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Evolving Land Use Dynamics and Settlement Morphology: A Case Study of Uppalapadu Village, Andhra Pradesh

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Abstract: ***This research examines changes in land use and settlement patterns in Uppalapadu, a peri-urban village in the Guntur District of Andhra Pradesh, India, with a bird sanctuary and fertile agricultural lands. Despite having been earmarked for development, issues such as ineffective development control, the lack of requisite infrastructure, and ecological fragility exist because of the perpetual proximity to the urban centers of Amaravati and Guntur. The research drew on satellite images (2007-2022), land use surveys, interviews with stakeholders from various sectors, and spatial analysis. The major findings regarding land cover change point to a relatively small increase in built-up areas (which is consistent with the gradual shift from rural to urban), a strong tendency to maintain, without major change, agricultural lands, and with little change in the quantity and condition of water bodies. The findings suggest that real estate development has stalled, growth in dependence on agriculture is still supported by small and marginal farmers, ecological resources continue to wear under the demands of pollution and ineffective waste disposal, and the marginal improvement of ecology is a function of continued environmental degradation. The findings further suggest that planned infrastructure development, ecological zoning, and facilitating eco-tourism can provide a form of balance between economic growth, sector development, and conservation in the transitional rural landscape.***
Keywords: Land use dynamics, Settlement morphology, Peri-Urban Village, Ecological conservation, Agriculture transition.

I. INTRODUCTION

Uppalapadu village, with a total area of 1659.8 Ha, located in Pedakakani Mandal in Guntur District, Andhra Pradesh (Figure 1), is significant because it exists on the cusp of rural and peri-urban dynamics. It is located 5.5 kilometers from Guntur and 3.8 kilometers away from the state highway that connects Vijayawada and Chennai. This makes it ideally situated at the intersection of urban development and the protection of the environment (Uppalapadu Panchayat, 2021).

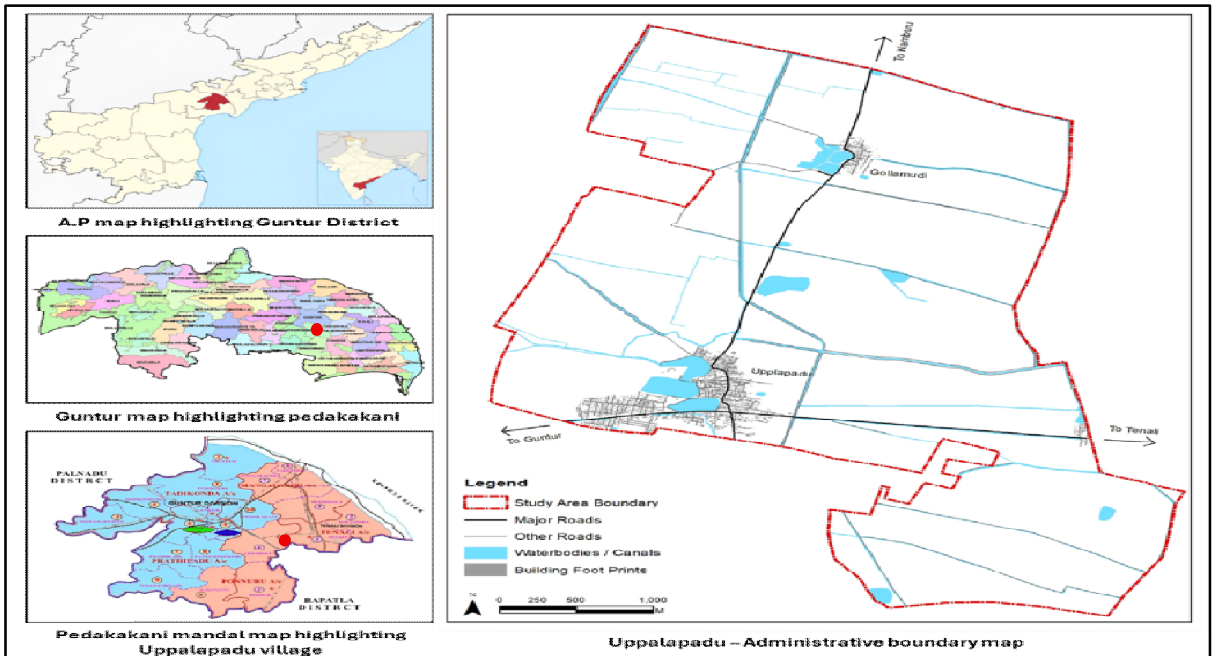


Figure 1:Geographic Context and Study Area Boundary of Uppalapadu Village (Source: Author)

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Uppalapadu is known for its notable bird sanctuary. The fact that there are more than 40 species of migratory birds, including the painted stork, spot-billed pelican, and white ibis, ensures that the ecological value of the area is much more than just a few birds and their habitat. The bird sanctuary's presence increases the area's biodiversity and opens up opportunities for eco-tourism. In terms of the area, the dominant land use pattern is thus agrarian, since the vast majority of the local population depends on agriculture. The land use pattern seen in Uppalapadu indicates that there are still more agrarian elements to the economy, with approximately 85% of the area used for agricultural purposes, with most crops being cultivated as paddy, particularly in the Kharif season (Uppalapadu panchayat, 2021).

