ISSN (e): 2250 – 3005 || Volume, 08 || Issue, 5|| May – 2018 ||
International Journal of Computational Engineering Research (IJCER)

IdentificaionofVegetation Change ofMuthurajawelaWetland inSri Lanka from 1992 to 2015 by Using GIS-Remote Sensing

Phan Truong Khanh[1], S.M.C.U.P. Subasinghe[2]
[(1)]Department of Environmental Management, University of An Giang, Vietnam.
[(2)]Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka.
Corresponding Author: Phan Truong Khanh

ABSTRACT
Muthurajawela wetland is a coastal wetland system of high biodiversity and ecological significance. At present, this Muthurajawela wetland is being rapidly degraded by inadequately planned development activities and other detrimental activities related to growing human population pressure. As over a time, there will be change in vegetation area. Therefore, an effective method should be used to re-evaluate the change in area. Remote sensing technology is the most effective method and is used in this study. Three Landsat (TM) satellite images (1992, 2001 and 2015) were taken for comparison. The results showed that Multi-temporal Landsat images with the average resolution have the ability to assess the vegetation coverage changes with guaranteed results as, we have established a six-vegetation cover layer classification map with an overall accuracy of 84.66% and a kappa coefficient of 0.81. The total natural land area of Muthurajawela wetland was 6,232 ha in 2015. Of which, 492.95 ha was marsh, 232.94 ha was grass, 281.62 ha was water and 5,225.27 ha was of forest land; The area of mangroves forest in 1992 increased by 317.66 ha compared to in 2001 and decreased by 300.42 ha in 2001 compared with in 2015, increasing only 17.24ha in 1992 compared with in 2015.
KEYWORDS:*Landsat, Remote sensing,Muthurajawela wetland, Sri Lanka.*

Date of Submission: 28-04-2018 Date of acceptance: 14-05-2018

I INTRODUCTION

Muthurajawela wetland is the largest saline coastal peat bog in Sri Lanka, which covers an area of 6,232 ha in total extent. About 1,777 ha of the northern section of Muthurajawela wetland was declared a wetland sanctuary [5]. This Muthurajawela wetland contains a high diversity of both flora and fauna, including several endemic and nationally threatened species, and also provides an important area for migratory birds. Because of the presence of these natural habitats and species, Muthurajwela wetland is a popular recreational destination, primarily attracting educational or school trips and day visitors from nearby Colombo [2]. Although more than 300,000 people live in the Muthurajawela wetland-Negombo area, just under 5,000 people live in and around the marsh itself, half of whom are squatters and about three quarters who live on unauthorized landholdings. About 80% of industries in the country are concentrated in Colombo and Gampaha Districts [12]. Further, the location of the Muthurajawela wetland in a rapidly developing urban area which makes it an extremely vulnerable ecosystem [4]. Due to the threats for Muthurajawela wetland ecosystems described, it is essential to make methodological or institutional proposals for policies to protect these valuable wetlands and to make recommendations for sustainable forest land use for environmental values in the situation of the global climate change. In order for that the current status as well as past changes must be known which provides a valuable data base on the contribution of forest ecosystems in reducing greenhouse gases. Therefore, the investigation and monitoring of structural change and the area change of forest vegetation has become a priority requirement for the management of Muthurajawela wetland. Further the annual reports prepared on the status and situation of the forest changes by the relevant agencies, most of these reports are mainly based on traditional methods of mapping the forest. Therefore applications of Remote sensing and GIS techniques will be very helpful to resolve these problems in a short time period. Obtaining information after a thorough study on vegetation cover will partly help the Management Board of Muthurajawela wetland to understand the forest resources change through different stages. This will also act as a scientific database to help management conserve wetland. For these reasons the present study was conducted in Muthurajawela wetland with the objectives of identifying the present plant distribution in wetland and mapping the vegetation cover change over the years of 1992, 2001 and 2015 using Remote sensing-GIS techniques.

II CHARACTERISTICSTHE STUDY AREA

Muthurajawela wetland in Sri Lanka is located on the west coast (70^{0}3’N, 79^{0}55’E) between the Negombo lagoon and Kelani river and spreading inland up to Ragama and Peliyagoda in the Gampaha district (Figure 1). The marsh, together with the Negombo lagoon, forms an integrated coastal wetland ecosystem of 6,232 ha in total extent.The daily high tide brings in seawater from the ocean into the wetland, and the continuous mixing of these two waters over thousands of years has led to a brackish, integrated coastal ecosystem that is biologically diverse and teeming with life. According to the result of the present study total of 157 plant species belonging to 62 families were recorded. Out of which, 16 aquatic weed species, 91 grass species, 23 liana species, 17 shrub species, 10 woody species.The area receives an annual average rainfall of 2000-2500mm, while the average annual temperature is 27^{0}C. The soil is a uniform, potentially acidic sulphate, and the land is poorly drained with a peaty substrate which is saturated for almost the whole year. The marsh receives water from the Kelani river and the Dandugamoya stream.

