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Beyond Land Cover Change: Integrating Geospatial Analysis, Remote Sensing, and Household Perceptions to Examine Urbanization Drivers and Environmental Risks in Eti-Osa, Lagos, Nigeria (2005–2025)

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Abstract

Coastal urbanization presents challenges in understanding patterns of land-cover transformation and planning for the environmentally sustainable development of cities. This paper explores the changes in land-use and land-cover (LULC) of Eti-Osa, Lagos, Nigeria from 2005-2025 and identifies the major drivers of urbanization and the environmental risks to households. The analysis integrates geospatial and quantitative techniques with LULC classifications and change-detection analyses, as well as household data collected through questionnaires (n = 450). LULC data showed that the coastal-built environment of Eti-Osa transformed dramatically from 2005 to 2025. From 2005 to 2015, the coastal built environment increased by 47% (from 73.5% to 28.1%). By 2025, the coastal built environment further increased to 53.7%. Conversely, between 2015 and 2025, the coastal water bodies of Eti-Osa transformed from 21.6% to 11.4%. The analysis further showed that between 2005 and 2015, 4,831 hectares of Eti-Osa's coastal environment transformed from bare land to urban environments. The households' questionnaires data showed that 65.1% of the households reported that their homes had been flooded in the previous 5 years. Also, the questionnaires showed that 64.4% of the respondents believed that the government's efforts to control coastal development of Lagos was 'very inadequate'. The results also showed that the respondents' perception of urbanization drivers and respondents' reported incidences of flooding were significantly correlated (AOR=1.543; 95% CI: 1.213-1.964; $p<0.001$). The findings from this research support the need for improved coastal development practices to incorporate adequate drainage and flooding management as well as community partnership.

Introduction

Urbanization creates many challenges with respect to conservation of land and the use of vegetation. In urban areas, particularly in coastal regions, loss of vegetation or wetlands leads to changes in the regulation of the water table and in the natural drainage of area. Ultimately, the changes increase the likelihood of flooding. Conversion of land to built-up areas increases exposure to a variety of natural hazards (Seto et al., 2012; Zhu et al., 2022). Areas most affected are the developing countries, where unplanned urbanization outpaces the ability of the government to provide the necessary urban and environmental services. Tellman et al. (2021) provided evidence of increasing exposure to flooding. Rentschler et al. (2022) estimated that 1.81 billion people face the highest risk from flooding. These studies highlight that in most urban areas, the greatest threats to the population

come from the interplay between the physical environment, the economy, and the conditions and capacity of the institutions of a country. In sub-Saharan Africa, urban areas are projected to double in size by 2050. Managing land use in such rapidly urbanizing areas is a challenge, and the modification of sensitive ecosystems intensifies concerns about flooding. Unregulated urban growth in Accra, Ghana, has been shown to increase flood risk (Andreasen et al., 2023). This is also the case for metropolitan areas in Nigeria, such as Port Harcourt and Lagos. Lagos, in particular, is challenged by rapid urban growth and transformation within an already built-up area within the context of the natural environment and coastal lagoon systems. Urban transformation and land use changes in Lagos have been analyzed in several studies, and their effects on the environment and flooding have been documented (Koko et al., 2021; Idowu and Zhou, 2021; Kasim et al., 2022).

Eti-Osa has also been impacted by unplanned, rapid urban growth. transformation and the reclamation of coastal land. Changes to the coastal landscape of Lagos and Eti-Osa have been well documented, and the impacts of land reclamation on the environment have been reported (Ibitoye et al. 2024). Observations of land use changes and their effects do not always address the socioeconomic factors of urban growth. Other factors may limit the understanding of the impact of urban growth and changes, including the capacity of governance and urban planning to absorb development, and the existing risk environment.

There has been growing interest in recent years for the integration of geospatial analysis with community-based environmental assessments. An example of this approach is the work of Aniramu and Orimoogunje (2025) on geospatial analysis and stakeholder perceptions of sustainable flood management in Lagos. Another example of geospatial analysis, this time combined with household perception, is the work of Aniramu et al. (2026) on Coastal flood risk assessment. Still, there are gaps in local level assessments of various factors including historical land use/land cover changes, drivers of urbanization, flood risk, and planning governance in Eti-Osa. From the body of literature that inspires this research, emphasis is placed on land-change science (Seto et al., 2012; Zhu et al., 2022). The science provides a different way of looking at the challenges of a changing world and gives specific examples to address urban expansion, and the security and welfare of the community. Flooding and the lack of adequate drainage in urban areas represent the impacts that may need urgent attention. Using the approach, it is acknowledged that inadequate and planned integration of infrastructure may contribute to environmental risks and troubles associated with floods, urban expansion, and other challenges.

The study investigates how land-cover change in the study area leads to risk conditions and the kinds of land cover-change associations seen in the study area within the period 2005-2025. The study aims to: (i) Study the magnitude and types of land cover change, and main transitions therein; (ii) Analyze the dominant driver/s of urbanization and changes in the environment; (iii) Identify the socio-economic and drainage factors associated with flooding in the sampled households, and (iv) Analyze views on the adequacy of plans to ameliorate the environment and plan in the study area. The study employs remote sensing and GIS to analyze land cover for the years 2005, 2015 and 2025, in combination with sampled households and questionnaires, and analyze the relationship between household views and land cover change.

The study provides additional information by synthesizing physical changes of the environment, and perceptions of the social and administrative/legal changes of the sampled environment within the same framework. From the environmental changes, the study identifies the types of changes within the coastal environment of urban areas, and provides frameworks for the integration of society and environment within such changes. The study offers new methods for analyzing physical and social changes of the environment. The study focuses on the management of environmental risks in urbanizing areas, and provides a

framework for analysis of such risks for the growth of similar areas.