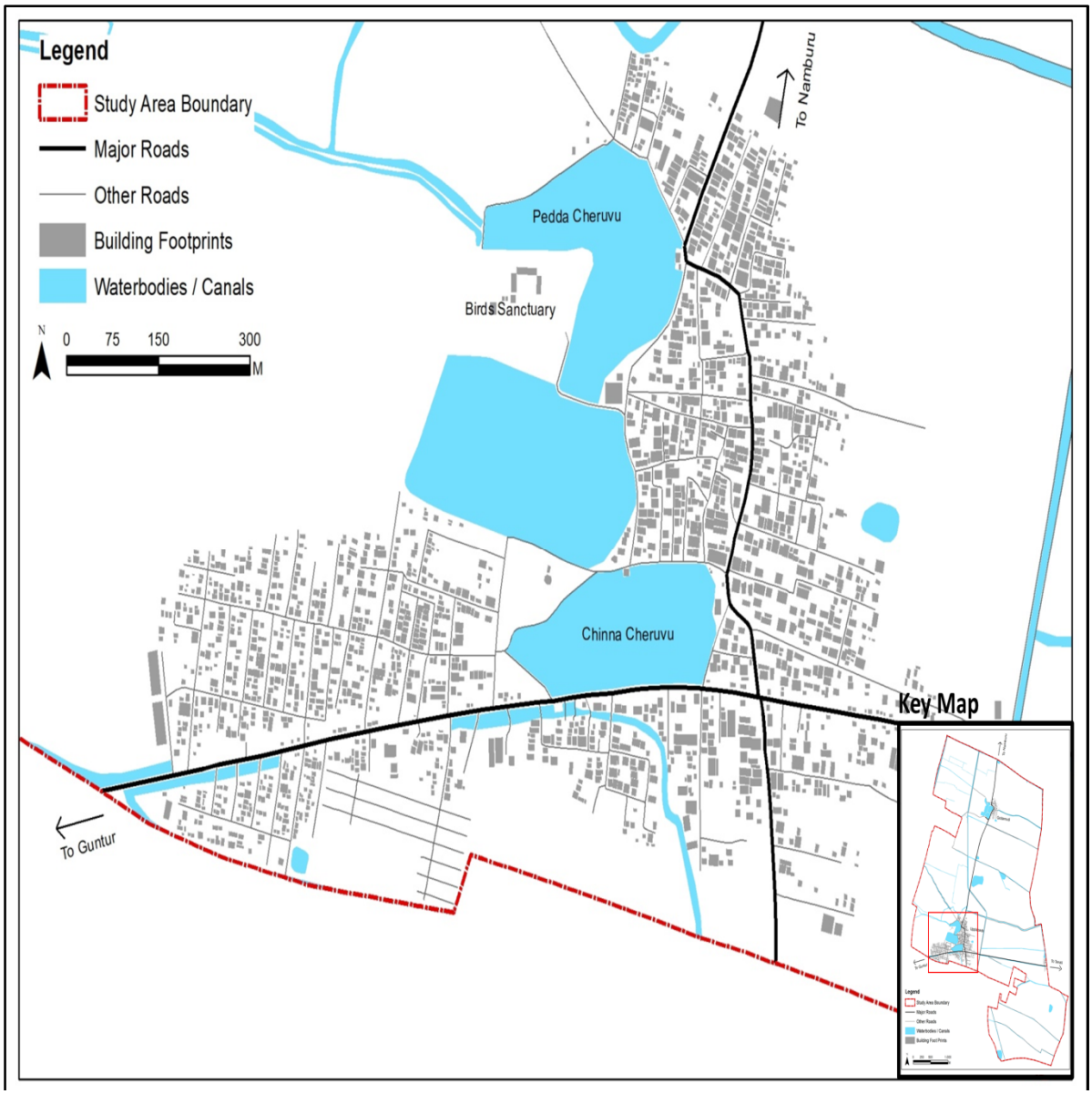


Figure 2: Uppalapadu Settlement Base Map - Year 2022 (Source: Author)

The trend of land use change in Uppalapadu has been slow. The built-up area has grown marginally from 70.08 ha in 2007 to 72.43 ha in 2022 (Figure 2). While the limited growth has helped neighborhood spatial development remain somewhat orderly, urban development from Guntur and Vijayawada has placed pressure on the village to develop. The village is caught between urban growth and maintaining a rural identity. Government land is comprised of (1.4%) 23 ha of Endowments land and (2.1%) 35 ha of Assigned land (Figure 3). This government land is fragmented and primarily found under canals, waterbodies, or roads which limits the land use development potential of the village.

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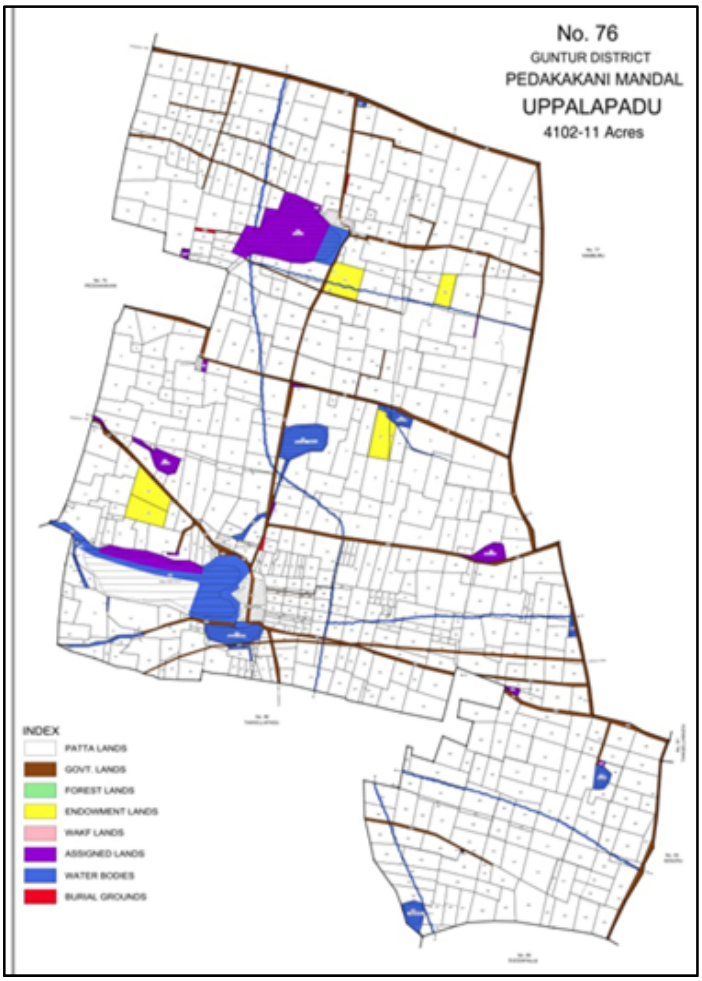


