Journal of
Environment
(JE)

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CARI Journals

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 4, Issue No. 1, pp 1 – 23, 2024
www.carijournals.org

Geospatial Assessment of Environmental Impact of Urban Growth in Akure South, Ondo State, Nigeria.

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Accepted: 14th Dec 2023 Received in Revised Form: 30th Dec 2023 Published: 13th Jan 2024

Abstract

Purpose: This comprehensive study examines the environmental impact of urbanization in Akure South, Ondo State, Nigeria, using a fusion of geospatial and microbiological analyses. Employing Landsat imagery from 2000, 2011, and 2022, processed through ArcGIS 10.8 and TERRSET software, the study maps and quantifies urban expansion and land use changes.

Methodology: The research concurrently leverages, microbiological techniques to assess air pollution, as well as water and soil contamination levels.

Findings: The result highlighted an increase in built up area from 9.31% in 2000 to 17.45% in 2011 and 29.54% in 2022, which is evident particularly in Akure township area, correlating with a notable decline in environmental quality. Pollution hotspots, identified through rigorous spatial analysis, point to areas severely impacted by urban growth and high level of air pollution, as well as water and soil contamination. In addition, Land Use/Land Cover (LULC) prediction shows that built up area will likely cover about 30.09% by 2042. These findings underscore the urgent need for strategic urban planning and robust pollution control measures.

Unique contributor to theory, policy and practice: The study advocates for a balanced approach to urban development, integrating environmental sustainability to mitigate the adverse effects of rapid urban growth. This research contributes to the broader discourse on urbanization's environmental impact, offering valuable insights for policymakers and urban planners in similarly developing regions of the world.

Keywords: *Soil Contamination, Water Contamination, Air Pollution, Land Use/Land Cover, Cellular Automata Markov*

1.0 Introduction

The concept of "Urbanization" refers to the conversion of natural areas into developed regions for various purposes, such as housing, commerce, and industry, on a global scale (Xie *et al*., 2005). This process is predominantly caused by humans and leads to the transformation of towns, cities, and rural-urban areas while concurrently causing a decrease in population in rural areas due to migration to urban centers (Ohwo & Abotutu, 2015). Environmental issues resulting from urbanization include pollution, slum development, deforestation, global warming, etc. These issues have been categorized as ecological, poaching and habitat loss, escalating desertification, and soil erosion (Komolafe *et al*., 2014). As urban growth rates increase, these environmental issues also worsen. For instance, in Ondo State, Nigeria, urbanization has put strain on the urban ecology by threatening agricultural land and vegetation (Ibelewa *et al*., 2021). This increase has also resulted in environmental contamination of the air, water, and land, negatively impacting the ecosystem (Oyinloye, 2013). The Nigerian government has made efforts to address these issues by introducing policies aimed at reducing pollution and revitalizing the water supply, sanitation, and hygiene sector in line with the Sustainable Development Goals (SDGs) (World Bank Group, 2021).

Some identified challenges of environmental impact include: (i) the increased urban rate which has led to an increased environmental problem, (ii) the continuous increase in the conversion of vegetative areas into urban zones which has further exacerbates the influence on land use and land cover, (iii) the absence of coordination and monitoring of urban expansion leading to heightened land utilization and modification, potentially impacting both land cover and the pace of transition from rural to urban areas, and (iv) Air, water and land contamination cannot be easily quantified in the study area, culminating in cases of cholera and other viral disease outbreaks.

The goal of this research is to geospatially assess the environmental impact of urban growth in Akure South Local Government Area. The following research questions enable the research aim to be achieved: (i) What is the Land Use/ Land Cover (LULC) pattern of the study area? (ii) What is the urban growth trend of the study area? (iii.) What is the spread of air pollution, water and soil contamination in the study area (iv) What will be the spatial and temporal trajectory of Akure South over the next two decades? By processing Landsat imageries of the year 2000, 2011 and 2022, Land Use/Land Cover (LULC) map was produced to examine LULC pattern, urban growth trend, while the hotspot analysis was used to determine the spread of air pollution, water and soil contamination in the study area.

2.0 Literature Review

The review of past journals for the present studies show that Urban Growth and expansion has been done severally. For example, Owoeye, (2019) used AII and Markov chain model to analyze the urban growth and agricultural land depletion in Akure region from 1986 to 2014, he found that population increase and urbanization process were the main drivers of land use changes and environmental impacts and recommended effective zoning strategy and sustainable monitoring measures to control urban expansion and protect agricultural lands. Koko *et al.,* (2021) applied the Post Classification Change Detection (PCCD) and Maximum Likelihood Classification (MLC) techniques to examine the urban growth and land cover change in Lagos from 1990 to 2020. They found that urban sprawl caused significant loss of natural resources and environmental problems, and suggested using optical and SAR techniques and remote sensing and GIS tools for sustainable urban development. Ojo *et al.,* (2019) examined the land use and land cover changes in Akure forest reserve from 1988 to 2018. Their findings shows that light vegetation was the dominant land cover and recommended policies and practices to enhance forestry management and conservation. Idayat *et al.,* (2016) analyzed urban growth and land use changes in Akure from 1986 to 2015. They found that urbanization was the main driver of growth and suggested regional planning and development to achieve sustainable infrastructure. Azam and Khan, (2015) employed empirical investigation and least square method to examine the impacts of urbanization and other variables on CO_2 emissions in four SAARC countries from 1982 to 2013. They discovered that urbanization had different effects on the environment in each country and recommended long-term urban planning polices to reduce CO_2 emissions and pollution. Patra *et al.,* (2018) research employed satellite imageries, conventional techniques, IDW, and K-means methods to examine the urbanization impacts on land use, climate, and groundwater in Howrah Municipal Corporation (HMC) and suggested a comprehensive urban development approach to curb illegal expansion. Maria and Mitchell, (2018) employed nighttime data to assess the extent and distribution of built-up areas in South America from 2001 to 2011 and found that most expansion occurred in small and medium cities and rural areas. Fertner *et al.,* (2016) compared the drivers, impacts, and response of urban sprawl and growth management in eight European and US cities, using quantitative and qualitative methods based on the PLUREL project. Hanberry, (2023) analyzed the urban growth and density changes at different scales from 2000 to 2020 using Worldpop model and finds that urbanization increased both land use and population concentration, especially in India. Richter, (2020) used two datasets (NRI and NLCD) to measure and compare the urban expansion rates and patterns in the continental US from 1982 to 2016 and found that urban expansion was slowing down and becoming more compact. While Megahed *et al.,* (2015) research employed SVM and LCM to produce and analyze the land cover maps and urban growth scenerios in the Greater Cairo Region from 1984 to 2025 and found that urbanization increased the loss of natural resources and cultural heritage. Dyvak *et al.,* (2021) research employed mobile complex to measure the concentration of nitrogen dioxide emissions from vehicles in the air and a mathematical model to simulate the diffusion of this harmful substance in the soil and groundwater. Beena and Jaya (2016) used various methods to measure the concentration of toxic trace metals in the soil samples collected from the surroundings of KMML industrial area and found that the soils were contaminated with higher levels of metals than the normal distribution. Armaya'u *et al.,* (2020) research focused on the measurement of heavy metals in soil samples from an irrigation site in Kastina, Nigeria, and found that the soil was contaminated with cadmium and lead above the permissible limits. Onyenechere *et al.,* (2021) measured and compared the physiochemical and microbial properties of soil and water samples from Jos and Sokoto, and found that the informal sector activities had a negative impact on the environmental quality and health risks. Similarly, Omonona *et al.,* (2019) measured the water quality and heavy metal levels in soil and water samples from Omo Forest Reserve and discovered that the reserve was polluted by human activities. Omorogieva *et al.*, (2016) investigated the soil and water quality in two suburbs of Benin City, Nigeria, and their findings shows that the water was contaminated by leachate from a nearby landfill and the soil was porous and unconfined. Kliest *et al.,* (1989) examined the influence of soil contamination by volatile organic compound, their result shows that contamination affected indoor air quality. Famuyiwa *et al.,* (2018) researches dwell on the level of Potentially Toxic Elements (PTEs) in soil samples from different land use types in Lagos, Nigeria, and their findings shows that the PTEs were higher in industrial and dump sites than in other areas.