Materials and Methods

The study covers Eti-Osa Local Government Area (LGA), which is within the Lagos metropolitan region of southwestern Nigeria. The region is rapidly urbanizing with new settlements and commercial and transport activities. It is also ecologically sensitive. The coastline provides opportunities for land reclamation and building. The region is exposed and vulnerable to both natural and human-induced hazards and disasters. Since the late 20th century, the region has experienced rapid urbanization with a corresponding large demand for housing. The region has swamped the natural built environment which caused a substantial change in the regional land cover. Regional land cover change has altered regional drainage systems and significantly contributed to regional flood risks. Flood risks are particularly high in coastal regions, and the modification of natural land cover and drainage systems has exacerbated these risks.

It is important that the region be planned for to ensure that urbanization is planned for in an appropriate and sustainable manner. The selection of Eti-Osa was based on the region's sensitivity and its impact on sustainable urban coastal planning.

The study analyzes changes in land cover over a twenty year period from 2005 to 2025. The classified data covers approximately 17,776 square kilometers. The study area map gives the location of the administrative boundary, regional land features, and other surrounding areas of interest.

2.2 Research Design and Data Sources

The research seeks to understand changes related to urbanization through both qualitative and quantitative methods. Part of this study relies on analysis of land-use and land-cover changes and on the results of surveys conducted on households. The study consists of two analysis. The first focuses on detection of changes in land cover for the years 2005, 2015 and 2025, and identification of land cover changes and their spatial transformation. The second analysis focuses on questionnaires completed by households concerning factors that, in the opinion of the respondents, promoted urbanization and changes in the environment, and flooding. The questionnaires also addressed the adequacy of drainage and infrastructure and the existing urban planning.

This research contains three sets of data collected over a ten year period. The 2005 data is compared to the 2015 data and the 2015 data is compared to the 2025 data. This allows the identification of changes that occurred during the ten year periods and the cumulative changes that occurred from 2005 to 2025. The two sets of data were analyzed through different methods. Changes in land use were analyzed to determine urban development and growth. Household data was analyzed through surveys completed by the households and land use was analyzed using remote sensing. Data was analyzed using descriptive statistics and logistic regressions. Through this analysis, and comparison of the remote sensing and household data, it allowed authors to determine the correlation of these changes, while not determining the reason.

2.3. Satellite Image Processing and LULC Classification

The component used classified land cover datasets for 2005, 2015 and projected to 2025. These datasets were further classified to water, built up, bare and vegetated surfaces. These classes reflect major land cover features, and allow us to compare land cover conditions for the different years. Water was classified to include major surface water features. Built up land covers included artificial surfaces, and facilities and infrastructure. Bare surfaces comprised of soils and land without any vegetation. Vegetation includes all areas dominated by vegetation.

Comparison of classified LULC datasets for different years allows assessment of land cover conditions for the various years and identify changes. Changes in land cover conditions are primarily attributable to processes of land cover conversion. Classified LULC datasets allow assessment of land cover changes for the different years. GIS outputs contained LULC maps for the

3 years along with area estimates for the classified land cover for the 3 years. These maps, provided a basis to examine processes of land cover/LULC change, and assess the changes for bare, built up and water land covers. The focus was to assess and interpret changes for land covers within the urban environment.

2.4. LULC Change Detection and Accuracy Assessment

Post-classification comparison provides the analytical framework for examining LULC transitions across the three observation years. The study's GIS outputs report change-detection matrices for 2005–2015, 2015–2025, and 2005–2025, distinguishing persistent land-cover categories from areas undergoing conversion.

The magnitude of net change in each LULC category is expressed as:

$$\Delta A_i = A_i,t_2 - A_i,t_1 \quad (1)$$

where ΔA_i represents net area change in category *i*, while A_i,t_1 and A_i,t_2 represent the corresponding areas in the initial and subsequent observation years.

Percentage change is calculated as:

$$PC_i = [(A_i,t_2 - A_i,t_1) / A_i,t_1] \times 100 \quad (2)$$

where PC_i denotes percentage change relative to the initial area. Positive values indicate net expansion, whereas negative values represent net reductions.

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The model is expressed as:

$$\log[p/(1-p)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \quad (3)$$

where p represents the probability of reported household flooding; β_0 is the intercept; β_1–β_4 are regression coefficients; and X_1–X_4 represent the four explanatory variables.

Associations were expressed as adjusted odds ratios (AORs), with 95% confidence intervals and p-values. An AOR greater than 1 indicates increased odds of reported flooding, whereas an AOR below 1 indicates reduced odds, conditional on the other variables included in the model. Statistical significance was evaluated at $p < 0.05$, with overall model fit assessed using the likelihood-ratio chi-square statistic and a pseudo-R^2 measure. The regression results require verification against the original statistical dataset, particularly the construction and internal consistency of the perception index, predictor coding, treatment of uncertain flooding responses, and number of valid observations included in the model.

Finally, geospatial and questionnaire findings were integrated through comparative triangulation. Observed land-cover transitions were examined alongside residents' perceptions of development expansion, vegetation reduction, land reclamation, flooding, and drainage deficiencies. Planning-governance assessments provided additional context for interpreting environmental management challenges. The integration was interpretive rather than a spatially linked household exposure model, since no household coordinates or parcel-level linkage were provided. Consequently, the analysis identifies areas of convergence between landscape transformation and reported household experiences but does not establish that particular land-cover transitions caused individual flooding events. This distinction supports a more cautious and methodologically defensible interpretation of urban environmental risk.

3. Results

A total of 450 questionnaires were distributed across the selected communities in Eti-Osa, yielding a 100% response rate (N = 450). The data were analyzed using SPSS Version 27. Descriptive statistics were used to summarize respondent characteristics and perceptions, while

binary logistic regression was employed to determine the factors associated with household flooding.

