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Detecting Urban Wetland Changes due to Natural and Anthropogenic Factors in Sri Lanka: Based on GIS and RS*

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Abstract - Urban wetlands are affected by both human activities and climate changes. The spatio - temporal transformation and seasonal inundation determine the structure and functions of tropical wetland ecosystems. Information on the spatial and temporal changeability of inundation is necessary to understand and manage these ecosystems. The western region of Sri Lanka represents one of the most emerging growth centrees in the country and there is an extreme pressure on the natural environment and wetland ecosystems. A combination of methods of environmental history, urban ecology and wetland science based on geographical information system (GIS) and remote sensing (RS) have been applied to the research. Moreover, this research focuses on understanding and assessing the current potential spatial stress on a regional wetland ecosystem due to human interference. This study uses remote sensing images of three time periods (during 1996-2016) to interpret the chronological spatial data of the wetland landscape changes over the 20 years time span. The result shows that the wetland system in this study area presents a trend of widely extent urban-rural situation with rapid land use changes urban expansion, wetland degradation, rapid urban built up land and that different driving forces make a complicated patterns of this wetland ecosystem.

Keywords—Wetland science; Environmnetal history; Urban ecology ;GIS;Remote Sensing

I. INTRODUCTION

Sri Lanka is a tropical country with the tropical monsoon climate, and it belongs to Keppens´ Am classification. It has four spatially diverse climate zones within significant climate type, namely dry, wet, intermediate and arid. The wetlands are one of the major ecosystems in the island and it also highly concentrated in the western region of Sri Lanka. It also can be seen diverse that the human activities influence the spatio-temporal changes of this area. Thus, it is expected to research identification of spatio-temporal variations, altered by human activities and natural conditions in the western wetlands in Sri Lanka. The climate events and Spatio-temporal changes are creating some problems due to the rapid urban growth in the region. And also humanly activates in the buffer zone of these wetlands can be seen a high difference in land use.

II. METHODS

A. Study area

The study was comprised of four divisional secretaries namely Ja Ela, Kadana, Wattala, and Negombo and area is located in the wet zone, covering an area of 102.82 km^2.There are two parts of the wetland. They are Muthurajawela marsh area and Negombo lagoon area. Moreover, the study area located in Colombo metropolitan region an urban-to-rural gradient at a mean elevation of 0m-30 m.

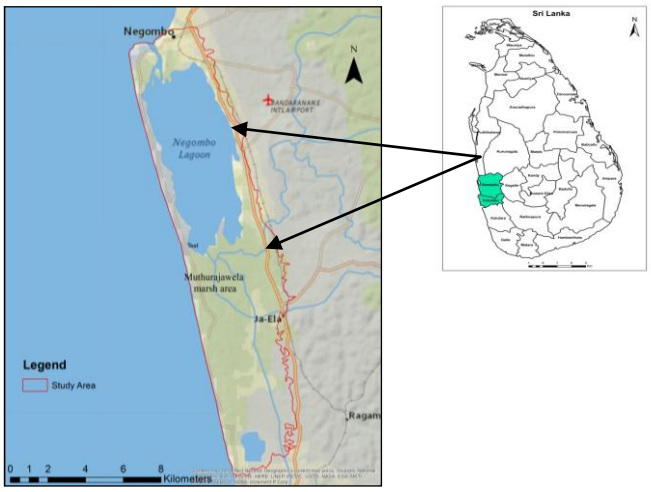

Figure 1: Study area

B. Data

Historical Land sat imageries were the primary source of data in this study. The available land sat imageries, which cover the study area, were taken in 1996, 2006 and 2016 respectively. From 1996 to 2016 daily Precipitation data was taken to identify the wettest month and driest month in the study area by using moving average method. Furthermore, the metric maps at a nominal scale 1:50,000 and 2005 land use map were used to demarcate the study area. All paper maps were scanned to convert to the digital format for the geo referencing.

C. Method

Geo processed Land sat imageries were all first make the band composite by using Arc GIS 10.3 software. Band 5 is the most important band for wetland classification because they can discriminate soil moisture levels and vegetation types (Ozesmi, S.L., and Bauer, M.E; 2002). Maximum Likelihood Classification was used in mapping the Muthurajawela marsh and Negombo lagoon area. There are seven lands used, and land cover classes were carried out to image interpretation and classification based on defined for this research. Classes are the definition in this study area is built up, deep water, other vegetation, agriculture, marshland and abandon paddy, mangroves and scrub, shallow water and sediments respectively.