Figure 3: Government Land Detail of Uppalapadu Village - Year 2022 (Source: Mandal Revenue Office)

Uppalapadu, located at the rural-urban fringe, is constantly faced with obstacles for the lack of infrastructure, poor waste management, degradation of water bodies, and no development controls related to its bird sanctuary. Agriculture is restricted due to marginal conditions, limited markets/storage (Uppalapadu Panchayat, 2021). There remains little development despite urbanisation pressures. This study will respond to key gaps of land use planning and peri-urban issues with relevance to ecological context, sustainable infrastructure and the future viability of the sanctuary while affirming how bird habitats support local livelihoods which warrants further research.

II. LITERATURE REVIEW

The transformation of land use in rural India is a result of agricultural intensification, urban expansion, development of physical infrastructure, and policy changes. Areas that were once predominantly agricultural are now hybrid rural-urban forms characterized by mixed agricultural, residential, and commercial land use (Misra, 2019). While the 73rd Amendment and subsequent policies empowering the Panchayati Raj have decentralized planning; gradually the processes of decentralized development and planning have not kept pace with rapid land use conversion and rural urbanization (Reddy & Reddy, 2015). Urban expansion and migration is continuing the real estate speculation on land, resulting in unpredictable land use change (Narain, 2009). Rapidly increasing values of land surrounding Guntur and both city center and periphery land surrounding Vijayawada have resulted in widespread disregard of earlier patterns of occupancy, and disconnected fragmented ownership parcels, exacerbated by political voids in governance by elected officials (Patel & Deb, 2017). Remote sensing and GIS are valuable tools for monitoring and predicting landscape transformation due to land-use land-cover (LULC) dynamics (Jat et al., 2008; Mondal et al., 2021).

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III. DATABASE AND METHODOLOGY

The Methodology flowchart in Figure 4 illustrates a land use planning process that makes use of secondary and primary data. The process is a synthesis of land use surveys, stakeholder input, and spatial data to produce maps of existing land use. The analysis of existing land use maps identifies key issues that can be used to formulate a vision and land use recommendations in support of sustainable and strategic development planning.