3.1. Socioeconomic Characteristics of Respondents

Table 3.1 presents the demographic profile of the respondents. The results indicate a relatively balanced gender distribution (52.4% male, 47.6% female). The dominant age brackets were 26–35 years (38.2%) and 36–45 years (31.1%). A significant majority of the respondents were highly educated, with 58.7% holding tertiary degrees and 14.2% possessing postgraduate qualifications. The most common occupations were business/trading (34.4%) and private employment (24.0%). In terms of residency, 44.2% of the respondents have lived in the community for over 20 years, making them highly reliable observers of the 20-year land-use changes. Housing tenure was predominantly tenant-based (56.0%), followed by owner-occupiers (32.0%).

Table 3.1: *Socioeconomic Characteristics of Respondents (N = 450)*

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	236	52.4
	Female	214	47.6
Age	18–25 years	45	10.0
	26–35 years	172	38.2
	36–45 years	140	31.1
	46–55 years	68	15.1
	Above 55 years	25	5.6
Education	No formal education	12	2.7
	Primary	35	7.8
	Secondary	75	16.7
	Tertiary	264	58.7
	Postgraduate	64	14.2
Occupation	Civil servant	68	15.1
	Business/trading	155	34.4
	Private employee	108	24.0
	Artisan	72	16.0
	Student	38	8.4
	Other	9	2.0
Income (₦)	Below 50,000	42	9.3
	50,000–99,999	98	21.8

	100,000–199,999	145	32.2
	200,000–399,999	112	24.9
	400,000 and above	53	11.8
Duration in Community	Less than 5 years	65	14.4
	5–10 years	82	18.2
	11–20 years	104	23.1
	Above 20 years	199	44.2
Housing Tenure	Owner-occupier	144	32.0
	Tenant	252	56.0
	Family-owned	45	10.0
	Other	9	2.0

3.2. Perceptions of Urbanization Drivers and Land Cover Changes

To align with the geospatial findings, respondents were asked to identify urbanization drivers and observed land-cover changes (Section B & C). As shown in Table 3.2, population growth (88.4%) and housing demand (84.2%) were overwhelmingly identified as the primary drivers of urban expansion. The Likert-scale responses (1 = Strongly Disagree to 5 = Strongly Agree) revealed strong agreement that population growth has increased demand for land (Mean = 4.62, SD = 0.58) and that housing/commercial development has accelerated expansion (Mean = 4.55, SD = 0.62).

Regarding observed land-cover changes, 92.4% of respondents noted a physical change in their environment. Specifically, 87.3% observed an increase in buildings, while 71.6% reported a reduction in vegetation. A substantial 74.0% confirmed observing land reclamation and wetland filling. This aligns closely with the GIS analysis, which showed that built-up areas expanded to cover 53.7% of the total land area by 2025, while bare surfaces and wetlands experienced significant alterations.

Table 3.2: *Respondents' Perceptions of Urbanization Drivers and Land Cover Changes*

Perception Item	Agreement (n)	%	Mean	SD
Urbanization Drivers				
Population growth has increased demand for land.	417	92.7	4.62	0.58
Housing/commercial development accelerated expansion.	409	90.9	4.55	0.62
Observed Land Cover Changes				
Noticed physical environmental changes.	416	92.4	-	-

Observed increase in built-up development.	393	87.3	-	-
Observed reduction in vegetation cover.	322	71.6	-	-
Observed land reclamation/wetland filling.	333	74.0	-	-

4.3. Environmental Risks and Household Vulnerability

Section D of the questionnaire assessed household exposure to environmental risks. As presented in Table 3.3, flooding (76.4%) and poor drainage (68.2%) were the most frequently reported environmental problems.

Crucially, **65.1% (n = 293)** of respondents confirmed that their household had experienced flooding within the past five years. Among these, 34.2% reported experiencing flooding five times or more, indicating a chronic vulnerability. The primary effects of these environmental problems were property damage (43.1%) and health concerns (28.7%). Respondents generally rated their exposure to environmental risks as "High" to "Very High" (61.3%).

Table 3.3: *Environmental Risks and Household Vulnerability (N = 450)*

Variable	Frequency (n)	Percentage (%)
Experienced Flooding (Past 5 Years)		
Yes	293	65.1
No	142	31.6
Not sure	15	3.3
Flooding Frequency (if Yes)		
Once	45	15.4
Twice	68	23.2
Three or four times	80	27.3
Five times or more	100	34.2
Major Effect of Environmental Problems		
Property damage	194	43.1
Health concerns	129	28.7
Income/business disruption	75	16.7
Transport difficulties	40	8.9
No significant effect	12	2.7

Table 3.4: LULC of Eti-Aso 2005 - 2025

2025			2015		2005	
Class	**Area_ha**	**% coverage**	**Area**	**% coverage**	**Area_ha**	**% coverage**
Water Bodies	2023	11.4	3847	21.6	3441	19.4
Built Up	9540	53.7	4993	28.1	13063	73.5
Bare Surface	3987	22.4	7091	39.9	805	4.5
Vegetation	2226	12.5	1845	10.4	467	2.6
Total	**17776**	**100.0**	**17776**	**100.0**	**17776**	**100.0**

