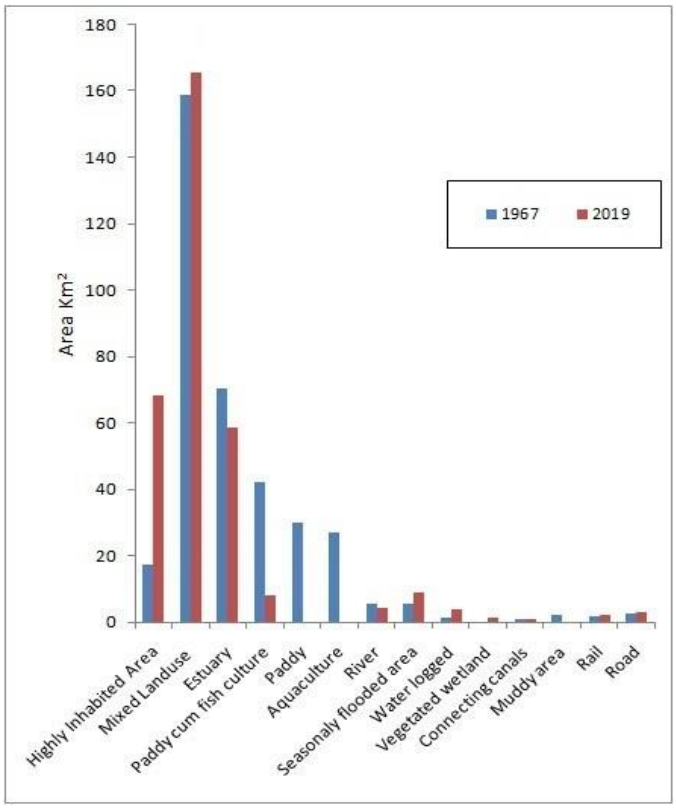


Fig 1-: LULC Changes from 1967 -2019

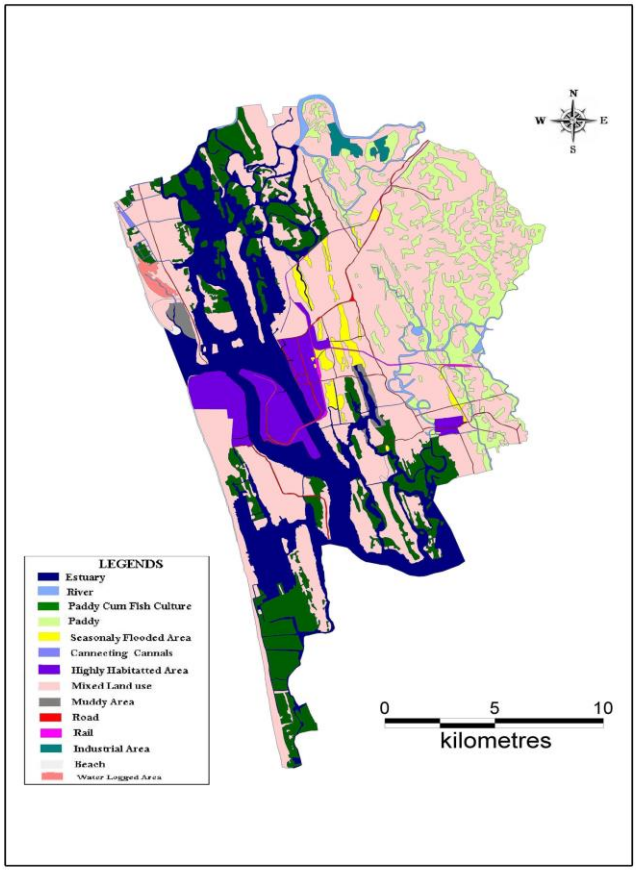


Fig 2-: LULC Map 1967

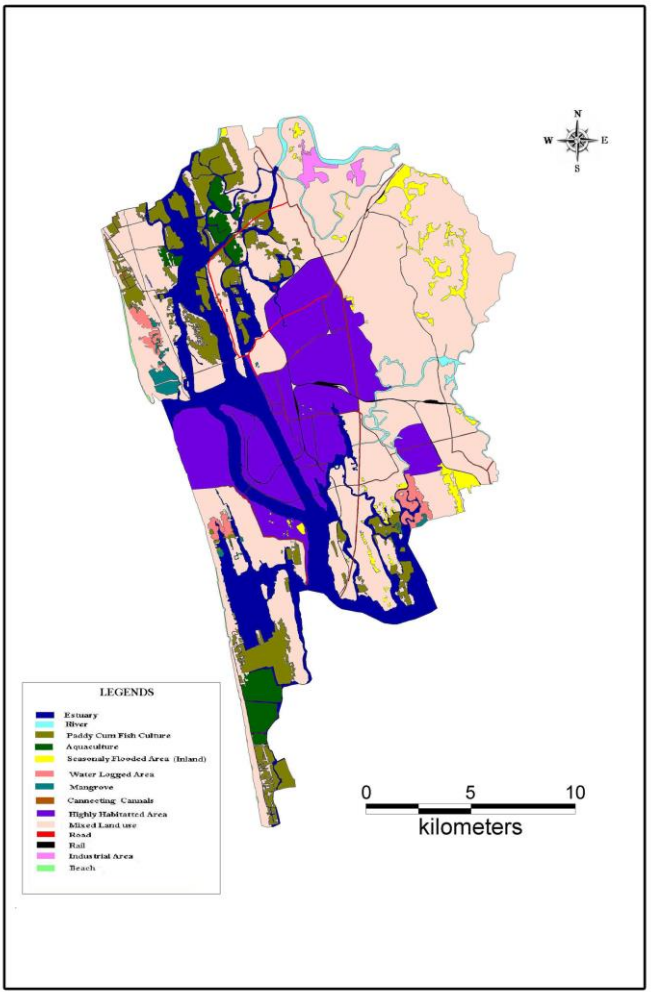


Fig 3-: LULC Map 2019

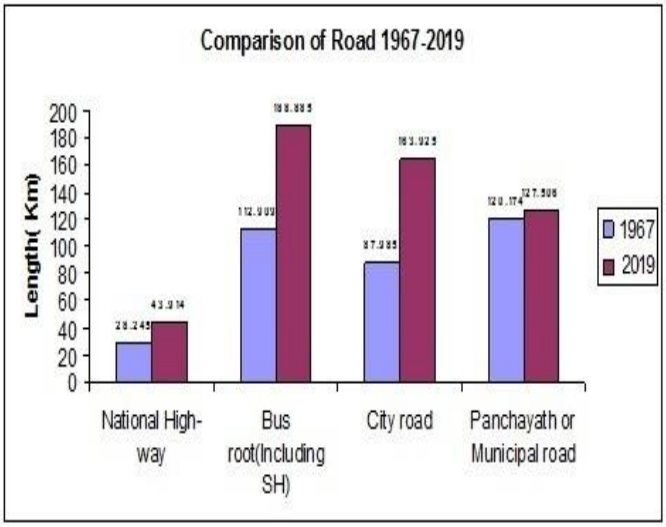


Fig 5-: Comparison of Roads 1967-2019

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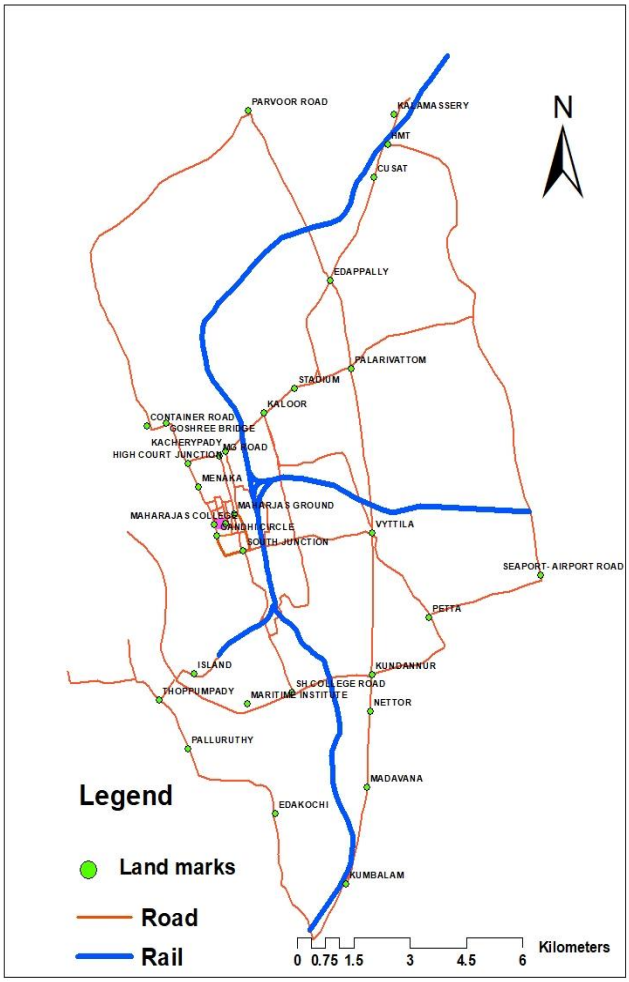


Fig 4-: Road Map

## IV. CONCLUSION

It is seen that large extent the highly habitated areas have increased but the roads and other infrastructure haven't developed according to the urbanization. Also indicating the Wetlands in Cochin City are already under severe threat and need for Wetland management. A large area of Mangrove reclaimed during these period. This study limited by time and financial constraints. More comprehensive study and monitoring can be essential for developing the Sustainable Management Plan for Cochin City.

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