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Evaluation of Land Use- Land Cover Changes in and Around Vellayani Lake, Thiruvananthapuram, over the Last Thirty Years- An Analysis using Remote Sensing and GIS

Neena P. T[1], Smitha Asok V[2], Rajesh Reghunath[3], Arya Unnikrishnan S. U[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: ***Vellayani Lake is the largest fresh water lake in Thiruvananthapuram district. It is one of the three rain-fed fresh water lakes in Kerala. The waters of the lake are extensively used for drinking and irrigational purposes. 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. Land use- land cover changes over 30 years (1989-2018) around 2 Km buffer zone of Vellayani Lake was studied using Landsat 8 OLI and Landsat 4-5 TM imageries. Land use-land cover maps of 1989, 2006 and 2018 were prepared for the analysis. It was observed that there was significant Spatio-temporal variation in the study area. Accuracy assessment was carried out for checking the accuracy of unsupervised images. In this study an overall accuracy of 81.33% and overall Kappa coefficient of 0.7689 was obtained and is rated as substantial.***
Keywords: Landuse land cover , Accuracy assessment, GIS, Remote Sensing

I. INTRODUCTION

Land use or land cover monitoring is an important aspect on the study of impact on ecosystem. Land use changes can be determined by analyzing land cover maps. It provides information about current landscape (Fisher et al., 2005). The land use changes due to human activities can be observed using the past and current remotely sensed data (Hua, 2017). Remotely Sensed data provides valuable multi temporal data on the processes and patterns of land use or land cover change, and GIS is useful for mapping and analysing these patterns. Using GIS, GPS and Remote sensing tools is effective and efficient decision making techniques for making land use land cover classification mapping of one specific area of interest (Vijayasoorya, 2016).

Land use land cover patterns depends human usage and land use have the ability to affect the land cover and vice versa (Papastergiadou, 2010). Stefanids, (2016) studied that lakes in Mediterranean climate zone experience high variation in rain fall and are vulnerable to changes in climate, land cover and antrapogenically induced effects on water and salinity. Borah, (2017) observed that human activities and climate change are considered most important factors responsible for the land use land cover changes. Land use and land cover changes affect ecosystem processes like nutrient transportation in lakes (Dewan, 2009).Land use or land cover changes of lakes and wetlands revealed a significant shrinkage of water surface (Erasu, 2017). Land use land cover changes increase turbidity of freshwater ecosystem (Ghosh, 2017). A Land cover change has a unique signature on the topography and soil distribution results in natural resource changes (Lillisand, 1983). Madanian, (2015) observed that population increase, spread of settlements and increased use of land use resources are affect the land use land cover changes.

II. STUDY AREA

The Vellayani Lake is linear shaped and one of the largest rain fed freshwater lake in Thiruvananthapuram district, Kerala. The lake water is mainly used for drinking and irrigational purposes. It is observed that the area of the lake, which was 750 ha in 1926, had been reduced in 397.5 ha by 2005. Lake Vellayani is located in Western low lands near the coastal. The salinity of the lake rise as a result. The climate of the Vellayani area is classified as “hot tropical”. The total annual average rainfall is around 1600 mm per annum. The study area receives rain from the southwest and northwest monsoons, the former providing most precipitation. The temperature in the area ranges from 25^{o}C to 35^{o}C (Abhijna, 2014).Lake occupies a low relief depression in a Holocene terrace deposit. The depression is considered to have formed as a consequence of sagging along the Vellayani fault. The lake area support a

rich variety of plants ranging from rare orchids, medicinal plants and spices to hedge plants, tuber crops, plants yielding edible fruits and fibre (Veena, 2014).

