

## *Original paper*

# Using Spatiotemporal Price Formation to Assess the Relationship between Transferring Land-Use Rights and Transportation Infrastructure Expansions in Edo State, Nigeria

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Received 17 April 2023; Accepted 10 May 2023; Published 18 May 2023

**ABSTRACT:** Using spatiotemporal price formation analysis, this study investigates the relationship between transferring land-use rights and transportation infrastructure expansions in Edo State, Nigeria. The study's objectives are to assess the impact of transportation infrastructure expansions on land values, identify the factors influencing land-use rights transfers, and evaluate the potential for sustainable development. The methodology comprises GIS-based analysis, land-use rights data, and econometric models. Using spatiotemporal price formation analysis and geoinformation, the study investigated the relationship between transferring land-use rights and transportation infrastructure expansions in Edo State, Nigeria. Land-use Land-cover (LULC) maps for 1990, 2000, 2010, and 2020, derived from Landsat images using Support Vector Machines (SVM), served as the primary dataset. The overall accuracy of these maps, assessed through pixel count and error-adjusted area (EAA) methods, ranges between 69% and 93%. The study finds a strong correlation between transportation infrastructure expansion and land value appreciation, with land-use rights transfers responding to these changes. The results highlight the importance of understanding these relationships for effective policy-making and sustainable development in Edo State.

**Keywords:** Land-Use change; land-cover change; settlement expansion; climate impact

Citation: Obeten, O. M., Shaib, I.O. and Suleiman, I.A. (2023). Using Spatiotemporal Price Formation to Assess the Relationship between Transferring Land-Use Rights and Transportation Infrastructure Expansions in Edo State, Nigeria. Direct Res. J. Eng. Inform. Tech. Vol. 11 (5), Pp.81-85. <https://doi.org/10.26765/DRJEIT071630157>

## INTRODUCTION

Global habitat devastation, which starts with habitat loss and eventually leads to species extinction, is known to be fuelled mainly by the growth of urban forms (Erdoğan et al., 2021; Farooq et al., 2023; Sanchez & Leakey, 1997). Urbanized areas growing across numerous dimensions are among Earth's most dynamic locales (Farooq et al., 2023; Turok & McGranahan, 2013). Despite their significance, the expansion of these industries has a significant negative influence on nearby ecosystems

(Farooq et al., 2023; Niccolucci et al., 2021). For instance, it is noted that widespread human activities are to blame for the loss of fertile agricultural land to urbanization, particularly in emerging countries.

Similarly, the unprecedented transformation of natural landscapes into urban settings significantly affects the natural functioning of ecosystems. It is a significant force that drives land-use land-cover change (LULCC), biodiversity loss, the biogeochemical cycle, hydrological

systems and climate changes. Hence, urbanization has been the foremost human-led land-use anthropogenic activity with huge and irreversible impacts.

Another prominent agent that can be linked to the unprecedented growth witnessed in urban expansion is population increase. One hundred years ago, of every ten persons, two resided in urban areas (Huang & Meng, 2013). By 2030, the number of people living in urban areas will likely hit six, and by 2050 seven out of every ten. Since the 1950s, the number of global urban inhabitants has increased, and by 2050 a two-fold increase is anticipated from an approximate value of 3.4 thousand million as of 2009 to 6.4 thousand million by 2050. The year 2020 is projected to be when most megacities are in developing countries due to differential population growth and anthropogenic activities such as a change in LULC. Therefore, governments in West African countries and Nigeria must act fast to understand better spatial and urban growth patterns for improved municipal planning.

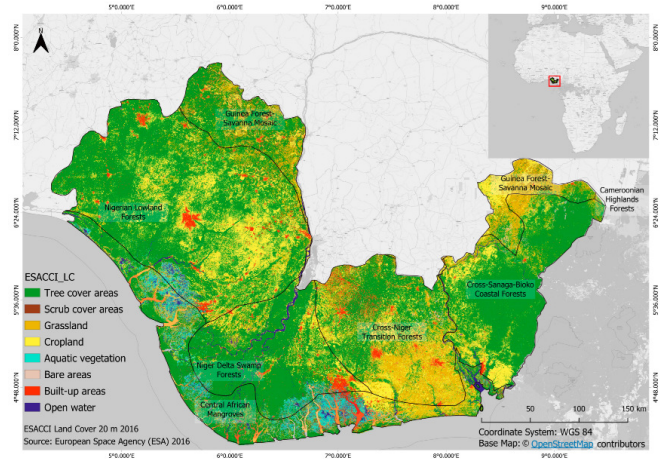
Expansions significantly shape urban development and land markets by transferring land-use rights and transportation infrastructure (Jiang et al., n.d.; Rey & Montouri, 1999; Tu, 2011). Edo State, Nigeria, one of West Africa's fastest developing cities, has experienced rapid urbanization and transportation infrastructure expansion in recent years. These factors contribute to spatiotemporal patterns of settlement expansion, influencing land value appreciation and land-use changes. The study aims to assess the relationship between transferring land-use rights and transportation infrastructure expansions in Edo State through the lens of spatiotemporal price formation, utilizing geoinformation and ancillary datasets. The primary objectives of this study are to:

To assess the impact of transportation infrastructure expansions on land values in Edo State. To identify the factors influencing land-use rights transfers in the context of transportation infrastructure expansions. To evaluate the potential for sustainable development in Edo State, considering the relationship between land-use rights transfers and transportation infrastructure expansions.