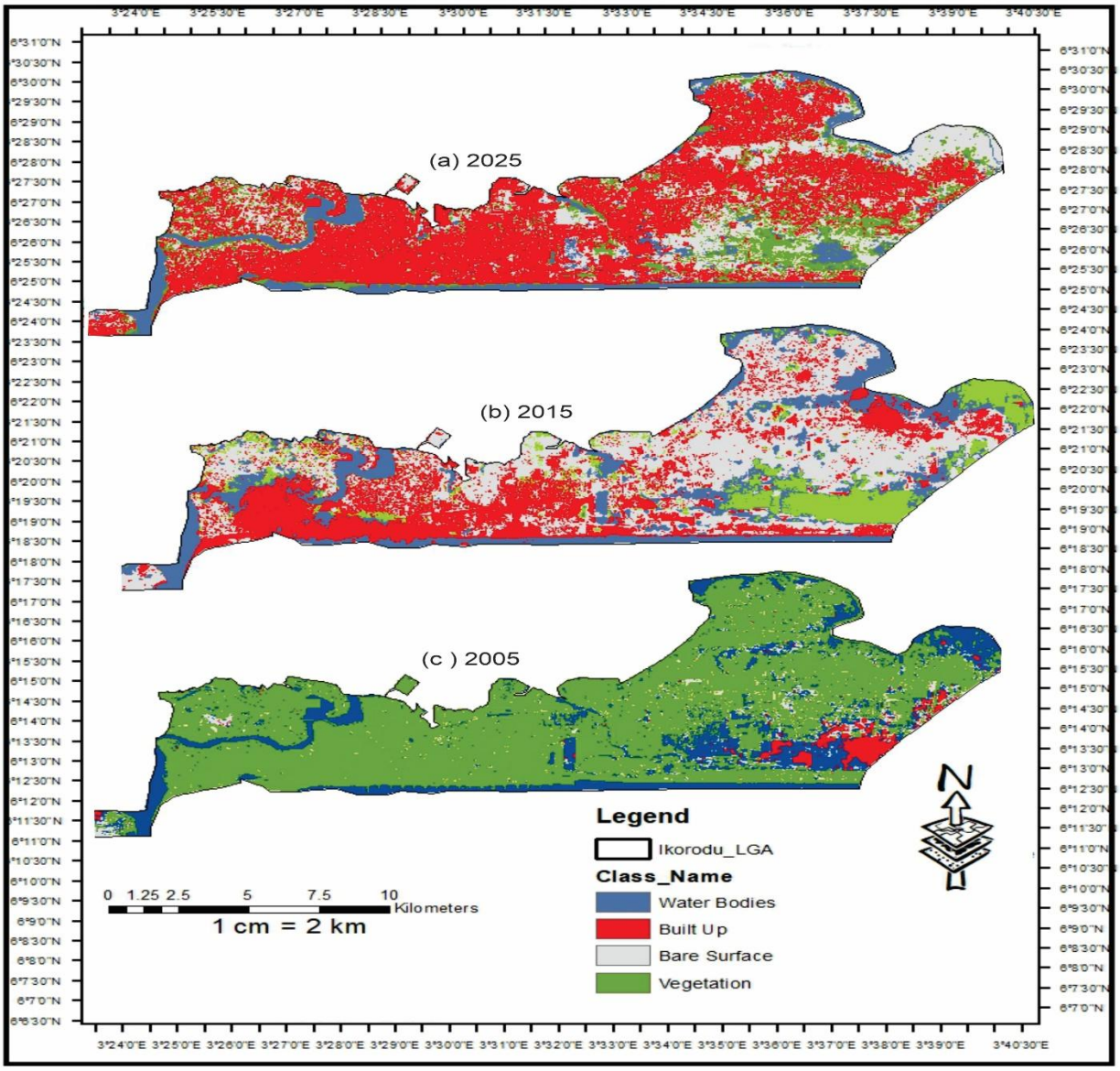


Figure 1: LULC Map of Eti Aso 2005 - 2025

Table 3.5: Change Detection Analysis of Eti-Aso 2005-2015

Changes Detected	Area Change	% of Change
Water Bodies-Water Bodies	2001	11.27
Water Bodies-Built Up	160	0.90
Water Bodies-Bare Surface	428	2.41
Water Bodies-Vegetation	845	4.76
Built up-Water Bodies	1532	8.63
Built up-Built Up	4763	26.82
Built up-Bare Surface	6126	34.50
Built up-Vegetation	631	3.55
Bare Surface-Water Bodies	199	1.12
Bare Surface-Built Up	66	0.37
Bare Surface-Bare Surface	488	2.75
Bare Surface-Vegetation	51	0.29
Vegetation-Water Bodies	106	0.60
Vegetation-Built Up	1	0.01
Vegetation-Bare Surface	47	0.26
Vegetation-Vegetation	313	1.76

Table 3.6: Change Detection Analysis of Eti-Aso 2015-2025

Changes_detected	Area_Change	% of Change
Water Bodies-Water Bodies	1516	8.54
Water Bodies-Built Up	476	2.68
Water Bodies-Bare Surface	1263	7.11
Water Bodies-Vegetation	583	3.28
Built Up-Water Bodies	154	0.87
Built Up-Built Up	3997	22.51
Built Up-Bare Surface	469	2.64
Built Up-Vegetation	369	2.08

Bare Surface-Water Bodies	92	0.52
Bare Surface-Built Up	4831	27.21
Bare Surface-Bare Surface	1481	8.34
Bare Surface-Vegetation	685	3.86
Vegetation-Water Bodies	254	1.43
Vegetation-Built Up	230	1.30
Vegetation-Bare Surface	771	4.34
Vegetation-Vegetation	584	3.29

