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Impact of Aquaculture industries on geomorphology around Buckingham canal, Kancheepuram District, Tamil Nadu, India using Remote sensing and GIS Techniques

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ABSTRACT

Aquaculture has been fast growing industry because of significant increase in the demand for fish and seafood throughout the world. However, the concerns were raised about the possible impacts of these aquaculture industries on the ambient aquatic ecosystem and degradation of the land environment. Rapid scale growth of intensive aquaculture systems can often lead to adverse impacts on the geomorphology of land environment and nearby water resources. The present study was aimed to evaluate the impacts of aquaculture industry development along Buckingham canal between Sadras backwater in the South and Muttukadu backwater in the North where it joins the Bay of Bengal near Mahabalipuram, Tamil Nadu, India. Remote sensing and GIS techniques were used to study the adverse impacts on geomorphology of the land environment and nearby water resources of the present study area. The Land use and Land cover (LULC) data indicated that about 1004.4 ha (hectare) of backwater area, 1503.81 ha of vegetation (shrubs, mud flats and mangrove) and 50.85 ha of agriculture land were largely converted in to Aquaculture ponds in last nearly three decades i.e. from 1990 to 2017 in the present study area.
Keywords: Aquaculture industries, Geomorphology, Buckingham canal, Remote Sensing and GIS Techniques.

I. INTRODUCTION

Aquaculture has been a fast-growing industry because of significant increase in the demand for fish and seafood throughout the world. It is growing more rapidly than any other segment of the animal culture industry (Gang et al. 2005). Aquaculture plays a significant role in the development of the country economy as well as state economy. On the other hand, in the coastal areas where farmers yield low income from agricultural activities, flood prone areas, mud flats and open shrubs fields were largely converted in to aquaculture ponds. So from the past nearly three decades aquaculture has been fast growing in the study area since 1990s and has transformed the landscape and environmental conditions in the recent years. Therefore, aquaculture activities pose major threat to land degradation as well as water resources due to poor planning of land and water resources management in the study area. The Buckingham canal is one such place where the aquaculture activities have been phenomenally increased. The conversion of backwater area, vegetation (shrubs, mud flats and mangrove) and agriculture land in to aquaculture pond leads to degradation of land environment and water pollution. Hence, it is essential to monitor the development of aquaculture industries, so that effective measures can be taken to prevent conversion of backwater, vegetation (shrubs, mud flats and mangrove) and agriculture land in to aquaculture ponds and water pollution. Brackish water aquaculture practiced in the study area and majority of the aquaculture ponds are situated either side of the Buckingham canal. Those aquaculture ponds are required large amount of brackish water for daily change activities, due to this practices the polluted water discharged back in to the canal from the upstream side of the aquaculture ponds that same water is used by downstream side aquaculture ponds, this is the main cause for increasing pollution in many folds. Remote sensing and GIS techniques are very efficient tool to analyze the large scale changes in the geomorphology of the land environment due to industries and anthropogenic activities. In the present study the geomorphological changes around Buckingham canal by

aquaculture industries were investigated for the last nearly three decades using Remote sensing and GIS techniques.

II. STUDY AREA

The study area is located along Buckingham canal in the Thirukalukundram and Chengalpattu taluk eastern part of Kancheepuram district, Tamil Nadu, India. The Buckingham canal is inland navigational canal with a total length of 420 km with 163 km lying in Tamil Nadu and 257 km in Andhra Pradesh. It extends parallel to the Coromandel Coast of South India from the Krishna District in the state of Andhra Pradesh to the Villupuram District in the state of Tamil Nadu. The canal joins majority of the natural backwaters along the coast to the port of Chennai (formerly Madras). It was built by the British Raj, and was a significant waterway throughout the late nineteenth and the twentieth century. The present study area covered at a distance of about 37 km between Sadras backwater in South and Muttukadu backwater in North where the Buckingham canal joins the Bay of Bengal. The total area covered for LULC in this present investigation is about 17742.78 ha. The study area is geographically lying in between 12°30'34.27"N and "80°09'45.74"E and 12°48'14.53"N, "80°14'56.52"E and is shown in Fig. 1.

