

## THE LAND USE CHANGE DETECTION OF COASTAL AREAS IN AMPARA DISTRICT IN SRI LANKA

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### ABSTRACT

*The major livelihoods of the study area is paddy cultivation, coconut plantations, fisheries (inland fisheries, lagoon fisheries and marine fisheries), livestock rearing, weaving, trade and government and non-governmental services. Before the tsunami, the local people depended on the above livelihoods. But after the tsunami, the source of income from the above activities decreased drastically. This study primarily aims at assessing the effect of natural and human causes of land use / land cover changes and the environmental implications in respect of population growth, urbanization of selected coastal areas and agricultural development in the district of Ampara. In 1981, there were buildings covering 13.15 km<sup>2</sup> equivalent to 19.36 per cent, but in 1991, it increased to 17.37 km<sup>2</sup> equivalent to 26.58 per cent. In 2001, the area under buildings was 21.75 km<sup>2</sup> equivalent to 32 per cent and in 2011 it further increased to 24.97 km<sup>2</sup> equivalent to 36.77 per cent. In this way, the land area for buildings has come to occupy second place whereas the cultivable land occupies the first place, in comparison. The results of analysis have been tabulated as well as prepared as charts to show the trends of land use changes in the study area. Among eight land use categories, both the built-up land and paddy fields account for most in the research area: 13.15 km<sup>2</sup> and 39.3 km<sup>2</sup>, respectively, in the year 1981 and the same has increased to 36.77 km<sup>2</sup> and 49.83 km<sup>2</sup>, respectively, in the year 2011. In this coastal fringe, fishing is the chief occupation. So, the dense settlements have also been a cause for soil erosion just as climatic conditions have come to affect the soil erosion. This study recommends that the Wetlands and lagoon conservation as well as building up of a green urbanization in sub-urban areas and under management of coastal land issues such as coastal erosion management and pollution of the coastal areas have been considered and management of natural disasters and man-made disasters are also considered for sustainable land use management system in the future. In Sri Lanka, the land use has undergone changes as a result of human interaction, natural disasters, urbanization and political instability. Therefore, a study of this nature would bring enlightenment to people in the fields of land use planning, land use management and environmental conservation.*

**Keywords:** land use, livelihood, detect, plantation, settlement

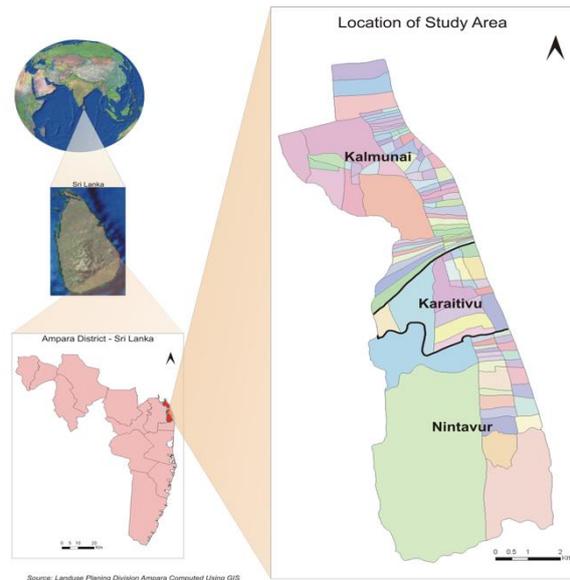
### Introduction

People's minimum basic needs are food, clothing and shelter. With increase in population, century by century, the demands for basic needs tended to move along the paths of forestry for hunting, gathering fruits and collecting woods; and agriculture for cultivating food crops, growing cereals, vegetables and planting trees and animal husbandry for subsistence. In this way, the life-cycle of human has been rooted firmly in the soils of the land, controlled by the conditions of climate, hydrology, topography and nutrition. Now the people have science and technology, skills, wills and endeavour to increase the agricultural production and to promote process of agriculture and other relevant and necessary activities with the help of farmers, policy frames, different departments dealing with the affairs of land protection, agriculture, land use and resource management, food production, community development, new settlements and other activities for the improvement of conditions for welfare of the society through micro, medium and macro projects in the selected study area located in Ampara District related to land use change and development of new lands under the Gal Oya Valley irrigation system, to direct attention to agricultural development and to start agro-based real industries with colonization and rural reconstruction and urbanization. Eastern Province Coastal Community Development Project (2009).