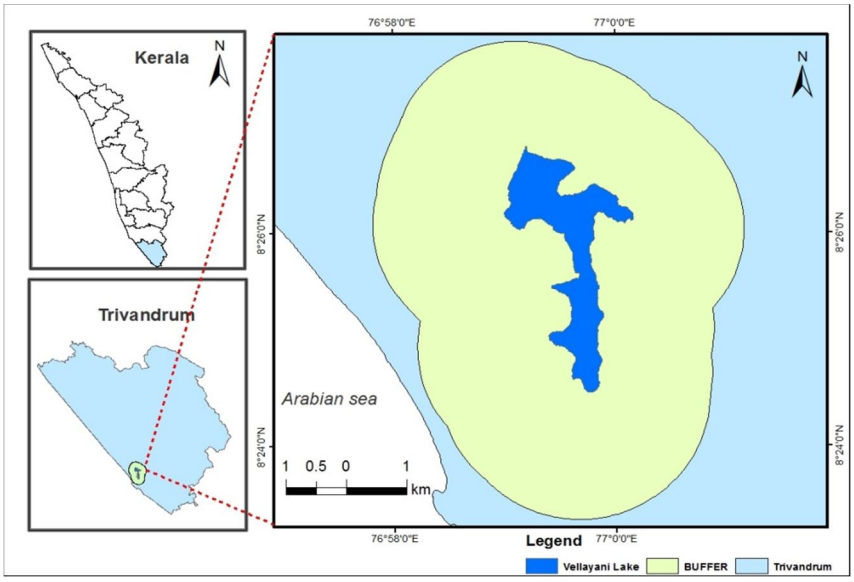

Fig.1 location map – Vellayani lake

III. MATERIALS AND METHODS

A. Satellite Image Pre-Processing And Study Area Delineation

Boundary of the Vellayani Lake is delineated from Google Earth. Temporary files were created and the boundary drawn as polyline. This file is saved as .kml. This file is opened in ArcMap and converted from polylines to polygon and saved as shape files. In this study LANDSAT 8 OLI of February 2018, LANDSAT 4-5 TM of 2006 and LANDSAT 4-5 TM of 1989 satellite images were downloaded from the USGS Global Land Cover Facility. The data is cloud free (less than 10%) and level 1 type. The three images were taken over a time period of 30 years (1989-2018) to study the land use land cover changes on the study area. The three images were layer stack and also georeferenced with the UTM Zone 43 N coordinates on the WGS 84 reference system. A 2 Km buffer zone around the Vellayani Lake was created in ArcMap. The buffer encloses the places Vazamuttam, Muttakkad, Palapporu, Kalliyoor, Vellayani and Kochukovalam etc. The buffer was subset with each of the layer stacked satellite images for to do unsupervised classification.

B. Classification Analysis

The unsupervised classification method was used to classify the images into the various land cover categories. In unsupervised classification individual pixels were compared with satellite images. This then must be interpreted by the user as to what the colour patterns may mean in terms of classes, etc. ERDAS imagine was used to this process, analyze and interpretation of spatial data and geographic information to achieve the objectives of the study. Auxiliary data such as Google Earth image, topographic map and others were used for visual interpretation of the land cover classes. The category includes water body, settlement, vegetation, agriculture and aquatic vegetation. In order to analyze the nature, rate and location of land use and land cover changes, land cover maps of 2018, 2006 and 1989 were created in ArcMap.

C. *Accuracy Assessments*

One of the most important final steps at classification process is accuracy assessment. The aim of the accuracy assessment is to quantitatively assess how effectively the pixels were sampled into the correct land cover classes. Moreover the key emphasis for accuracy assessment pixel selection was on areas that could be clearly identified on both Landsat high resolution image, Google Earth and field data, a total of 75 points or locations were created in the classified image of the study area.

Overall accuracy (%) = (number of correct points/total number of points)*100

User's accuracy (%) = (Correctly classified pixels/classified total pixel)

Producer's accuracy (%) = (Correctly classified pixels/Reference total pixels)

A more appropriate way of presenting the individual classification accuracies are as follows;
Commission error = 1-User's accuracy
Ommission error = 1-Producer's accuracy
The Kappa coefficient (K) can be calculated as follows,
$K= (P_o-P_c)/ (1-P_c)$
Where,
P_o = proportion of units which agree, = Overall accuracy
P_c = 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 K <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 and patel, 2013).