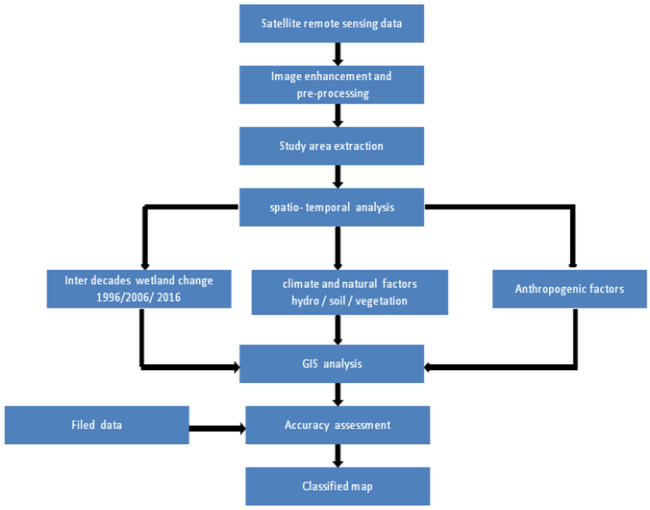

Figure 2: Three stage satellite image analysis process

D. Results

Assessment of LU/LC changes and formation in the Muthurajawela marsh and Negombo lagoon study area are extracted from the Land sat TM, Land sat ETM+ and Land sat OLI images (30 m) for 1996, 2001and 2016 using the Maximum Likelihood method of supervised image classification technique in GIS software.

Fig. 3 shows the spatial distribution of the major land use and land cover classes in the study area for the year 1996, 2001and 2016. The areal distributions of LULC classes in square kilometer and annual average change in square kilometer for the three different periods are shown in Table 1 and Table 2 respectively. The values of the graphical representation are shown in Fig. 4 and figure 5. The different types of the LULC features such as built-up, deep water, vegetation, agriculture, marshland and abandoned paddy, mangrove and scrub, shallow water and sediment are experienced significant changes during 20 years time span in the study area

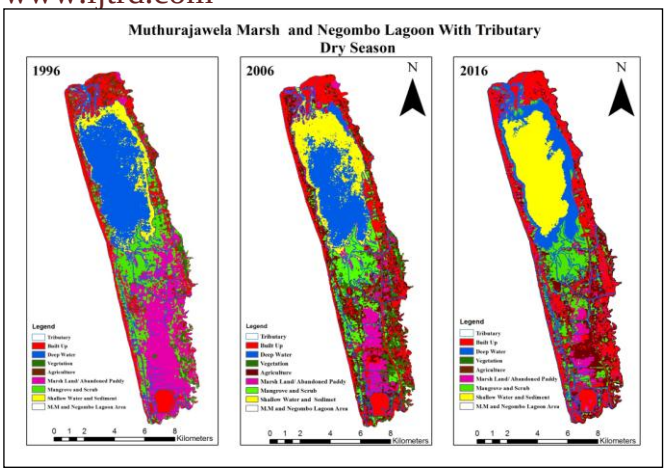

Figure 3: Land cover and land use change of 1996, 2006 and 2016 Muthurajawela marsh and Negombo Lagoon

Table 1: Seven classes change matrix resulting from supervises classification of satellite imageries 1996, 2006 and 2016 in Muthurajawela Marsh and Negombo lagoon in dry season

Table 2: Annual average change of 1996, 2006 and 2016 in study area

	Area km^2		
Signature	**1996**	**2006**	**2016**
Built up	15.44	19.58	24.47
Deep water	25.40	18.58	10.87
Vegetation	5.04	10.59	3.40
Agriculture	4.20	16.69	16.99
Marshland/Abandoned paddy	30.02	12.30	11.21
Mangroves/ scrubs	15.96	12.31	15.53
Shallow water / Sediment	6.72	12.73	20.32