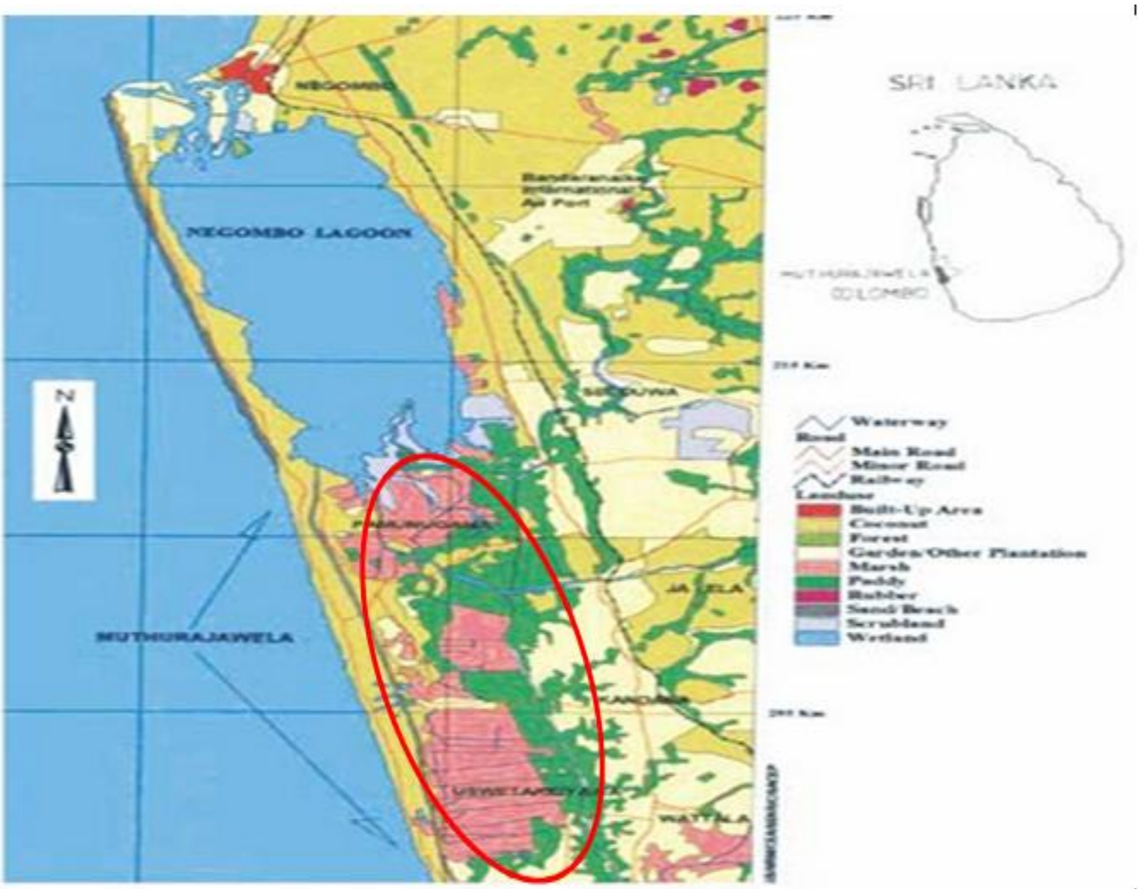

Figure 1:Location of the Muthurajawela wetland of Sri Lanka

III METHODOLOGY

Secondary data collection

Geographical locations,rainfall, temperature, hydrologic, socio-economic status of the surrounding community and topographic sheet maps and maps of land use 1:50,000 and other thematic maps (related to this study in the period 1992, 2001, 2015) were used as the secondary data to general the base maps of this study.

Field data collection

Consult the ideas of The National Park managers and doing a walking to divide transect, habitats and plots. Using Global Positioning System (GPS) locate the basic and key positions of habitats and plots in the park to provide a basis for checking the accuracy of image interpretation. A total of 36 plots (189 samples) were randomly selected to determine the target classes present in the study area. Data on plant community composition, species abundance and relevant environmental characteristics were collected from those plots. In addition, ground cover percentage of the plants, plant/tree height and species diversity were also recorded.This technique was selected since an even distribution of the data as well as representation of the land use and land cover types in the study areas was desired. The GPS points were collected at sites as Figure 2. All of collected ground truth (training samples) was used in image classification and the accuracy assessment.