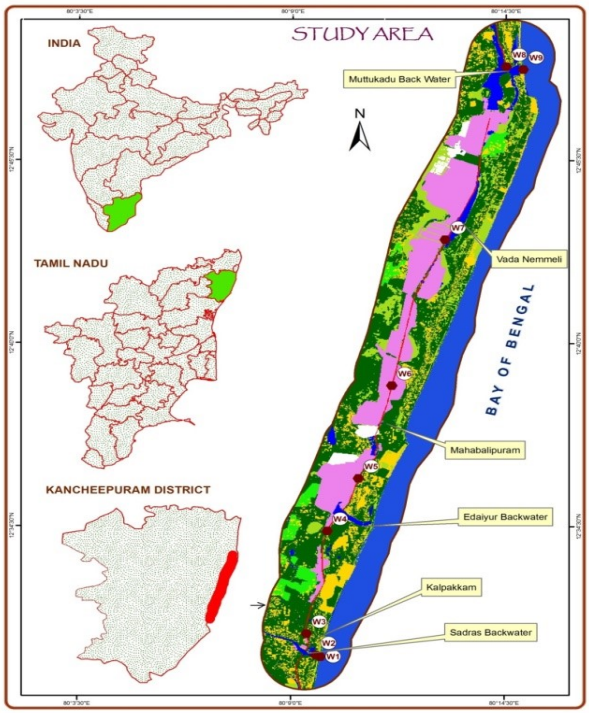

Figure 1. Location map of the study Area

III. MATERIALS AND METHODS

The satellite data from LANDSAT -7 imagery for 1990, 2000, 2010 and LANDSAT - 8 imagery for 2017 have been used for Land use and Land cover change detection analysis for the study area. Apart from satellite data thematic maps, field measured data and other relevant published information has also been included. The software used are such as ERDAS Imaging (9.1 Version) for LULC detection and ArcMap (9.3.1 Version) for Mapping of LULC, boundary delineation and locating water sampling sites for the study area. The following flow chart depicting the general methodology used is shown in Fig. 2.

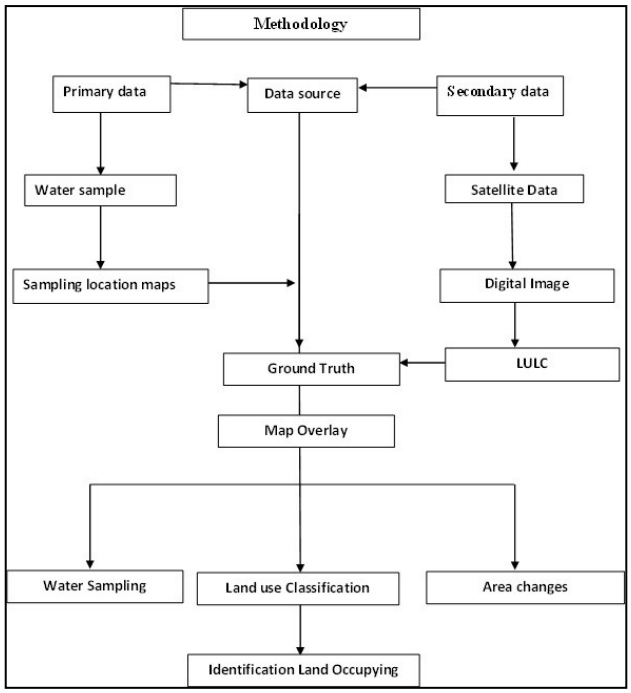

Figure 2. Flow chart depicting general methodology of the study area

IV. LAND USE AND LAND COVER MAP

Land use refers to the land which is occupied by human beings for various activities and land cover refers to the land covered by natural resources like forest, water resources etc. Land use map was prepared for the present study area located along Buckingham canal in the Thirukalukundram and Chengalpattu taluk eastern part of Kancheepuram district, Tamil Nadu using LANDSAT thematic images.