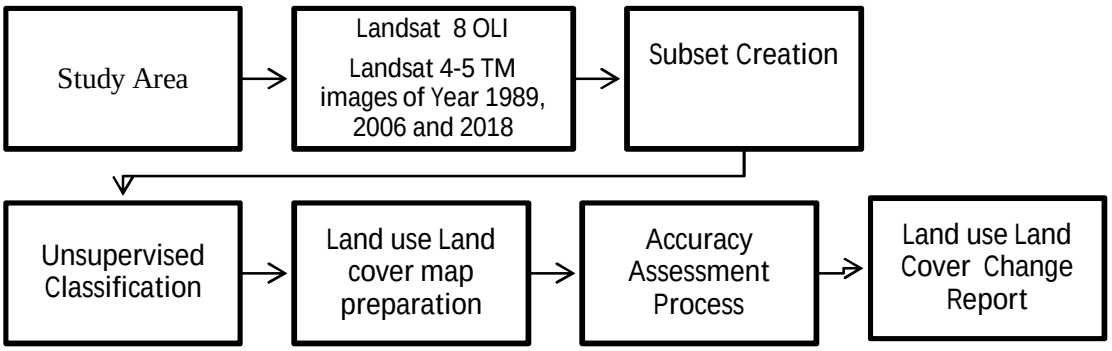

Fig. 2 schematic workflow

IV. RESULTS AND DISCUSSION

A 2 Km buffer zone around the Vellayani Lake was created in ArcMap for the study of land use -land cover changes around the Lake.The land use categories of Vellayani Lake and 2Km buffer zone divides into 5 major classes which include water, agriculture, aquatic vegetation, vegetation and settlement.

A. Land Use Pattern -1989, 2006 And 2018

The land use land cover classification 1989 showed that majority of the study area was under agriculture with14.8689 sq.km. In 1989 the area under vegetation was 14.211sq.km. Settlement was spread 6.62 sq.km. The water body occupies in 4.7% of the total class and aquatic vegetation was the least class with 1.1744sq.km. The land use classification of Vellayani Lake 1989 was given in the Table 1 and Figure 3 and 7.The land use land cover classification show the majority of the study area was under vegetation with 13, 1652 sq.km. Agriculture was reduced to 11.1159sq.km and water was reduced into 3.6%. Settlement was increased to 11.6955sq.km and aquatic vegetation also increases into 1.301%. The land use land cover changes are depicted in Table 1, Figure 4 and 8. Agriculture was reduced than the previous years and settlement also increases. In 2018 area under agriculture was 9.388sq.km; water body encloses 1.1988 sq.km. Major land use class of the area was settlement with an area extent of 13.7223sq.km. It includes houses, buildings, roads and other human constructions. Vegetation declines to 34.11% which comprises of all kinds of plants and trees. Aquatic vegetation was extent to 1.99%. This may be due to the increasing human activities. The land use classification is given in the Table 1, Figure 5 and 9.

Agriculture, vegetation and water body decreases due to the increase of settlements and aquatic vegetation. Agriculture decreases 9.82% in 2006 than 1989 and 4.7% in 2018 than 2006. Vegetation decreases 2.67% in between 1989 -2006 and 0.685% decrease in 2006-2018. 1.09% of water body decreases in the period 1989-2006 and 0.46% in between 2006-2018. Settlement increases 13.45% in 1989-2006 and 5.16% in between 2006-2018. Aquatic vegetation is also increases 0.13% in 1989-2006 and 0.69% in between 2006 and 2018.

Comparison of Land use-Land cover Changes						
	Km^2			Percentage		
Class	1989	2006	2018	1989	2006	2018
Agriculture	14.8689	11.1159	9.388	39.19%	29.37%	24.67%
Aquatic Vegetation	0.4455	0.4923	0.7587	1.17%	1.30%	1.99%
Settlements	6.6222	11.6955	13.7223	17.45%	30.90%	36.06%
Vegetation	14.211	13.1652	12.9798	37.46%	34.79%	34.11%
Water	1.7865	1.3689	1.1988	4.70%	3.61%	3.15%