### STUDY AREA

The study area is located between the latitudes of 7°25' 24"N and 7° 27' 25" N and on the longitudes initially of 81° 45' 31" E to 81° 50' 32" E. General land use of this study area is mainly agricultural land, wetlands and grasslands. Agricultural land has paddy, coconut, Chena cultivation and sugarcane. Wetlands are mainly the marshy lands. Green land covers are the mangroves. This area has a high density of population. There is land scarcity for settlement expansion which has become a major issue in the region (Population of Density 2,330 per km<sup>2</sup> in 2011).

**Figure 1: Study area**



(Retrieved by: Arc GIS)

## OBJECTIVES

### Primary objective

Assessing the effect of natural and human causes of land use / land cover changes and the environmental implications in respect of population growth, urbanization of selected coastal areas and agricultural development in Ampara District.

### Secondary objective

- To examine and analyse the spatial and temporal changes in land uses and land cover, especially in agricultural land uses, wetlands and green areas of the Ampara coastal zone.
- To explore and assess the damages caused to the physical environment by the Tsunami and to assess the changed patterns of livelihoods of the people in Ampara district.
- To provide suggestions to the land use problems and to make proper land use management in the study area.

## RESEARCH METHODOLOGY

### Primary data collection

Questionnaires, Direct Interviews, Participatory rural appraisals and Field visits and observations such tools were used to collect primary data. 450 questionnaires administered in the field survey of the study area.

### Secondary data collection

Published / unpublished (earlier) studies, Government Documents / Reports, Departmental Reports, Private (NGOs) Sources, Remote Sensing Analysis, Printed Maps and Collections. Reports from Department of Survey, population details from the Census reports of Sri Lanka, land use information from Land Use Policy Planning Division, Department of Agriculture: published quarterly and annual reports, Department of Forestry and Department of Wildlife.

## RESULT AND DISCUSSION

### The land use change detection in Kalmunai MC Area 1981-2011

In Kalmunai Municipal Council (MC) area, the land use system has been detected and classified from 1981 to 2011.

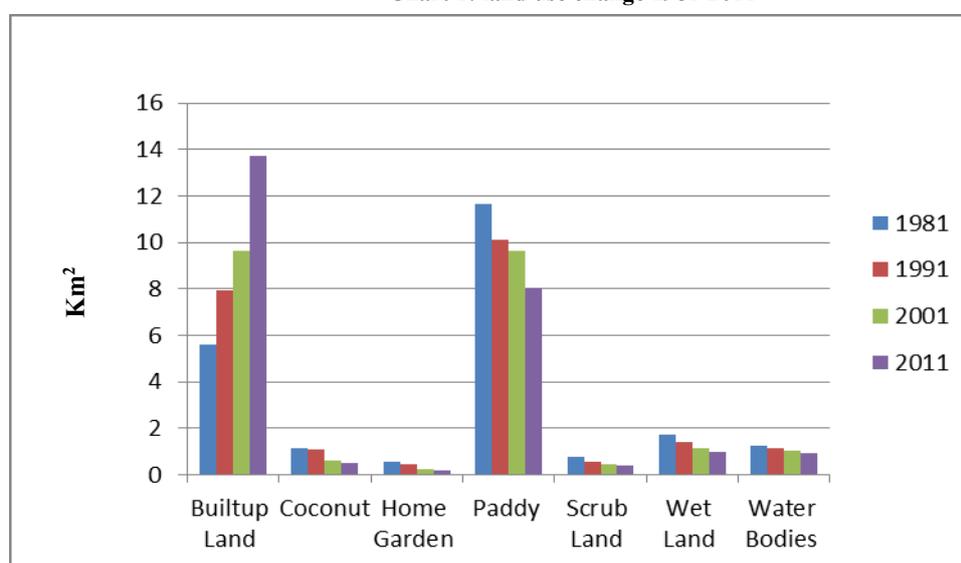
**Table 1: Land Use Types and Changes in Kalmunai MC Area**

CATEGOR Y	1981		1991		2001		2011	
	EXTENT OF COVERAG E	PERCEN T						
BUILT-UP LAND	5.62	24.78	7.94	35.01	9.62	42.42	13.74	60.58

COCONUT	1.13	4.98	1.07	4.72	0.60	2.65	0.48	2.12
HOME GARDEN	0.55	2.43	0.45	1.98	0.24	1.06	0.16	0.71
PADDY	11.63	51.28	10.13	44.66	9.65	42.55	8.02	35.36
SCRUB LAND	0.78	3.44	0.56	2.47	0.42	1.85	0.38	1.68
WET LAND	1.74	7.67	1.41	6.22	1.14	5.03	0.98	4.32
WATER BODIES	1.23	5.42	1.12	4.94	1.01	4.45	0.92	4.06
<b>Total</b>	<b>22.68</b>	<b>100.00</b>	<b>22.68</b>	<b>100.00</b>	<b>22.68</b>	<b>100.00</b>	<b>22.68</b>	<b>100.00</b>

(Source: field data collection, 2015)

Chart 1: land use change 1981-2011



#### Built-up land

In 1981, there were buildings for the purposes of covering an area of 5.62 km<sup>2</sup> equivalent to 24.78 per cent of the total area of Kalmunai Municipal Council. It had population strength of 61,881 in 1981, but in the course of 10 years' time, the areal extent of building space increased to 7.94 km<sup>2</sup>, equivalent to 35.01 per cent of the total area.

