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Urban Sprawl Analysis using GIS Application of Bhagur City

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Abstract: ***The word "Urban Sprawl" means growth is more than the normal and the criteria that makes it different from urban growth is this excessive nature. Cities grow continuously and planned growth is achieved when there is a right balance between urban growth and urbanization. But when growth is above normal its pressure on the region and the city will face major new challenges. Urban sprawl is unrestricted growth in many urban housing areas, business development and roads in large parts of the world, without worrying about urban planning. Urban Sprawl are of three types i.e., linear growth, cluster growth and leapfrog growth. This paper inspect the use of Remote Sensing and GIS in mapping of urban sprawl (1990-2021) and landuse/ landcover change detection to detect changes that has been taken place between these periods in Bhagur city. The paper helps to study the software such as ArcGIS, used to classify between built up and agricultural land using temporal signatures obtained from satellite images. To numerically understand the growth pattern Shannon's entropy is used. Shannon's entropy is used as an index to quantify the degree of dispersion or concentration of built-up areas. Entropy approach shows concentration growth pattern in Bhagur city.***

Keywords: Urban Sprawl, GIS, Remote sensing, Land use/ Land cover, Shannon's entropy.

I. INTRODUCTION

The definition of an urban area is usually based on population, residents, percentage based on non-agricultural income and the provision of public services and utilities. The way in which we develop our country and its urban areas is a critical component to create a sustainable community. The shape of urban areas or cities or small towns ultimately relate to our environmental and social conditions. Sprawl has been directly related with increased pollution, energy use and traffic congestion and the decline of socialism. In addition, increase in footprints of physical and environmental aspects of urban areas, leads to the loss of wildlife and natural areas. While the causes and consequences of sprawl are more towards negative side, there are different policies and techniques that can reduce such unsustainable growth patterns. Local-level planning policies can assist guide environmental growth and sustainability and help local communities in developing urban areas through specific land use areas. Such planning policies can assist focus on growth in targeted areas, prevent further development, and protect or restore regional natural resources.

II. STUDY AREA

The Bhagur is birth place of Vinayak Damodar Savarkar is the apex of the Indian freedom struggle, and is in the vicinity of the holy city of Nasik, Bhagur cherishes a great historical importance. Bhagur is adjoining to the Nashik city, one of the fast developing cities and districts of Maharashtra. Bhagur is surrounded by Deolali Military cantonment and Nasik Road, which is a densely populated and fast developing area of Nashik city itself.

Bhagur area is lying between 19.87°North Latitude and 73.83°East Longitude. Bhagur is a C class Municipal Council in Nashik Tahsil in Nashik district. It is situated at a distance of 18 kms towards south of Nashik city and 10 kms from Nashik-road. Deolali Camp, one of the most important Military Cantonment Town is located only at a distance of 4 kms towards north of Bhagur. Nashik- Sinnar road is passing on just abutting eastern limit of Municipal Council. Sinnar is about 20kms towards east of Bhagur.

A. Topography and Landscape

The town is situated at the foot of north- south Sahyadri Ranges in Nashik district. The river Darna flows towards east along the southern boundary of municipal limit. The land within the municipal limit is fairly plain land having gentle slope on its south and east.