	Annual average change (km^2/year)		
Signature	**1996-2006**	**2006- 2016**	**1996 - 2016**
Built up	0.41	0.48	0.90
Deep water	- 0.68	- 0.77	- 0.72
Vegetation	0.55	- 0.71	- 0.08
Agriculture	1.24	0.03	0.63
Marshland/Abandoned paddy	- 1.77	-0.10	- 0.94
Mangroves/ scrubs	- 0.36	0.32	-0.02
Shallow water / Sediment	0.60	0.75	0.68

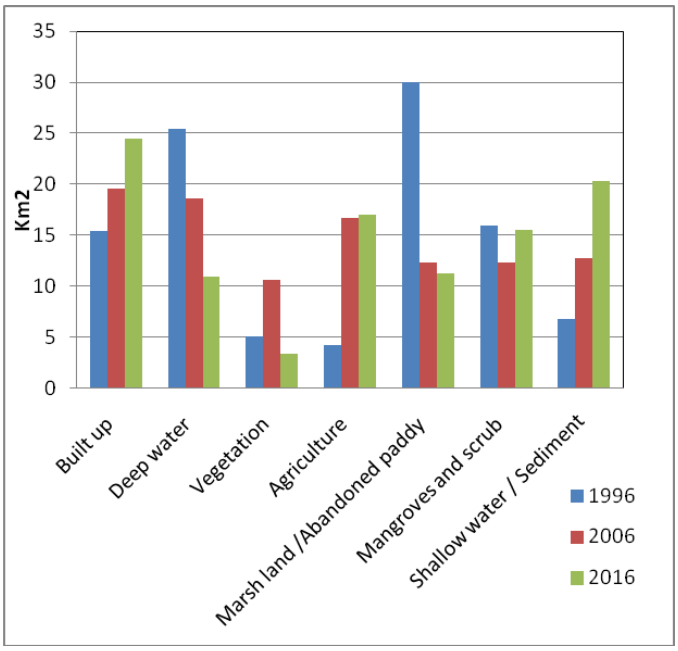

Figure 4: Net change of area of LULC fracture classes during 1996, 2001 and 2016.

E. Assesment of LULC change between 1996, 2001 and 2016

Built up

Built up comprises residential, industrial, transportation, communications, and utilities, industrial and commercial complexes, mixed urban or built-up land and road. The total area of this class is estimated as (Table 1)15.44 km^2 in 1996, 19.58 km^2 in 2006 and 24.47 km^2 in 2016; the annual average change of the built-up area was 0.41km^2, 0.48km^2 and 0.90km^2 respectively (Table 2). During these periods, there is an increase of the area of 24.47 km^2 in built up due to urbanization, encroachment for settlement and real estate activities.

Deep water

The deep water distributed along the lagoon area, and coastal plain in the study area. The areal distribution of this land cover shows a significant decreasing trend from 25.40 km^2 to 10.87 km^2 during 1996–2016 (Figure 4). During these periods, there is a reduction of the area of 9.53 km^2 in deep water due to sediment deposited of the lagoon area.

Vegetation

The vegetation comprises evergreen forest land, grassland, brush various types of vegetative covers and others species in the study area. The vegetative cover is reduced in various parts of the study area from5.04 km^2 to 3.40 km^2 (Table. 1) during 1996–2016 with a total loss in the area as 1.54 km^2. Moreover, due to human encroachment activities, the vegetation area decreased in the study area.

Vegetation

The agricultural land comprises with cultivated areas with fields: Paddy cultivation, Vegetables and Coconut cultivation of the study area. It is primarily used for cultivating paddy, coconut cultivation, and vegetables to human life. The distribution of this land use shows a significant increasing trend from 4.20 km^2 in 1996, 16.69km^2 in 2001 and 16.99km^2 in 2016 to 96.87 km^2 (Figs. 4). During these periods, there is an increase in the area of 12.79km2 in agricultural land due to transfer marshland.

Marshland and Abandoned paddy

This feature class comprises of seasonally flooded areas with abandoned paddy, trees and scrub, bog soil and back swamp of the study area. The marshland and abandoned paddy reduced in various parts of the study area from 30.02 km^2 to 11.21 km^2 (Table. 1) during 1996–2016 with a total loss in the area as 18.71 km^2.

Mangroves and scrub

Mangrove and scrub consisting seasonally flooded areas covered with Mangrove, rooted, herbaceous and hydrophytes. The spatial extent of this land use estimated as 15.96 km^2 in 1996, 12.31 km^2 in 2001 and 15.53 km^2 in 2016.

