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Understanding Urbanization Patterns and Demographic Shifts in Vaniyambadi Town: A Spatial Approach

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Abstract: ***During the last several decades, the urbanization trends in worldwide push the people into the urban areas due to large number of opportunities i.e., educational, employment, better quality of life, and land use in these areas experienced significant changes and restructuring. This paper delves into the nuanced interplay between demographic shifts and the spatial structure of urban settings, employing Vaniyambadi Town as a case study. Through a combination of demographic analyses, spatial modelling, and field surveys, we systematically explore the transformations in population dynamics and its impact in the spatial structure of the town. Based on a site survey, this paper analyses the spatial characteristics of land use change in Vaniyambadi town. The results reveal a reduction in agricultural land from 44% in 1984 to 24.62% in 2023 and further to 14.76% in 2043. This reduction is primarily attributed to population growth, the establishment of settlements, mixed residential usage, and has led to a significant loss of cultivated land, indicating increasing land scarcity in the future.***
Keywords: Demographic shifts, land use change, Urbanization trends, spatial analysis, Demography in urban planning

I. INTRODUCTION

Demographics profoundly shape the dynamics of land use changes in cities. The preferences of different demographic groups, influenced by factors like age, income, and lifestyle, impact residential choices and drive alterations in residential land use. Population growth or decline directly correlates with shifts in demand for housing, infrastructure, and amenities, influencing the overall urban landscape. Economic characteristics, including income levels, dictate the demand for commercial and industrial spaces, thus molding the city's commercial land use. Cultural and lifestyle preferences of specific demographic segments contribute to the development of distinct districts, such as entertainment or cultural hubs. An aging population, on the other hand, may prompt the need for healthcare facilities and senior housing, reshaping land use patterns. Demographic factors also influence transportation needs, affecting infrastructure development around transit hubs. Educational demands, driven by changes in the age distribution of the population, impact the necessity for schools and universities, influencing land use accordingly. In essence, understanding demographic trends is crucial for urban planners as they strive to align land use patterns with the evolving characteristics and preferences of the city's population, ensuring a responsive and sustainable urban environment. In the case of Vaniyambadi town, diverse methods such as arithmetic increase, geometric methods, incremental increase, and growth rate methods are employed for population projections. State Government’s masterplan document of 1984 & 2005 for Vaniyambadi town and author’s field survey for existing land use map of 2023 were taken for the analysis and the proposed land use map prepared for the year of 2043 to foster the sustainable development. Demographic analysis extends beyond mere size and density to encompass crucial factors such as age structure, sex ratio, literacy rate, and workforce participation rate. The sex ratio, indicating the number of females per 1,000 males, emerges as a pivotal metric for predicting population dynamics. Disparities in sex ratios can influence social and economic aspects, potentially influencing population growth or decline. Literacy means a person aged seven and above, who can both read and write with understanding in any language, is treated as literate (Census of India).

II. STUDY AREA

Tirupathur district, formed in 2019 by trifurcating Vellore district in Tamil Nadu, India, encompasses the town of Tirupathur as its headquarters. The district's topography in Vaniyambadi reveals an average altitude of 354 meters (1161 ft), as shown in Fig.1 with the main wind current flowing in a north-easterly direction and lies in the Eastern Ghats region and on the banks of the Palar River.

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The temperature trend, as depicted in the maximum temperature diagram, suggests potential warming in Vaniyambadi due to climate change as shown in Fig.2. Settlement evolution in the region traces back to 1000 AD when settlements emerged along a river, expanding southward for agriculture and trade. By 1100 AD, a temple became the central point, while the British era in 1850 AD marked profound changes with the Industrial Revolution. Factories and railway development fueled growth, with the settlement expanding southward along railway lines, capitalizing on economic opportunities as shown in Fig.3. This historical evolution reflects the intersection of geography, climate, and economic shifts shaping the dynamic development of Tirupathur district.