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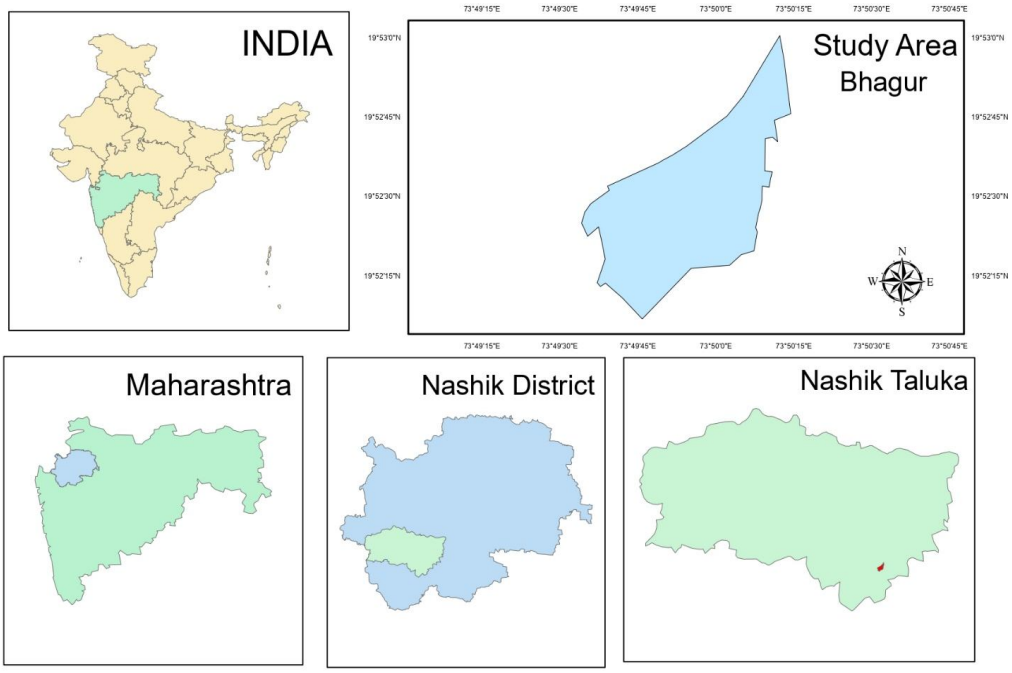

Fig No. 1 Study Area

B. Growth of Population

As per the 2011 census, the total population of Bhagur Municipal Council was 12,353 souls as against the 2001 census population of 12,457 souls, indicating the growth rate of -0.83 % during 2001-2011 decade. Similarly, population for 1991 was 12,078 souls indicating decadal growth of 3.13 %. Following table shows decadal population growth.

Table No. 1 Population Growth

Year	Population	Decennial variation	Percentage variation
1991	12078	-	-
2001	12457	379	3.13
2011	12353	-104	-0.83

C. Structure of Population

As per the 2011 census total population of Bhagur town is 12353 souls, out of which 6201 male and 6152 female populations. The percentage of male and female to the total population is 50.20% and 49.80% respectively. Sex ratio comes to 992 females per 1000 males.

D. Occupational Structures and Employment

Table given below shows the occupational structure within municipal council area of Bhagur as per census 2011. The total population of the city i.e. municipal council as per 2011 census was 12353 souls out of which 6201 were males and 6152 were females forming sex ratio of 992 females per 1000 males. The total working population in the city is 4450 both including main and marginal workers which works out to be 36.02 % of the total population Contribution of females in the working population was comparatively less i.e. about 966 females forming only 21.70 % of the total working population. Occupation structure of the Bhagur town as per 2011 census is given in table below from which it is seen that no. of workers in tertiary sector are much more than in primary and secondary sectors, indicating the service character of the town.

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Table No. 2 Occupational structure

Sr. No.	Sector	Occupation	Male	Female	Total	% of Total
1	Primary	Cultivator	151	22	141	3.16
		Agriculture	111	125	236	5.3
		Total	262	147	377	8.46
2	Secondary	Household Industry	109	62	171	3.85
3	Tertiary		3154	757	3902	87.68
		Total	3516	966	4450	

E. Existing Land Use Survey

It is the basic fundamental and most important survey. It shows the use or uses to which each and every piece and parcel of land within the jurisdiction of the Planning Authority is put. This survey is the best indicator of the character of the area to be planned. Its analysis helps in determining the optimum and most beneficial distribution of the land uses in the interest of the community, which in turns gives guidance to proper zoning and framing proper proposals in the Development Plan. The total area within the Bhagur Municipal Council limits is about 0.65 sq.km. Existing land use of the Bhagur Municipal Council area is shown on existing land use map submitted to the Council by the Town Planning Officer vide letterNo.3458 dated 24/12/2013. Total developed area is about 45.56 % of the total council area, out of which 23.13 % is residential. The area under cultivation is about 8.91 % of the total area. Out of the total developed area, predominant land use is residential. From detailed existing land use analysis of the entire council area, the inferences could be drawn as follows:

1) The residential development marked on the existing land use map, indicate that the trend of residential development is mostly in Gaothan portion i.e congested area
2) The commercial activity is mainly concentrated within the gaothan area.
3) Public – Semi Public user constitute 3.18 % of the developed area.
4) Industrial use constitutes to mere 0.20 % of the developed area.