Table 3.7: Change Detection Analysis of Eti-Aso 2005-2025

Changes_Detected	**Area_change**	**% of Change**
Water Bodies -Water Bodies	1438	8.097758757
Water Bodies -Built Up	280	1.576754139
Water Bodies -Bare Surface	1127	6.346435409
Water Bodies -Vegetation	592	3.333708751
Built up -Water Bodies	466	2.624169388
Built up -Built Up	8837	49.76348688
Built up -Bare Surface	2434	13.70649848
Built up -Vegetation	1314	7.399481924
Bare Surface -Water Bodies	34	0.191463003
Bare Surface -Built Up	391	2.20182453
Bare Surface -Bare Surface	239	1.345872283
Bare Surface -Vegetation	140	0.788377069
Vegetation -Water Bodies	77	0.433607388
Vegetation -Built Up	28	0.157675414
Vegetation -Bare Surface	185	1.041783985
Vegetation -Vegetation	176	0.991102602

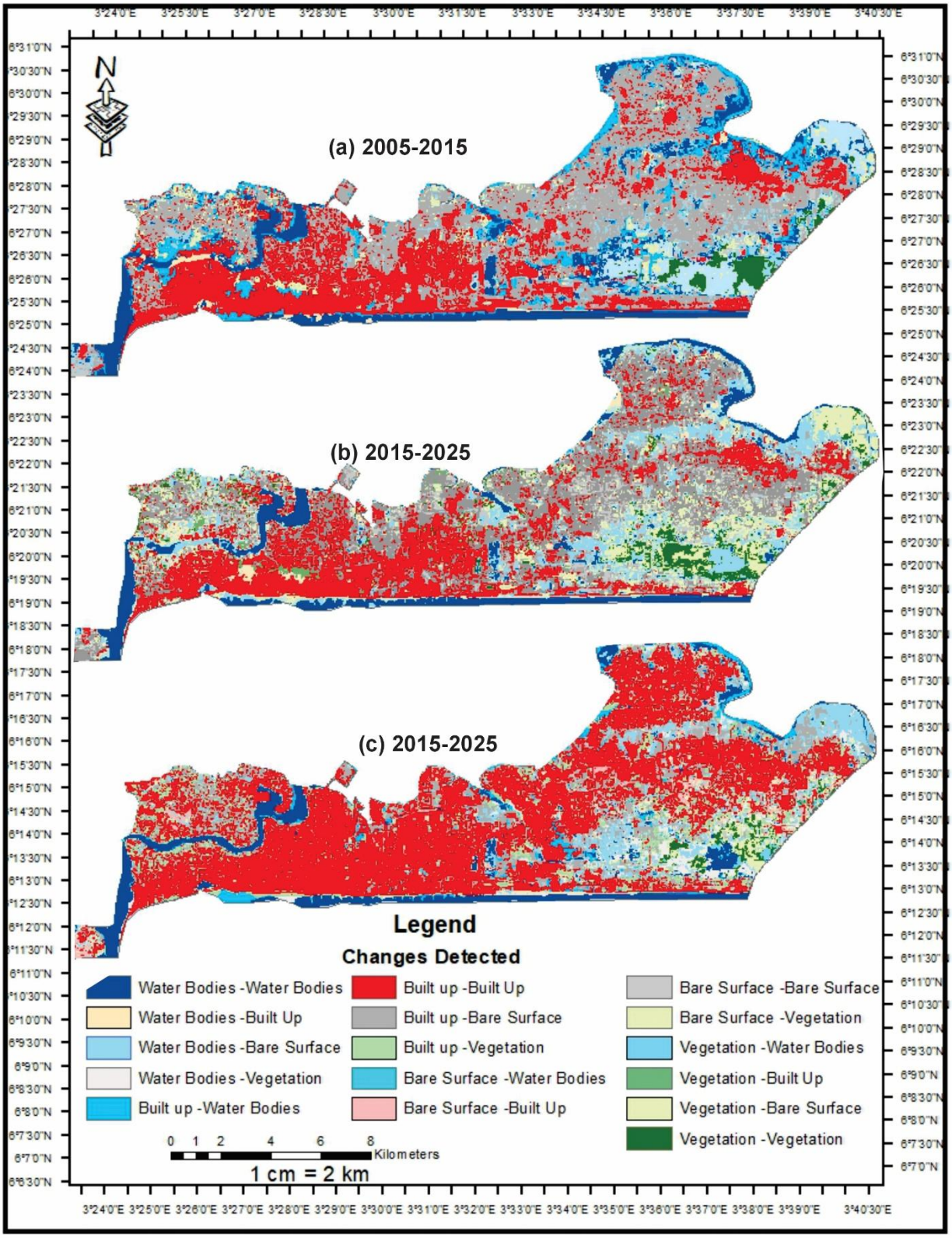


Figure 2: change Detection Map of Eti-Osa 2005-2025

3.4. Planning Governance and Environmental Mitigation

Survey participants assessed urban planning and governance (Section F). The results primarily indicated deficiencies in urban planning and governance. With regard to the control of development in the urban context, about 22.4% of participants assessed this as either effective or very effective. In contrast, 64.4% of participants assessed this as ineffective or very ineffective. Also, about 78% of participants reported they had never been consulted on major development projects. Respondents also reported low agreement on the adequacy of the government's management of physical development (mean = 2.15). Also, respondents reported low agreement on the adequacy of the drainage system (mean = 2.08). Respondents reported high agreement on the need for residents to participate in environmental management (mean = 4.45). Positive respondents' coping strategies were reported by 58.2% of households. Among these strategies, 31.1% of participants reported coping with the environment by improving the drainage system. Also, 24.4% of participants reported that their household improved the environmental condition by raising the threshold of the house or floor.

The objective of this analysis was to assess what factors determine flooding of household levels. Flooding of households was measured by a nominal variable, which took the value of 1 if the respondent reported household flooding within the last 5 years and 0 otherwise. The independent variables measured the respondent's length of residence, level of income, drainage adequacy, and the Urbanization Driver Perception Index (Urban Index for short), which was computed from the respondent's perception of the drivers of rapid urbanization, as detailed in Section B.