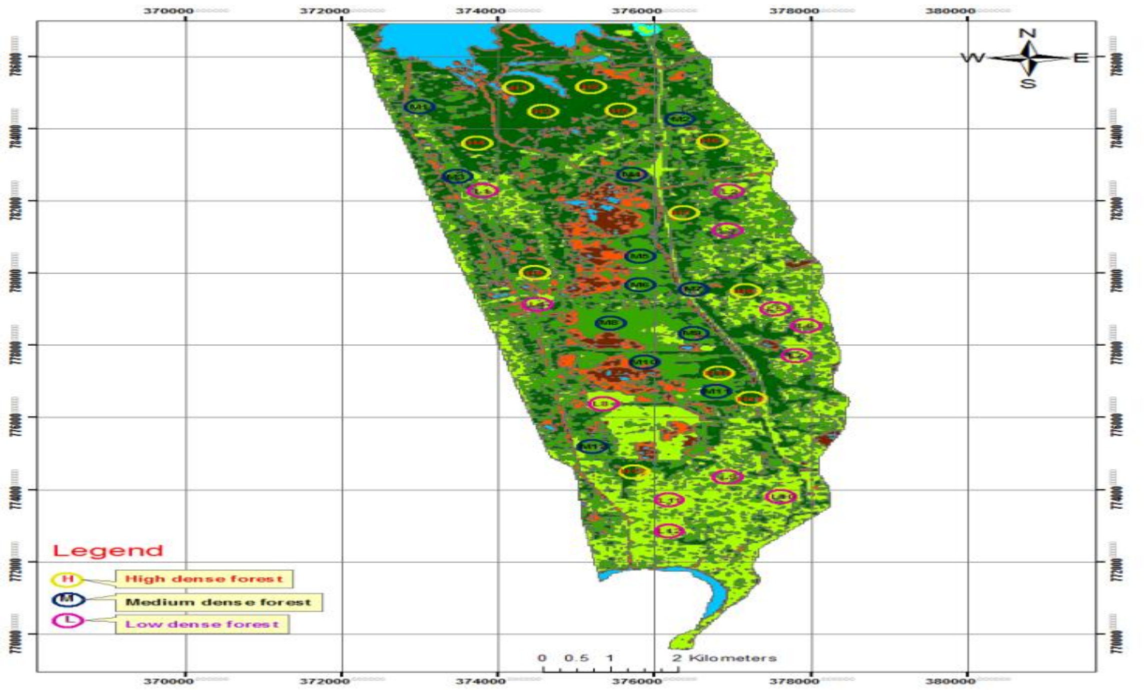

Figure 2: Layout of sample plots in Muthurajawela wetland of Sri Lanka

Map building

Three Landsat (TM) satellite images of different bands for 1992, 2001 and 2015 were downloaded from http://earthexplorer.usgs.gov and those were clipped to the study area basedon the respective landuse maps. These multiband images were re-projected to UTM Zone 44 North, WGS-84 Datum. Thereafter, each image was exported to the ERDAS 2014 EX software and an image difference tool was used to detect the changes between 1992, 2001 and 2015 based on the Normalized Difference Vegetation Index (NDVI) as it is a useful method for determining plants depending on the distribution density. NDVI is functionally equivalent to simple band ratios of TM images and can be described as NDVI = (NIR band - RED band)/(NIR band + RED band), where: NIR band = spectral reflectance for band 4; RED band = spectral reflectance for band 3. Use of NDVI for this purpose has been well-justified by Gandhi et al. (2015).

Interpretation keys are then established followed by unsupervised classification which was first used to produce land cover classes for the study area using the ISODATA algorithm in ERDAS ER Mapper, which classifies the image into a pre-selected number of classes using an iterative calculation procedure to ensure maximum statistical separability based on the spectral data.This activity was able to identify 6 vegetation classes, viz., water, marsh, grass, low dense forest, medium dense forest, high dense forest with a 84.66%precision.

IV RESULTS

Survey results in the field

The study divided the Muthurajawela wetland into 3 types of densities, i.e., low dense forest zone (1,975 trees/ha), medium dense forest zone (3,000 trees/ha) and high dense forest zone (4,241.67 trees/ha). Total of 89 plant species were identified in low dense forest, of which 6 wood species, 7 shrub species, 9 liana species, and 67 grass species. Total of 64 flora species were identified in medium dense forest, of which 8 wood species, 10 shrub species, 13 liana species and 33 grass species. And 54 plant species were record in high dense forest including 10 wood species, 15 shrub species, 16 liana species and 13 grass species. And 37 grass species and 16 aquatic weed species were usually present in wet areas along the canals and bogs. *Annonaglabra,Bruguiera cylindrical* and*Rhizophoramucronata*were the three most abundant species. Relative abundance of three these species were 43-44%, 38-40%, 7-10% respectively (Table 1). The remaining species occupy a very small proportion of the area (1-2%). Due to the high level of human activity within the Muthurajawela wetland (such as growing pressures from urban, residential, recreational and industrial development), the flora composition at Muthurajawela wetland seems to be changing rapidly.

Table 1:Percentage presence of woody species in the Muthurajawela wetland in 2015

Species name	Low dense forest	Medium dense forest	High dense forest
Annonaglabra	43.47%	43.33%	44.99%
Cerberamanghas	1.69%	0.83%	0.78%
Syzygiumcaryophyllatum	2.11%	2.49%	2.19%
Pandanustectorius	1.69%	0.55%	0.78%
Hibiscus tiliaceus	1.69%	1.67%	1.57%
Excoecariaagallocha	0.42%	0.30%	0.39%
Dolichandronspathacea	1.26%	1.67%	1.17%
Rhizophoramucronata	7.59%	10.28%	7.66%
Bruguiera cylindrical	39.24%	38.33%	40.08%
Sonneratiacaseolaris	0.84%	0.55%	0.39%

Within the recorded flora, one endemic *(Phoenix zeylanica*), and two other species *(Eleocharisdulcis*and*Acrostichumaureum)* were present in Muthurajawela wetland. Broad leaved shrubs were widely distributed in Muthurajawela wetland, i.e., *Cerberamanghas,Syzygiumcaryophyllatum, Pandanustectorius, Hibiscus tiliaceus, Excoecariaagallocha, Dolichandronspathacea*and*Annonaglabra.* In particular, *Annonaglabra* is the dominant species was distributed in the southeast of Muthurajawela wetland. The mangrove in the northern border of Muthurajawela wetland is dominated by *Avicenniamarina,Rhizophoramucronata, Bruguiera cylindrical*. The lentic flora in open water bodies is dominated by *Nymphaeastellata* and *Eleocharisdulcis*. The riparian vegetation includes *Pandanustectorius, Cerberamanghas* and *Syzygiumcaryophyllatum.*Thereedbeds consist of *Phragmiteskarka*.

Map analysis

The resultant NDVI values after classification of the study site into 6 vegetation classes are given in Table 2. Results of the showed that the NDVI values for Muthurajawela wetland ranged from -0.472 to 0.669. Areas with high NDVI values (image has bright colors) had values of 0.435-0.66, and these are the places where there was a well-developed plant community with high density populations, which was distributed in the north-east of wetland. When NDVI value decreased, the density of vegetation cover also decreased respectively. Places with lower NDVI (0.334-0472) were the places with the average wood density, which was distributed in the center of the study area. The places had the NDVI ranging from 0.199-0.334, were the places with a low density of plant, which were distributed mainly in the south east of the Muthurajawela wetland. The grass vegetation had NDVI of 0.038 to 0.199, growing everywhere in the study area, except where the mangroves occupy. The NDVI value was zero or negative were the places when these were no green vegetation for e.g bare soil, streams or flooded land. NDVI value of marsh and water were -0.199 to 0.038 and -0.472 to -0.199 respectively (Table 2).