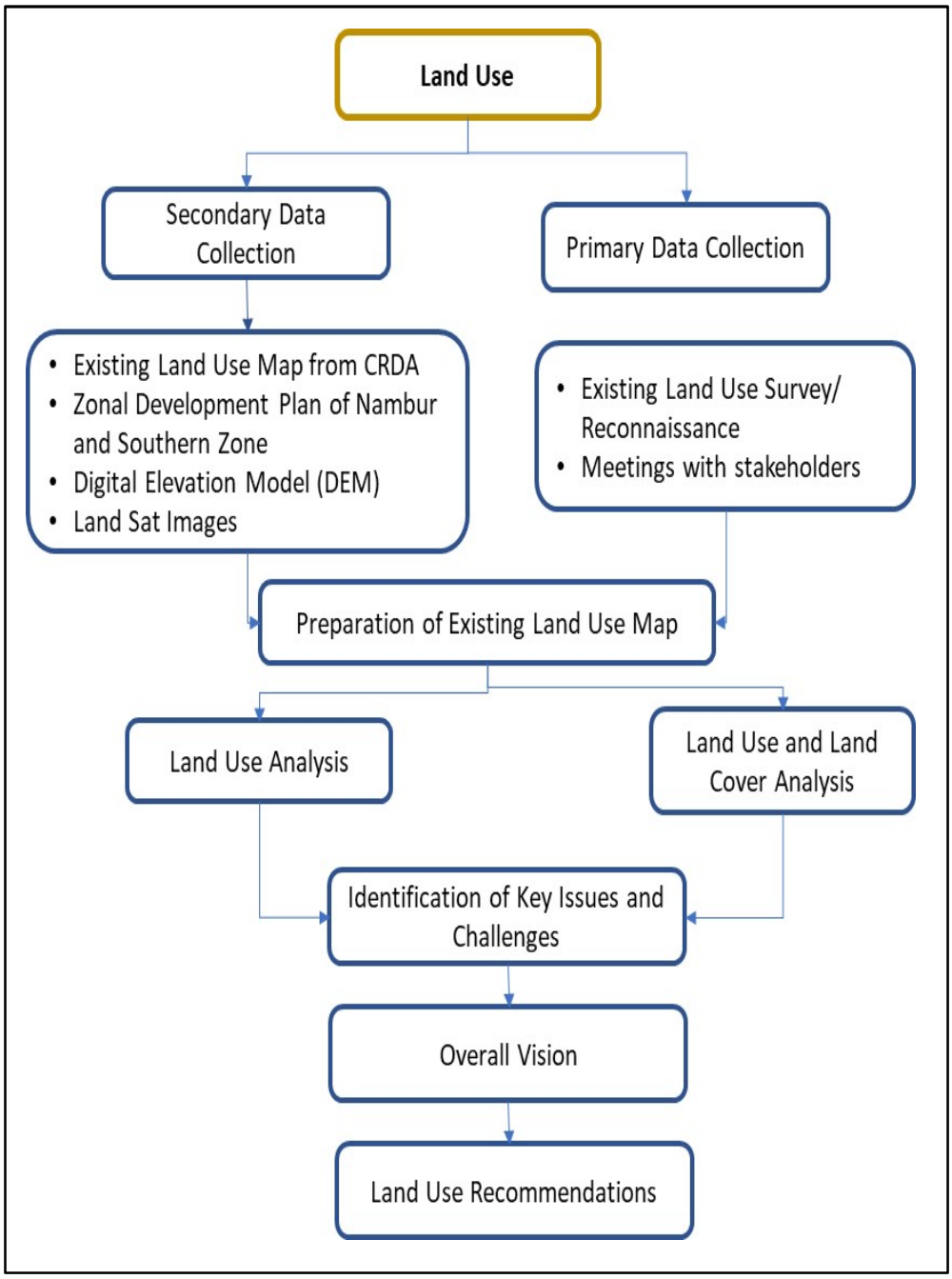


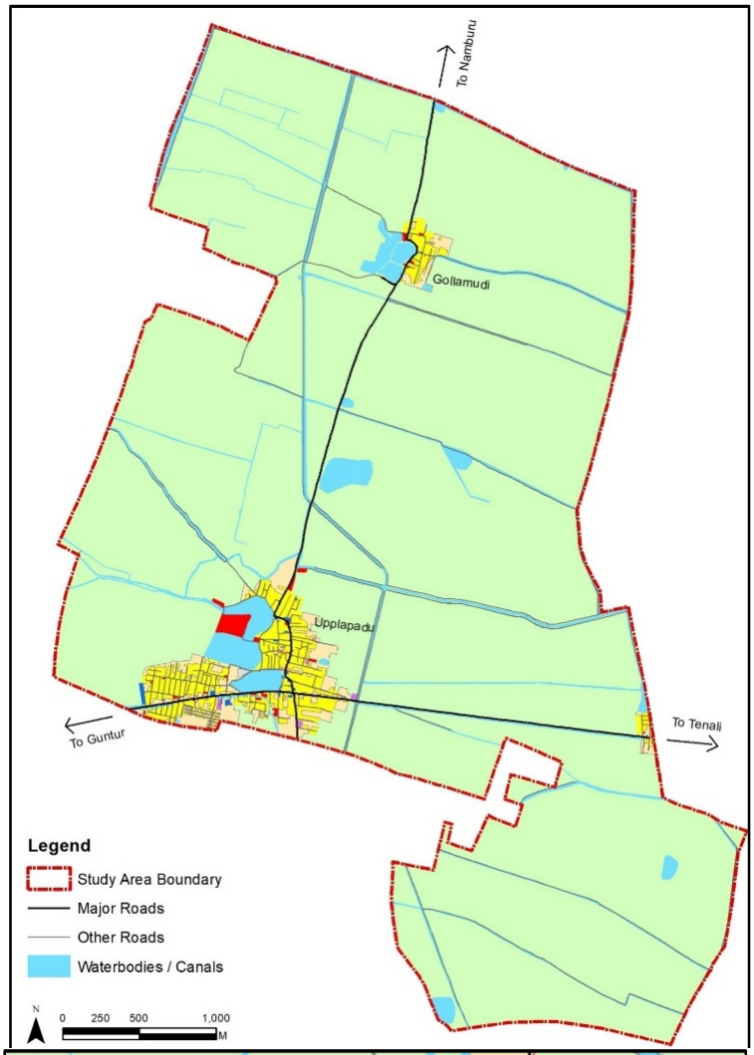
Figure 4: Methodology flowchart (Source: Author's illustration)

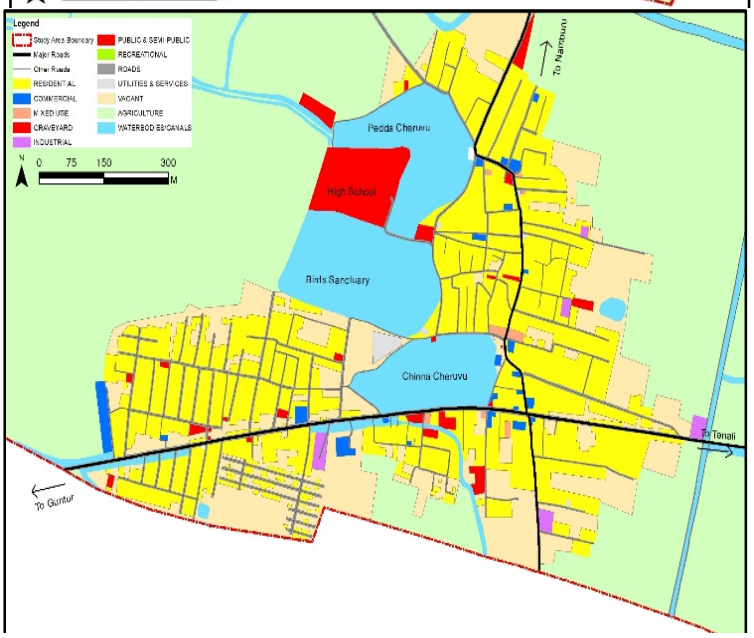
A. Existing Land Use (Year 2022)

Table 1 depictsUppalapadu's land use remained agriculture-dominant (1,482.26 ha; 85%), slightly down from 1,497.1 ha in 2007. Built-up area increased modestly from 70.08 ha to 72.43 ha (11%), reflecting low-density growth over 15 years.