The extent of land used for buildings was 9.62 km<sup>2</sup>, equivalent to 42.42 per cent of the total land. The total population was 100,861. In 2011, the buildings covered 10.64 km<sup>2</sup>, equivalent to 38.10 per cent. When analysing the fact that though 2 per cent of the buildings were abandoned due to the displacement of people as a result of the conflicts in 1990 and the tsunami, in the face of population growth, urbanization, development, commercial investment, post-tsunami rehabilitation works. Area under fisheries, and buildings also increased. Besides, due to cultural practices, more houses were built to be given to the female children as dowry at the time of their marriage, as the Muslims are a major component of Kalmunai MC Population.

#### Paddy lands

The paddy land used in 1981 indicates to 11.63 km<sup>2</sup>, an equivalent of 51.28 per cent of the geographical area. In 1991, it was 10.13 km<sup>2</sup> equivalent of 44.66 per cent, thereby showing a decrease in paddy land use. In 2001, the land used for paddy cultivation 9.65 km<sup>2</sup>, equivalent to 42.55 per cent showing a decline. In 2011, the land area was 8.02 km<sup>2</sup>, equivalent to 35.3 per cent. This shows that lands used for paddy cultivation from 1981 to 1991 have been used for industrial, commercial and business activities and building for office complexes. Again from 1991 to 2001, the land was used for administrative building blocks, hospital, road development, and public service centres. Consequently, the paddy land area has become reduced in size in Kalmunai Municipal Council. For using the paddy land areas for other purposes, prior permission should have been obtained from the Ministry of Agriculture but, the activities were carried out without the permission losing agricultural land sites.

#### Coconut plantations

In 1981, 1.13 km<sup>2</sup> of land equivalent to 4.98 per cent of land used for coconut cultivation. In 1991, the land was reduced to 1.07 km<sup>2</sup> equivalent to 4.72 per cent, thereby showing a reduction in areal extent. In 2001, 0.60 km<sup>2</sup> land was under coconut cultivation which was equivalent to 2.65 per cent of the total geographical area. In 2011, the land area was 0.48 km<sup>2</sup> equivalent

to 2.12 per cent. This reduction in acreage was due to the major cyclone in 1978 in the coastal area that had damaged a large number of coconut gardens. Settlement, human activities, natural disaster, and building complexes are the factors that account for reduction of coconut land. Besides, the coconut plantations were also affected by diseases due to less attention from the people of this area.

#### Wetlands

In 1981, the wet land was found in 1.74 km<sup>2</sup> equivalent to 7.67 per cent which was reduced to 1.41 km<sup>2</sup> equivalent to 6.22 per cent in 1991. Then, in 2001, it was reduced to 0.98 km<sup>2</sup> equivalent to 4.32 per cent in extent. In 2011, it was 1.14 km<sup>2</sup>, a slight upping over the last few years. In this region, wet land is very important source and it should be preserved.

#### Scrub land

In 1981, scrub land of 0.78 km<sup>2</sup> equivalent to 3.44 per cent of the total area. But in 1991, it was reduced to 0.56 km<sup>2</sup> equivalent to 2.47 per cent. Later in 2001, it declined to 0.42 km<sup>2</sup> equivalents to 1.85 per cent, but in 2011, the scrub land area decreased to 0.38 km<sup>2</sup> equivalents to 1.66 per cent of the area, indicating a dramatic change in decline to reach about half of what was in 1981. To put it differently, the area of the scrub land in 1981 was 3.44 per cent and it declined to 2.47 per cent in 1991 and continued to decline to 1.85 per cent in 2001, but in 2011, it decline further to 1.68 per cent. This attributed decline can be attributed to the settlement of the tsunami affected people.

#### Water bodies

The water logged lagoons are found mainly in Neelavanai and Sammanthurai areas. To put it clearly, the area underwater bodies in 1981 was 1.23 km<sup>2</sup> equivalents to 5.42 per cent of the land; it however decreased to 1.12 km<sup>2</sup> equivalent to 4.94 per cent in 1991. In 2001, the area of lagoons was just 1.01 km<sup>2</sup> equivalent to 4.45 per cent of the geographical area. Later in 2011, it came down further to 0.92 km<sup>2</sup> equivalent to 4.06 per cent indicating a downward trend.