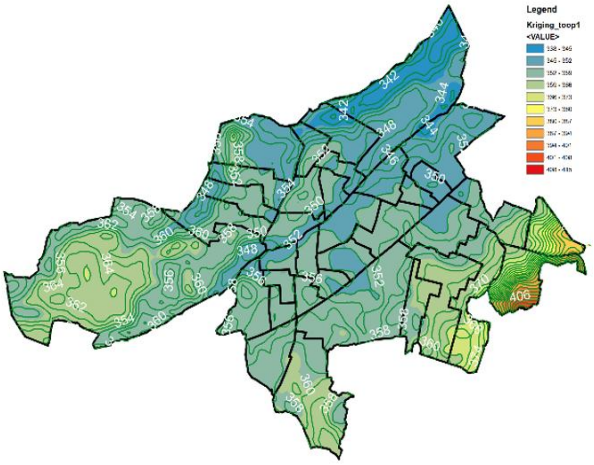

Fig. 1 Topography map of Vaniyambadi
(Sorce: ArcGis)

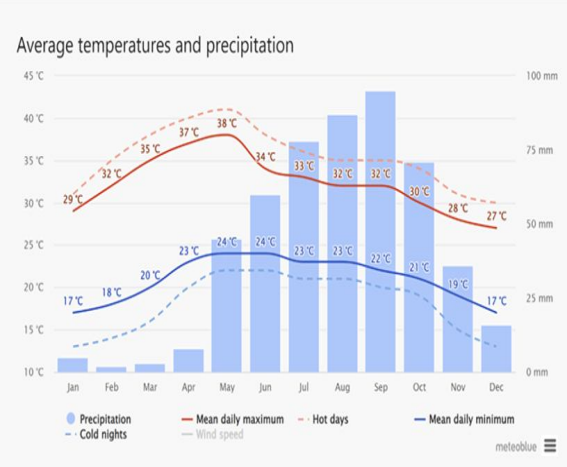

Fig. 2 Average temperature & percipitation
(Sorce: Meteablue)

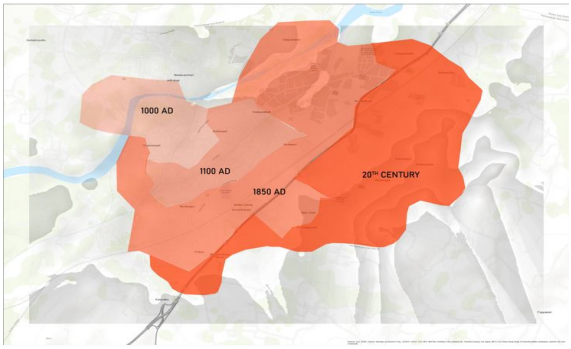

Fig. 3 Evolution of the town

III. DISCUSSION

A. Population Distribution

As per the Indian Census conducted in 2011, the population of Vaniyambadi town was 95,061. To gain insights into the population trends of Vaniyambadi town, historical data from 1911 to 2011 was examined. The average growth rate over this time frame was calculated to be approximately 17.04%. This substantial growth rate implies a rapidly changing demographic profile in Vaniyambadi town. From 1911 to 2011, the population of Vaniyambadi saw a considerable increase of 4.65 times. The current population density within Vaniyambadi town is 9975 persons per square kilometre, and the average population density equates to 178 persons per hectare. A significant observation is that the town underwent its most rapid growth during the 1931-1941 decade, with the latest decade's growth rate being 10.85% as shown in Fig.4.