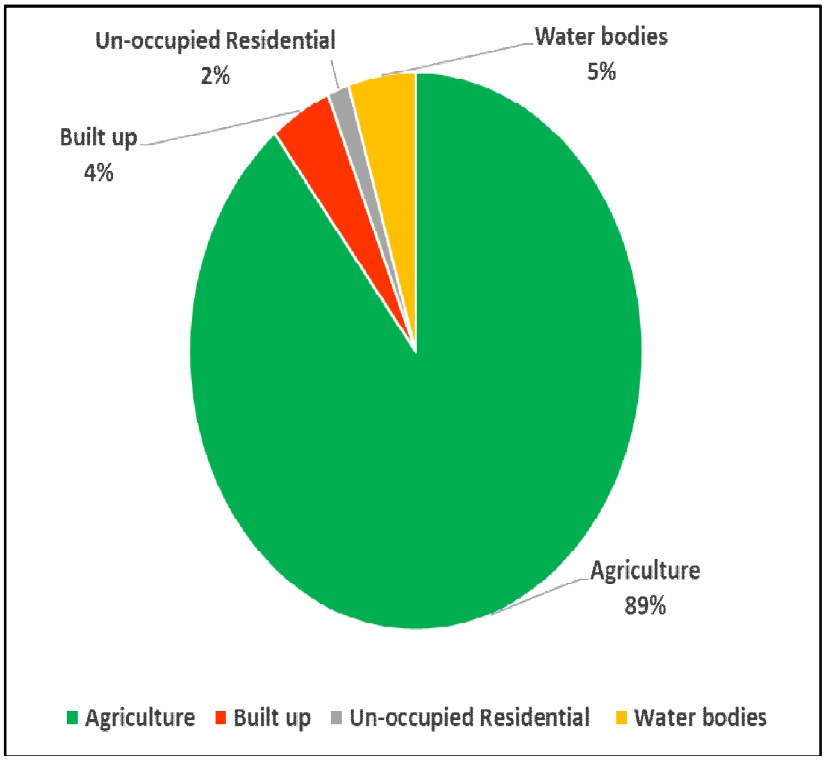
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Table 1: Existing Land Use map highlighting Uppalapadu settlement and land use distribution statistics - Year 2022 (Source: Author)





Land Use	Area in Ha 2007	Area in Ha 2022	%
Agriculture	1497.1	1482.26	85%
Built-Up Area	70.08	72.43	11%
Vacant Land	12.41	25.53	0%
Water bodies	79.4	79.64	4%
Total	1659	1659.8	100%

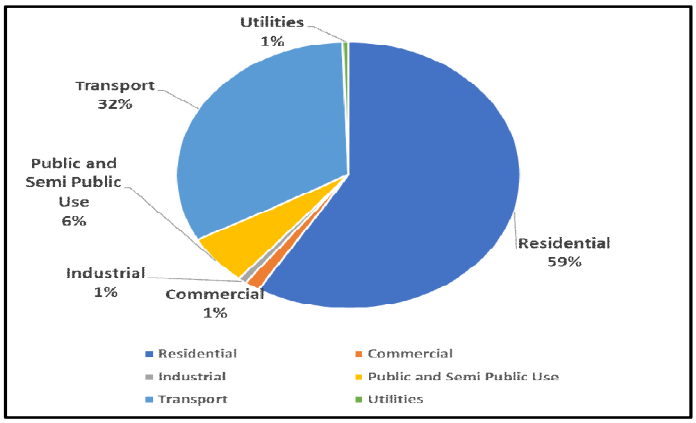


B. Land Use - Built-Up Area

Table 2 ill of built-up land use indicates that residential land constituted the largest proportion at 59%, increasing from 38.03 hectares to 42.55 hectares. Commercial, industrial, and public/semi-public uses accounted for very small proportions at around 1% each, representing limited economic diversification and insufficient service infrastructure. Transport and utility land uses represent a considerable portion of the built-up area at 33%, and the transport infrastructure alone accounts for 32% of the built-up area.

Table 2: Built-up area distribution - Year 2022 (Source: Author)

Land Use	Area in Ha 2007	Area in Ha 2022	%
Residential	38.03	42.55	59%
Commercial	1	1.04	1%
Industrial	0.5	0.57	1%
Public and Semi-Public Use	4.4	4.37	6%
Transport and Utilities	26	23.52	32%
Total	70	72.43	



The "mass and void" analysis shows that only a small 4% (16.2 ha) of built-up land is there, with 96% still used for agriculture, transportation (roads), and waterbodies. Plot density of 65 plots/ha is consistent with RADPFI density 60 plots/ha, which suggests limited densification from the RADPFI, despite the residential unplanned growth in agricultural and ecological land use, this shows that there is weak planning on behalf residential growth development. uppalaapadu does not has a commercial development and public infrastructure for the health and welfare of citizens with regards to planning suggest infrastructure zoning investor development to advance sustainable growth for the area while protecting agrarian ecological landscape.

C. Digital Elevation Model

The Digital Elevation Model (DEM) and the cross section profiles indicate that the village of Uppalapadu has a predominantly flat landscape with slope values varying between -0.8% and 1.2%. The low-lying slope is suitable for paddy cultivation which requires wet/saturated fields. Although the landscape appears flat, reviewing slope and gradient is necessary for the planning of stormwater, roads infrastructure, and flood mitigation, the DEM data can help with designing the correct gradients to help mitigate flooding, improve the integrity of floodprepared infrastructure, and prevent adverse effects on ecologically sensitive areas.