Results of the logistic regression analysis indicated that the model was significant ($\chi 2(4) = 21.03$, $p < 0.001$ $\chi 2(4) = 21.03$, $p < 0.001$), and the model explained the variance in flooding status of the respondents between 2.6 % and 3.4 %, as detailed in the model fitness statistics.

Based on results reported in Table 4.15, perception of the Urbanization Driver Index was a positive and significant predictor of household flooding. A unit increase in the perception of unregulated urbanization, land reclamation and building, increased the odds of household flooding by 54.3 % (OR = 1.543, 95 % CI = 1.213 to 1.964, $p < 0.001$ OR = 1.543, 95 % CI = 1.213 to 1.964, $p < 0.001$). Long residence duration (above 20 years) and low respondent's income were also positively associated with household flooding. The perception of adequacy of the drainage system decreased the odds of household flooding by 28 % (OR = 0.72, $p < 0.01$ OR = 0.72, $p < 0.01$).

Table 3.8: ***Logistic Regression of Factors Associated with Household Flooding***

Predictor	**Adjusted Odds Ratio (AOR)**	**95% CI**	**p-value**
Urbanization driver perception index	1.543	1.213–1.964	< 0.001
Residence duration (> 20 years vs < 5 years)	1.850	1.120–3.050	0.015
Income level (High vs Low)	0.650	0.450–0.940	0.022
Perception of adequate drainage (Likert)	0.720	0.580–0.890	0.002

Note. N = 450; likelihood-ratio $\chi^2(4)=21.03\chi 2(4)=21.03$; model $p<0.001p<0.001$; McFadden pseudo-R2=0.034$R2$=0.034. *CI* = confidence interval. *AOR* > 1 indicates increased odds of household flooding.

3.6. Triangulation of Household Views and Geospatial Data

Remote sensing and geospatial analysis predict that nearly 54% of Eti-Osa will be built up by 2025. The analysis further reveals that the loss of natural buffers (bare land and vegetation) has increased at the same pace as the built up area. Household survey data for Eti-Osa reveals that respondents reported unregulated land reclamation and construction as one of the main causes of drainage problems and land flooding. It is important to state that the house-hold survey data and flood-related issues were reported at the same time as the remote sensing and GIS change analysis.

Analysis of Survey Data

4.1 Changes in Urban Land Use of Eti-Osa

Results indicate that during the study period, the area experienced significant changes in land use. While the general trend may demonstrate continuous urban growth, the analysis of different land uses for the period 2005 to 2025, reveals that the most significant land use change for the study area occurred between the years 2015 and 2025. The built up area for 2015 was 4,993 square kilometers and increased to 9,540 square kilometers in 2025. During this same period, the area of bare land (natural surfaces) decreased from 3,994 square kilometers to 2,240 square kilometers. The built environment of Eti-Osa therefore occurred on formerly bare land.

This study's results correlate with others that detail physical development and changes in land use in metropolitan Lagos. Koko et al. (2021) and Idowu and Zhou (2021) examined the growing build up and the associated changes in the city's natural land use. Kasim et al. (2022) also noted growing urbanization in Lagos with the progressive occupation of environmentally sensitive land. Other studies noted sustained increases in urban built up land, the opposite of what was found in this study. The analysis in this study shows a decrease in the extent of urban built up land between 2005 and 2015. Given these results, one must consider if the classifications show continuous urban growth, and consider classification inadequacies and the coverage of the dataset being classified. The change-detection matrix provides us with extra information about the transitions. Between 2015 and 2025, 4,831 hectares of bare surface changed to built-up area (27.21% of the study area). It is likely that during the last decade, more exposed land converted to built-up area. Conversion from bare surfaces to built-up areas could indicate development; however, bare surfaces may represent land that has recently been cleared to be developed. Thus, land may be considered bare only for a transitional period. The 2005 land-cover map indicates the dominance of built-up area. There are potential classification errors that may lead to land being classified as built-up, and then reclassified to a bare surface. This may occur if land is cleared to be developed, but the development does not occur for a period of time. Thus, the 2005 map may not depict the dominance of built-up area as reported. The orientation of the map should be considered when analyzing the classification. Changes in the accuracy of classification may also affect the estimated changes in land cover. Classification changes may result in land that has previously been developed to revert to a natural state, such as forest.

4.2. Modification of Landscape and Environmental Considerations

The results also show changes in vegetation and water bodies, but require interpretation. From 2015 to 2025, the coverage of water bodies decreased from 21.6% to 11.4%. The transition matrix shows that during the same period, 1,263 hectares changed from water bodies to bare surface. Changes from water bodies to bare surface, particularly in coastal areas, can have significant environmental consequences. Changes to surface water bodies and systems in coastal environments can impact the storage and drainage of water, and the pathways and rate of water flow. Ibitoye et al. (2024) stated that land reclamation in the Eti-Osa and Lagos Island regions led to the loss of coastal wetlands and water bodies, and noted the need for the sustainable management of coastal areas and drainage. Like Ibitoye et al. (2024), the current study supports land use changes in coastal areas. However, the classification system used in this study is not able to differentiate water bodies and

wetlands. Therefore, the changes identified in the study could represent land reclamation or wetland loss due to other factors.

Interpretation of vegetation data presents further challenges. While the classified area data show that vegetation increased between 2005 (2.6%) and 2015 (10.4%), and 2025 (12.5%), 71.6% of survey respondents indicated that they had observed a reduction in vegetation cover. It is likely that the survey respondents observed a loss of vegetation in areas less than that shown in the classified area data. There are a number of reasons for the apparent contradiction. These may include the classes of vegetation used in the data classification (e.g. due to changes in the condition of vegetation), image capture conditions, and limitations of the classification process. The unresolved difference between the two data sets shows the importance of independent evaluation of both data types, that is, assessment of geospatial data and household observations.