Table 2:Normalized difference vegetation index value (NDVI)

NDVI value	Vegetation cover classes
-0.472- -0.199	Water
-0.199 -0.038	Marsh
0.038- 0.199	Grass
0.199-0.334	Low dense forest
0.334- 0.472	Medium dense forest
0.435- 0.669	High dense forest

The three vegetation cover maps built for Muthurajawela wetlandfor 1992, 2001 and 2015 are given in Figure 3-6. However, according to the results, map analysis using NDVI calculation is found to have some drawbacks. For instance, the NDVI values of medium dense forest and high dense forest were approximately similar. Therefore, the interpretation of these two classes was initially not accurate. However, it was corrected by field observations with the help of a high quality GPS device. Further, an error matrix was used to accurately evaluate the results of the classification. The results of accurate assessment of vegetation classification based on the actual data set for the year 2015 are shown in Table 3.

Table3:Assess the accuracy of the Landsat image interpretation of vegetation cover classification in the Muthurajawela wetlandin 2015

Class Name	Reference Totals	Classified Totals	Number Correct	Producer Accuracy	User Accuracy
Water	26	27	22	84.62%	81.48%
Marsh	33	30	27	81.82%	90.00%
Grass	11	11	9	81.82%	81.82%
Low dense forest	25	23	20	80.00%	86.96%
Medium dense forest	48	56	45	93.75%	80.36%
High dense forest	46	42	37	80.43%	88.10%
Totals	**189**	**189**	**160**		
Overall Classification Accuracy = 84.66%					
Overall Kappa Statistics = 0.8091					

The results showed that the accuracy of vegetation cover interpretation after field survey was over 80%. However, the highest accuracy was given in image interpretation, by marsh (90%), followed by high dense forest (88%) and low dense forest (86%). The remaining layers had an accuracy of 81% (Table 3). The overall accuracy was (84.66%) and the Kappa coefficient was 0.81.Final results of the image classification of Muthurajawela wetlandfor 2015 are given in Figure 5; 6. The status of vegetation cover area of the study area in the period of 1992-2015 using satellite imagery is illustrated in Figure 7.

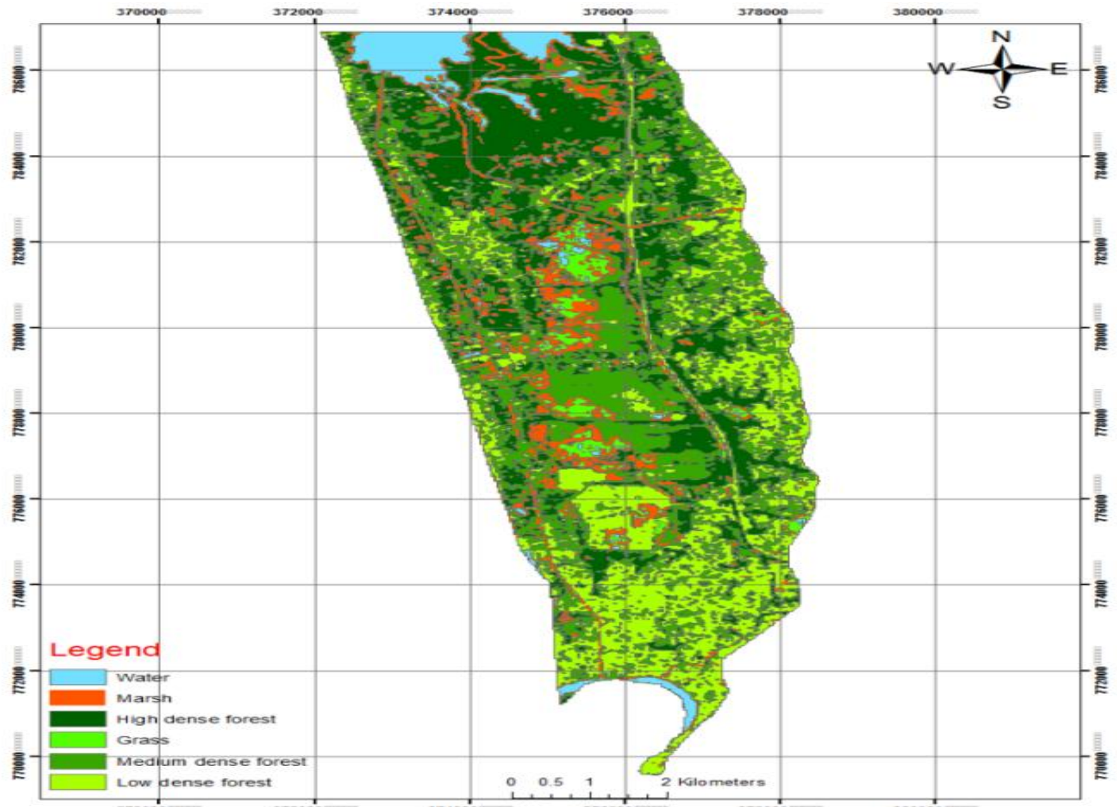

Figure 3: The vegetation cover map of the Muthurajawela wetland in 1992 built by unsupervised classification