In addition, researchers have carried out urbanization relationship with environmental pollution and contamination either air, water or soil, some of these researchers are; Bulent, (2020) whose research focused on the use of remote sensing and multivariate statistics to examine the water quality and its influencing factors in different watersheds and riparian areas; Camera *et al.,* (2019) reviewed the effects of land use on water quality in Malaysia and found that agriculture, forestry, and urbanization were the main sources of pollution; Also, Hassan-Rashid *et al.,* (2018) used interviews to study the effects of urbanization on water quality, scarcity, and pollution in Pakistan and recommended self-awareness as a remedy; Shaharoona *et al.,* (2019) research focused on survey and analysis of the soil and groundwater quality in Oman, and the public awareness of the impact of urbanization on them; Mahmood *et al.,* (2019) conducted an econometric analysis of the factors influencing CO_2 emissions in Saudi Arabia, and the policy implications for reducing them; while Ohwo and Abotutu, (2015) did a comprehensive review of the various environmental problems caused by urbanization, especially in the Niger Delta region of Nigeria.

Therefore, the review literatures confirmed that remote sensing and geographical information systems can be used to map urban growth. It also confirms that microbiological techniques can be used to quantify soil, and water contamination as well as air pollution. However, no study was found that has actually quantified well water and soil contamination as well as air pollution simultaneously in assessing environmental impact of urban growth particularly in the study area. Therefore, this research filled this gap by quantifying soil and well water contamination and air pollution concurrently through geospatial data analysis and microbiological techniques.

3.0 Materials & methods

3.1 Study Area

The research was conducted in Akure South, which is part of the Local Government Areas (LGAs) in Ondo State, located in the central senatorial district. It covers an area of 331 square kilometers

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 4, Issue No. 1, pp 1 – 23, 2024

and is situated in Akure (Figure 1), the state capital, between latitudes 7° 5′ 0 " and 7° 20′ 0 " North of the Equator and longitudes 5° 5′ 0 " and 5° 20′ 0 " East of the Greenwich Meridian, with an elevation of approximately 250 meters above sea level. The neighboring LGAs are Akure North to the northeast, Ifedore to the northwest, and Idanre to the south. The selected study sites for the research, are; Adofure, Oda, Ipinsa, Aiyelaboro/Adejubu, and Akure township which serves as representatives of various geographical zones within Akure South. Ipinsa, located at the north, Aiyelaboro/Adejubu at the south, and Adofure at the west, while Oda and Akure township were at east and center respectively. The population of Akure South was 353,211 in 2006, but it has grown to 691,000 in 2021, with an annual growth rate of 3.90%, and is projected to reach 517, 421 in 2023. The study area experiences rainfall almost every month of the year, with heavy downpours during the rainy season and lighter downpours during the dry season, due to its location in the tropical rainforest ecological zone of Nigeria. The temperature that range throughout the year is from 65.0 to 88.0 °F, while the mean annual relative humidity is 77.1%. Similarly, the precipitation varies by 228mm or 9 inches between the driest and wettest months of the year.

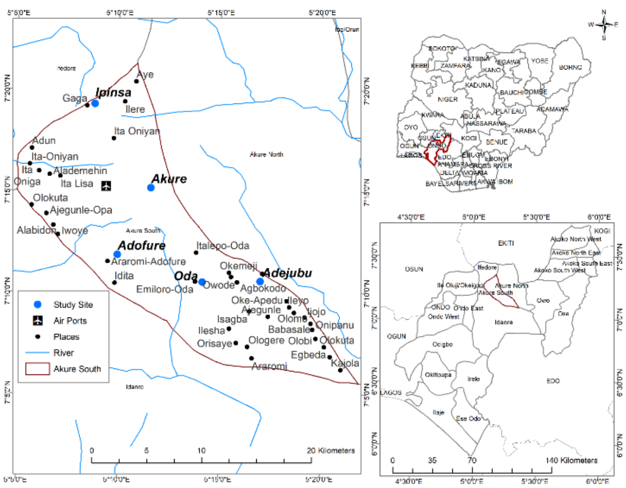

Figure 1: Study Area

3.2 Data Collection and Processing

The flowchart of the research methodology is as shown in Figure 2

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ISSN 2789-3863 (Online)
Vol. 4, Issue No. 1, pp 1 – 23, 2024

