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Land Use Change Detection in Akkulam-Veli Lake, Thiruvananthapuram, over the Last Three Decades- an Analysis using Remote Sensing and GIS Tools

Arya Unnikrishnan S. U.[1], Smitha Asok V[2], Rajesh Reghunath[3], Neena P. T[4]
[1, 2, 4]*Post Graduate Department of Environmental Sciences, All Saints' College, Thiruvananthapuram*
[3]*International and Inter University Centre For Natural Resource Management University Of Kerala Karyavttom*

Abstract: ***The backwater of Akkulam-Veli, adjoining the Arabian Sea in the South-West part of Indian Peninsula, is a coastal wetland system and forms an integral part of the local ecosystem. Akkulam-Veli Lake is considered to be an important site for tourism in Thiruvananthapuram district which is therefore subjected to anthropogenic interferences. This study aims to study the implications of land use changes on the lake. Land use and land cover are very important elements in relation to water quality. To assess this LULC changes over a period of 30 years (1989-2018), a 2 km buffer area around Akkulam-Veli Lake was studied using Landsat 4-5 TM and Landsat 8 OLI image respectively. LULC map for 1989, 2006 and 2018 were prepared with the aid of GIS and Remote Sensing. It was observed that there was a significant spatio-temporal variation in the areal extent of land use in the buffer area of Akkulam- Veli Lake. In order to check the accuracy of unsupervised classification, accuracy assessment was employed and a substantial overall accuracy of 82.6% and overall Kappa coefficient of 0.784 was obtained.***
Keywords: Landuse- Land cover, Accuracy Assessment, Remote Sensing, GIS

I. INTRODUCTION

Land use changes are manifested, generally, as change in cropping pattern, slope modification, soil excavation, conversion of paddy lands and swampy areas and filling of wetlands etc. Such changes affect the environment adversely by way of intense soil erosion, water logging, water scarcity, mono cropping and loss of biodiversity (KSCSTE, 2007). The land use change is significant due to various physical and socio – economic factors and the land use pattern of an area is directly related with the level of techno-economic advancement, nature and degree of civilization of its inhabitants (Whyte, 1961). Satellite datas are best opted for land-use land-cover assessments over a wide range of scenarios as depicted in a study conducted by Rajani et al., 2017, where forest fragmentation analysis was done along fringe forests of Kollam Districts. The study revealed that there was a great spatial variability for the pattern of forest loss and land use has been changed throughout the region which in turn affected the species diversity of the area.

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II. STUDY AREA

The Akkulam-Veli Lake, a famous tourists destination, is located in the southwest coast of India (08 ˚30 ’- 08 ˚31 ’N and 76 ˚52 ’- 76 ˚53 ’E; area 1 km , depth =<1 m, is covered by the Survey of India topographic sheet 58D/14/SE (on 1:25,000 scale)) is a smallest inland lake, separated from the Arabian Sea on its western side by a sand bar and remains connected with the sea only during monsoon season. The western part of the lake towards the sea with a length of 1.25km and a width of around 100 m forms the Veli Lake whereas the north- eastern part is the Akkulam Lake, an extension of Veli Lake lies starting from the bund. Mud flats in the shallow regions of the Akkulam part of the lake get exposed during ebb tide and the siltation in Akkulam Lake affects the free flow of water towards the Veli Lake. The Travancore- Shornur (TS) canal or Parvathy Puthen Ar (the erstwhile navigation canal) their tributaries drain the urban precincts of Thiruvananthapuram and finally debouch to the Akkulam-Veli Lake . Numerous dwellings and slum are situated all along these rivers. The land use change is monitored by creating a buffer of 2 km around Akkulam-Veli Lake which encloses Vettukadu, Karikkakam, Anayara, Manvila, Poundukadavu and Pulayanarkotta (Fig 1).