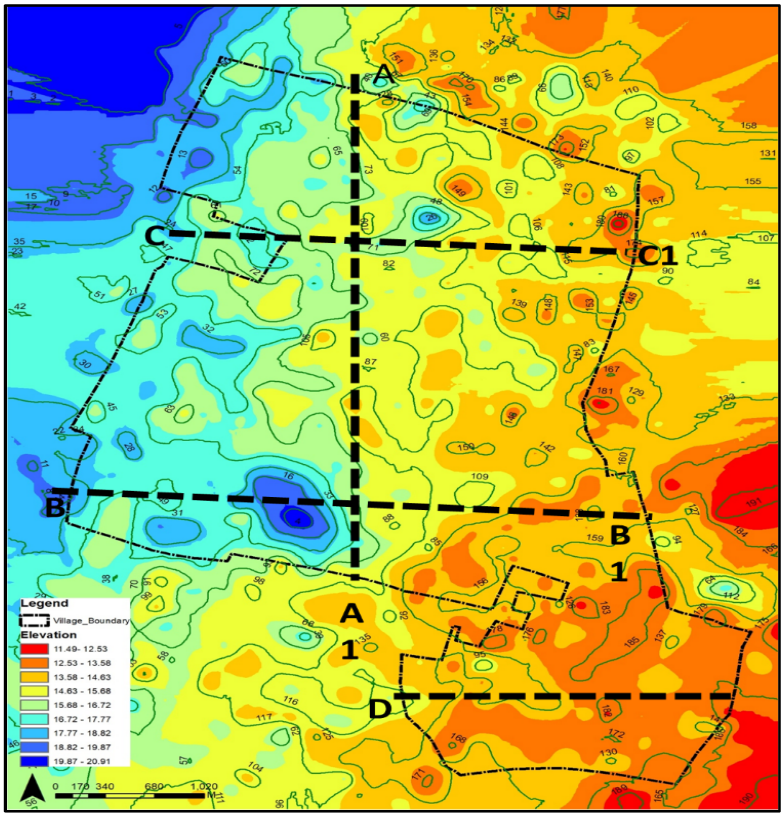


Figure 5: Digital Elevation Model Map - Year 2022 (Source: Author)

Cross-sectional analysis of four alignment sectionsA–A1, B–B1, C–C1, and D–D1from Figure 6 demonstrates the performatively even terrain. The section A–A1 covers an elevation change between 26 and 26.3 meters with an average slope of about 0.9%. This indicates an almost flat terrain.

The B–B1 sec-tion shows a much greater variation with slopes ranging from 1% to 1.2% and an elevation change from 24 to 26.3 meters. The C–C1 section exhibits differences in accounts to slope (the slope ran-ges from 1.2% to 1.2% with an elevation interval of 18.8 meters sloping down to 22.5 meters), suggesting that there is a very slight bowing of the western cross-section (some leveling). The D–D1 has a much flatter profile (8.8 to 9.29 meters), where the variation in slope was also much less than the previous sections (-0.8% to 0.8%).

Uppalapadu's relatively flat landscape, gentle slopes, and preferential drainage towards the west provide an environment conducive for urban growth with a plan. The benefits of the flat landscape and gentle slopes mean that relatively little disruption of the existing environment would take place.

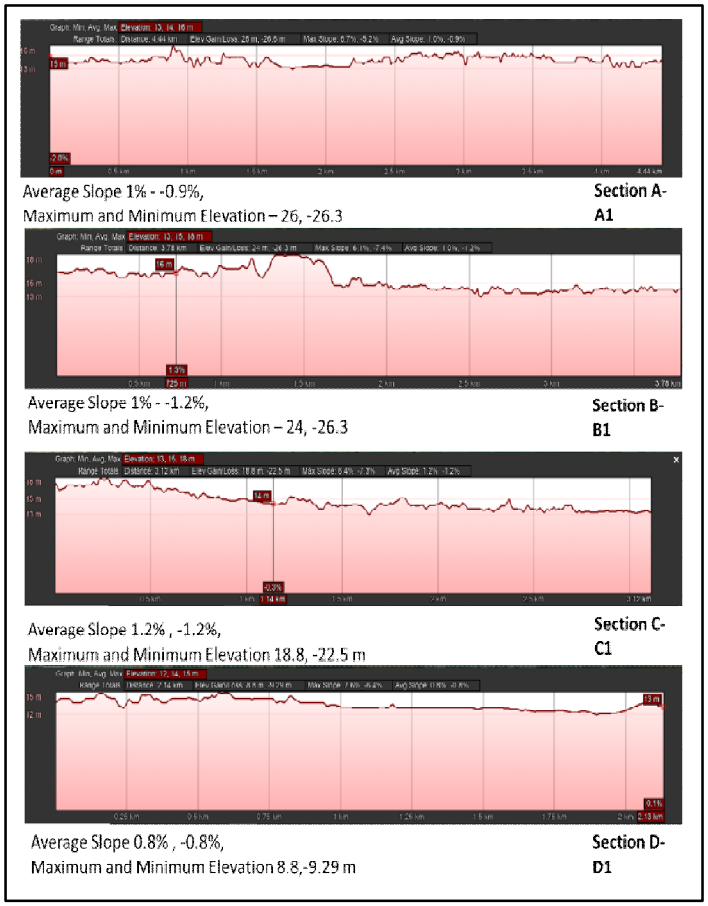


Figure 6: Cross Sectional Elevations (A1, B1, C1, D1) (Source: Author)

D. Temporal Land Use Transformation (2004–2021)

Satellite imagery from 2004, 2010, and 2021 (Table 3) illustrates nearly two decades of land use changes in Uppalapadu. In 2004, the settlement was compact, had dense built-up areas, and was surrounded by large agricultural fields as a rural settlement with relatively unimpacted ecological systems. In 2010, the landscape began to shift with early signs of peri-urban transition occurring near the Bird Sanctuary and Chinna Cheruvu lake which was a direct consequence of Guntur's proximity and new infrastructure connectivity. Although fragmentation and spatial reorganization was evident, the limit of growth remained small. By 2021, more obvious changes can be seen in the semi-urban landscape with new areas emerging to the east and south, improved transport links and speculation relating to the housing demand. Agriculture and the waterbodies remained mostly unchanged, although more limited encroachment on the agricultural and residential areas indicated better environmental awareness and awareness of their local habitats.