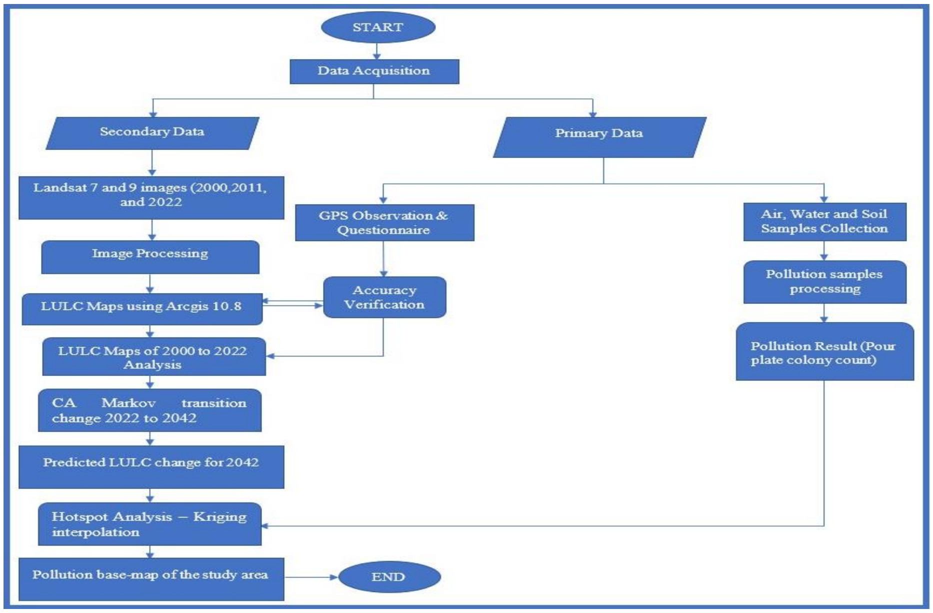

Figure 2: Flowchart framework of research methodology

In this research, an all-inclusive data collection approach was undertaken, incorporating both primary and secondary sources to construct a detailed understanding of the study area. Field observations played a critical role, with the collection of ground coordinates and environmental samples using the Galaxy G1 GPS, petri dishes, and universal bottles. These tools were essential in precisely determining the locations for soil, air, and water sample collection and ensuring the accuracy of these samples for a thorough analysis of environmental conditions. Parallel to these measurements, was a well-structured questionnaire distributed among the residents of selected communities, including household heads, youths, adults, and traders. This survey aimed at gathering insights into the demographic profiles and perceptions of environmental pollution from the community members, thereby adding a qualitative dimension to the study. The data collection was supported by a combination of hardware and software tools. The study focused on five strategically selected communities within Akure South Local Government Area, chosen through a simple random sampling technique. This selection was informed by population data from the National Population Commission, which was projected from 1991 to 2023. A diverse sampling frame was established, encompassing house owners, traders, students, and adults, to ensure a wide range of perspectives. The sample size for the study was determined using Yamane's formula (1967), taking into account the total population of 517, 421 from the selected localities (N) and the desired level of error margin (e), typically set at 5%. The formula used was:

Sample size (n) = N/ [{1 + N(e)^2}] ………………………………………………Equation 1

For research population of 517,421,

$$n = \frac{517{,}421}{1 + 517{,}421(0.05)^2}$$

$$\frac{517{,}421}{1294.5525} = 399.67$$

Thus, the sample size computed by equation 1 was 400 and distributed proportionally according to the population value contributed by each locality selected for this research to the research population.

This method ensured a representative sample from the community, capturing a broad spectrum of views and experiences. A multi-stage sampling method was employed to refine the selection process, focusing on specific localities within the local government area. This approach was critical in gaining a inclusive understanding of the demographic and environmental dynamics of the study area. The primary research was integral to collecting data on environmental attitudes and demographics. Secondary data played a significant role, with the use of Landsat Enhanced Thematic Mapper Plus (ETM+) imageries for 2000 and 2011, and Landsat OLI-2/TIRS-2 for 2022, sourced from the United States Geological Survey at 30m resolution, supplemented by Google Earth Imagery. This combination provided a macroscopic view of the environmental evolution over time.

An extensive approach was taken to process both primary and secondary data. Specifically, ArcGIS 10.8 was used in processing satellite imagery, providing a visual representation of the study area over time while the modeling urban growth rates and predicting changes up to 2022, TERRSET software was instrumental. SPSS was deployed for a comprehensive statistical analysis of the questionnaire responses, adding quantitative rigor to the collected data. The Satellite image processing involved identification of band combinations, creation of image composites, and clipping to focus on the study area within the Landsat Imagery. Supervised classification techniques were applied to categorize land cover types (Figure 3), using training sites to generate spectral signature files and employing the maximum likelihood method for classification (Table I).

Table I

Supervised Classification

CLASS NUMBER	COLOR	LAND COVER
1	Red	Vegetation
2	Light Red	Light Vegetation
3	Dark Brown	Rock Outcrop
4	Cyan Blue	Built up Area

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Vol. 4, Issue No. 1, pp 1 – 23, 2024
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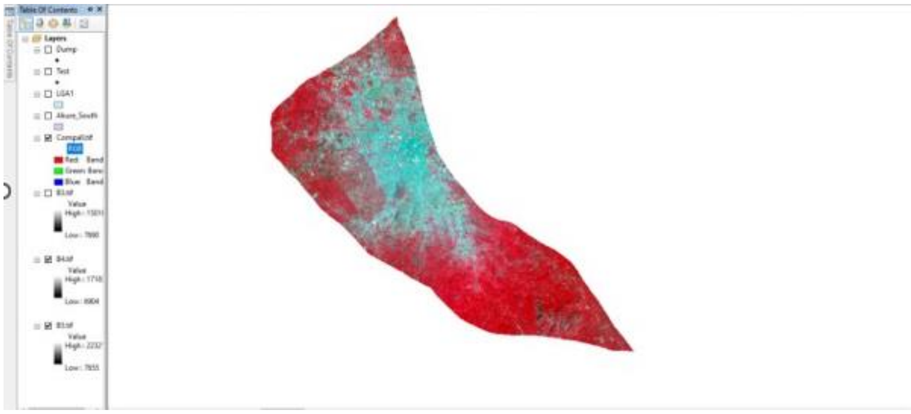