#### The land use change detection in Karaithivu 1981 – 2011

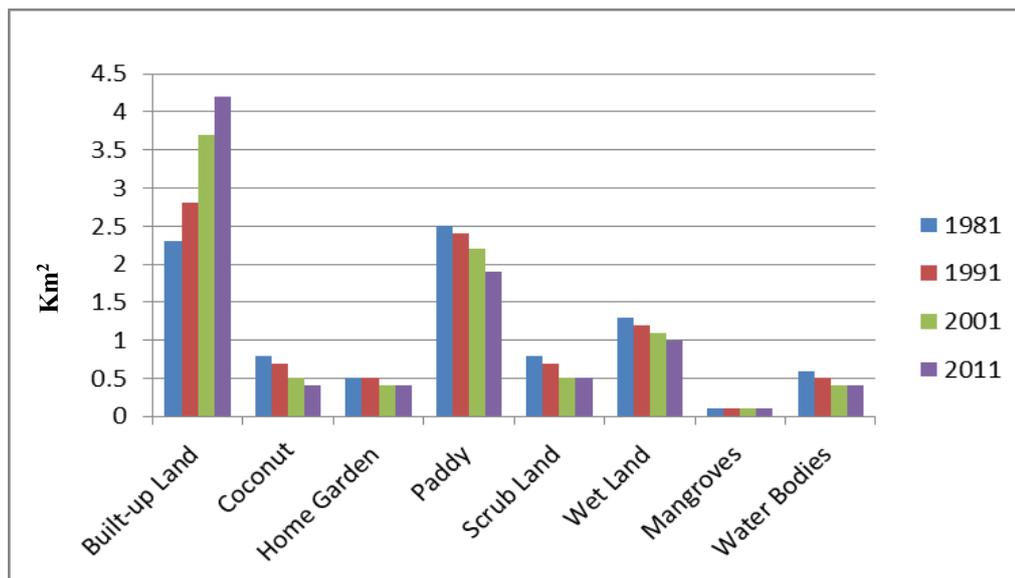
The land area of Karaitivu Division is made up of paddy fields, road networks and drainage systems, households and gardens, inland water bodies, Government premises, public buildings, deserted lands, and open spaces.

**Table 2: Land Use Types and Changes in Land Use in Karaithivu**

Category	1981		1991		2001		2011	
	Extent of Coverage (Sq.Km)	Percent						
Built-up Land	2.3	25.84	2.8	31.46	3.7	41.57	4.2	47.19
Coconut	0.8	8.99	0.7	7.87	0.5	5.62	0.4	4.49
Home Garden	0.5	5.62	0.5	5.62	0.4	4.49	0.4	4.49
Paddy	2.5	28.09	2.4	26.97	2.2	24.72	1.9	21.35
Scrub Land	0.8	8.99	0.7	7.87	0.5	5.62	0.5	5.62
Wet Land	1.3	14.61	1.2	13.48	1.1	12.36	1	11.24
Mangroves	0.1	1.12	0.1	1.12	0.1	1.12	0.1	1.12
Water Bodies	0.6	6.74	0.5	5.62	0.4	4.49	0.4	4.49
Total	8.9	100.00	8.9	100.00	8.9	100.00	8.9	100.00

(Source: field data collection, 2015)

**Chart 2: land use change in Karaithivu, 1981-2011**



(Source: field data collection, 2015)

In Karaithivu, the settlement area was 2.33 km<sup>2</sup> before but in 1991 it was 2.83 km<sup>2</sup> and had expanded to 3.73 km<sup>2</sup> in 2001. In 2011, it was 4.23 km<sup>2</sup>. This steady expansion of settlement area is due to population growth, rehabilitation of the people after tsunami disaster in 2004 and reconstruction of houses for settlements away from the buffer zone.

In 1981, the land used for coconut cultivation was 0.80 km<sup>2</sup>, in 1991 it was 0.70 km<sup>2</sup>, in 2001, it was 0.50 km<sup>2</sup> and in 2011, it dropped down to 0.40 km<sup>2</sup> in the course of 25 years. The main reason was the growth of population, the need for more buildings. The cyclone of 1978, the conflicts after 1983 and the tsunami tragedy in December 2004 have all caused a reduction in the extent of coconut gardens in this area. In 1981, the home garden land was around 0.50 km<sup>2</sup> and it was the same in 1991, at 0.50 km<sup>2</sup>. But in 2001, it was around 0.40 km<sup>2</sup> and so in the course of 25 years, nearly 0.10 km<sup>2</sup> of land was used for other purposes out of the home gardens.