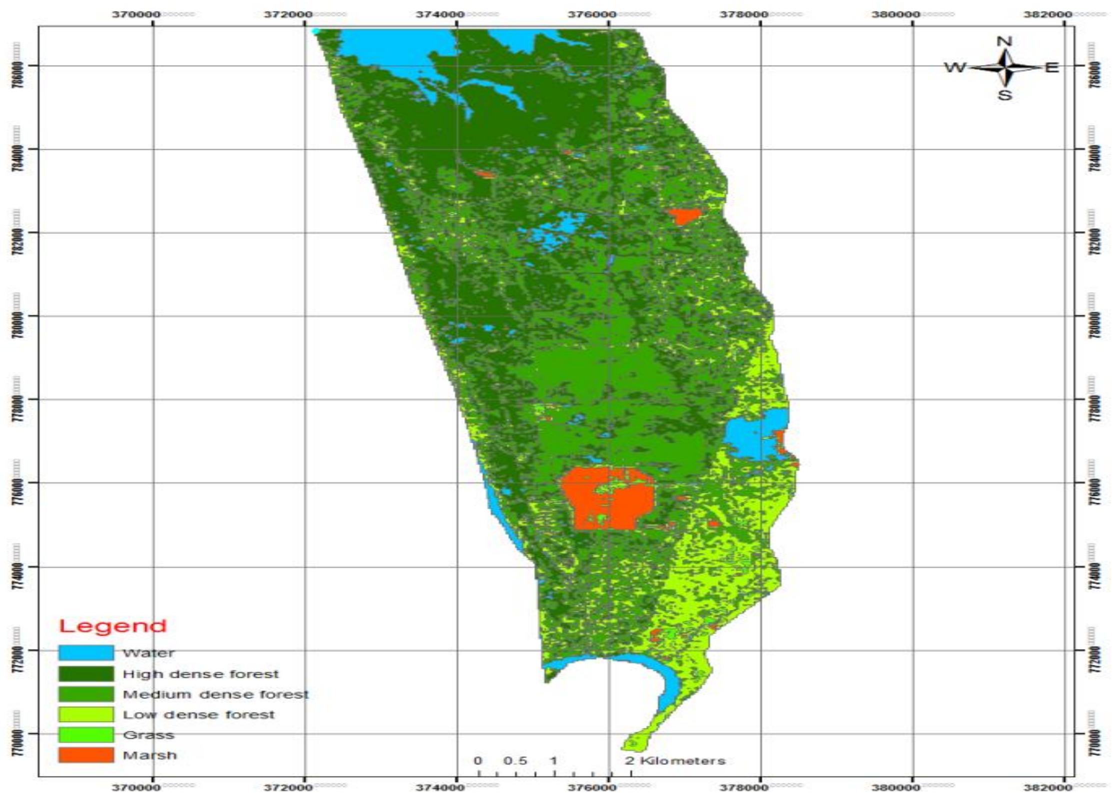

Figure 4: The vegetation cover map of the Muthurajawela wetland in 2001 built by unsupervised classification

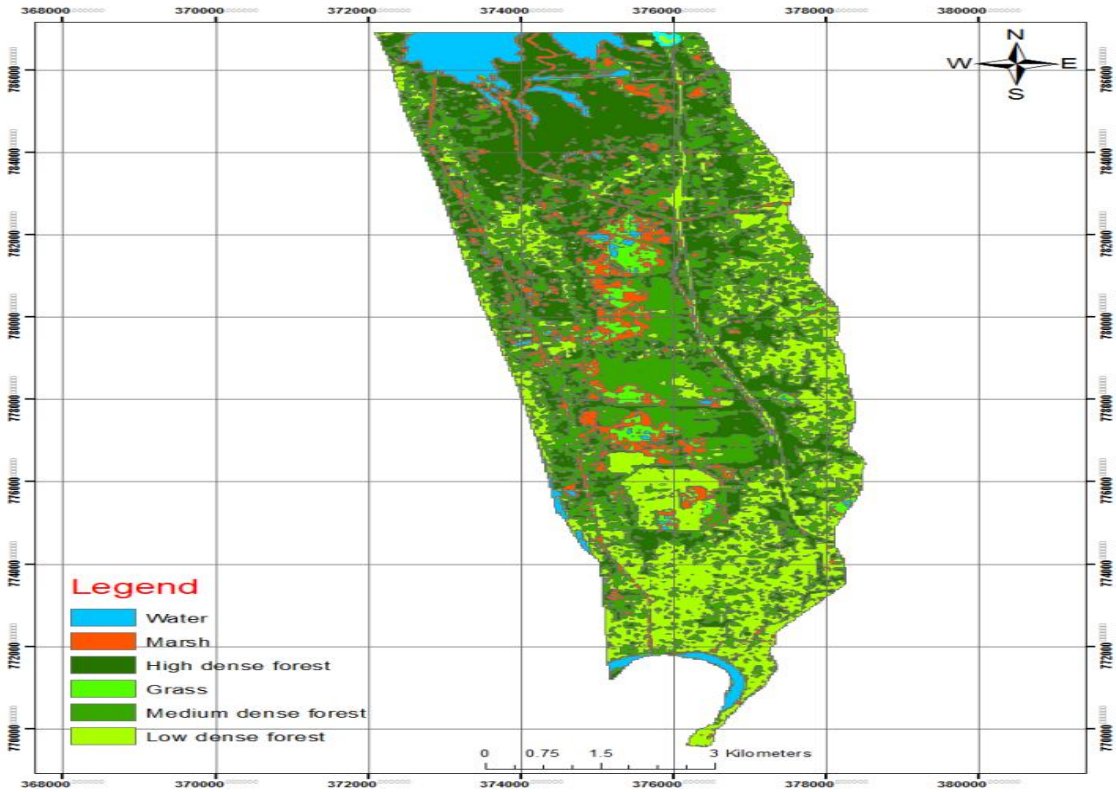

Figure 5: The vegetation cover map of the Muthurajawela wetlandin 2015 builtby unsupervised classification