Table No. 3 Existing Land Use Survey

Sr.No.	Land Use	Area in Ha.	% to developed area	% to Total Area
I)	Developed Area			
1	Residential	15.11	50.94	23.13
2	Commercial	0.88	2.97	1.35
3	Industrial	0.13	0.44	0.2
4	Public & Semi Public	2.08	7.01	3.18
5	Public Utility	1.56	5.26	2.39
6	Traffic & Transportation	3.47	11.7	5.31
7	Defence Land	5.64	19.01	8.63
8	Garden & Playground	0.79	2.66	1.21
	Total	29.66	100	45.4
II)	Undeveloped Area			
9	Agricultural Land	5.82		8.91
10	Vacant & Barren Land	17.74		27.16
11	Water Bodies	12.1		18.52
	Total	35.66		54.6
	Grand Total Area	65.32		100

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III.LITERATURE REVIEW

According to L. C. O. Verzosa, R. M. Gonzalez (2010), Urban sprawl, or the unplanned and uncontrolled spreading out of built-up areas, causes problems in the allocation of basic needs and increases risk to life and property in the face of disasters. The integration of remote sensing and geographic information systems can be used in adopting Shannon's entropy to measure urban sprawl. Shannon's entropy is an index that determines the distribution of built-up within a defined area. It characterizes the pattern i.e. dispersed or concentrated of built-up over time that can help policy makers to identify which area is being used inefficiently. In the study of city Baguio situated in northern Philippines the researcher observed that the sprawl pattern is growing in the concentrated pattern. The researcher also compared his observations with the natural calamity occurred in the Baguio city in the year 2009 which will help in strategic planning for disaster preparedness. They concluded with the statement that the high values of Shannon's entropy indicate that the Baguio city is precariously approaching its critical level and city government must keep track for the safe planning of urban development.

Sunil Sankhala, B. K. Singh (et al 2014) in their study of Jaipur city produced a land use/ land cover map of the city at different year in order to find the changes that have taken palace particularly in the built -up land and subsequently to analyze the urban sprawl of the different time period. The researcher used IRS LISS-II (1995), LISS-III (2000, 2006) and LANDSAT TM (2010) satellite images for generation of land use/ land cover map. Geographical maps are produced from descriptive satellite imagery shows Jaipur is also witnessing urban sprawl. The city grows northwest and southeast and respectively. The main reasons for this increase are the availability of land at very low prices in those areas, good communication network, availability of better infrastructure and facilities, proximity to the metropolitan area etc. in urban areas.

Vivek Garg, Dr. Alok Sharma (et al 2018) in their study of urban sprawl analysis of Jabalpur city used GIS application to generate maps and used Shannon's entropy to evaluate urban growth. The researcher compared the land use areas for the year 2005, 2011 and 2017 and found out a decrease of 66% in agricultural areas and an increase of 312% in the residential areas from year 2005 to 2017. To support their theory they compared it with the relative shannon's entropy value and found compactness and unplanned growth pattern in built-up area.

According to Monalisha Mishra, Kamal Kant Mishra, A.P. Subudhi, in their reserch topic Urban Sprawl Mapping And Land Use Change Analysis Using Remote Sensing And GIS (case Study Of Bhubaneswar City, Orissa) monitored urban land use land cover change between 2000-2005. To achieve their objectives the researchers obtained satellite data from Liss-III imagery of 1997 and 2000 and Cartosat-1 image of Nov-2005. For classification and distinguishing the researcher made 15 different zones and comparing each areas helped them to understand the urban sprawl in Bhubaneswar City. They concluded made commentating that GIS and satellite images is very useful for the study for predicting the future land uses even when not much of old land use data is available. This is useful for the urban planning authorities in developing countries where land use data is not available regularly.