In Karaithivu the paddy fields were found in 2.05 km<sup>2</sup> in 1981, it was 2.2 km<sup>2</sup> in 1991, 2.40 km<sup>2</sup> in 2001 and 1.90 km<sup>2</sup> in 2011. The changes are attributed to the need for space for commercial activities, building constructions and for management purposes, and also for resettlement and rehabilitation with opportunities for sustainable livelihoods. Figure 5.8

Scrub land in 1981 was in 0.80 km<sup>2</sup> and over the next 10 years, it was confined to 0.70 km<sup>2</sup>. In 2001, it was at 0.50 km<sup>2</sup> and in 2011 it was at 0.5 km<sup>2</sup> and thus only 0.30 km<sup>2</sup> of land was reduced between 1981 and 2011 under scrub land, which is in any case a positive transformation for the Karaithivu area.

Water bodies were in an area of 0.60 km<sup>2</sup> in 1981 and this quickly fell to 0.50 km<sup>2</sup> in 1991 and the slide down further reduced the area to 0.40 km<sup>2</sup> in 2001. In the next six years, there was however no change and the area under water bodies stood at the same level at 0.40 km<sup>2</sup>. This shows that there is just a little change of about 0.20 km<sup>2</sup> in this area. This land is used for buildings and religious institutions for cultural festivities and functions.

#### The land use change detection in Nintavur 1981 – 2011

Nintavur has 25 GN Divisions. Eleven GN Divisions were affected by tsunami. The boundaries of Nintavur are the Bay of Bengal on the east, Oluvil and Addalachenai DS Division on the south, Samanthurai on the west and Karathivu on the north. Nintavur has a total population of 24,625. The population density is 443 persons per km<sup>2</sup>. The total land area is 36.3 km<sup>2</sup>.

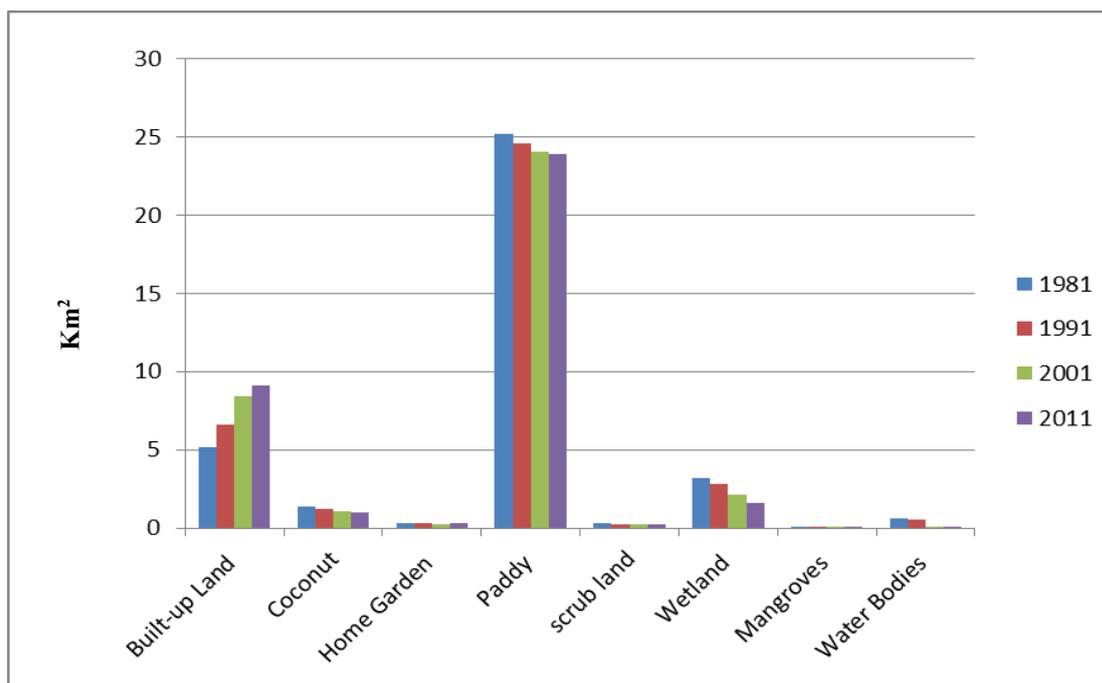
**Table 3: Land Use Types and Changes in Nintavur**