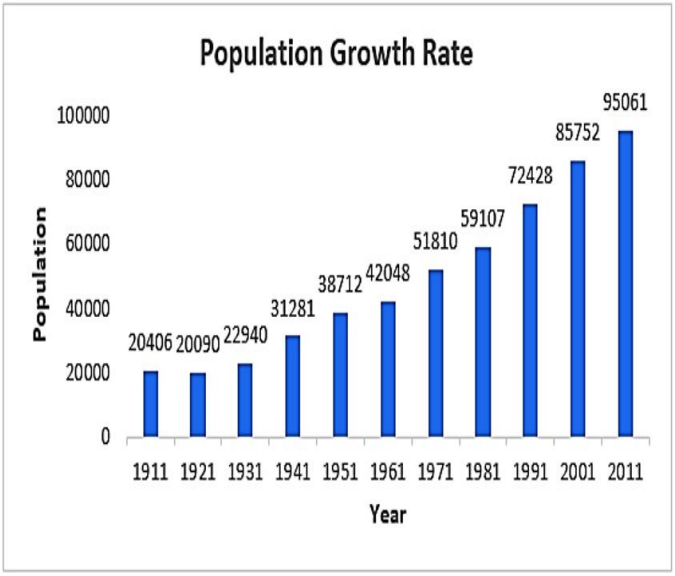

Fig. 4 Population growth from 1911 to 2011
(Sorce: Census of India)

B. Population Distribution of the Town (Ward wise)

Data for Vaniyambadi town's population is derived from the Census of India 2011. Upon analysis, it is found that ward no. 35 has the highest population of 5311 among all the wards, whereas ward no. 27 has the lowest population. However, in terms of population density, ward no. 24 is the most densely populated, accommodating 542 individuals per hectare, while ward no. 1 has the lowest population density of 11 persons per hectare due to its expansive area as shown in Table 1. The average population density for Vaniyambadi is approximately 178 persons per hectare, which is higher than the state's average.

Table.1 Ward wise population distribution

Ward No.	Population	Area in Hectares	Density
1	2496	220.43	11
2	1668	24.36	69
3	2422	15.59	155
4	1995	17.19	116
5	2357	39.97	59
6	1530	11.08	138
7	1427	14.21	100
8	2567	13.49	190
9	1852	9.21	201
10	1613	8.52	189
11	1632	23.67	69
12	1620	88.29	18

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13	2424	40	60
14	4061	8.31	488
15	4832	6.73	718
16	2779	16.02	173
17	2030	21.17	96
18	1831	20.47	89
19	1672	13.9	125
20	2058	7.08	291
21	2908	7.7	378
22	1400	9.2	152
23	2468	8.35	295
24	3807	7.02	542
25	2973	7.35	404
26	5236	25.25	207
27	525	22.96	23
28	3872	50.84	76
29	5834	67.4	86
30	3727	15.55	239
31	2741	40.57	67
32	1654	37.54	44
33	2280	25.93	88
34	3085	22.39	137
35	5311	29.91	177
36	2374	18.41	129

C. Literacy Rate

According to the 2011 Census, Vaniyambadi town has a literacy rate of 85.13%, which is higher than the state average of 80.09% (Handbook, 2011). This literacy rate serves as a valuable indicator of the town's socio-economic progress.Specifically, the literacy rate in Vaniyambadi town increased significantly from 67.95% in 2001 to 85.13% in 2011 (Handbook, 2011). The male population has a literacy rate of 89.31%, contributing to 52% of the total literacy rate, while the female population has a literacy rate of 81.07%, accounting for 48% of the total literacy rate. The literacy gap between males and females is 8.24%, which is lower than the national literacy gap of 16.68% and the state's literacy gap of 13.33%, as shown in Fig.5.