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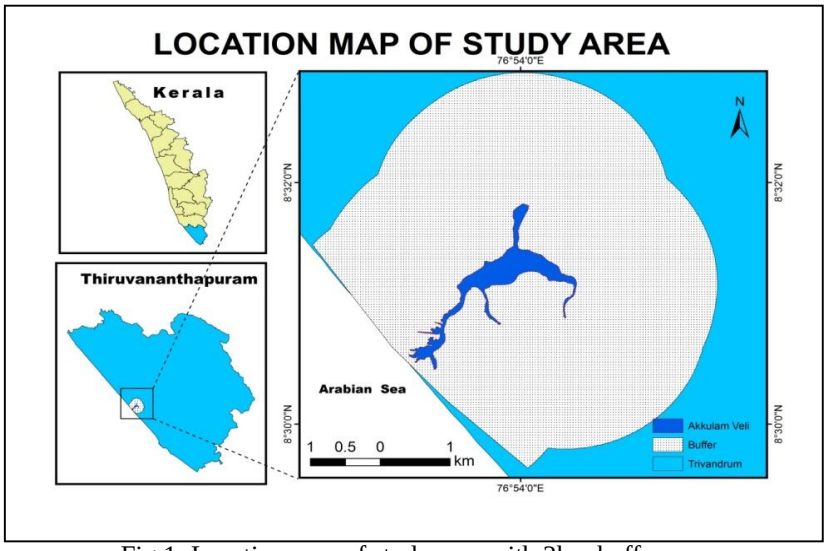

Fig 1: Location map of study area with 2km buffer area

III. MATERIALS AND METHODS

A. Preprocessing Of Landsat Data And Study Area Delineation

This study employs LANDSAT 8 OLI of February 2018, LANDSAT 4-5 TM of 2006 and LANDSAT 4-5 TM of 1989 satellite images downloaded from the USGS Global Land Cover Facility. The data is cloud free (less than 10%) and level 1 type(Anderson et al.,2017). The three images were taken over a time period of 30 years (1989-2018) to study the land use land cover changes in the study area. A buffer of 2 km was created around Akkulam- Veli Lake by analyst tool in ArcMAP, which encompasses Vettukadu, Karikkakam, Anayara, Pulayanarkotta, Cheruvaikkal, Manvila and Poundukadav. Buffer was created to assess the study of landuse landcover changes in and around AV-Lake. These three images were layer stacked and also geo referenced with the Universal Transverse Mercator (UTM) projection Zone 43 N with a spatial resolution of 30 m.

B. Image Classification

In this study, a total of, six LULC classes were established as water body, settlement, vegetation, agriculture, aquatic vegetation and barren land. Three dated landsat images were compared using unsupervised classification followed by supervised classification technique in Erdas Imagine (Cui et al.,2016). The supervised classification technique employs three Landsat images with different dates are independently classified. A supervised classification method was carried out using training areas and it was cross checked with Google Earth and toposheets (Fig 9).

C. Accuracy Assesment

A total of 75 locations were monitored within a range of 2km buffered area by covering not less than 10 locations for each class. The advantage of GPS is that it gives accuracy in real time or 1 to 3 meter post processing (Sharif et al., 2017). These ground control points were used for further accuracy assessment. The aim of accuracy assessment is to quantitatively assess how effectively the pixels were sampled in to the correct land cover classes.

Overall accuracy (%) = (number of correct points/total number of points)

A more appropriate way of presenting the individual classification accuracies are as follows;

Commission error = 1- User's accuracy

Omission error = 1- Producer's accuracy

The Kappa coefficient (K) can be calculated as follows,

$$K = (Po - Pc)/ (1-Pc)$$

Where,

Po = proportions of units which agree, = Overall accuracy; Pc = Proportion of units for expected chance agreement

A kappa coefficient of 90% may be interpreted as 905 better classifications than would be expected by random assignment of classes. The general range for Kappa values are if <0.4, a poor Kappa value; while, if 0.4<K>0.75, is a good Kappa value and if K>0.75, it is an excellent Kappa value (Bharatkar, 2013).

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IV. RESULT AND DISCUSSION

From Figures (2,3,4) it is possible to compare and compute the availability of land designated for each class in three periods. Water body acquires an area of 1.54sq.km, 1.34sq.km and 0.98sq.km in 1989, 2006 and 2018 respectively. Decreased availability of water has been reflected in the productivity of that particular area implying the gradual decrease in agriculture ranging from 3.81sq.km, 2.71sq.km and 0.506sq.km for a period of 1989, 2006 and 2018 respectively. Akkulam – Veli buffer of 2km shows a wide progress in settlement area implying urbanization. Settlements area is found to increase from 4.23 sq.km to 5.87sq.km and 7.82sq.km. A stable use of land has been monitored in vegetation area in which only a minute decrease and subsequent increase pattern has occurred from 1989 to 2018. It remained in the range of 12.86 sq.km, 12.58sq.km and 12.34sq.km. The presence of aquatic vegetation mainly water hyacinth has been reported as a major problem in and around AV-Lake. The Fig 2,3 & 4 shows the gradual increase in aquatic vegetation from 1989, 2006 and 2018 as 0.18 sq.km, 0.29sq.km and 1.15sq.km respectively.