Table 3: Temporal Land Use Transformation - 2004, 2010, 2021



2004 — Satellite Image



2010 — Satellite Image



2021— Satellite Image

IV. RESULTS AND DISCUSSION

A. Land Use and Land Cover (LULC)

The Land Use and Land Cover (LULC) analysis of Uppalapadu presents significant changes between 2016 and 2022. In 2016, the area was primarily agricultural land, occupying 72% of LULC, and barren land occupied about 14%. Built-up areas occupied about 10% and water bodies occupied about 4%. In 2022, agricultural land increased to 80%, while barren land decreased significantly to 5%. This could be a result of either seasonal cropping or rehabilitation of the land. Built-up areas increased to 11%, but this is a marginal increase and shows limited development, and water bodes have remained stable at 4% which is indicative of maintained aquatic ecologies. The village retains its rural character, but urban encroachment continues to move into the area albeit gradually. Agricultural intensification appears to indicate better land use, while limited growth in built-up area suggests control on development, with a large portion of need being provided for via the continuous expansion of urban areas like Guntur.

Table 4: Land Use And Land Cover (LULC) Map (Source: Author)



B. Land Utilisation& Farming Patterns

The land utilisationdistribution from Table 5 reflects that the village remains heavily reliant on irrigated agriculture. Out of a total land of 1659.9 hectares, 1443 hectares (86.9%) remain under irrigation, while 216.9 hectares (13.1%) have been taken up for non-agricultural use. This denotes a slight increase in the area occupied by non-agricultural land, from 205 hectares in 2007. Of the total area under irrigation, paddy has been grown in almost 1442 hectares, accounting for nearly 100% of the Kharif cropping. The source of irrigation in the area is a combination of canals, with 72% sourced through the Krishna Western Delta Canal and the remainder of the area (28%) relying on the Guntur Channel Canal.

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Table 5: Land Utilisation distribution - Year 2022 (Source: Author)

Land Utilisation	2007	2022	%
Irrigated Area	1453	1443	86.9
Non Agriculture Use	205	216.9	13.1
Total	1658.	1659.9	100.0

The farmer classification from Table 6 indicates that the overwhelming majority of farmers are small and marginal. Of the 2135 farmers, 26% are marginal (less than 1 hectare) and 72% are small (1–2 hectares), amounting to almost 99% of the farming population. Smallholders account for 73% of the total agricultural land area, further demonstrating the extensive and highly fragmented land ownership pattern in the area. There are only 39 large farmers in the area, with a total land ownership of 152 hectares.

Table 6: Distribution of Farmers by Category and Land Holdings - Year 2022 (Source: Author)

Category	Marginal Farmers	Small Farmers	Large Farmers
No	557	1539	39
Aggregate Land Holdings	223	1042	152
Total	780	2581	191

The data highlights the importance of adequate targeting of agricultural support policies with smallholders, improved irrigation efficiency, and related infrastructure for smallholders to underpin agricultural productivity and livelihoods in the face of continued urban encroachment.

C. Stakeholders Perspective

Uppalapadu remains an agrarian locality where about 80% of the village's population is dependent on agriculture for sustenance. The village is situated on the periphery of Guntur, a sizeable urban center, but aside from the two designated residential layouts thus far, there has not been significant pressure from urban sprawl or speculative land conversion as seen in Table 7, The primary crop of the village is paddy and is grown during the Kharif season. During the Rabi season, the farmers will grow maize, green gram, black gram, and other pulses. Most farmers are small farmers and operate on fractured landholdings. About 20% of the population reportedly travels to Guntur to work, meaning there is partial economic reliance on urban employment. Notably, the village has no significant industrial aggregations, processing units, or storage units, framing its dependence on traditional agricultural and rural development requirements.

Table 7: Visual documentation of the existing situation (Year 2022).





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D. SWOC analysis

While the SWOT analysis indicates the strengths of Uppalapadu include a world-famous bird sanctuary, biodiversity, and well-irrigated agriculture, weaknesses such as widespread poor water quality, open drainage systems, no waste treatment, no post-harvest storage for farm produce, limited health and recreation facilities, and frail ecological governance exist. Eco-tourism, better planning eg infrastructure, growing sustainable agriculture supported by urban centres in Guntur and Vijayawada all present involvement opportunities. On the other hand, threats remain from human-wildlife conflicts, increased pressure on the bird sanctuary, and environmental degradation due to uncontrolled growth. There is an urgent need to respond to these challenges using sustainable development, general planning, and inclusive processes to ensure rural and ecological development.