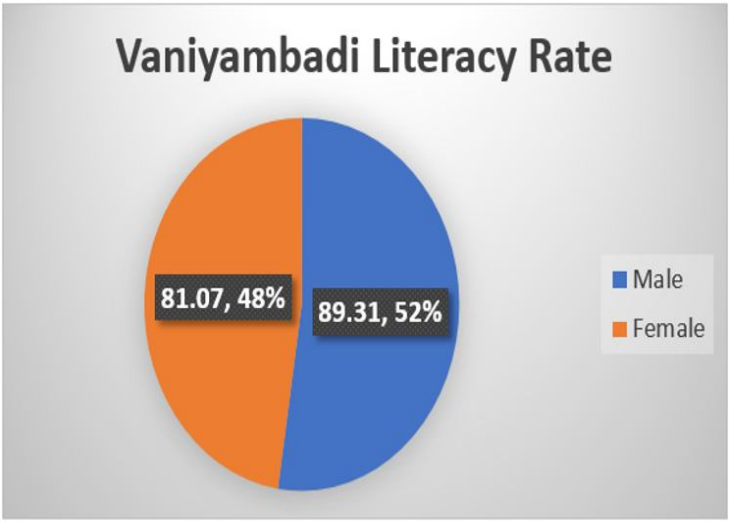

Fig. 5 Literacy rate of Vaniyambadi town
(Sorce: Census of India)

D. Sex Ratio

The sex ratio is defined as the number of females for every 1000 males, according to the Census of India 2001 for Vellore. In the 2011 Census, the sex ratio of Vaniyambadi was recorded at 1023 females per 1000 males, which is higher than the district average of 1007, the state average of 996, and the national average of 943. It's worth noting that the city's sex ratio demonstrated improvement, rising from 1004 females per 1000 males in 2001 to the current rate of 1023 females per 1000 males in 2011, as shown in Fig. 6.

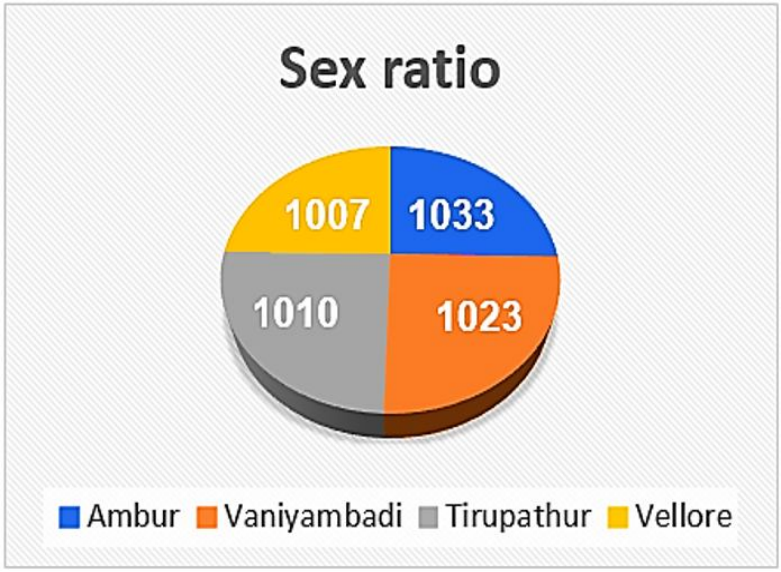

Fig. 6 Sex ratio comparison of the town
(Sorce: Census of India)

E. Economic Profile

The workforce population in Vaniyambadi municipality is relatively lower compared to neighboring municipalities within the Vellore district. One significant factor contributing to the growing non-working population percentage in Vaniyambadi is religion.Moreover, the lower workforce participation rate of women and the higher non-working population rate of women emphasize the need for policies focused on promoting gender equality, enhancing access to education, and improving healthcare services. It's worth noting that the national average for women's workforce participation stands at 25.51%, while the state average is slightly higher at 31.8% (Census of India 2011). This highlights the need for targeted interventions to support women's participation in the workforce and promote their socio-economic empowerment as shown in Table.2.

Table 2 Comparison of workforce population

Name of town	P/M/F	Total Population	Main workers %	Marginal workers %	Total workers (main+marginal) %	Non wrkers %
Vaniyambadi (M)	P	95061	29.08	3.55	32.62	67.38
	M	46992	49.80	5.25	55.04	44.96
	F	48069	8.82	1.88	10.71	89.29
Ambur (M)	P	114608	32.35	3.12	35.47	64.53
	M	56382	51.55	3.85	55.37	44.63
	F	58226	13.76	2.45	16.20	83.80
Tirupathur (M)	P	64125	31.70	4.00	35.70	64.30
	M	31903	49.42	4.93	54.35	45.65
	F	32222	14.15	3.08	17.24	82.76