V. AQUACULTURE DEVELOPMENT IN THE STUDY AREA

In the study area there was no aquaculture activities at the time of topo maps preparation by Survey of India (SOI) i.e., in the year 1968 (MynarBabu et al, 2013). But in the year 1990 the satellite data of LANDSAT-7 shows, there was enormous amount of land has been converted as brackish water aquaculture ponds. In the year 1990, the total aquaculture activity in the study area was only 733.23 ha. However, the aquaculture activity was rapidly increased to 1279.71 ha in the year 2000, and 2275.92 ha in the year 2010 and the LANDSAT-8 shows that total aquaculture activity in the study area is 2785.14 ha in the year 2017. The rapid increase in aquaculture farming, other industrial activities and decrease in the backwater, vegetation (Shrubs, Mud flats and Mangroves) are shown in the Fig 3, 4, 5 & 6 for the present study area.

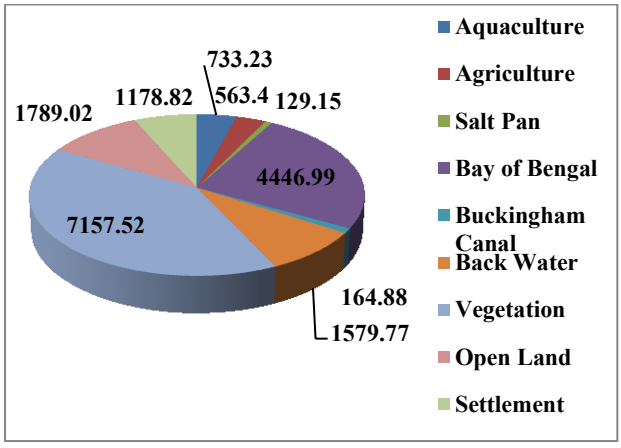

Figure 3. Aquaculture and other industrial activities in the study during 1990 in ha

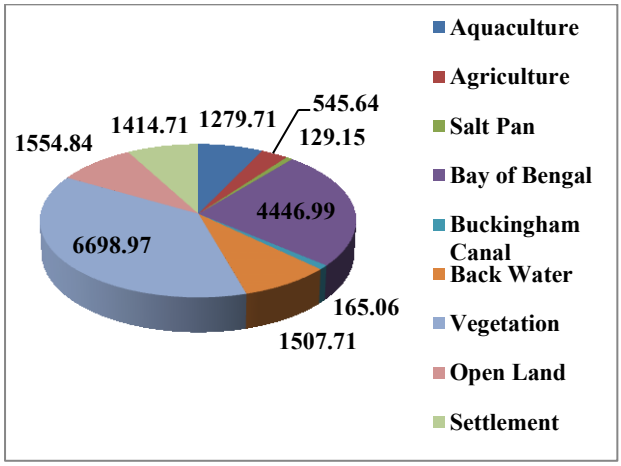

Figure 4. Aquaculture and other industrial activities in the study during 2000 in ha

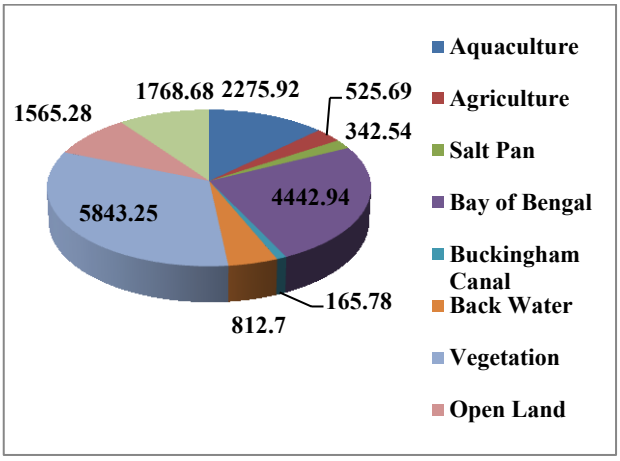

Figure 5. Aquaculture and other industrial activities in the study during 2010 in ha