Table.1 comparison of land use- land covers changes

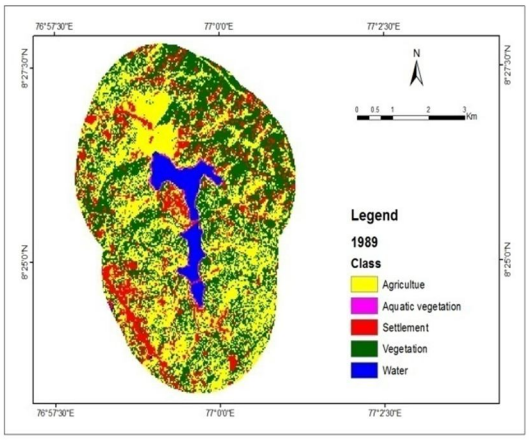

Fig. 4 land use map 2006

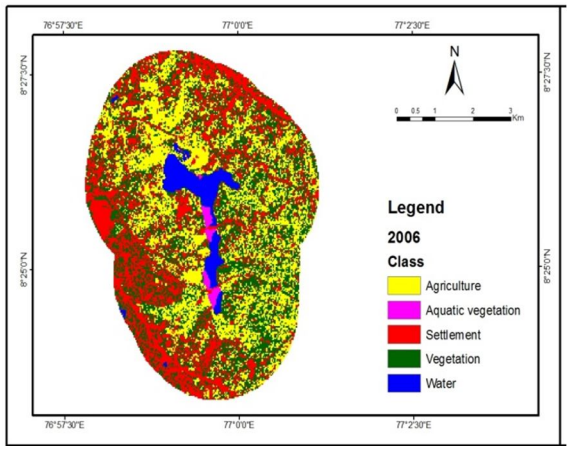

Fig.3 land use map 1989

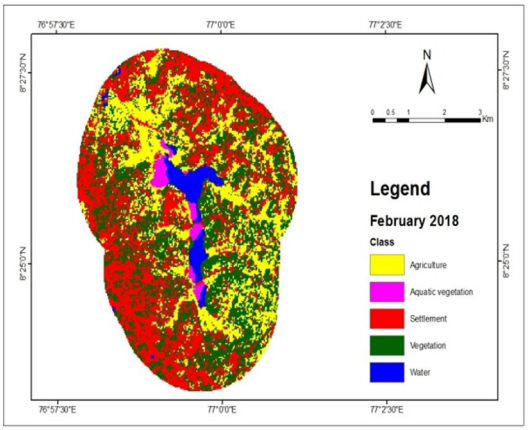

Fig.5 land use map 2018

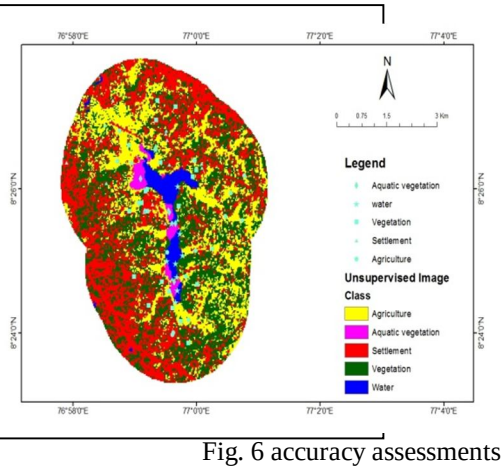

Fig. 6 accuracy assessments

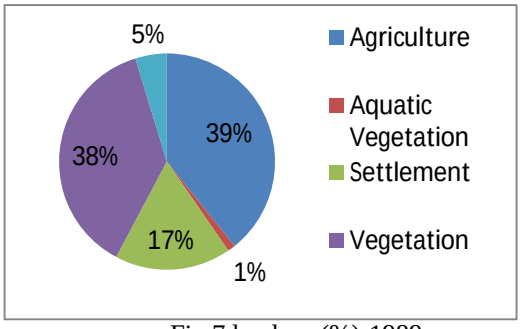

Fig.7 landuse (%)-1989

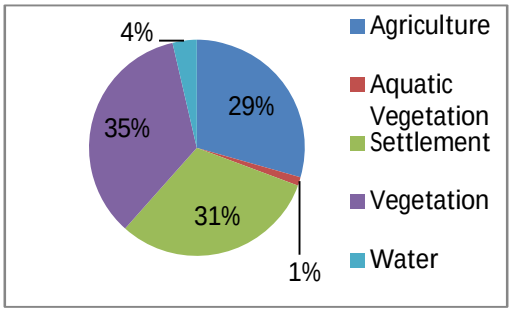

Fig.8 landuse (%)-2006

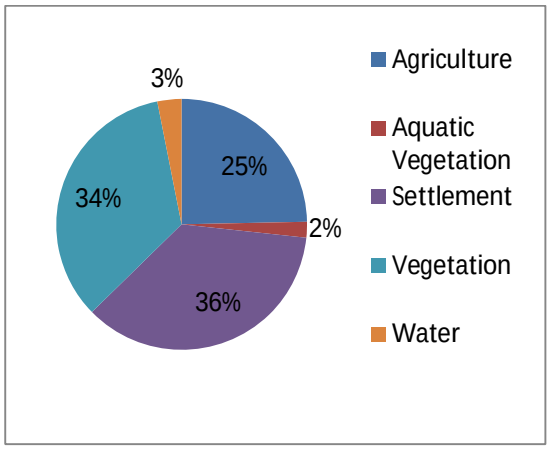

Fig.9 landuse (%)-2018

Similar studies has been conducted by Mallupattu et al., 2013 aimed to analyse Land use Land cover changes using Remote Sensing data and GIS at an Urban area, Tirupathi, Tamilnadu, India. They use LISS III and IRS satellite images from 1976 to 2003. They observed that there is a significant increase in built-up area, open forest, plantation and other lands. It is also noted that Agriculture land, water spread area and dense forest were cleared during the Study period which may be due to antrapogenic activities. Rawat and Kumar, 2015 also monitor land use Land cover changes in Almora, Uttarakhand, India using Landsat TM images. Unsupervised classification technology has been employed to study the changes over a period of 20 years, 1990 to 2010.

B. Accuracy Assessment

A total of 75 ground truth points were randomly collected for accuracy assessment. These points were depicted above the classified image and identify the number of correctly sampled points and wrong points. Based on this image an error matrix was formed for further analysis. In this study total of 61 points are identified as right and 14 are wrong. Using the data in error matrix (Table 2) Kappa accuracy is calculated.

The overall classification accuracy = 81.33%

SL No	Classified	Agriculture	Aquatic vegetation	Settlement	Vegetation	Water	Total	Correct sampled
1	Agriculture	12	2	1	1	0	16	12
2	Aquatic vegetation	1	5	0	0	0	6	5
3	Settlement	1	0	19	1	0	21	19
4	Vegetation	1	1	2	16	1	21	16
5	Water	0	1	1	0	9	11	9
	Total	15	9	23	18	10	75	61

Table.2 theoretical error matrix

The result from accuracy assessment showed an overall accuracy obtained from the random sampling process for the image is 81.33%. User's accuracy ranged from 0.75 to 0.904. While producer's accuracy ranged from 0.555 to 0.9. The measure of Producer's accuracy reflects the accuracy of prediction of the particular category. The User's accuracy reflects the reliability of the classification of the user. Settlement was found to be more reliable with 90.4% of user accuracy. The Commission error means the points which are included in the category but they really do not belong to that category. The Commission error is highest in the agricultural areas. The Omission error means the number of points which are not included in the category but they are actually belong to the category. In this study an Overall Kappa coefficient of 0.7687 was obtained (Table 3) which is rated substantial.