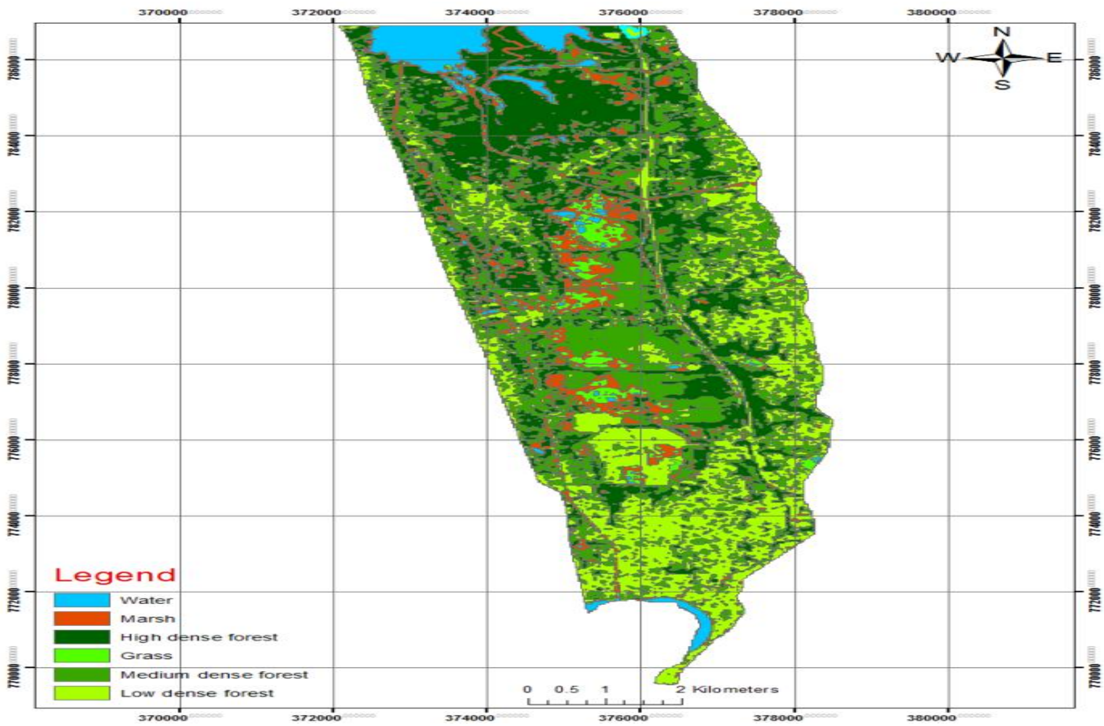

Figure 6: The vegetation cover map of the Muthurajawela wetlandin 2015 built bysupervised classification

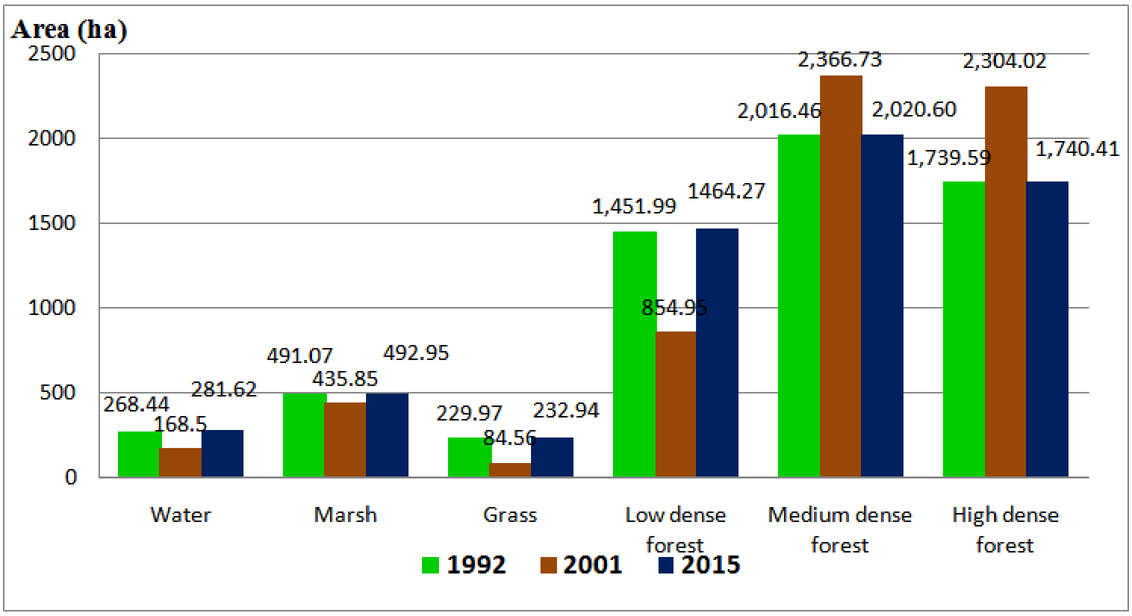

Figure 7: Vegetation cover change of Muthurajawela wetlandin 1992, 2001 and 2015

In general, the mangrove forest at Muthurajawela wetland had a high coverage (>75%). However, the area of woody species varied between 1992 and 2015. Since 1992 the area of the low dense forest group was 1,451.99 ha, reduced to 854.95 ha in 2001, then increased back to 1,464.27 ha by 2015 (Figure 7). Meanwhile, in 2001 the area of the medium and high density vegetation groups increased compared to 1992 and again decreased by 346.13 ha (5.66%) for medium density forest, and by 563.61 ha (9.15%) for high density forest in 2015 (Figure 7, Figure 8). Total area of three density groups together, the area of mangroves in 1992 increased by 317.66 ha compare to 2001, while the area of mangroves in 2001 decreased by 300.42 ha compare to 2015. The cause of this decline was due to: mangrove ecosystems in large extent of Muthurajawela wetland exploited for commercial, agricultural, residential, tourism, and industrial development. It is also being used as dumping ground for domestic and industrial waste thus, facing to imminent threats reducing the quantity and quality of mangroves.