IV.DATA COLLECTION

For the purpose of the study necessary information has been collected through primary and secondary sources.

1) Satellite data: Landsat TM satellite images for the years 1990, 2000, 2010 and 2021 were obtained from United States Geology Survey (USGS).
2) Census of India- Primary census abstract- 1991, 2001, 2011
3) Bhagur Development Plan Report.
4) Software used for analysis: Arc GIS, Google Earth Pro, AutoCAD.

Table No. 4 Information of utilized satellites imagery (Source: US Geological Survey)

Satellites	Acquisition date	Sensor	Spatial resolution
Landsat 8	03-02-2021	OLI_TRS	15m
Landsat 5	05-02-2010	TM	30m
Landsat 7	05-03-2000	TM	15m
Landsat 5	01-02-1991	TM	30m

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V. DATA ANALYSIS

The temporal changes in the LULC of Bhagur city was determined by digital classification of 1991, 2000, 2010 and 2021 Landsat TM satellite images obtained from United States Geology Survey (USGS). The Landsat satellite images are combination of different spectral bands with spatial resolutions ranging from 15 to 60 m. Landsat images are usually about 115 miles long and 115 miles wide (or 185 kilometres long and 185 kilometres wide). For our study, the raster image was obtained by combination of 7 spectral band images using ArcGIS software. This raster image can be arranged in different band combination which include natural colour, infrared colour, and various vegetation indexes to extract unique and new information that helps to distinguish between vegetation, urban area, water bodies, hilly region, etc. This combined raster image is pansharpen with the panchromatic band number 8. The panchromatic band spans are a longer range of wavelengths and can generate 15m panchromatic images using ArcGIS software. For extraction of shape file of the area of interest, the Bhagur city boundaries map was obtained from Bhagur municipal council. Using arctool the area of interest for this study is masked and primary layer is created for classification. For supervised classification by ArcGIS application individual training sites are made by selecting polygons of different pixel size. Based on training samples, for each land cover class a the signature file is created. The maximum likelihood classifier (MLC) was used for spectral classification of the landsat images based on the training sites (signatures), at a 15 m resolution. The four land cover classes were identified in the study area, namely, built up area, agricultural land, Barren lands and water bodies. Finally, the generalized images are created for the final version of LULC maps for 1991, 2000, 2010 and 2021.

A. Land Use/ Land Cover Map of Bhagur in year 1991

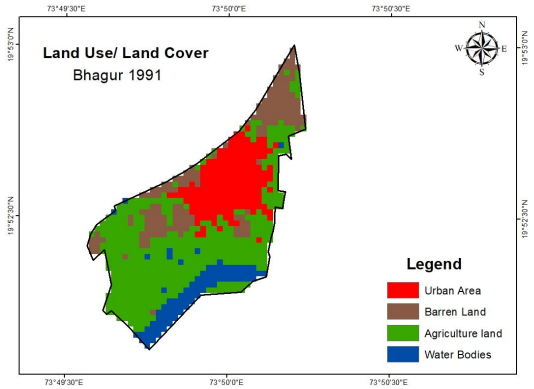

Fig. 2 Land Use/ Land Cover Map of Bhagur in year 1991

Class Name	Area (Sq.m.)
Urban Area	165678.58
Barren Land	145831.05
Agriculture land	398980.31
Water Bodies	81184.95

Table 5. Land Use/ Land Cover Area

The analysis of LULC changes based on post-classification change detection and landscape metrics has revealed that in the first period, during 1991, the urban area in Bhagur city was about 16.57 ha whereas Barren Land & Agriculture Land was 14.58 ha and 39.89 ha respectively. Water Bodies that is Darna river flows to the south side of city covers about 8 Ha of total area.