SL NO	classified data	Parameters				
		User's accuracy	Producer's accuracy	Commission error	Omission error	Kappa coefficient
1	Agriculture	0.75	0.8	0.25	0.2	0.7506
2	Aquatic vegetation	0.833	0.555	0.167	0.445	0.775
3	Settlement	0.904	0.826	0.096	0.174	0.7931
4	Vegetation	0.76	0.888	0.24	0.112	0.7539
5	Water	0.818	0.9	0.184	0.1	0.7713

Table .3 classification accuracies for various classes

Rwanga and Ndambuki, 2017 conduct Accuracy Assessment of Land use Land cover classification using Remote Sensing and GIS. The study had an overall accuracy of 81.7% and Kappa coefficient of 0.722. In their study the Kappa coefficient is rated as substantial and hence the classified image found to be fit for further research. Bharatkar and Patel, 2013 assess the Accuracy of classified image. They had an overall accuracy of 88.52% and Kappa coefficient of 0.842. Adithya et al., 2017 also analysed accuracy of land use changes on Shenturuny Wild life sanctuary, Kollam using satellite imageries.

V. CONCLUSION

The present study had been conducted to assess the implications of Land use changes of Vellayani Lake, Thiruvananthapuram In this study a 2 km buffer around the Lake was prepared to assess the land use- land cover changes over a period of 30 years (1989-2018). Landsat 8 OLI and Landsat 4-5 TM images were used for this purpose. Land use-land cover maps of 1989, 2006 and 2018 were prepared for further analysis. The total area is classified into 5 major classes and they are agriculture, aquatic vegetation, settlements, vegetation and water. The result shows that there was a vast increase of settlement and decrease of agricultural area and vegetation. The area of water body decreases and aquatic vegetation is also increases. It may be due to the anthropogenic activities like destruction of land, cutting trees, construction activities, clearing of water for agriculture, improper agricultural practices, pollution etc. Accuracy assessment was carried out in this study for checking the accuracy of Land use land cover maps. Kappa accuracy is a best method for this purpose. In this study an overall accuracy of 81.33% and overall Kappa coefficient of 0.7689 was obtained and is rated as substantial. The results obtained from the study will prove to be immensely useful in understanding land use land cover chnges on Vellayani Lake, one of the important rain-fed freshwater Lakes in Kerala. It was identified that Sand-mining, encroachments, land reclamation, and conversion, extraction of water, pollution and unauthorized constructions as the immediate threats to the water body. Proper conservation measures are needed for the protection of Lake from the surrounding land use changes.