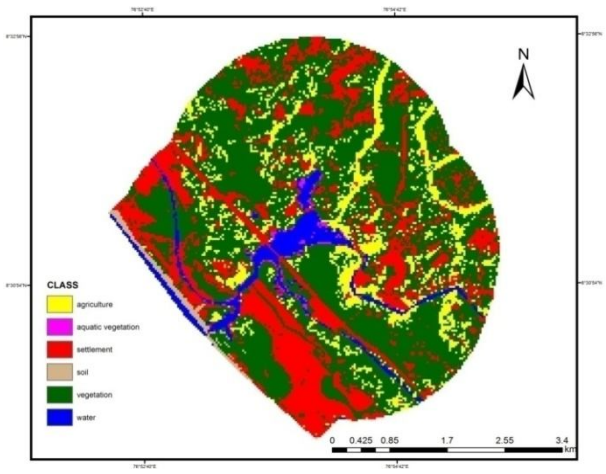

Fig 2: Landuse1989

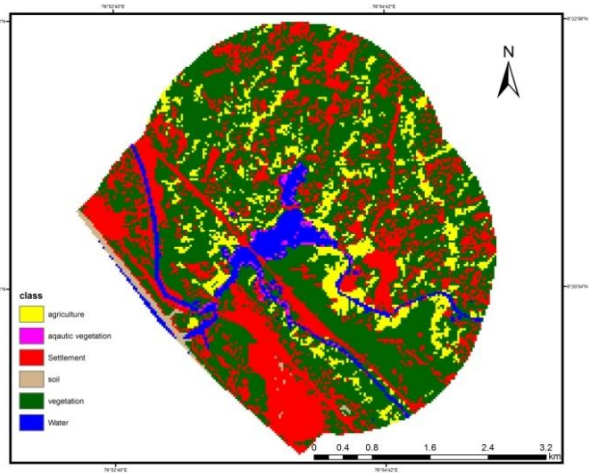

Fig 3: Landuse 2006

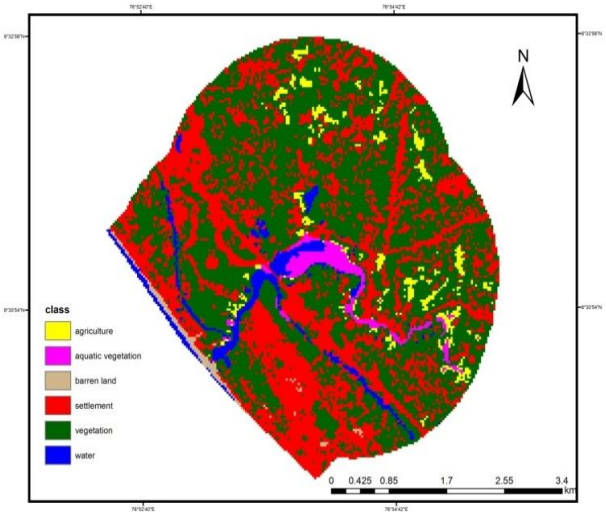

Fig 4: Landuse 2018

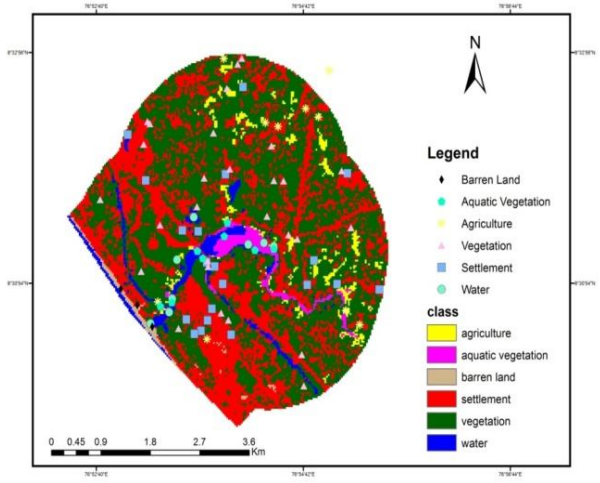

Fig 5: Overall accuracy assessment

A. Land Use Pattern 1989

The result obtained from 1989 land use image (Fig 6) shows the dominating landuse of vegetation (56%) which is followed by settlement(18%), agriculture(16%), water body(7%),barren land(2%) and aquatic vegetation(1%). Most of the agriculture was formed to be around the Akkulam-Veli Lake, in which it may facilitate the irrigation facilities to the agricultural fields. Only 1% of aquatic vegetation was present during 1989.

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B. Land Use Pattern 2006

From (Fig 7) it is observed to have the dominating vegetation (54%) and settlement (25%) which is followed by agriculture (12%), water body (6%), barren land (2%) and aquatic vegetation (1%). A gradual increase in settlement has been observed during this period pointing to progression of urbanization pattern.

C. Landuse Pattern 2018

The result obtained from (Fig 8) shows that vegetation (53%) is dominating among the other land uses, but still the gradual elevation is present in settlement (34%). Agricultural is considered to be on the verge of its degradation because only 5% of agricultural areas remain in the Akkulam-Veli. The most common crops for agriculture include coconut, mango, jackfruit and cashew plants.