Figure 3: Supervised Classification

An accuracy assessment was performed to validate the classified imagery against ground truth data, involving calculations of overall accuracy, user accuracy, producer accuracy, and the Kappa coefficient. The statistical analysis of the survey data utilized Pearson's chi-square test, coded and analyzed using SPSS, to explore relationships between demographic and environmental factors. Hotspot analysis and Kriging interpolation were used to identify spatial clusters and predict unknown values for geographic point data in pollution studies. Land change was modeled using TERRSET software while employing the Land Change Modeler and Markov chain analysis was used to predict future land cover changes for the year 2042. Contamination tests for soil, water, and air quality was determined. This involved collecting samples in sterilized bottles and petri dishes, followed by laboratory analysis to assess microbial growth. Materials and culture media were thoroughly sterilized, and the pour plate method was used for culturing, with subsequent colony counting to analyze contamination and levels.

Maintaining data quality was a crucial aspect of the research. For the Landsat data, a classification accuracy assessment was conducted to validate the reliability of the imagery. The GPS's precision in mapping pollution sites was vital in ensuring the accuracy of the environmental samples. A pilot test of the questionnaire was also performed prior to its distribution, which helped refine its design and enhance its effectiveness in eliciting meaningful responses.

3.2.1 **Land Use Land Cover Change Modelling**

The Land Change Modeler (LCM), an integrated software within IDRIS, was used along with the Markov tool to predict land cover changes based on Land Cover maps from 2011 and 2022. To achieve this, the shapefile of land cover maps for the years 2011 and 2022 were obtained. TERRSET software was launched and the Land Change Modeler (LCM) tool within the IDRIS interface was selected. The Markov tool settings within the Land Change Modeler (LCM) were configured (20 years was inputted as number of time steps), the convergence criteria and initial transition probabilities and other relevant settings were done. Land cover maps from 2011 and 2022 were inputted as the base map for analysis. Thereafter, Markov chain tool, was clicked on and transition potential files were generated to define the likelihood of transitioning from one land type class to another. The composite map was divided into discrete classes representing different levels of transition suitability and the class boundaries based on the suitability values in the analysis were defined. Each location in the composite map were assigned to the appropriate class. The projection date was set to 2042 to forecast the land cover conditions for that year, and then Cellular Automata Markov tool within LCM based on University of Bristol (2012) formula (equation 2) was then selected to predict land cover changes.

$X(t+1) = F(X(t), P)$ ………………………………………………Equation 2

Where:

$X(t+1)$ represents the predicted land cover distribution for the next time step

$X(t)$ represents the current land cover distribution

F is the cellular automata rule that defines the local transition rules governing land cover changes based on the neighboring cell's states.

P is the Markov chain transition probability matrix that represents the likelihood of transitioning from one land cover class to another over a specific time period.

The Cellular Automata Markov (CAM) component of LCM iterates this formula for each cell of the study area, considering the transition potentials and rules, to simulate the future land cover changes (2042) based on initial land cover conditions (2011 and 2022).

4.0 Result and Discussion

The analysis of the result is categorized into five sections viz: the land cover changes, the spatial extent of urban growth, Land Use/Land Cover Accuracy Assessment Classification, hotspot analysis, and Prediction of Land use/Land Cover Changes based on Land Change Modeler (LCM)

4.1 Analysis of Land Cover Changes

The land cover changes in Akure South Local Government Area from 2000 to 2022, as depicted in Figure 4, provide insight into the region's evolving landscape in response to urban development and agricultural practices. In 2000, the area was predominantly covered by natural vegetation which signify forest, making up 56.60% of the land, with light vegetation signifying agricultural land comprising 31.54%, built-up environment at 9.31%, and rock outcrop at 2.55%. By 2011, there was a noticeable shift in this distribution. The built-up environment had expanded to 17.45%, a clear indicator of the growing urban footprint in the region. This expansion led to a decrease in vegetation cover to 55.39% and light vegetation to 22.56%, while rock outcrop increased to 4.60%. The reduction in vegetation can largely be attributed to the study area's rapid urbanization. As Akure South developed, forests and other vegetated lands were cleared for residential, commercial, and infrastructural developments, leading to a decrease in green spaces. This trend is consistent

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ISSN 2789-3863 (Online)
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with urban studies documenting the impact of urban expansion on natural vegetation (Ibilewa *et al*., 2021; Oyinloye, 2013).

The decrease in light vegetation signifying agricultural land in 2011 was similarly linked to urbanization. As the demand for land for housing and infrastructure grew, areas previously dedicated to agriculture were repurposed. However, by 2022, there was an observable increase in light vegetation to 27.37%. This resurgence might be attributed to several factors, including shifts towards more intensive or commercial farming practices, possibly driven by policy initiatives promoting agriculture, economic incentives, and the adoption of modern farming techniques. Studies support this observation, indicating a potential shift towards more productive farming practices by 2021 include the researches by Oparinde *et al.,* (2020) and Aliyu *et al.,* (2020). Furthermore, the built-up environment continued its expansion by 2022, covering 29.54% of the land, while vegetation, signifying forest further decreased to 36.74%. These changes highlight the ongoing urbanization and population growth in Akure South, leading to increased pressure on resources such as water, energy (electricity and power supply), and other public services. The evolving land cover pattern reflects the dynamic interaction between urban development and land use, where initial urban expansion led to a reduction in natural and agricultural lands, followed by a recovery in agriculture as part of the region's adaptive response to socio-economic changes. Overall, the observed land cover changes in Akure South from 2000 to 2022 depict a region grappling with the dual demands of urban development and agricultural sustainability. This highlights the need for balanced land use policies and practices to ensure sustainable development while preserving natural and agricultural landscapes.