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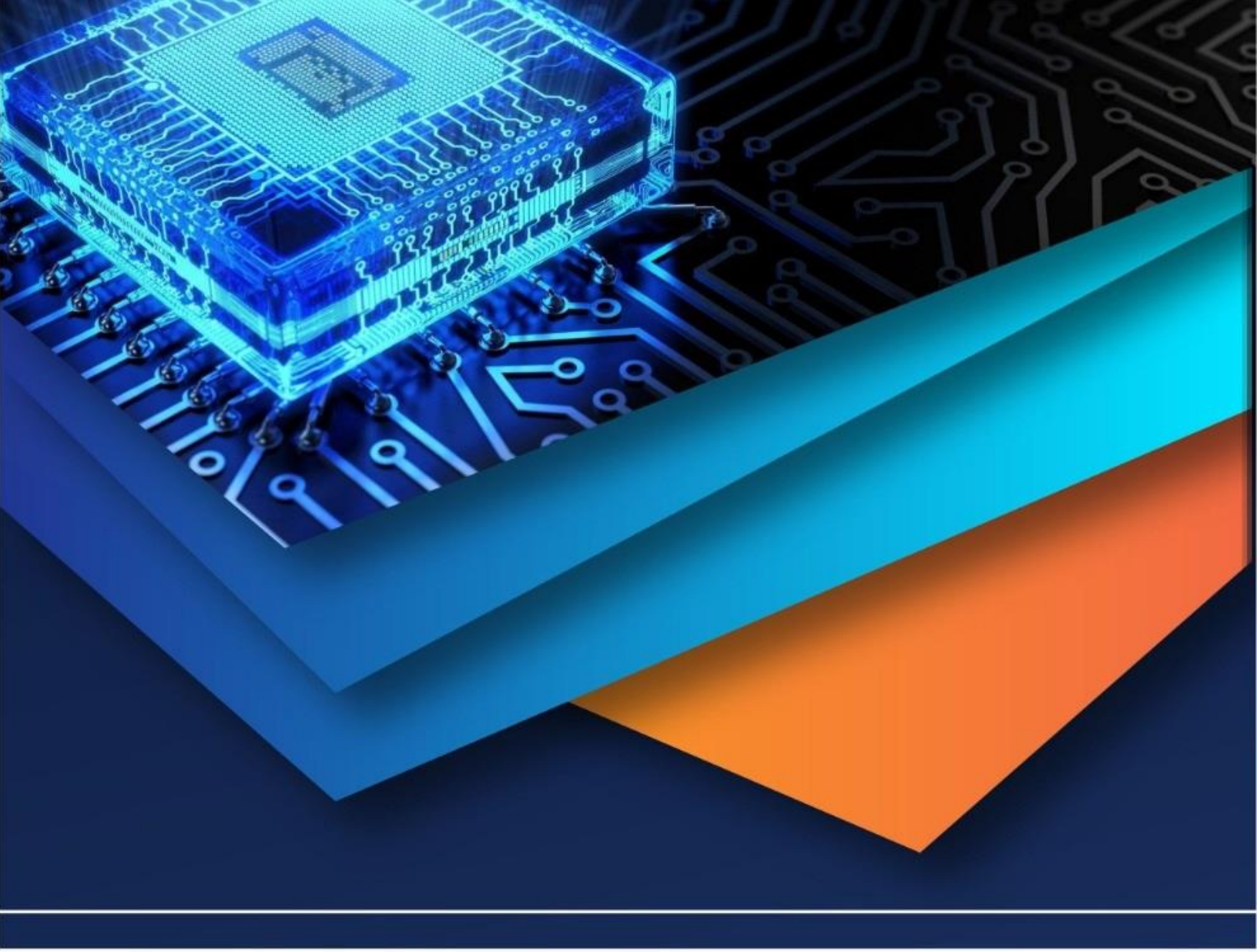

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