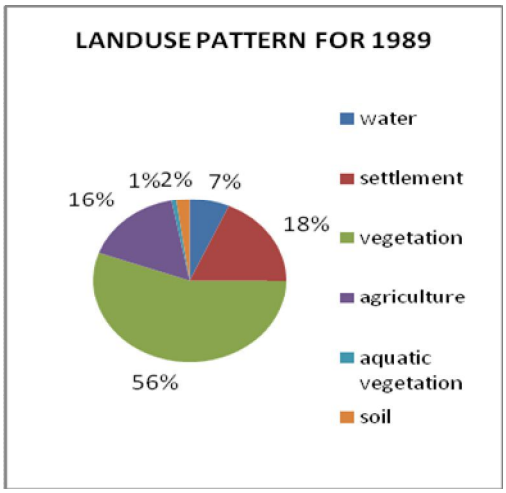

Fig 6 : LULC for 1989

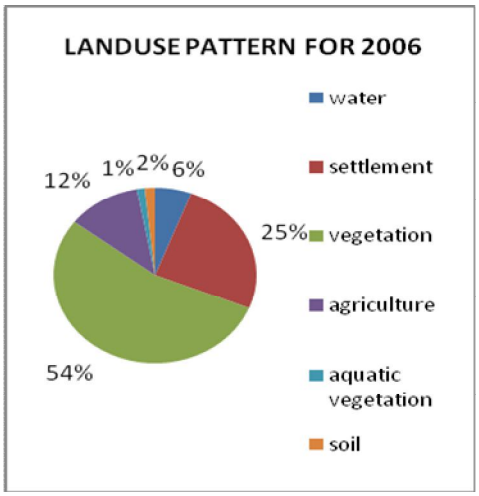

Fig 7 :LULC for 2006

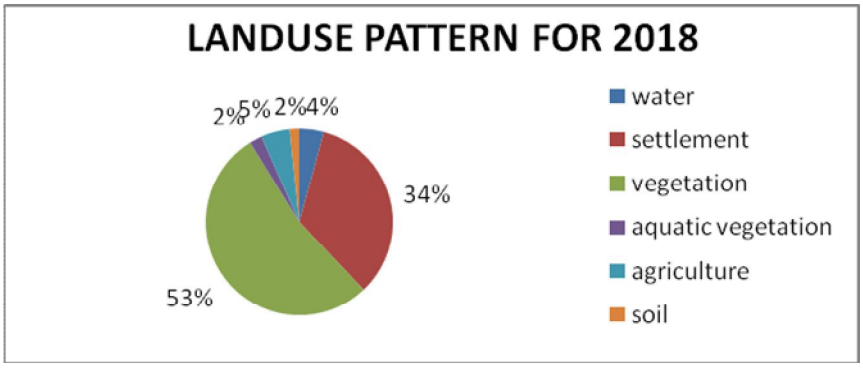

Fig 8: LULC for 2018

From Table 1, residential establishment increased exponentially during the period, 1989 to 2006 and also aquatic vegetation has been increased by 6.94% and 0.45% respectively. On the other hand agriculture, vegetation and water body has been decreased by 4.72%, 1.24% and 0.85% respectively. A negligible change has been occurred for barren land indicating that settlement area increased by clearing out of agricultural areas or vegetation areas, pointing to the lack of proper landuse. A gradual increase in settlement by widening and construction of new road took place and many of the multi-storeyed buildings, industrial establishment such as Techno park, Vikram Sarabhai Space Centre (VSSC), factories, Air Force Academy and Boat Club are situated in the area created various employment opportunities that might be resulted in the migration of people from nearby suburban or rural areas. This increase in population might be the main reason for the change in land use pattern. Increased use of land for aquatic vegetation has been reflected from 2006 to 2018 as 3.72%, which may cause negative impacts on the water body and the associated ecosystem. On the other hand, vegetation, agricultural area and water body decreased by 1%,9.54% and 1.57% respectively. The decrease in water body may be due to the encroachment activities by the skyscrapers.

Landuse- Land Cover Change In Percentage		
Class	1989-2006	2006-2018
Water Body	>0.85	>1.57
Settlement	<6.94	<8.38
Vegetation	>1.24	>1
Agriculture	>4.72	>9.54
Aquatic Vegetation	<0.45	<3.72
Barren Land	>0.59	<0.02

Table 1 Percentage change in landuse- land cover

D. Accuracy Assessment