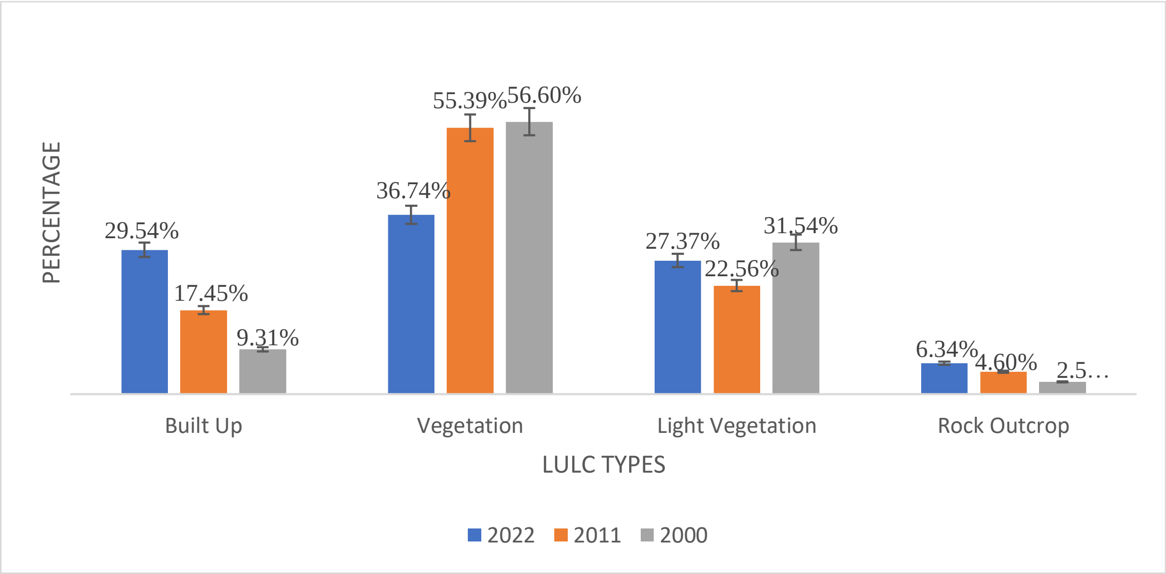

Figure 4: Area Coverage of LULC types in percentage for 2000, 2011 & 2022

4.2 Spatial Extent of Urban Growth

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ISSN 2789-3863 (Online)
Vol. 4, Issue No. 1, pp 1 – 23, 2024
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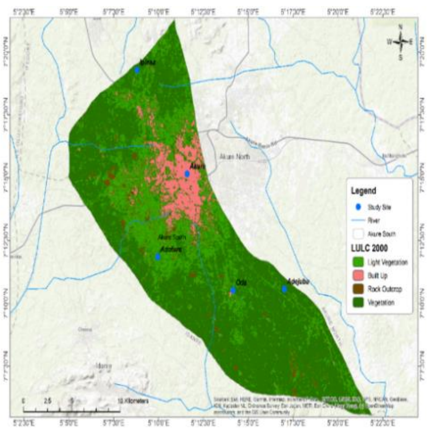
The land use and land cover map of Akure South Local Government Area illustrated in Figure 5a,5b, and 5c, vividly showcase the spatial extent of urban growth over a period spanning from 2000 to 2022. The map reveals the distribution of various land cover classes, including built-up areas, vegetation, light vegetation, and rock outcrops, and how these have transformed over time. The chart specifically details the growth of built-up areas, quantifying this expansion as an increase from 9.31% in 2000 to 17.45% in 2011, and a substantial rise to 29.54% by 2022. The northward growth, as depicted on the map (Figure 5c), can be attributed to several factors. The availability of developable land in the northern parts of Akure South likely made it a prime target for urban development. This area may have been more conducive to construction due to gentler topography, fewer environmental restrictions, and potential for infrastructural developments that often guide the direction of urban sprawl. The map suggests that new settlements and infrastructures have progressively been established in the north, consuming the vegetation and agricultural lands that once characterized the study are in line with Owoeye (2019). This trend of urban expansion in the northern direction has profound implications. It indicates a shift in land use from more sustainable, green spaces to concrete-dominated landscapes. This transition affects biodiversity, alters hydrological patterns, and reduces the land available for agriculture, thereby impacting food security. As the built-up areas extend, they demand more resources and services, potentially straining the capacity of local ecosystems and infrastructure. The increase in impervious surfaces also leads to higher runoff and lower groundwater recharge, which can exacerbate water scarcity issues.



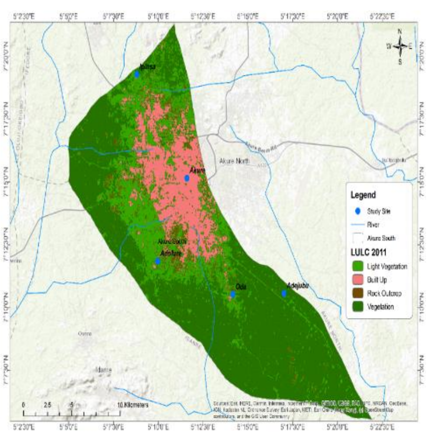


Figure 5a: Land Cover of 2000   Figure 5b: Land Cover Map of 2011

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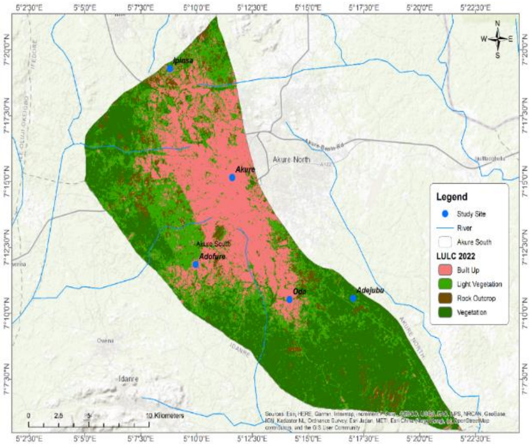

Figure 5c: Land Cover Map of 2022

Furthermore, the chart presents a clear visual representation of the urban growth trajectory, providing a quantitative backing to the qualitative observations from the land cover map. Together, they offer a comprehensive overview of Akure South's changing landscape, serving as a basis for discussions on urban planning, sustainability, and the need for policies that balance development with environmental conservation. The visual data underlines the importance of strategic planning to manage urban growth, especially in directions that could potentially threaten the region's ecological balance and agricultural productivity.