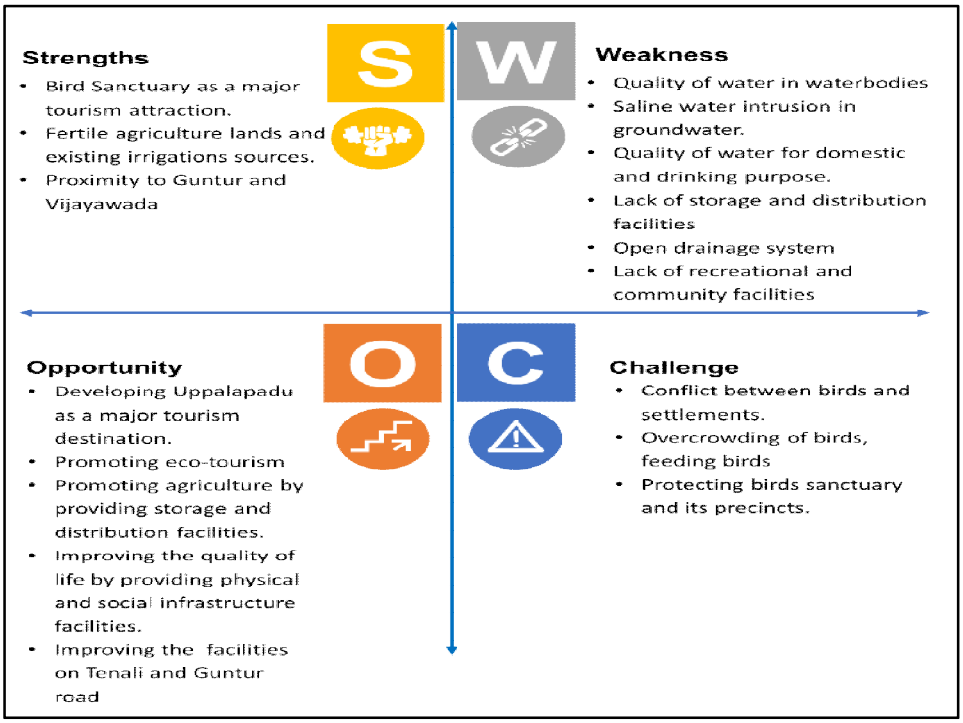


Figure 7: SWOC Analysis (Source: Author)

V. CONCLUSION

Examining the situation of Uppalapadu village brings to the fore urgent environmental, infrastructural, and socio-economic problems that constrain the village from advancing. The polluted lake water that is used for drinking and other household needs has dire health effects, especially compounded by open drainage and unscientific disposal of waste. The village is predominantly agrarian, and the lack of industries, markets, and financial systems to enable crop diversity has limited economic development and infrastructure activities. The healthcare services in the village are rudimentary and require immediate attention. Although there are some forms of activism that have sought to protect the Uppalapadu bird sanctuary, there are no official plans to improve or protect it as an eco-tourism site. This limits the eco-tourism possibilities for the village.

The village population decline has also halted the CRDA's development plans. In spite of these issues, the village has viable opportunities to become sustainable by improving environmental protection, health services, eco-tourism, and basic infrastructure. However, coordinated action by the government and community members is crucial for planning and implementing actions leading the village into an independent economy that will ensure the village maintains its cultural history and ecological values.

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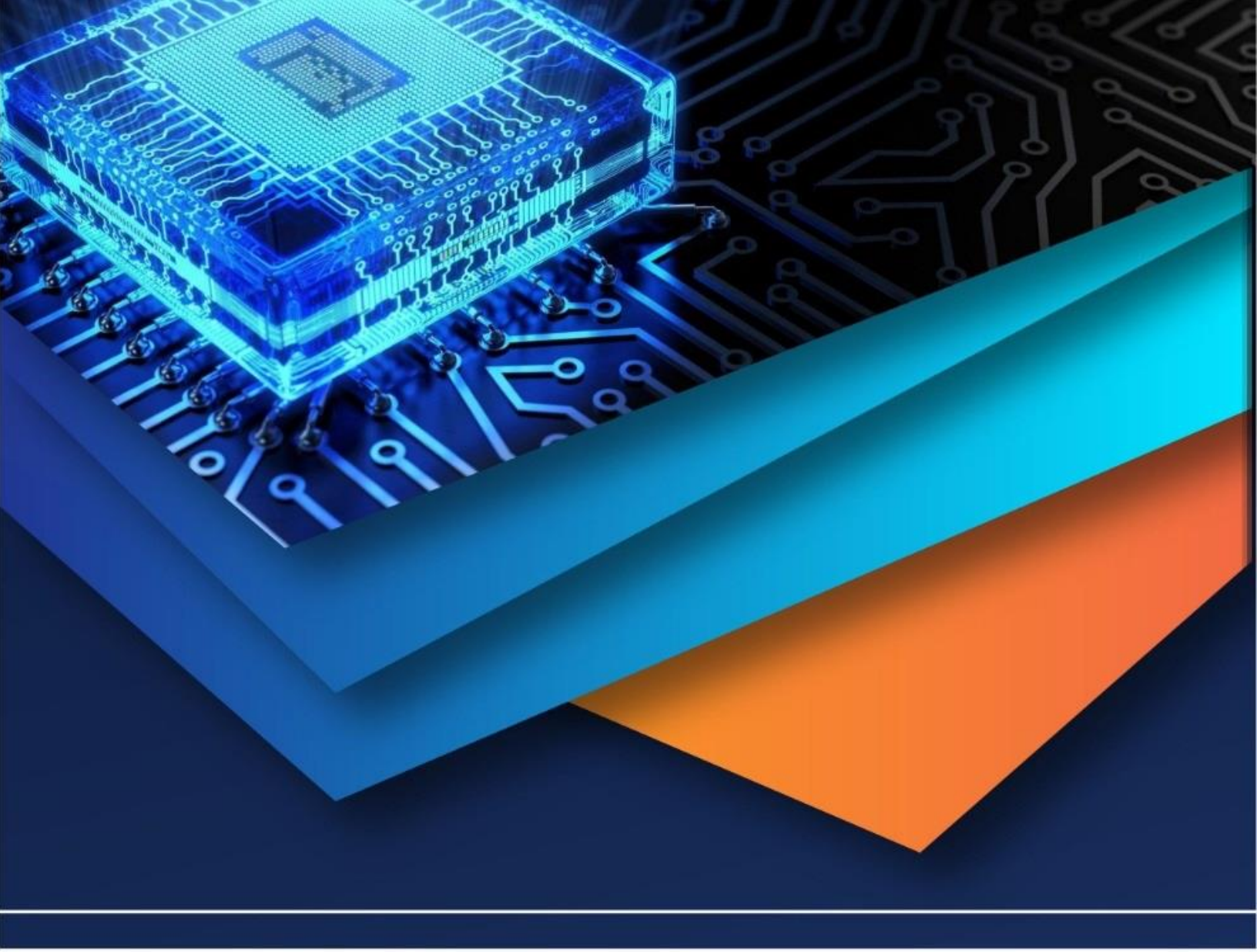
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