For the purpose of accuracy assessment, a total of 75 ground truth points were collected of which 62 points were correctly identified and 13 were detected as wrong. Using this data Kappa accuracy is calculated(Table 2).

The overall classification accuracy = $\frac{\text{No of correct points}}{\text{Total Number of points}} * 100$

= (62/75)*100

= 82.6 %

Sl No	Classified	Agriculture	Aquatic Vegetation	Vegetation	Settlement	Soil	Water	Total	Correctly Sampled
1	Agriculture	8	0	1	1	0	0	10	8
2	Aquatic Vegetation	1	6	0	0	0	2	9	6
3	Vegetation	1	1	20	1	0	0	23	20
4	Settlement	0	0	3	18	0	0	21	18
5	Soil	0	0	0	0	4	0	4	4
6	Water	0	1	1	0	0	6	8	6
	Total	10	8	25	20	4	8	75	62

Table 2 Theoretical error matrix

The result from accuracy assessment provided an overall accuracy from random sampling process as 82.6%. User's accuracy ranges between 0.66 to 1 while producer's accuracy ranges between 0.75 to 1 (Figure 5). The measure of producer's accuracy reflects the accuracy of prediction of particular category. The soil has 100% of users as well as producers accuracy (Table 3). The commission error reflects the points which were included in the classification category while they really do not belong to that category. Highest commission error is present in Aquatic vegetation. This study has provided an overall Kappa Coefficient of 0.784 which was rated as substantial (Bharatkar et al., 2013, Jiao et al.,2015).

Sl No	Classified Data	Parameters				
		Users Accuracy	Producers Accuracy	Commission Accuracy	Omission Accuracy	Kappa Coefficient
1	Agriculture	0.8	0.8	0.2	0.2	0.7825
2	Aquatic Vegetation	0.66	0.75	0.34	0.25	0.7363
3	Vegetation	0.86	0.8	0.14	0.2	0.7976
4	Settlement	0.85	0.9	0.15	0.1	0.7952
5	Soil	1	1	0	0	0.826
6	Water	0.75	0.75	0.25	0.25	0.768

Table 3 Classification accuracies for various classes

Workflow (Landuse Landcover Analysis And Accuracy Assessment)