F. Population Projection

To estimate the future population growth of Vaniyambadi municipality, various methods were utilized, including arithmetic increase, geometric approaches, incremental increases, and growth rate techniques. The average population projection derived from these four methods was considered for the analysis, which was used as the projected population growth for the current year 2021 and the future years of 2031 and 2041. The estimated population increase was calculated based on the growth trend from 1911 to 2011, taking an average decadal growth rate of 10.85%, which translates to an annual growth rate of 1.85%. Specifically, the projected population for the Vaniyambadi municipality is estimated to be 1,09,516 in 2021, 1,23,434 in 2031, and 1,37,647 in 2041. These projections provide valuable insights into the town's potential growth trajectory over the coming decades, as shown in Fig 7.

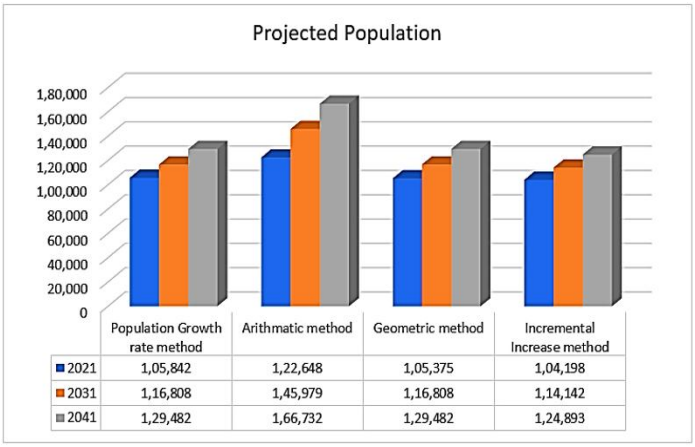

Fig. 7 Population projection
(Sorce: Author)

G. Spatial change analysis

During the primary data collection, the master plan document for Vaniyambadi town was reviewed and found that agricultural land accounted for the majority of the total land availability, making up 44%. Residential development followed closely behind, comprising 22.48% of the total land for a population of 20,406 (Census of India 1981, Vellore). However, the state government's proposed master plan document for Vaniyambadi showed a shift towards residential development as the most significant land contributor, accounting for 32.75% of the total land availability for a population of 85,752. The percentage of industrial land increased significantly from 4.90% to 27.07%, while agricultural land decreased from 44% to 13%. Using ArcGIS software and Google Earth Pro for satellite imagery, the 2005 land use percentage was verified with the government's masterplan document for Vaniyambadi town. Minor corrections in the land use distribution from the proposed masterplan document 2005 were made, and the corrected data were used to create a map. Land use maps for the present year of 2023 and the proposed 2043 land use map were also created for analysis as shown in Table.3. The results indicate that residential usage, commercial and mixed residential usage have increased, while agricultural land has decreased due to population growth and its impact on the city's spatial structure, shown in Figures 8,9,10.

Table 3 Land use percentage comparison of 1984,2005(proposed),2005(Assumed),2023&2043

S. No	Land Use	Year				
		1984	2005(proposed)	2005(Assumed)	2023	2043(proposed)
1	Residential	22.48%	32.75%	32.34%	33.55%	31.42%
2	Mixed Residential	0	0	0.31%	8.80%	18.58%
3	Commercial	2.32%	4.06%	2.46%	3.25%	5.53%
4	Industrial	4.90%	27.07%	14.16%	3.18%	3.29%
5	Institutional	5.89%	2.85%	3.58%	7.36%	7.31%
6	Vacant Land	0	0	3.20%	2.40%	0.00
7	Agriculture	44%	13%	27.68%	24.62%	14.76%
8	River	19.26%	19.32%	19.77%	19.14%	19.14%