4.3. Urbanization Drivers and Household Perceptions of Environmental Change

According to the survey results, the main drivers of land transformation are described as population growth and related economic and infrastructure development. Nearly 93% of the respondents said that population growth leads to increased demand for land. About 91% of the respondents said that land is transformed for housing and business developments. About 87% of the respondents mentioned that land is converted for building projects. Furthermore, 74% of the respondents mentioned land transformation by land reclamation and fill of wetlands. Respondents say that the biggest pressure on the environment comes from the need to build and develop. The respondents said that modifications of the built and natural environment are the main results of urbanization. Other studies have stated that urbanization is a result of the need to develop and use the land within the built environment. Andreasen et al. (2023) described land development practices as risk factors when integrated with deficient urban planning and governance systems. Land use transformation is of great concern to urban residents.

We need to distinguish between the reasons for land-cover change and urbanization-related reasons that are believed to lead to urbanization. Growth in the population and the demand for housing are considered the main reasons for urbanization by many of the respondents. However, other factors could also contribute to land-cover change. These could include government investments in infrastructure, land-owner speculation, and changes in government policies and regulations. Most probably, the respondents were aware of the development factors that most influence the land-cover change in their areas. The main strength of the study resides in documenting the development pressures that are of principal concern to the respondents. The study combines local knowledge of respondents and provides essential data to address the gaps in understanding the processes occurring in the study area.

4.4. Household Flooding, Socioeconomic Vulnerability, and Statistical Association

Concerns for the environment are evident in the responses provided. Of the respondents, 76.4% considered flooding as the main environmental concern, with 68.2% naming poor drainage. Of the samples analyzed, 65.1% reported flooding of their household in the past 5 years, and 23.2% reported that their household had experienced more than 10 floods. In addition, flooding caused physical damage to households and health problems to household members. Based on the answers provided, flooding was more than just a physical disturbance to households; it endangered the households' physical properties and resources, including household members' health and wellbeing. The authors recognize the role of the Lagos double crisis (rapid urbanization and infrastructure deficit) in augmenting the risk of flooding. Kasim et al. (2022) focused on the Lagos floods of 2012 and postulated an association between the 2012 floods and continuous urban expansion. On the other hand, Aniramu and Orimoogunje (2025) examined coastal urban flooding within the context of drainage infrastructure and community participation. The available data, however, did not determine how much flood events were

attributed to land cover changes as opposed to variations in intensity of rainfall, local elevation, flood water storage/detention, or coastal hydrological conditions. The data presented, therefore, offer an indication of flooding experienced by households; and not an absolute measure of flooding. Results from the logistic regression analysis give additional insights into the case of households. The urbanization driver perception index (the degree to which households believe urbanization has been driven by the government and the activities of land speculators, developers, etc.) was positively related to the probability of a household reporting flooding (AOR = 1.543, 95% CI: 1.213, 1.964; $p \leq 0.001$). This means that households who believed that there had been a significant drive towards urbanization by the government and land speculators had 1.543 times the probability of reporting flooding. The magnitude of the association between the two variables suggests that urbanization has led to a greater perception of flooding amongst the community, and this was also evident in the reported flooding.

Duration of residence and income were positively associated with flooding. Compared to persons living in their communities less than five years, persons living in their communities twenty years or more reported flooding almost twice as often (AOR = 1.850, $p = 0.015$). It is possible that respondents with greater duration of residence became more aware and sensitive to environmental conditions and problems. Some respondents may have lived in areas at greater risk of flooding. Longer duration of residence may have made respondents more likely to experience flooding, especially if respondents lived in areas poorly drained. Respondents with higher income were less likely to report flooding (AOR = 0.650; $p = 0.022$). This result is consistent with the body of literature that notes the potential for socioeconomic status to influence environmental condition, and the degree to to which persons are vulnerable and exposed to risk (Rentschler et al., 2022). A respondent's perception of drainage adequate was associated with flooding. Inadequate drainage and other structural (e.g. sewer, water, gas, etc.) conditions may have affected a resident's flooding experience. Because drainage conditions and adequacy were assessed by respondents' perception, and not by a professional engineer, the conditions may also reflect a respondent's flooding history. The statistical model was significant, but the McFadden's R^2 was 0.034. The model captures some critical correlations but explain little about flooding. Other physical factors such as intensity of precipitation and the effect of flood plain and drainage conditions may also have affected respondents' flooding experience.

4.5. Planning Governance and Sustainable Urban Development

Findings from the governance chapter show several concerns regarding current environmental planning systems and processes. About 64.4% of the respondents thought development control systems were either ineffective or very ineffective. About 78% of the respondents also reported they had no role in government consultations regarding big development projects in the area. The respondents, therefore, rated the government's monitoring of physical development and drainage systems as inadequate (means of 2.15 and 2.08, respectively). The respondents, however, supported, and in some cases strongly supported, the involvement of the community in the process of making decisions on environmental planning and protection (means of 4.27 and 4.45, respectively). The respondents seemed to disagree with the present systems in place to manage the adverse environmental impacts of development. Andreasen et al. (2023) also showed how fragmented governance of urban land and development in West Africa, particularly in the case of Lagos, posed a significant flood risk to the already vulnerable and over-burdened urban population. Although Okunola et al. (2026) studied a different region, their conclusions, especially with respect to governing and managing integration of flood risk, are broadly consistent with our Eti-Osa respondents.

There are several implications of the findings for urban planning and development.