B. Land Use/ Land Cover Map of Bhagur in year 2000

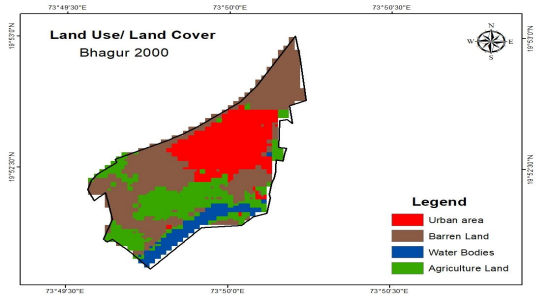

Fig. 3 Land Use/ Land Cover Map of Bhagur in year 2000

Class Name	Area (Sq.m.)
Urban area	195070.46
Barren Land	353084.99
Agriculture Land	188704.57
Water Bodies	58745.16

TABLE 6. LAND USE/ LAND COVER AREA

By analysing the above figure, it can be observed that urban area in year 2000 was about 19.5 ha whereas Barren & Agriculture Land totalled about 54 ha and area of water bodies was 5.8 ha.

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C. Land Use/ Land Cover Map of Bhagur in year 2010

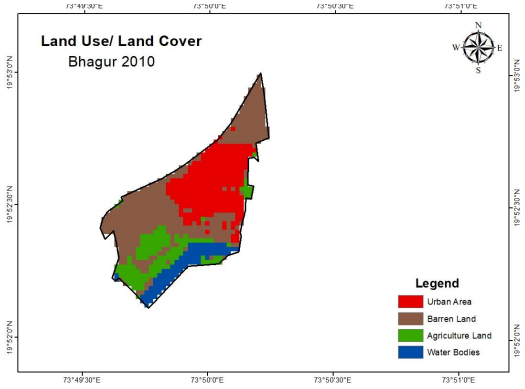

Fig. 4 Land Use/ Land Cover Map of Bhagur in year 2010

Class Name	Area (Sq.m.)
Urban Area	234152.01
Barren Land	359689.66
Agriculture Land	122030.67
Water Bodies	77712.38

Table 7. Land Use/ Land Cover Area

The analysis of LULC map based on post-classification change detection and area calculation has revealed that in the year 2010, the urban area in Bhagur city was surveyed has 23.41 ha and Darna river area was surveyed has 7.78 ha. The other remaining land which categorized mainly undeveloped or green land was in total 48 ha.

D. Land Use/ Land Cover Map of Bhagur in Year 2021

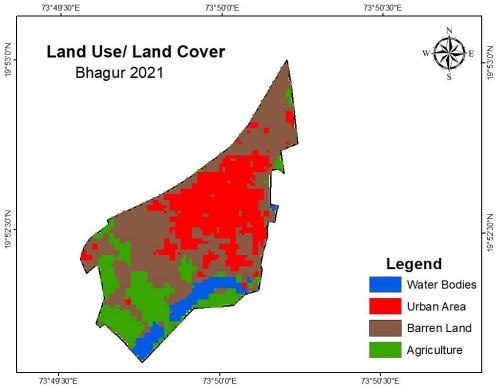

Fig. 5 Land Use/ Land Cover Map of Bhagur in year 2010

Table 8. Land Use/ Land Cover Area

Class Name	Shape Area
Urban Area	227040.3269
Barren Land	366138.452
Agriculture Land	150856.7206
Water Bodies	50833.84612

By observing LULC map of the current year 2021 based on post-classification change detection and area calculation has revealed urban area in Bhagur city has 23 ha and Darna river area is surveyed has 7.78 ha. The other remaining land which categorized mainly undeveloped or green land is nearly 52 ha.