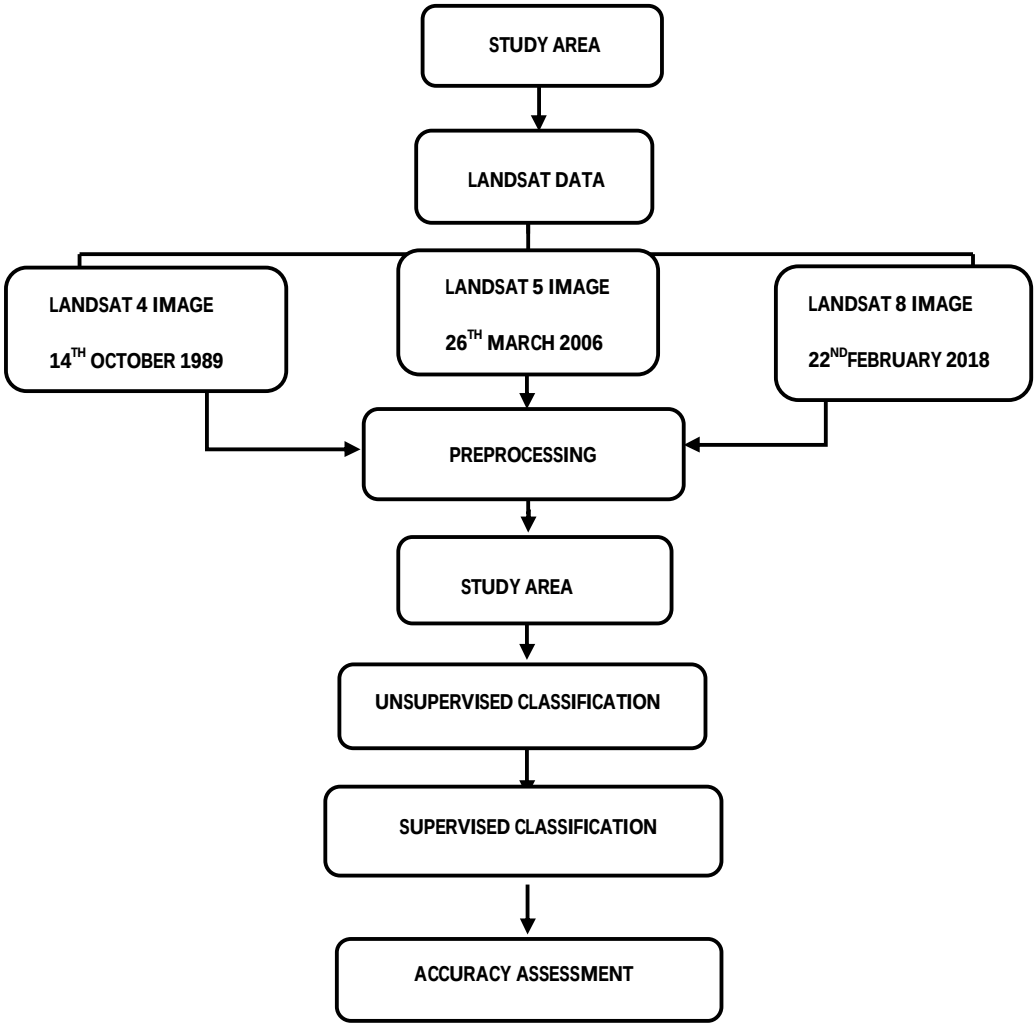

Fig 9 Work –flow on LULC analysis

Similar studies using Landsat data were executed by Vijayasoorya, 2016 for analysing the land use change of Neyyar Wildlife Sanctuary using an integrated approach employing Remote Sensing and GIS techniques. They opted Land sat 8 images (8 bands), Survey of India toposheets and Google earth images for visual interpretation of the land cover classes. Accuracy assessment of landuse/ land cover classification was used by Rwanga et al., 2017 in their study of Limpopo Province. They classified LULC in to agriculture, water body, built up areas, mixed forest, shrubs and barren land. The study has provided an overall accuracy of 81.7% and Kappa Coefficient of 0.722, which is rated as substantial.

V. CONCLUSION

Since from the time of urbanization the land has been used for various purpose including construction of buildings (governmental and nongovernmental), residential areas, infrastructure including roads, bridges etc without proper land use planning's. In this study a 2km buffer has been created around the Akkulam- Veli lake, in order to assess the land use and landcover change for a period of 30 years (1989- 2018). Landsat 8 –OLI and Landsat 4-5 TM imageries were used for this purpose. Land use landcover maps of 1989, 2006 and 2018 has been developed for further analysis. The total land utilizations has been classified in to 6 classes including water body, settlement, vegetation, agriculture, aquatic vegetation and barren land. The unsupervised classification accuracy assessment carried out on the results, provided a substantial overall accuracy of 82.6% and overall Kappa coefficient of 0.784. The result shows that there was a drastic increase in settlement area as well as the spread of aquatic vegetation and elevated decrease in vegetation and agricultural area. The overall area for water body has been decreased from 1989 to 2018. This may be due to the land encroachment activities performing around the Lake for the construction of large villas and apartments.