4.3 Land Use/Land Cover Accuracy Assessment Classification

The Land Use/Land Cover (LULC) classification for Akure South Local Government Area in 2000, 2011, and 2022 shows high accuracy levels, as indicated by Overall Accuracy rates of 82.2%, 78.0%, and 81.7%, respectively, and Kappa Coefficients of 0.76, 0.71, and 0.76 for all the years first indicated. These metrics demonstrate a substantial agreement between classified images and ground truth data. User’s Accuracy and Producer’s Accuracy further confirm the reliability of classification for each land cover class. For instance, in 2022, Built-Up areas had a User’s Accuracy of 95% and a Producer’s Accuracy of 70.37%. The Classification Evaluation, including Spatial Index Value (SIV), Class Index Value (CIV), and Classification Precision (CP), also illustrates the effectiveness of the classification process. These values provide insights into the spatial distribution and accuracy of each class. For example, the SIV for Built Up areas in 2022 was 1.35, indicating a higher spatial extent compared to other classes. Overall, the combination of accuracy measures and classification evaluation metrics underlines the robustness of the LULC classification, essential for understanding land cover dynamics and urban expansion in Akure South

4.3 Hotspot Analysis

The results of the hot spot analysis for soil and water contamination as well as air pollution are depicted in Figures 7a, 7b, and 7c. The areas with cold spots signify areas where contamination

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ISSN 2789-3863 (Online)
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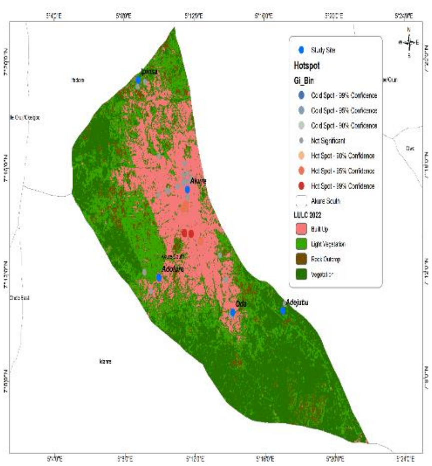
and pollution level are minimal. These locations are Ipinsa, Aiyelaboro/Adejubu, Oda, and Adofure. Similarly, the Hotspots are the locations where contamination and pollution level are very high which makes it dangerous for the residents of the area. The identified Hotspot area in the study area is located in Akure township. It was observed that this area has a high presence of dumpsites, some of which are located very close to residential and commercial areas. The major factor responsible for this is urban expansion, particularly in Akure township, where there are more commercial centers, schools, residential areas, business hubs, and markets, as observed during the research field work.



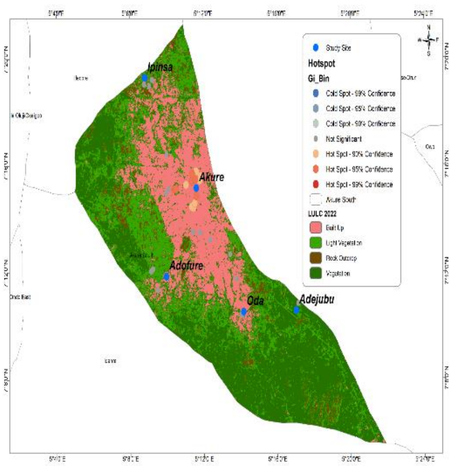


Figure 7a: Hotspot for Land Figure 7b: Hotspot for Water

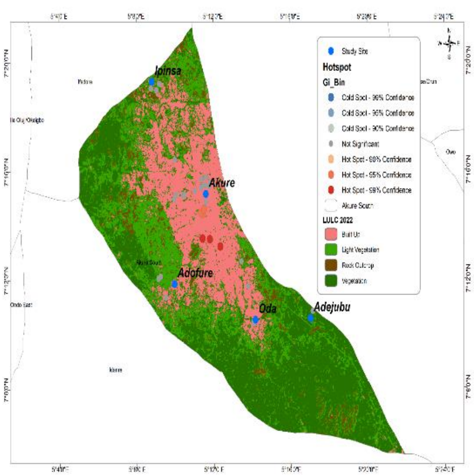


Figure 7c: Hotspot Analysis for Air

Additionally, the surroundings of the residential areas in the study area are littered with refuse and sewage waste, and roadside dumping is also common as shown in plate 1. This result is similar to Shaharoona *et al.*, (2019) findings, that residents are not mindful of the adverse effects their actions have on the soil and environment.

The pollution resulting from these activities exert a profound impact on the environment and, most importantly, the health of residents in the study area. This can lead to negative health outcomes such as

malaria, skin irritation, and other related health problems.

Plate 1: Pictures of dumpsites in Akure township

The spread of soil and water contamination as well as air pollution are depicted in figures 8a, 8b, and 8c. Very low-density spread indicates that the contamination and pollution level is minimal, this is because of low population density and considerable amount of vegetation in these areas. These areas are Adejubu, Ipinsa, and Oda. Significantly too, high-density spread indicates that the contamination and pollution level is high such as Adofure due to the high population of worshippers at CAC Prayer Center (Church) without adequate sanitary and environmental cleanness. Akure township connotes the hotspot as it indicates a very high density of contamination and pollution spread. This is as a result of high population density leading to overcrowding, accumulation of waste, dumpsites as shown in figure 6 putting residents at a high risk of contracting diseases due to soil, water, and air contamination. To address the environmental impact of urbanization, the government of Ondo State should take measures to reduce pollution levels.

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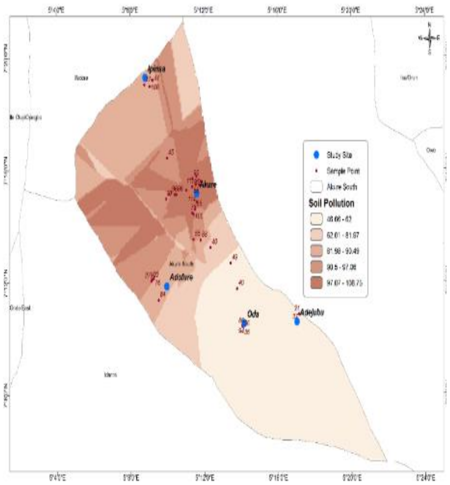