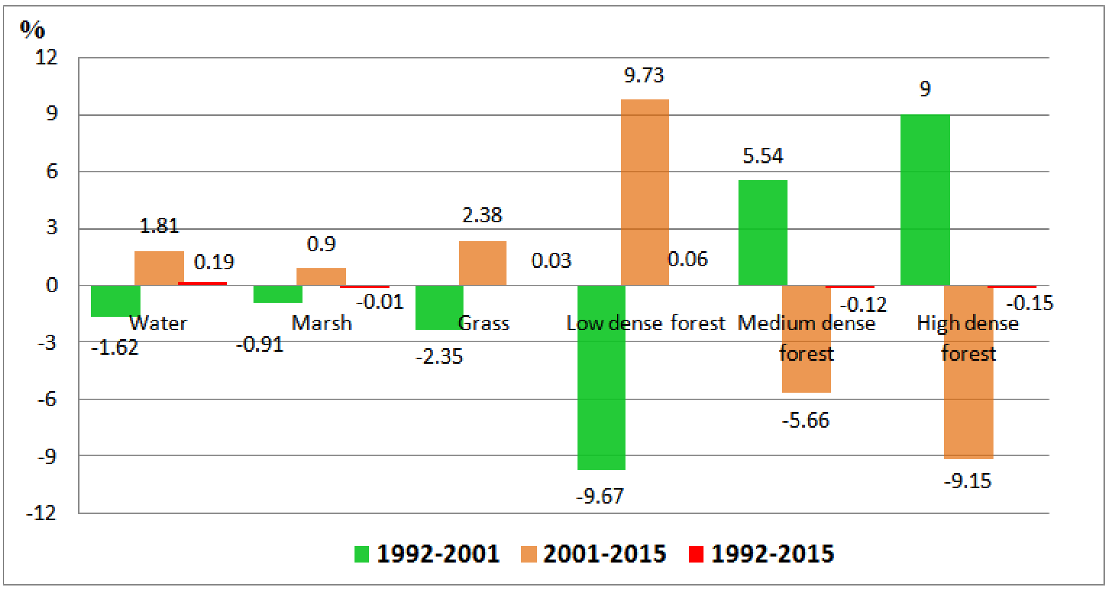

Figure 8: The changes percentage of vegetation area in Muthurajawela wetland 1992-2015

V DISCUSSION

Remote sensing images are especially appropriate for reconnaissance mapping and information monitoring for different types of wetlands over large geographic areas.Successful use of remote sensing for detailed interpretation in the study of wetlands depends mainly on the spatial resolution of images to give good results for interpretation, mapping, and the comparisons between different periods. From the study, we can confirm that the choice of remote sensing GIS technology is an optimal solution to the current forest cover mapping. Remote sensing technology allows the acquisition of information about state of the broad objects, economic and time savings. The GIS tool effectively supports, accurate, quick, efficient data extraction. The results of the assessment of the vegetation cover area changes showed an overview of the geographic change of the area.For example, Mansur and Rotherham (2010)stated that Landsat TM gave a good result for determination of land cover/land use changes in the Libyan Al-JabalAlakhdar region [7]. Also, Esam et al (2012) reported that Landsat TM imagery provided good accuracyfor quantifying land cover changes, and very useful information for natural resources management of the West Tahta Region, Sohage Governorate, Upper Egypt, but it still lacks the spatial resolution to map all important cover classes, especially in small areas, where the class area covered less than the pixel size in the TM image [3]. Finally, it might be worth noting that usual costs increase roughly in proportion to increases in mapping resolution [6].

In study area, the Landsat TM images were classified using two methods: unsupervised and supervised. Maximum likelihood classification (MLC) of supervised classification showed better results when compared with unsupervised classification for distinguishing vegetation classes. Supervised classification is depend on the user definition for training areas and field verification which all were proven to be useful for the selection of vegetation classes [8]. The six vegetation class-output map built by supervised classification using Landsat TM image analysis in 2015 for study area showed higher accuracy the unsupervised classification method for the same year. A limitation of unsupervised classification method is that the classes were produced based on the natural groupings of the spectral properties of the pixels, selected by the remote sensing software, which may not correspond to the actual features of the vegetation. In the Muthurajawela wetland, due to land use dynamics, the same type of vegetation gave different reflectivity levels. There was a confusion easily between grass and marsh because the marsh was a mixture of soil, water, shurb, *Acrostichumaureum, Eleochrisdulcis, Phragmiteskarka, Eichhorniacrassipes, Nymphaeanouchali, Pistiastratiotes*. In contrast, beyond the grass cover, bare soil was still present in the grass. Thus, the color of the plants in the marsh and grass layers were similar. Similarly, it could have been easily to have confusion the colors of the medium and high dense forests. Because, in the medium dense forest layer there still were many old woody trees, whereas high dense forest still has the presence of young woody trees although these two densities were statistically significant. It could be said that the color reflectance of forest trees depends not only on the density but also on the age of the forest (because forest age also determines forest canopy) and this also leads to fluctuations in color reflectance. Some other causes gave the results of inaccurate interpretation were: due to the resolution of the Landsat image data only at an average level (30 m). Therefore some the area of the barely soil distributed patches were not showed on image; there were many various methods using in image interpretation such as field survey, sampling, interpretation, statistics, so that the interpretation processing still exist unexpected errors. Due to the time difference between the image data and the sampling time.