E. Change Detection Between Year 1991 & 2021

Table 9. Land Use/ Land Cover Area change detection

Year	1991	2000	2010	2021
Class Name	Area (Ha)	Area (Ha)	Area (Ha)	Area (Ha)
Urban Area	16.56	19.50	23.41	22.7
Barren Land	14.58	35.30	35.96	36.61
Agriculture land	39.89	18.87	12.20	15.08
Water Bodies	8.12	5.87	7.77	5.08

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The city of Bhagur has undergone changes in structure and spatial extent over the last four decades. In 1991, the total urban area was 16.56 Ha, which became 19.50 Ha in 2000. In 2010 the urban area has been 23.41 Ha and in finally 2021 shows relatively no further increase in built-up area. So, comparing the growth with the era of industrialisation and urbanization between 1991 and 2021 the urban area in Bhagur city also grew by 37%. Similarly, the undeveloped area in 1991 was 54.47 Ha and then 54.17 Ha in 2000. In 2010 it decreases to 48.16 Ha and finally for 2021 the undeveloped area was observed as 51.70 Ha. Hence a proportionate decrease in barren & agriculture land with respect to increase in Urban area.

F. Shannon Entropy

To understand the sprawl pattern Shannon entropy value is calculated. Shannon's entropy is calculated by the following equation:

$$H_n = \sum_{i}^{n} p_i \log(\tfrac{1}{p_i})$$

where: pi is the probability or proportion of the variable occurring in the ith districts and n is the total number of districts or zones. We have used relative entropy for scale the entropy value from 0 to 1. The relative entropy is calculated by following equation.

$$H_n = -\sum_{i}^{n} P_i \mathrm{Log}(1/P_i)/\log(n)$$

The Shannon's entropy values are different between 0 and Log n. The value closer to zero means compact urban growth (higher density), while values closer to 'log n' indicates dispersed distribution of city's built-up environment.

To analyse the level of compactness or dispersion of the spatial urban expansion of the Bhagur city, the Shannon's entropy was computed. The values computed can be observed in following Table No. 10.

TABLE NO. 10 SHANNON ENTROPY VALUE

Year	Value of Shannon's Entropy	Value of relative Shannon's Entropy
1991	0.52	0.38
2000	0.69	0.42
2010	0.61	0.44
2021	0.92	0.51

While speaking in terms of sprawl pattern, it can be observed that the Bhagur city is witnessing cluster growth pattern. Apart from this, occurrences of polycentric sprawl can also be visible. In comparison to the value, gradual increase in value of relative Shannon's Entropy is observed, depicting gradual dispersion in urban growth.

VI. OBSERVATION

A. The land use maps generated from the interpretation of satellite imagery reveals that sprawl is towards north, east and centre of the city. The prime cause behind such expansion has been due to Nashik city located towards the north direction, which facilitates availability of better infrastructural and institutional amenities. Other reasons are availability of land at considerably cheaper rate in these areas, compared to adjacent city which are Deolali & Nashik.

B. In 1991, the total urban area was 16.56 Ha and in the year 2021 the urban area covered 21.7 Ha witnessing an increase of 31%. The increase in urban development area occurred mainly on vegetation and agriculture land.

C. The low values of Shannon's entropy indicate that the city is witnessing cluster form of sprawling. On the while the relative value of Shannon's entropy is increasing, indicating periodically gradual dispersion in concentration of urban areas.

D. The changes in urban extent in land use maps demonstrates that city is now expanding towards the south and south- west direction.

E. By comparison of demographic data it is observed that there is no growth in the population of Bhagur city. The primary reason is migration of people happening to Nashik city or other in search of educational facilities & employment.

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VII. CONCLUSION

The study has attempted to define GIS and its features and identify how GIS plays a key role in delivering the information needed to understand the urban sprawl. The study also provided a methodology which can be used for better estimation of urban growth and population using various land uses with time. The model developed in this study can be used for predicting the future land uses even when not much of old land use data is available. This can be very useful for the urban planning authorities in developing countries. Hence, GIS and Remote sensing can help a lot in monitoring urban sprawl compared to conventional techniques.

The land use/ land cover maps obtained after classification using GIS application demonstrates the growth during 1990-2021 is more in north, east and centre of the city showing tremendous rise in the built-up from agricultural area, vegetation and open spaces. Although, the city initially evolved in cluster form of development, now it is expanding towards south and south- west direction as the infrastructure facilities are improving and expanding.