First, planners need to evaluate the integration of environmental considerations at different stages

of the development process. This is particularly important for projects that divert natural drainage ways and develop within coastal areas. Second, although it is important for local authorities to provide improved drainage infrastructure to help address flooding, this must be based on more fine-grained assessment of flooding risk, rather than based on development control. Third, households affected by poor drainage have direct knowledge of flooding and other issues associated with development and could provide the local monitoring of the environment needed to complement more strategic evaluations. Evidence also indicates that residents are aware of environmental risks associated with flooding and other issues and are taking steps to respond. While household level responses to flooding and other environmental risks should be addressed, this cannot take the place of larger, more strategic responses by the state to improve drainage and other environmental infrastructure. It is important that the state and other actors involved make a commitment to long term, strategic environmental infrastructure planning and develop coordinated environmental systems in response to environmental issues, while encouraging community participation to help make up for poor drainage and other environmental systems.

4.6. Integration of Findings, Scholarly Contribution, and Limitations

This study integrates three primary aspects, namely, assessment of land cover change, household environmental experience and perceptions of land use planning. The major strength of the geospatial analysis is to reveal the nature and extent of the land cover transformations. Survey analysis, on the other hand, captured Household perception of developmental pressure and concerns with respect to institutional arrangement. These collectively illustrate the (possibly) multifaceted nature of urban environmental change. The study demonstrates the need to incorporate both physical and socio-economic conditions of the urban environment when assessing urban environmental change. The study integrated various (sometimes contradictory) datasets to fill information gaps. Moreover, the absence of direct relationships between land cover changes and household perception limits the extent to which hypotheses on land cover changes in the study area can be tested. In the absence of contradictory information, hypothesis testing or drawing strong conclusions on land use and land cover change in the study area is not advisable.

Subsequent studies should also include independently verified classification maps, as well as averaged rainfall and elevation data, drainage networks, and geographic data for sampled households. These enhancements should improve the assessment of spatial relations with regard to urbanization, sampled households, and floods. The treatment of undefined flooding, the construction of the perception index, and the veracity of survey finals also need to be corroborated. Considering these constraints, this study supports the case that, to responsibly plan and develop the urban coast, integrated assessments of the built and natural environments, including the planning regime, should be aligned. The principle conclusion is that, while alteration of the coast and land-cover change may be insufficient in explaining coastal flooding of sampled households, other components and factors (i.e., the built and social environment) should also be examined in a complementary and integrative manner to support coastal development and urban planning.5.1.

Conclusion

The study assessed the relation between changes in urban land-cover, identified drivers of urbanization, and the environmental risks perceived by households, in Eti-Osa, Lagos, Nigeria. It integrated geospatial data for different years, and analyzed LULC and household data. It incorporated multiple dimensions to assess potential consequences of coastal urbanization. The study found significant changes in land-use between 2015 and 2025. Developed land increased from 28.1% to 53.7% of the study area. From 2015 to 2025, build-up of land from bare surfaces was the major change, along with loss of water bodies and vegetation. From 2005 to 2015, the reverse was observed. There were also some inconsistencies between the mapped and tabulated data, and the authors suggested that there is a need to verify GIS data to determine the long-term trends of urban growth.

This household survey noted the main perceived causes of environmental change in the area as population growth and expanding demand for housing and business spaces. It reported that most households were worried about drainage problems and flooding, and the unregulated nature of development. The regression analysis showed that some of the factors that contributed to the perception of a flood risk in the area were the duration for which the household had lived in that location, the household's level of income and the adequacy of drainage. It is important to note, however, that the regression model was not able to capture the entirety of the concern that households have about flooding with these factors. One of the main contributions of the study is illustrating the complementarities that exist when examinations of environmental and landscape changes are integrated with social economic and planning-governance changes. Furthermore, this study provides a framework to assess the interrelations that exist between environmental risks and changes in urban areas, as well as changes in the built environment, household (in)security, and planning and governance systems. The framework is applicable to the contexts of rapidly urbanizing coastal areas in particular.

5.2. Policy and Planning Implications

There are three main recommendations for the planning and management of environmental risks in Eti-Osa. First, the process of land conversion must be tracked in more detail, and potential impacts of development in sensitive areas assessed. In addition, more relevant evidence should be gathered for environmentally-related land-use decisions. Rapidly changing areas (such as the coast and drainage corridors) should be monitored. Second, the plans for the management of drainage should take into account land-use and flooding risks. Drainage management should be improved based on the characteristics of the settlement, and flood waters should be managed using the drainage pathways. The management of flood waters should be combined with the assessment of environmental impacts of land reclamation. Third, urban environmental management should consider social equity, and public policies should aim to reduce the flood risk for low-income communities. Also, public

participation should be strengthened, along with the transparency of management processes and activities of the environmental and urban-planning agencies.

5.3. Study Limitations and Prospective Research

Results of this study were drawn with limitations. LULC analysis takes place over a period of three years and classifies changes over land-use into four categories. As a result, the analysis is not able to discern all changes and may not capture some important changes (i.e. wetland loss). Further, analysis of changes relies on the assessor's interpretation, and in the absence of an independent check, the results can not be fully trusted. Findings of this study rely on self-reported experiences of the household and do not incorporate all relevant variables. In addition, the potential validity of the questionnaire, and assumptions upon which the study was based, must be verified in order to consider the results as scientific evidence. Future studies should utilize relevant, alternative data sets including (a) satellite and aerial imagery, (b) other environments and climate variables, (c) household level data and (d) geospatial planning data to support better integration of stakeholder evidence. In this regard, this study emphasizes the value of integrated data and multi-disciplinary approaches to better understand the degree of flood exposure and risk in urbanized coastal areas. It is critical that the land-use and related infrastructure of Eti-Osa and similar areas improve to support the goals of sustainable development.

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