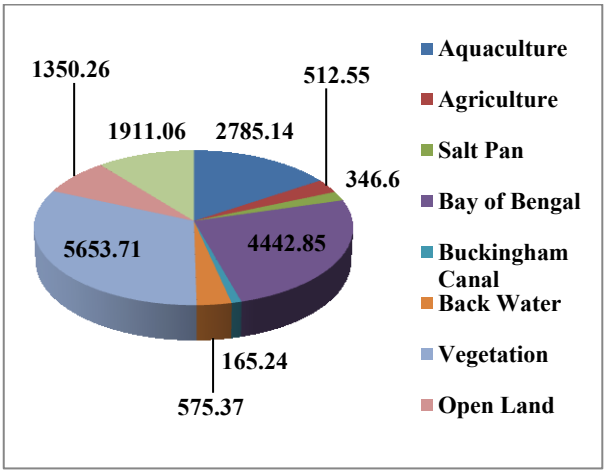

Figure 6. Aquaculture and other industrial activities in the study during 2017 in ha

From the above chart, of all categories, the reduction in the backwater area is found to be 1004.4 ha, reduction in the vegetation (shrubs, mud flats and mangrove) area found to be 1503.81, reduction in agriculture area found to be 50.85 ha and these areas were mainly converted in to aquaculture farms and salt pans in the study area for nearly last three decades. On the whole, increase in the aquaculture and salt pans are quite significant in the study area and conversion of vegetation (shrubs, mud flats and mangrove) backwater area and agriculture land in to aquaculture pond is considered as better indicator of the degradation of land and nearby water resources around Buckingham canal.

VI. RESULTS AND DISCUSSIONS

A. Impact of aquaculture on the backwater area:

In the study area the aqua farming is practiced in two taluks namely Thirukalukundram taluk and

Chengalpattu taluk. The total area taken for the present study is about 17742.78 ha out of which aqua farming is practiced in the study area is about 2785.14 ha. The total backwater area in the study area was found to be 1579.77 ha during the year 1990 and aqua farming was found to be only 733.23 ha. However, the backwater area decreased to 1507.71 ha in the year of 2000 and 812.7 ha in the year of 2010 and only 575.37 ha in the year 2017. The increase in the aquaculture farming and decrease in the backwater area, Vegetation (Shrubs, Mud flats & Mangroves) and Agriculture land is shown in the LULC map in Fig. 7, 8, 9 &10.

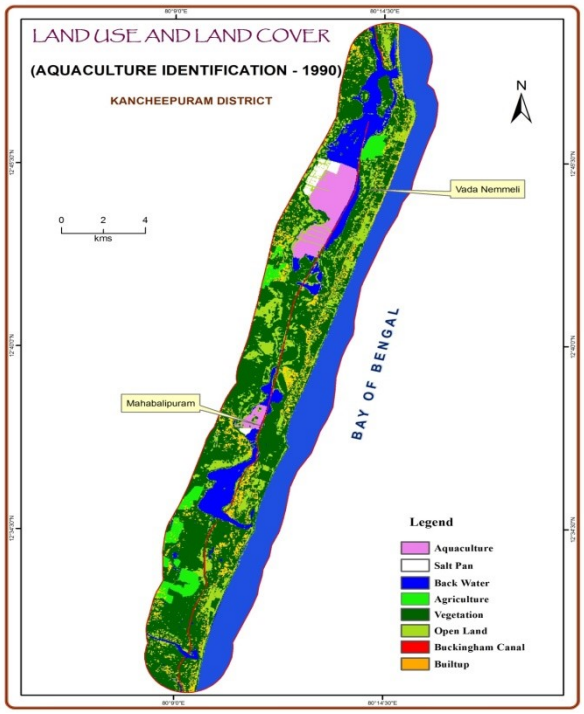

Figure 7. LULC map during 1990 in the study area

Figure 8. LULC map during 2000 in the study area

According to Philips et al. (1993) although pollutant laden discharge from shrimp ponds may help nutrient enrichment but can cause eutrophication of natural water bodies and its impacts on coastal environment is of great concern. Increasing eutrophication in natural water can lead to ecologically undesirable consequences.