Category	1981		1991		2001		2011	
	Extent of coverage (km <sup>2</sup> )	Percent	Extent of coverage (km <sup>2</sup> )	Percent	Extent of coverage (km <sup>2</sup> )	Percent	Extent of coverage (km <sup>2</sup> )	Percent
Built-up Land	5.2	14.33	6.6	18.18	8.4	23.14	9.1	25.07
Coconut	1.4	3.86	1.2	3.31	1.1	3.03	1	2.75
Home Garden	0.3	0.83	0.3	0.83	0.2	0.55	0.3	0.83

Paddy	25.2	69.42	24.6	67.77	24.1	66.39	23.9	65.84
Sparsely-Chena	0.3	0.83	0.2	0.55	0.2	0.55	0.2	0.55
Wetland	3.2	8.82	2.8	7.71	2.1	5.79	1.6	4.41
Mangroves	0.1	0.28	0.1	0.28	0.1	0.28	0.1	0.28
Water Bodies	0.6	1.65	0.5	1.38	0.1	0.28	0.1	0.28
Total	36.3	100.00	36.3	100.00	36.3	100.00	36.3	100.00

(Source: field data collection, 2015)

**Chart 3: land use change in Nintavur, 1981-2011**



(Source: field data collection, 2015)

In Nintavur, the land used for buildings covered 5.2 km<sup>2</sup> of the total geographical area. In 1991, it increased to 6.6 km<sup>2</sup>. But in 2001, it further went up to 8.4 km<sup>2</sup> and in 2011 it has reached the highest of 9.1 km<sup>2</sup>. The total increase in area under built-up area was 4 km<sup>2</sup> in the 25 years during 1981-2011. The population growth, expansion of residential building, and settlements. The land area used in 1981 was 9.4 km<sup>2</sup>, it was 1.2 km<sup>2</sup> in 1991, 1.1 km<sup>2</sup> in 2001 and it came down to 1.0 km<sup>2</sup> in 2011. The drastic changes were due to the cyclone in 1978 and the tsunami disaster in December 2004 when most coconut trees were destroyed or fallen.

### Home garden

The land area used for cropping in 1981 was 0.3 km<sup>2</sup>, in 1991, it was 0.3 km<sup>2</sup>, but in 2001, it came down to 0.2 km<sup>2</sup> and in 2011 it increased to 0.3 km<sup>2</sup>, back to what it was 25 years ago. In short, there was not any change between 1981 and 2001, but there indeed was during the period.

### Paddy cultivation

In 1981 the paddy land in Nintavur was 25.2 km<sup>2</sup> then, in 1991, it decreased as 24.6 km<sup>2</sup> in 2001 it was 24.1 km<sup>2</sup> and finally in 2011 it was 23.9 km<sup>2</sup>. Business expansion, demand for administrative building and rice mills. From 2001 to 2011, the land area under important uses had become reduced, as lands used in expanding roads and infrastructure facilities, extension of irrigation channels and the consideration of buffer zone to prevent the settlement from the tsunami impacts in the future had increased, with settlements shifting to the interior.

### Scrub land

In 1981, the area of scrub land was 0.3 km<sup>2</sup>, and in 2001, it was 0.2 km<sup>2</sup>, and in 2011, it was the same. So, only a very limited change has taken place in the lands under scrub land in Nintavur.

#### Wetland

In Nintavur, the muddy wetland occupied an area of 3.2 km<sup>2</sup> in 1981, while it declined in 1991 to 2.8 km<sup>2</sup>, in 2001 to 2.1 km<sup>2</sup> and then, in 2011, it further declined to 1.6 km<sup>2</sup>. These changes were due to population growth, the increase in the number of families that occupied the wetlands, in the process of filling-up of the low-lying lands with sand and soil for erecting buildings. But the sea and water plants which occupied the wetlands for the last 25 years had remained, uncleared. They did not disappear because they were not close to the settled areas. But they lay near the paddy lands and the coconut plantations, nevertheless.

#### Water bodies

The water-logged area in 1981 was 0.6 km<sup>2</sup>, it was 0.5 km<sup>2</sup> however in 1991, it went down drastically to 0.1 km<sup>2</sup> in 2001 and for the past 6 years it remained at 0.1 km<sup>2</sup>. In this way, it could be seen that 0.5 km<sup>2</sup> of land became water-logged in the quarter century under study in Nintavur.