This study shows that entropy is a good indicator in identifying and monitoring land development that is, dispersion and concentration of built-up areas. Compactness of development in the Bhagur city (indicated by low entropy) is a sign of vertically builtup development in the light of continuing increase in urbanization.

VIII. ACKNOWLEDGEMENT

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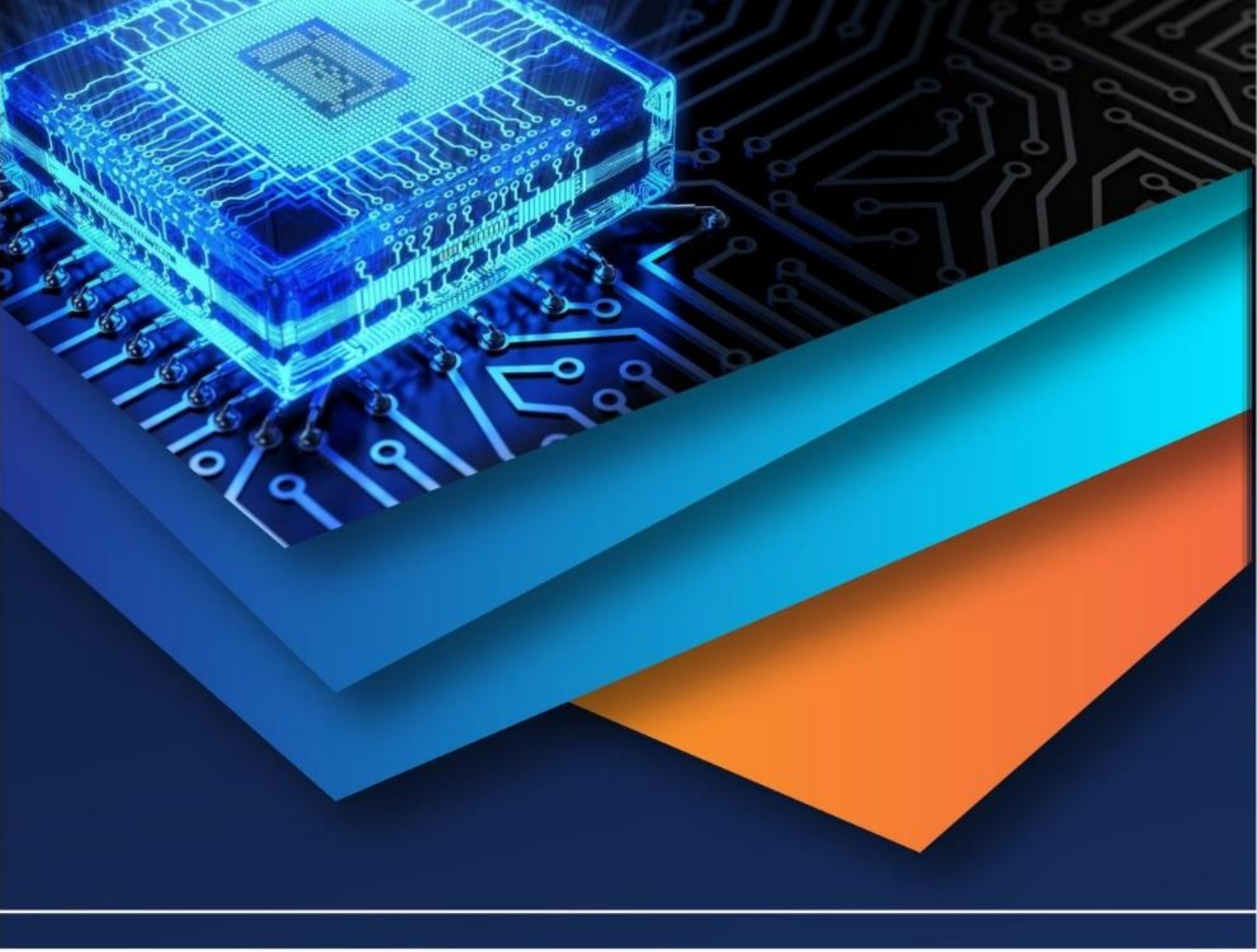

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