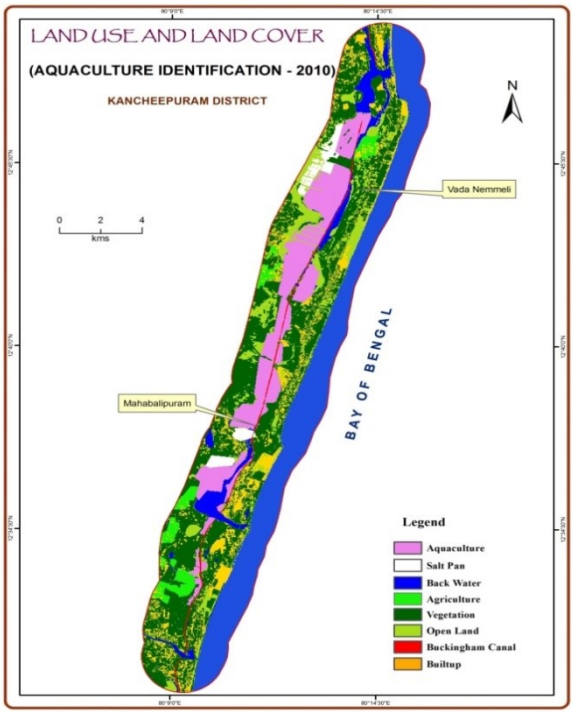

Figure 9. LULC map during 2010 in the study area

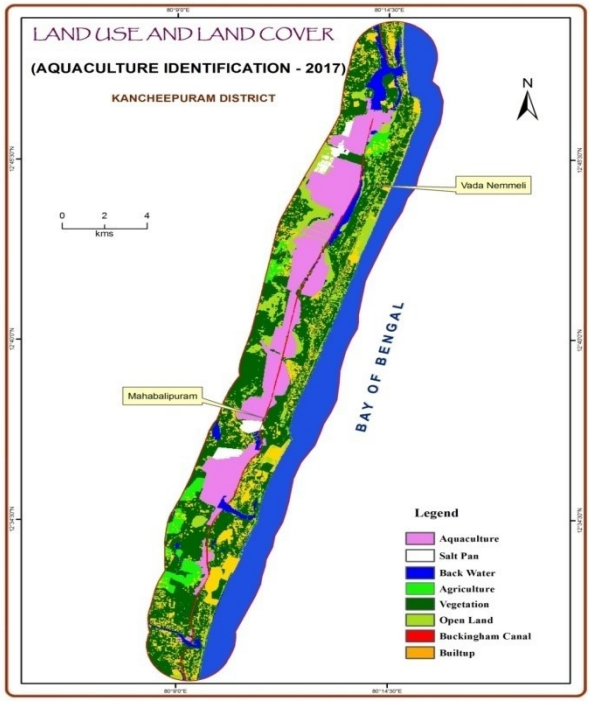

Figure 10. LULC map during 2017 in the study area

B. Impact of Aquaculture on Vegetation (Shrubs, Mud flats & Mangroves):

In the study area some of the Shrubs and Mud flats have been converted in to shrimp ponds in Thirukalukundram taluk and Chengalpattu taluk and Mangroves to some extent near Sadras creek in Thirukalukundram taluk near Mahabalipuram. The transformation was reflected in loss of essential ecosystem services generated by shrubs, mud flats and mangroves including the provision of fish/crustacean nurseries, wildlife habitat, coastal protection, flood control, sediment trapping and water treatment. The total vegetation in the study area was found to be 7157.52 ha during the year 1990. However, it was decreased to 6698.97 ha in the year of 2000 and 5843.25 ha in the year of 2010 and 5653.71 ha in the year 2017. The ecological and commercial problems of shrimp culture ponds are largely related to the removal of vegetation particularly shrubs, mud flats & mangroves and construct dykes with sluice gates to retain water. The original tidal regime, which is essential for the survival of mangrove tree species is totally disturbed. With the exception of the planted mangroves in area where the tidal regime is approximately restored; most of the mangrove flora hardly survive in shrimp pond areas because of drastic changes caused due to drainage of farm effluents. The decrease in the vegetation is shown in the LULC map in Fig. 7,8,9&10.