**Table 4: Land Use changes in Kalmunai, Karaithivu and Nintavur 1981-2011**

Category	1981		1991		2001		2011	
	Extent of Coverage (Sq.Km)	Percent						
Built-up Land	13.15	19.36	17.37	25.58	21.75	32.03	24.97	36.77
Coconut	3.33	4.90	2.97	4.37	2.2	3.24	1.88	2.77
Home Garden	1.35	1.99	1.25	1.84	0.84	1.24	0.86	1.27
Paddy	39.33	57.91	37.13	54.68	35.95	52.94	33.84	49.83
Scrub Land	1.88	2.77	1.46	2.15	1.12	1.65	1.16	1.71
Wetland	6.24	9.19	5.41	7.97	4.34	6.39	3.58	5.27
Mangroves	0.2	0.29	0.2	0.29	0.2	0.29	0.2	0.29
Water Bodies	2.43	3.58	2.12	3.12	1.51	2.22	1.42	2.09
Total	67.91	100.00	67.91	100.00	67.91	100.00	67.91	100.00

(Source: field data collection, 2015)

In 1981, there were residential and other buildings covering 13.15 km<sup>2</sup> equivalent to 19.36 per cent of the total geographical area. But in 1991, the land use increased to 17.37 km<sup>2</sup> equivalent to 26.58 per cent. In 2001, the buildings occupied an area of 21.75 km<sup>2</sup> equivalent to 32 per cent and, in 2011, it increased to 24.97 km<sup>2</sup> equivalent to 36.77 per cent, a tremendous increase indeed. In this way, the land area for building occupied the second place whereas the cultivable land occupied the first place, in comparison.

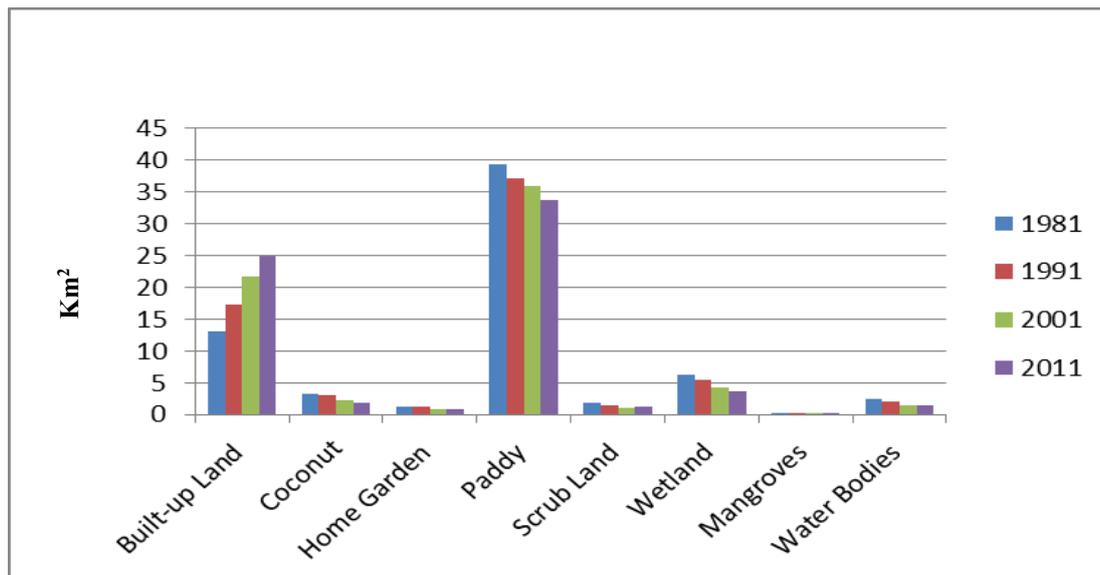
#### Land use changes in Kalmunai MC, Karaithivu and Nintavur 1981-2011

##### Paddy land

The paddy land in 1981 was 39.33 km<sup>2</sup> equivalent to 57.91 per cent of the total area. In 1991, it was 37.13 km<sup>2</sup> equivalent to 54.68 per cent, and in 2001, it increased to 35.95 km<sup>2</sup> equivalent to 52.94 per cent. In 2011, the paddy area began to cover 33.84 km<sup>2</sup> equivalent to 49.83 per cent of the total geographical area. It is noticeable that 5.49 km<sup>2</sup> of lands were reduced in the course of 25 years period.

In 1981, wet lands were 6.24 km<sup>2</sup> equivalent to 9.19 per cent of the geographical area; in 1991, it was 5.41 km<sup>2</sup>, equivalent to 7.97 per cent whereas in 2001 it was 4.34 km<sup>2</sup> equivalent to 6.39 per cent and in 2011 the area was 3.58 km<sup>2</sup> equivalent to 5.27 per cent. In this way, the land area was reduced by 2.76 km<sup>2</sup> in the course of 25 years.