The use of NDVI is highly appreciated and widely used as it provises a model of plant growth, eliminates atmospheric influences and reduces the oscillation of the sensor. For example, the satellite image classification based on the NDVI index by Thom for Thanh Mai commune, Cho Moi Bac Can, Vietnam and the decision tree method. The decision tree was built on the basis of an algorithmic function set in the ENVI software to classify objects based on the NDVI threshold [9]. Their results produced a Kappa accuracy of 88%. Or research by author Thanh "Establishing the vegetation map based on remote sensing image analysis in Tua Chua - Lai Chau". Thanh has used the method of classification with the 2006 Landsat image data for 7 different vegetation classes. The sited research presents a Kappa index of 0.7 lower than our Kappa coefficient. The results showed that the method of unsupervised and supervisor classification in some cases have not yet achieved the desired results [10]. In a study by Tien "Mapping the vegetation cover map of Tram Chim National Park, Tam Nong, Dong Thap, 1995-2013". The author classified the 6 vegetative classes by supervisor classification with SPOT 1995 and ASTOR 2013 and a Kappa coefficient of 0.8. The results showed that if we use different types of images such as SPOT or ASTER, the accuracy results of interpretation of image is equivalent to using our LANDSAT image [11]. In a study titled "Application of remote sensing and GIS to establish vegetation cover map of Chan May area, Phu Loc district, Thua Thien Hue province" by Anh (2012), Anh using Landsat TM image with 10m resolutionclassified interpretation image quite exactly with field sampling, divided 13 groundcoverings classes with relatively high precision. This result shows that with a 10m resolution Landsat image resolution will result in better interpretation than our 30m resolution Landsat image [1]. In referencing the above studies, our interpretation results with a 0.81 kappa coefficient, which are quite high and in the acceptable range. The experimental result we present currently meet the needs at the region levels for statistics and inventory and forest planning. Historically, the methods of establishing forest cover maps from Remote sensing and GIS data have not been fully defined nor completely accurate. However, most of the object classes of basic characteristics of the area is determined to be quite accurate. In order to accuracy, we supplement with the actual survey and available materials. The outstanding feature is that the map has been set up in a modern, highly synchronized manner which is conducive for science to exploit, edit and update the content data with various methods and with more detail.

VI CONCLUSION

Multi-temporal Landsat images with a 30m spatial resolution can be used for the assessment of vegetation coverage changes with guaranteed results. Specifically, we have established a six-vegetation cover layer classification map with an overall accuracy of 84.66%, and a kappa coefficient of 0.81.

Experimental results also showed that the combination of remote sensing and GIS technology was very effective in determining the variable area, degree of variation and the change tendency of each object: The total natural land area of Muthurajawela wetland was 6,232 ha in 2015. Of which, 492.95 ha was marsh, 232.94 ha was grass, 281.62 ha was water and 5,225.27 ha was of forest land; The area of mangroves forest in 1992 increased by 317.66 ha compared to in 2001 and decreased by 300.42 ha in 2001 compared with in 2015, increasing only 17.24ha in 1992 compared with in 2015.

Remote sensing images are key data sources for earth monitoring programs considering the great advantages that they have. It is more easily obtainable to produce and update vegetation inventories over large regions if aided by satellite imagery and appropriate imagery analysis. A growing number of studies have examined a wide variety of vegetative phenomena (including mapping vegetation cover) by using remote sensed data. However, although remote sensing technology has tremendous advantages over traditional methods in vegetation mapping, we should have a clear understanding of its limitations.

REFERENCES

[1]. Anh, N.H. and Kien, D.T. (2012). Application of remote sensing and GIS to establish ground cover map of Chan May area, Phu Loc District, Thua Thien Hue province. Available at: http://vietanenviro.com/home/ index.php /archives /3846>. (Accessed 10 February 2013).

[2]. Emerton, L. and Kekulandala, B. (2002). Assessment of the Economic Value of Muthurajawela Wetland. IUCN-the World Conservation Union, Sri Lanka Country Office and Regional Environmental Economics Programme Asia, Colombo.

[3]. Esam, I., Abdalla, F. and Erich, N. (2012) Land Use and Land Cover Changes of West Tahta Region, Sohag Governorate, Upper Egypt. Jounral of Geographic Information System, 4: 483-493.

[4]. IUCN, (2003). Assessment of the economic value of Muthurajawela wetland. Available at:http://portal.nceas.ucsb.edu/working_group/valuation-of-coastal-habitats/review-of-social-literature-as-of-1-26-07/Emerton%202003.pdf

[5]. Lucy Emerton (Ed). (2005). Values and Rewards: Counting and Capturing Ecosystem Water Services for Sustainable Development. IUCN, pp. 83-86. ISBN 9558177431.

[6]. Lunetta, R.S. and Balogh, M.E. (1999) Application of Multi-Temporal Landsat 5 TM Imagery for Wetland Identification. Photogrammetric Engineering & Remote Sensing, 65: 1303-1310.

[7]. Mansur, S. and Rotherham, I.D. (2010). Using TM and ETM+ data to determine land cover/land use changes in the Libyan Al-jabalAlakhdar region. Landscape Archaeology and Ecology End of Tradition, 8: 132-138

[8]. Soliman, G. and Soussa, H. (2011). Wetland change detection in Nile swamps of southern Sudan using multitemporal satellite imagery. Journal of Applied Remote Sensing, 5(1): 053517, Doi: 10.1117/1.3571009.

[9]. Thom, T.T., Que, P.T. 2014. Using remote sensing data and GIS to establishment of forest status map at the scale of 1:10.000. Journal of Forest Science & Technology, 4: 161-168.

[10]. Thanh, H.X. 2013. Establishment of vegetation map based on remote sensing image analysis, MSc Thesis. Water Resources University, Vietnam.

[11]. Tien, P.D. Thang, T.N. Duong, L.V, 2014. Mapping change vegetation cover at Tram Chim National Park, Dong Thap, 1995-2013. Proceedings of the nationwide GIS application workshop in Vietnam, 2: 615-623.

[12]. UNEP, (2001). State of the Environment Sri Lanka. United Nations Environment Program, Nairobi, Kenya.

Phan Truong Khanh. "Identificaion of Vegetation Change of Muthurajawela Wetland in Sri Lanka from 1992 to 2015 by Using GIS-Remote Sensing." International Journal of Computational Engineering Research (IJCER), vol. 08, no. 05, 2018, pp. 42-52.