C. Impact of Aquaculture on Agricultural land:

In the study area some of the agricultural land is largely converted in to aquaculture ponds in Thirukalukundram taluk and Chengalpattu taluk. Hence, it is directly increased pressure on fresh water resources. Some of the agricultural land situated near aquaculture pond face water logging and salt water intrusion problems so that crop output was reduced. The total agriculture land in the study area was found to be 563.4 ha during the year 1990. However, it was reduced to 545.64 ha in the year of 2000 and 525.69 ha in the year of 2010 and 512.55 ha in the year 2017. The pumping of brackish water into aquaculture ponds and its long contact with these fertile soil results in conversion of these land into aquaculture farms which is evident in the study area of Thirukalukundram taluk and Chengalpattu taluk. The intensive shrimp farming practice in South East Asia is based on brackish water salinity 15 - 25 ppt. pumping of large volume of ground water to achieve brackish water salinity led to the lowering of ground water levels, affecting of aquifers and salinization of adjacent land and waterways. Salinization reduces water supplies not only for agriculture land, but also for drinking and other domestic needs (PatilPawan and Krishnan 1998). Even when fresh water is no longer pumped from aquifers, the discharge of salt water from shrimp farms located behind mangroves still causes salinization in adjoining rice and other agricultural lands (Primavera 2006). Similarly Chaudhury and Meena (1995) studied the impact of shrimp farming on agricultural fields and fresh water resources. The soil data (EC, pH, Organic matter, available nitrogen, total nitrogen, potassium, phosphorus and soil texture) and water samples for Salinity, pH and dissolved oxygen collected from paddy fields closed to the shrimp farms at a distance of 0, 30 and 60m. The electrical conductivity of the soil clearly showed that the impairment of soil in the paddy fields situated adjacent to the shrimp farms up to a distance of 60m. The study recommends that the setting up of buffer zones between the areas of aquaculture and agriculture is mandatory as the production of paddy was low in fields skirting shrimp farms due to salinization (Panchatcharam, 1996). Aquaculture culture has adversely affected food security through loss of rice lands due to conversion of ponds or salinization of soil. Rice production has been affected by seepage of salt water and pollutants from the aquaculture ponds (Hein, 2000). Expansion of shrimp farms in the

Nellore District of Andhra Pradesh and other rice growing areas in South India has turned rice fields in to fallow lands (Shiva and Karir, 1997). Although the pollution potential of shrimp pond effluents are minimal compared to domestic or industrial waste water (Macintosh and Phillips, 1992), problems arise because of the large volumes of water discharged from intensive farms and compounded due to the high concentration of farm units in areas with limited water supplies and inadequate flushing. The decrease in the crop land is shown in the LULC map in Fig. 7, 8, 9 & 10.

VII. CONCLUSION

Aquaculture has several positive and negative impacts on the environment. However, it has a major role in the rural employment and economic development of coastal villages. The practice of aquaculture has been observed to increase in recent times in the study area; the majority of the Backwater, Vegetation (Shrubs, Mud flats & Mangroves) and Agricultural lands have been converted to aquaculture ponds nearly last three decades. For the practice of aquaculture, the brackish water is used from the nearby canal and also pumping from ground water. Extensive aquaculture may lead to excessive use of ground water thus it may cause depletion in ground water of the study area. The water quality in these aquaculture ponds are usually saline, which slowly infiltrates and reaches the water table, it cause to salinity intrusion to ground water in the nearby villages. Salinization reduces water supplies not only for agriculture but also for drinking and other domestic needs. The study recommends that the setting up of buffer zones between the areas of aquaculture and agriculture is mandatory as the production of paddy was low in fields skirting shrimp farms due to salinization of soil. (Panchatcharam, 1996). Aquaculture is increasing at a rapid pace in the study area and is evident from the satellite imagery of 1990, 2000, 2010 and 2017. Extraction of data on aerial extents of different land use and land cover features of the study area through GIS analysis for identifying the backwater area, vegetation (Shrubs, Mud flats & Mangroves) and Agriculture land which shows it is largely converted in to aquaculture ponds which is serious concern and needs to be investigated further. The present study also highlights the importance of Remote sensing and GIS Techniques identifying this type of environmental degradation due to unplanned development of aquaculture ponds in the study area. The present study is gaining significance due to rapid expansion of the aquaculture industries and to evaluate the long term impact on the geomorphology of the study area.

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