**Chart 4: land use change in Kalmunai MC, Karaithivu and Nintavur 1981-2011**



### Coconut plantations

In 1981, there were coconut trees on 3.33 km<sup>2</sup> equivalent to 4.90 per cent. After 10 years, in 1991, the coconut land was around 2.97 km<sup>2</sup> equivalent to 4.37 per cent of the area and in 2001, however, it was 2.2 km<sup>2</sup> equivalent to 3.24 per cent only. In 2011, the land area was 1.88 km<sup>2</sup> equivalent to 2.77 per cent of the geographical area. In this way, land was reduced by 1.45 km<sup>2</sup> in Nintavur indicating that coconut areas were used for settlement and other human activities.

### Water bodies

In 1981, this water-logged area was 2.43 km<sup>2</sup> in extent equivalent to 3.58 per cent of the total land. In 1991, it was reduced to 2.12 km<sup>2</sup> equivalent to 3.12 per cent. In 2001, there was 1.51 km<sup>2</sup> of land equivalent to 2.22 per cent; finally in 2011 it was 1.42 per cent equivalent to 2.09 per cent. In this area, the total change in water logged areas was 1.01 km<sup>2</sup>.

### Scrub land

In 1981, the scrub land had an extent of 1.88 km<sup>2</sup> equivalent to 2.77 per cent, and, in 1991, it was 1.46 km<sup>2</sup> equivalent to 2.15 per cent. In 2001, the scrub land was 1.12 km<sup>2</sup> equivalent to 1.65 per cent. In 2011, it was 1.16 km<sup>2</sup> equivalent to 1.71 per cent. In this way, a land area of 0.72 km<sup>2</sup> was changed into the scrub land.

### Home garden

In 1981, there were 1.35 km<sup>2</sup> of home gardens equivalent to 1.99 per cent and, in 1991, it was 1.25 km<sup>2</sup> equivalent to 1.84 per cent and, in 2001, it was 0.86 km<sup>2</sup> equivalent to 1.27 per cent. In other words, the area of home garden was reduced by 0.49 km<sup>2</sup> in the course of 25 years.

### Coastal beach land

In 1981, about 0.2 km<sup>2</sup> equivalent to 0.29 per cent. In 1991, it was the same and in 2001 and 2011 also the same. So there was no change that took place for the period of 25 years.

## CONCLUSION AND RECOMMENDATIONS

The detection of land use in the coastal area of ampara district has been identified with this study from 1981 to 2011. In the interval of each 10 years, some places has experience drastic changes. The population growth and urbanization has caused the land use changes in the study area. Accordingly, the objectives have been attained by this study using the assessments.

## RECOMMENDATIONS

### Coastal erosion management

Taking into account erosion trends, land and beach use, socio-economic and environmental conditions (including critical habitats) in a balanced way.

- Recommending appropriate solutions that are cost effective as well as socially and environmentally acceptable.
- Making optimal use of soft solutions, including beach nourishment with sand from offshore sources.
- Considering the possibility of land acquisition and purchase of development rights as a soft solution for managing vulnerable coastal stretches (where necessary) based on surveys, and
- Addressing needs for monitoring and evaluation of plan implementation and communication with stakeholders – including local administration bodies and people/communities.

### **Monitoring**

- Study and identify coastal erosion trends and areas subject to, or liable to, high levels of erosion, including area where erosion control works have been previously introduced.
- Prepare a status report on coastal conditions to be updated periodically.
- Develop a programme to introduce shoreline management planning in the study area where appropriate, including parameters for monitoring and evaluation of the programme.
- Initiate the process of shoreline management planning at appropriate locations on a pilot basis.
- Initiate preparation of site specific responses to erosion management, including shoreline management planning where appropriate.
- Identify areas for land acquisition, and propose financial mechanisms for land acquisition and purchase of development rights.
- Consider applying the general principles of shoreline management at appropriate locations during project approval procedure in the coastal zone.
- Seek EIAs where warranted for proposed works on the coastal zone.

### **Coastal pollution control management**

- Impose CEA standards for discharges on new development activities in the coastal zone subject to permits under provisions of the Coast Conservation Act.
- Impose a compliance programme in collaboration with CEA against existing developers violating the stipulated standards.
- Implement the guidelines stipulated by the Inter-ministerial Committee on Aquaculture Development for all aquaculture projects.
- Initiate an awareness programme in collaboration with the department of fisheries and aquatic resources development for fishing communities to encourage proper disposal of oil waste.
- Initiate studies on water quality in collaboration with other concerned agencies on water quality and publicize the results.

### **Suggestions for further, appropriate development**

- Land utilization, Land Suitability and Land Uses.
- Farm Size Management.
- Land Evaluation and Land Use Planning.
- Land Legislation and Policy.
- Environmental Management.
- Agricultural Management.
- Population management.

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