Shallow water and sediment

Shallow water and sediment comprise with rivers, tributaries, lagoon areas of the study area. There are two sub rivers namely lower Aththanagalu Oya and lower Kelani Ganga river along with their tributaries are flowing westerly. The spatial coverage of this class extent as 6.72 km^2 in 1996 and it is increased to 20.32 km^2 in 2016 (Fig. 4).

Table 3: Accuracy assessment of LULC Classification for 1996, 2001 and 2016

Kappa and overall accuracy LULC classification of year 1996,2001 and 2016		
Year	Overall accuracy %	Kappa statistic
1996	89.44	0.8197
2001	79.99	0.7101
2016	81.16	0.7612

For this study, the 280 samples (40samples per class) are taken for accuracy assessment of all feature class of the classified images for the year 1996, 2001 and 2016. The statistical analysis of accuracy assessment is shown in Table 3. The result shows the overall accuracy is estimated 89.44% in

1996, 79.99% in 2001 and 81.16 in 2016 for the classified images respectively. The Kappa coefficient value of the year 1996, 2001 and 2016 is 0.8197, 0.7101 and 0.7612 respectively.

CONCLUSION

In 1996, 1,777 hectares of the northern part of Muthurajawela wetland was declared as a Wetland Sanctuary based on ecological considerations and high biodiversity by the government of Sri Lanka. Declaration of the preserved area in 1996 successfully resulting in, to improve the natural process of wetland propagation. Especially sediment area in the east in 1996 had been entered to words south part by 2006. It has been propagating to mangrove and scrub by 2016. The base reason this is natural process of wetland development. This is a process of propagation of wetland first sedimentation, encroachment of natural development of buttress to words sediment area. The propagation of wetland had been stopped by 2016 because unavailability of further sediments (Figure 5). However, the Human impact of the boundary area of this preserve area has an increasing trend along the period (Figure 5).

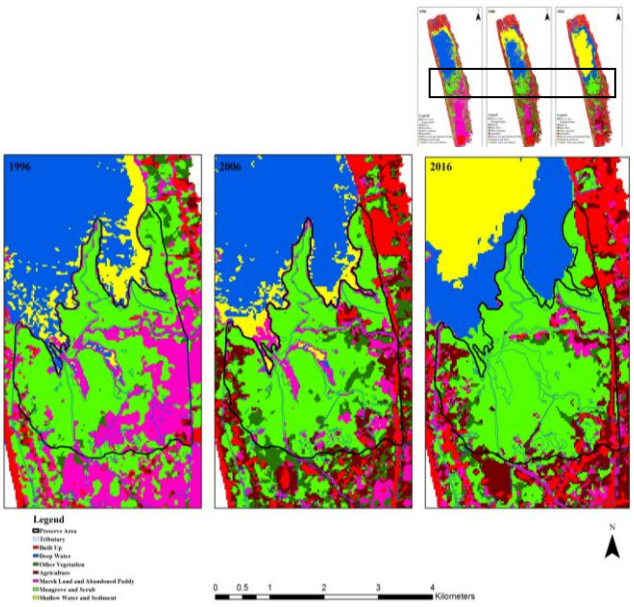

Figure 5: Enlarge middle part of the study area.

There is high influence marshland by 2006. Due to expansion of new high way areas, this wetland mainly because of accessibility the general public have encroach the area. Another major land use change could be identify it is improvement of agricultural land because of government policy of developing abandon paddy land (Figure 1). The marsh area (Figure 1) is inhabited by endemic species as well as this is a unique breeding area. Human encroachment of marshland area of the study area is illegal. And very critical phenomena to have the solution without delay, because this process will wrongly influence biodiversity in this vicinity.

The phenomenon of the wetland has been dramatically changed during annually. 20 years changes of LULC features reveal the socio-economic background in the area due to natural and anthropogenic activities. In the study area, it can apparently observed that area in Marshland, agricultural land, and other vegetation are converted into built-up, and it is increased in spatial extent from 2001 to 2016 due to human encroachment and urban expansion activities. During the last 20 years, the agricultural land is encroached for built-up due to the rapid population growth and this affect wetland degradation, loss of biodiversity in the study area. Similarly the marshland is increased in the study area due to illegal setting and other human activities.

Acknowledgment

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