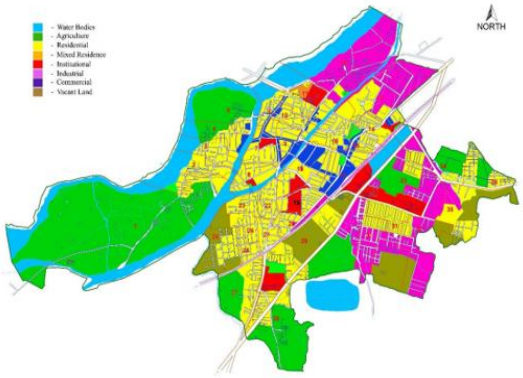

Fig. 8 Land use map 2005

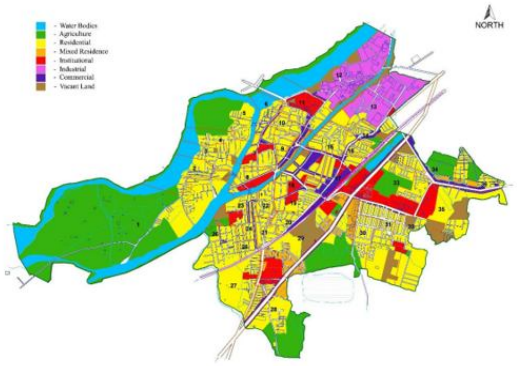

Fig. 9 Land use map 2023

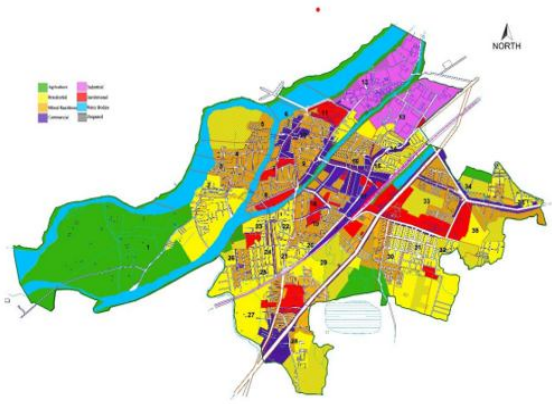

Fig. 10 Land use map 2043

IV. RESULTS & DISCUSSION

The above (Table.3) provides the statistical analysis of land use changes in Vaniyambadi municipality. It shows the decrease in agricultural area while built - up area increases rapidly between 1984 and 2023. The built – up area increases from 22.48% in 1984, 32.34% in 2005 and 33.55% in 2023 in the total land area in Vaniyambadi town. Agricultural area reduced enormously from 44% in 1984 to 17.68% in 2005 and 24.625 in 2023. Industrial area increases from 4.90% in 1984 to 14.16% in 2005.

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Mixed residential & commercial area also increases gradually. River flowing area remains same in the past decades. This is due to the rapid population with unplanned growth. It is observed that the huge agricultural lands are converted into built - up land & industrial land. In Vaniyambadi, more numbers of leather and tanning industries are setup after 1985 hence, the development of industrial happens largely. Based on the employment opportunities more settlements were created within the Vaniyambadi municipal boundary. Then, the restrictions on industries due to pollution level, the tanning industries were reduced notably after 2005. As a result, Demographic changes impacts spatial structure of this town. It shows that the literacy rate increases in Vaniyambadi , the agricultural depended labours are decreases (Ttable.2 shows the main workers percentage in lesser than the marginal workers). Commercial and mixed residential developments were increased due to the development of residential settlements based on the population growth.

V. CONCLUSIONS

The statistical analysis of land use changes in Vaniyambadi municipality reveals a significant shift over the decades, characterized by a substantial decrease in agricultural land and a rapid expansion of built-up and industrial areas. This transformation, driven by unplanned urban growth and the establishment of leather and tanning industries post-1985, has reshaped the town's spatial structure. Demographic changes, including rising literacy rates and a decline in agricultural-dependent labor, have accompanied this shift. Despite concerns over pollution leading to restrictions on industrial activities, commercial and mixed residential developments have increased to accommodate population growth. Overall, the findings emphasize the complex interplay between economic development, environmental sustainability, and demographic shifts in shaping the urban landscape of Vaniyambadi.