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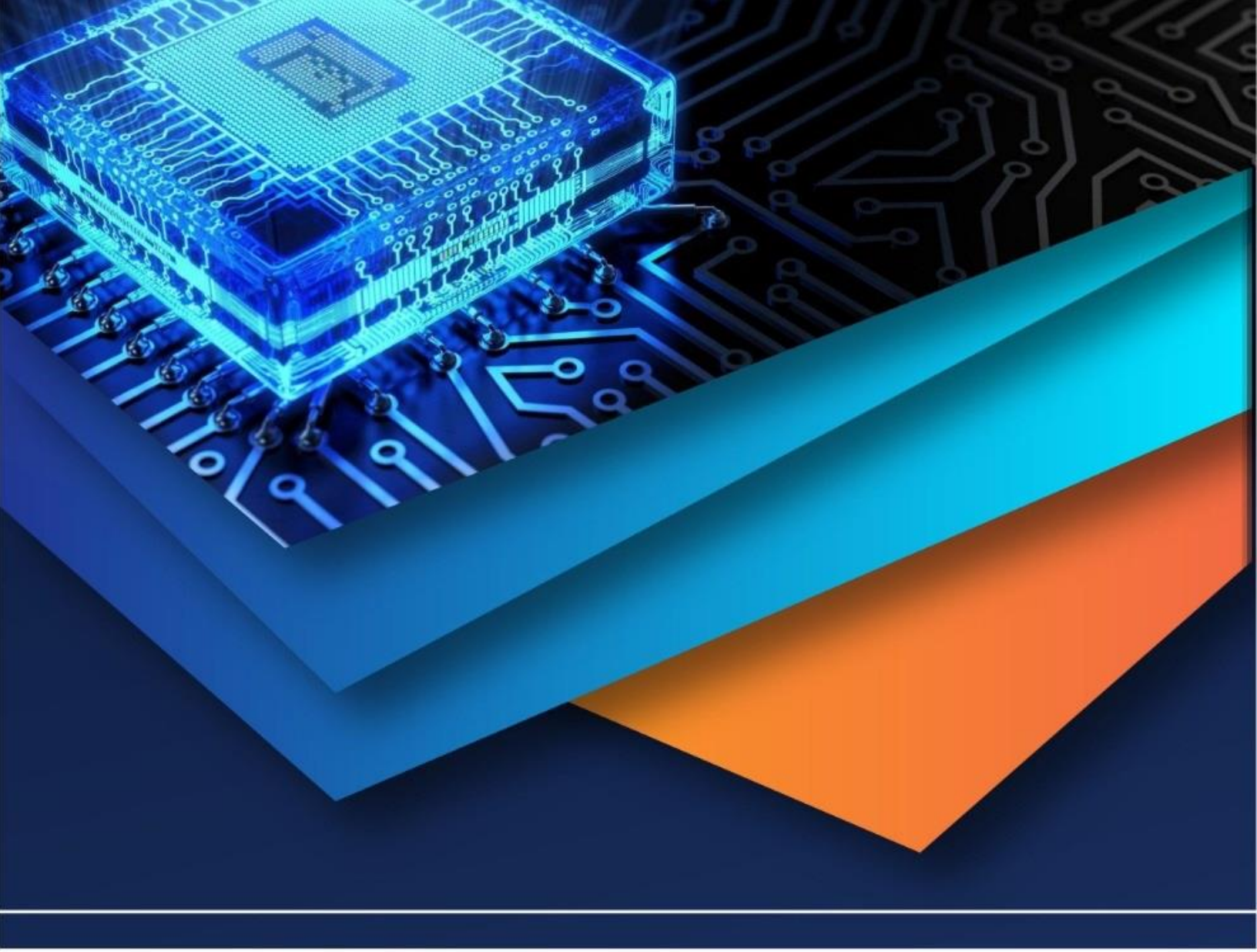

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