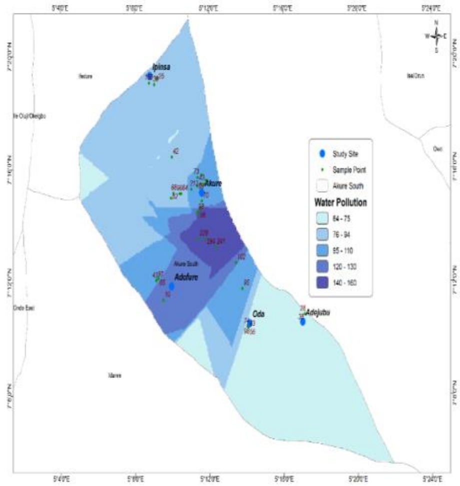

Figure 8a: Soil Contamination Map   Figure 8b: Water Contamination Map

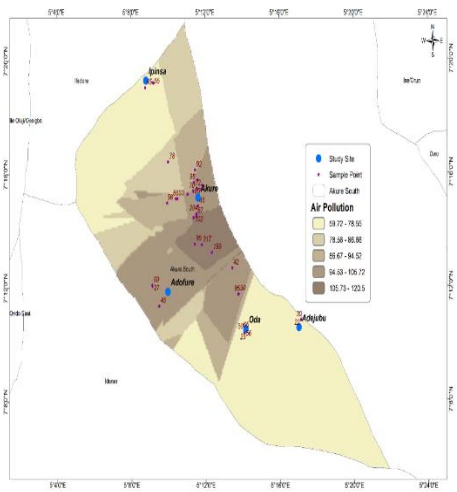

Figure 8c: Air Pollution Risk Map

4.3 Prediction of Land use/Land Cover Changes Based on Land Change Modeler (LCM)

The predicted land cover distribution for the next time step (2042) (X(t+1) was calculated by applying the cellular automata rule (F), as shown in (equation 2) to determine the current land cover distributions (2011 &2022) (X(t)) and considering the Markov chain transition probabilities (P) given in the table II

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 4, Issue No. 1, pp 1 – 23, 2024
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Table II:

Chain Transition Probabilities.

CLASS	Cl. 1	Cl. 2	Cl. 3	Cl. 4
Class 1	0.9181	0.0015	0.0584	0.0220
Class 2	0.0037	0.7076	0.2482	0.0404
Class 3	0.3086	0.0546	0.5283	0.1085
Class 4	0.5279	0.0269	0.1989	0.2464

Source: Author's Data Analysis

The future changes on each land cover types based on the analyzed data of previous years were determined using equation 3 by Ijaware and Titilade (2022).

Changes=$\frac{\text{Changes between 2011 and 2022}}{Time\ differences\ between\ 2011\ and\ 2022}\ Time\ differences\ between\ 2022\ and\ 2042$ … …..Equation 3

According to the changes between 2011 and 2022 as shown in Table III, built up environment had an increase of 4135.15 hectares, vegetation had decreased drastically to 5997.33 hectares, light vegetation (Agriculture) increased by 1716.93 hectares and rock outcrop increased by 607.32 hectares between those years. The projected land cover area of the study area for year 2042 shows that built up area will occupy an area of 12947.64ha (39.09%), Vegetation will occupy 9171.45ha (27.69%), Light vegetation will occupy an area of 8793.39ha (26.56%) while Rock outcrop will occupy an area of 2208.99ha (6.67%) of the study area. The implication of this is that there may likely be a significant increase in the built-up environment which can be a result of increase in population, and socio-economic activities while there would be a likely decrease in vegetation which can lead to alteration of landcover. It is also likely green areas are converted to urban areas.

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 4, Issue No. 1, pp 1 – 23, 2024
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Table III:

Projected land use/land cover of the study area for 2042

CLASS	2011 (ha)	2022 (ha)	2011 to 2022 (11 years) (ha)	Calculated Area (Year 2042) (ha)	Predicted Area (2042) (ha)	
Built Up	5773.14	9908.28	4135.14	7518.44	12947.64	39.09 %
Vegetation	18320.58	12323.25	5997.33	10904.24	9171.45	27.69%
Light Vegetation	7461.54	9178.47	1716.93	3121.69	8793.39	26.56%
Rock Outcrop	1520.37	2127.69	607.32	1104.22	2208.99	6.67%
TOTAL	**33075.63**	**33537.69**	**12456.72**	**22648.59**		

The prediction as shown in Figure 9 revealed that there is a decrease in vegetation and light vegetation, signifies a decrease in forest and agriculture. This decrease according to this research could be a result of the increase in built-up in the study area. These findings are consistent with previous studies by Owoeye (2019) and Oyinloye (2013) on the dynamics of urban growth in Akure and the depletion of agricultural land use

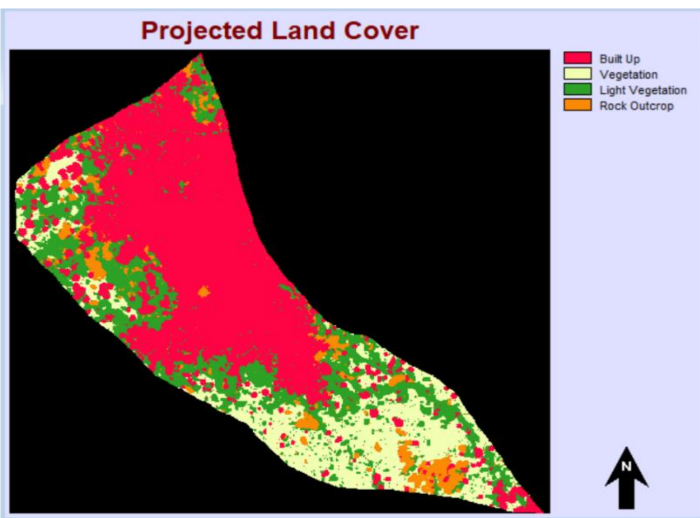

Figure 9: Predicted Land Cover Map in Akure South for the year 2042

5.0 Conclusion

This research provides an understanding of the spatial patterns of urban growth and microbial pollution in Akure South Local Government Area (LGA) through the use of remote sensing, GIS and microbiological techniques. It contributes to knowledge on the extent and severity of air pollution as well as water and soil contamination in Akure South Local Government Area (LGA). According to the Land Use/ Land Cover (LULC) analysis of the study area, there was an increase in the spatial extent of Akure South Local Government Area (LGA) between the year 2000 and the year 2022, the increase population was majorly felt in Akure township, which is the major urban center in the study area. This aligns with Olamiju *et al.*, (2018) findings that there is a rapid expansion of built-up area in Akure. Also, the increase in built up area signifies a transition in land cover and as well utilization of land over the years which invariably resulted to alteration in the land use and in the land cover of the study area. This finding is consistent with Owoeye and Akinluyi (2018), that the unguided urban growth affects the land use pattern of the study area. Additionally, evaluation of the impact of urban growth on well water and soil contamination as well as air pollution, shows that environmental pollution such as air pollution as well as water and land contamination might be caused by urban growth. The increasing urban population has resulted in unsanitary living conditions, polluted air, garbage-filled streets, and dumpsites, as highlighted by Daramola and Ibem (2010), with implications for the health of the study population.