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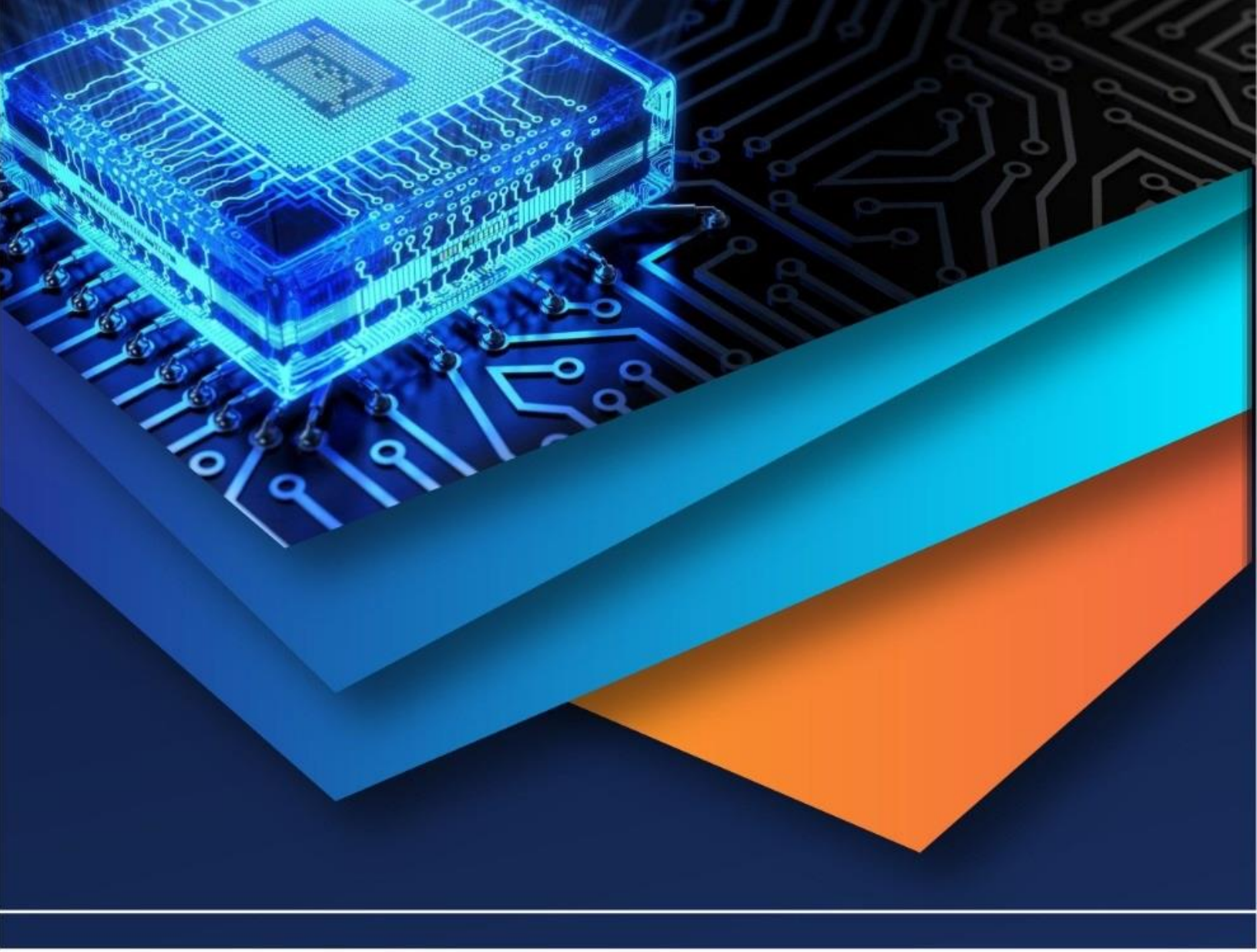

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