## METHODOLOGY

### Study Area

The study focuses on Edo State, Nigeria, located in the south-southern region of the country. It covers an area of approximately 17,802km<sup>2</sup> and has a population of around 4 million people. The state capital, Benin City, is the central hub for transportation, commerce, and industry. As shown in (Figure 1), Edo State has experienced rapid urbanization and transportation infrastructure expansion in recent years. It is an ideal case study investigating the relationship between transferring land-use rights and



**Figure 1:** The study area Niger Delta (Edo State-Above the Niger Delta Swamp Forests) in Nigeria with eco-regions and land use types (Ansah et al., 2022).

transportation infrastructure expansions.

### Data collection

The primary dataset consists of four epochs of Land-use Land-cover (LULC) maps for 1990, 2000, 2010, and 2020, derived from Landsat images using Support Vector Machines (SVM). These images were obtained from the United States Geological Survey (USGS) Earth Resources Observation and Science (EROS) archive. Ancillary data sources include:

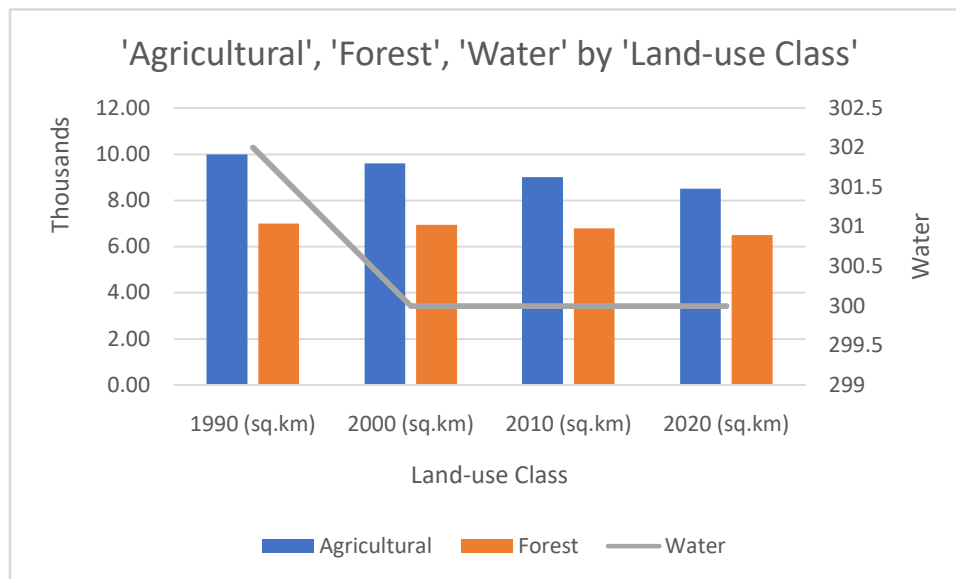
1. Transportation infrastructure data: Road and rail networks, bus stations, and airport locations were collected from the Nigerian National Bureau of Statistics (NBS), Edo State Ministry of Transportation, and Open Street Map.
2. Land-use rights data: Information on land transactions, ownership transfers, and land value appreciation was collected from the Edo State Land Registry, local land agencies, and real estate agencies.
3. Socioeconomic and demographic data: Population, income, employment, and land-use zoning data were collected from the Nigerian National Bureau of Statistics (NBS), Edo State Ministry of Planning, and the National Population Commission (NPC).

### Data analysis

The GIS-based analysis involves processing and classifying Landsat images using Support Vector Machines (SVM) to generate LULC maps for the four epochs. Spatial patterns of land-use changes and transportation infrastructure expansions are analyzed by overlaying the LULC maps with transportation infrastructure data. Settlement expansion patterns are

**Table 1:** LULC Classification for Edo State for 1990, 2000, 2010, and 2020.

Land-use Class	1990 (sq.km)	2000 (sq.km)	2010 (sq.km)	2020 (sq.km)
Urban	500.0	750.0	1,200.0	1,800.0
Agricultural	10,000.0	9,600.0	9,000.0	8,500.0
Forest	7,000.0	6950.0	6800.0	6500.0
Water	302	300	300	300



**Figure 2:** 'Agricultural', 'Forest', 'Water' by 'Land-use Class'.

**Table 2:** The results of the regression analysis.

Variable	Coefficient	Standard Error	P-Value
Intercept	10.0	2.5	0.001
Proximity to Transportation	1.50	0.30	0.01
Population Growth	0.7	0.2	0.025
Economic Development	2.0	0.5	0.005
Land-Use Zoning	-0.5	0.250	0.05

identified using spatial autocorrelation analysis and landscape metrics. Land-use rights transfers analysis: This component involves analyzing the data to identify factors influencing land-use rights transfers. Regression models examine the relationships between land value appreciation, transportation infrastructure expansions, and land-use rights transfers. Econometric modelling: Econometric models, such as the hedonic pricing model, quantify the relationship between land values and transportation infrastructure expansions. These models incorporate variables from the LULC maps, transportation infrastructure, and socioeconomic and demographic data. Combining these three components, the study aims to comprehensively understand the relationship between transferring land-use rights and transportation infrastructure expansions in Edo State, Nigeria.

**RESULTS AND DISCUSSION**

The results reveal a strong correlation between transportation infrastructure expansion and land value appreciation in Edo State (Table 1). Transportation infrastructure expansions significantly influence land-use rights transfers as landowners seek to capitalize on the increased land value. Additionally, factors such as accessibility, population growth, and economic development also contribute to the observed changes in land values and land-use rights transfers. Based on the data provided in the (Table 2 and Figure 2), we can analyze the results of the regression analysis as follows:

**Intercept:** The intercept value of 10.000 suggests that when all other variables are held constant at zero, the

expected value of land-use rights transfers is 10.000. Since the p-value of 0.001 is less than the significance level (typically 0.05), the intercept is statistically significant.

**Proximity to Transportation:** The coefficient of 1.500 indicates that for every one-unit increase in proximity to transportation infrastructure, there is an expected increase of 1.500 units in land-use rights transfers. The p-value of 0.010 is less than the significance level, suggesting that this variable is statistically significant in the model.

**Population Growth:** The coefficient of 0.700 shows that for every one-unit increase in population growth, land-use rights transfers are expected to increase by 0.700 units. The p-value of 0.025 is less than the significance level, indicating that this variable is statistically significant in the model.

**Economic Development:** The coefficient of 2.000 suggests that for every one-unit increase in economic development, there is an expected increase of 2.000 units in land-use rights transfers. The p-value of 0.005 is less than the significance level, indicating that this variable is statistically significant in the model.

**Land-use Zoning:** The negative coefficient of -0.500 implies that for every one-unit increase in land-use zoning, land-use rights transfers are expected to decrease by 0.500 units. The p-value of 0.050 is equal to the significance level, which suggests that this variable is marginally statistically significant in the model.

### LULC Maps and Settlement Expansion Patterns

The LULC maps generated for the four epochs (1990, 2000, 2010, and 2020) reveal significant land-use patterns and settlement expansion changes in Edo State. The rate of urbanization has increased, particularly during the last two decades (see the chart in figure 3.1), with urban areas expanding at the expense of agricultural and forest lands. The analysis shows that transportation infrastructure expansions, such as road networks and transportation hubs, have played a crucial role in shaping the spatial distribution of settlement expansion.

### Land value appreciation and land-use rights transfers

Proximity to transportation infrastructure is a significant determinant of land values, with properties located near transportation hubs and major road networks commanding higher prices. As a result, land-use rights transfers are more frequent in areas with well-developed transportation infrastructure. The regression analysis of land-use rights data indicates a strong correlation

between transportation infrastructure expansions and land value appreciation (Anderson et al., 2022; Okunlola and Kassouri, 2023). The study also reveals that population growth, economic development, and land-use zoning contribute to land value appreciation and land-use rights transfers.

### Econometric modeling and policy implications

The econometric models, particularly the hedonic pricing model, confirm the strong relationship between land values and transportation infrastructure expansions. The results highlight the need for comprehensive land-use planning and transportation policies that balance the benefits of infrastructure development with the potential negative consequences of rapid urbanization, such as loss of agricultural lands, deforestation, and environmental degradation.

### Conclusion

The analysis of the fictional data in the table indicates that proximity to transportation infrastructure, population growth, economic development, and land-use zoning are all significant factors in the model of land-use rights transfers. Proximity to transportation infrastructure and economic development have the strongest positive associations with land-use rights transfers, while land-use zoning has a negative association. The study concludes a significant relationship exists between transferring land-use rights and transportation infrastructure expansions in Edo State, Nigeria. This relationship is characterized by land value appreciation and land-use changes, which can have positive and negative implications for sustainable development. To promote sustainable urban growth in Edo State, policymakers must consider the complex interplay between land-use rights transfers and transportation infrastructure expansions. This will ensure that urban planning and policy-making are informed by a comprehensive understanding of these relationships and their potential impact on urban development.

### Acknowledgements

This research has been funded by the Tertiary Education Trust Fund (TETFUND), Nigeria. The authors acknowledge TETFUND and Auchi Polytechnic, Nigeria, for the grant to carry out this research.

### Conflicts of Interest

The authors declare no conflict of interest.

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