6.0 Recommendation

The study recommends the following:

i. The government should improve waste management practices and restrict illegal disposal and dumping of waste in public places.

ii. There is a need for stakeholders and policy makers in the urban planning sector to logically plan and coordinate the urban expansion and to address environmental pollution as the crucial problem impacted by urban growth in the study area

iii. Additionally, researchers should regularly review the impact of urban expansion on environmental degradation, including trends in air pollution, soil and water contamination.

Acknowledgement

The authors, acknowledge the assistance provided by Mr. B. Jauro and Mr. A. D. Morakinyo during the field work, as well as the resources and facilities provided under the administration of the Federal University of Technology Akure, Nigeria. Without their contributions, this research would not have been possible

References

1. Aliyu, M., Afunwape, M., Arowosegbe, O., and Olusola, O. (2020). Monitoring and forecasting of LULC in Akure rainforest habitat in Nigeria. *Reports on Geodesy and*

Geoinformatics, 110, 29-38. Retrieved December 18, 2023, Available at https://doi.org/10.2478/rgg-2020-0009.

2. Azam, M. & Khan, Q. (2015). Urbanization and Environmental Degradation: Evidence from Four SAARC Countries—Bangladesh, India, Pakistan, and Sri Lanka. *Environmental Progress & Sustainable Energy*, *00*(00), 1-9. Retrieved November 22, 2022, Available at https://doi.org/ 10.1002/ep.12282

3. Armaya'u, U., Zango, Z., Kadir, H. A., & Musawa, S. R. (2020). Assessment of Heavy Metals in Soils samples from Lambun Sarki Irrigation Sites of Kastina Metropolis. *Resources and Environment,* 10(4-9), Retrieved December 24, 2023, Available at SSRN: https://ssrn.com/abstract=3634156

4. Beena, K., & Jaya, D. (2016). Evaluation of soil contamination in the surroundings of Kerala Minerals and Metals Limited (KMML) industrial area in Kollam District, Kerala, South India. *Journal of Soil Sciences and Environmental Management*, 7, 92-99, Retrieved December 24, 2023, Available at https://doi.org/10.5897/JSSEM2015.0533

5. Bulent, K. C. (2020). Assessment of relationship between land use and surface water quality trends within the riparian zone: a case study from Sivas, Turkey. *Desalination and Water Treatment*, *182*, 414-433.Retrieved November 25, 2022, Available at https://doi.org/ 10.5004/dwt.2020.25632.

6. Camara, M. Jamil, R. N. & Bin-Abdullah, A. F. (2019). Impact of land uses on water quality in Malaysia: a review. *Ecological Processes*, *8*(10), 1-10. Retrieved Novemeber 23, 2022. Available at https://doi.org/10.1186/s13717-019-0164-x

7. Daramola, A., & Ibem, E. O. (2010). Urban Environmental Problems in Nigeria: Implications for sustainable development. *Journal of Sustainable Development in Africa*, *12*(1), 124-145.

8. Dyvak, M., Rot, A., Pasichnyk, R., Tymchyshyn, V., Huliiev, N., & Maslyiak, Y. (2021). Monitoring and Mathematical Modeling of Soil and Groundwater Contamination by Harmful Emissions of Nitrogen Dioxide from Motor Vehicles. *Sustainability*, Retrieved December 24, 2023, Available at https://doi.org/10.3390/SU13052768

9. Christian, E., & Beniah, I. (2019). Phytoremediation of Polluted Waterbodies with Aquatic plants: Recent Progress on Heavy Metal and Organic Pollutants. Retrieved December 24, 2023, Available at https://doi.org/10.20944/preprints201909.00

10. Famuyiwa, A., Lanre-Iyanda, Y., & Osifeso, O. (2018). Impact of Land Use on Concentrations of Potentially Toxic Elements in Urban Soils of Lagos, Nigeria. *Journal of Health & Pollution,* 8. Retrieved December 24, 2023, Available at https://doi.org/105696/2156-9614-8.19.180904.

11. Fertner, C., Gertrud, J., Thomas, A.S.N., & Kjell, N. (2016). Urban Sprawl and growth management – drivers, impacts and responses in selected European cities. *Future Cities and Environment*, 2(1). Retrieved December 24, 2023, Available at https://doi.org/10.1186/s40984-016-0022-2

12. Hanberry, B. B. (2023). Urban Land Expansion and Decreased Urban Sprawl at Global, National, and City Scales during 2000 to 2020, *Ecosystem Health and Sustainability*, 9. Retrieved December 24, 2023, Available at https://doi.org/10.34133/ehn.0074

13. Hassan, R. Manzoor, M. & Mukhtar, S. (2018). Urbanization and Its Effects on Water Resources: An Exploratory Analysis. *Asian Journal of Water, Environment and Pollution*, *15*(1), 67-74. Retrieved November 23, 2022, Available at https://DOI:10.3233/AJW-180007

14. Ibelewa, D., Aliyu, M., Alalu, U. O., & Abdulrasheed, T. H. (2021). Urban Growth and Its Impact on Urban Land Cover Change in Akure South Local Government, Ondo State, Nigeria. *Asian Journal of Environment & Ecology*, *16*(4), 32-40. Retrieved February 23, 2022, Avaialble at https://doi.org/10.9734/AJEE/2021/v16i430255.

15. Idayat, O. A. Samuel, S. A. Muibi, K. H. John, O. Alaga, A. T. & Victoria, A. (2016). Urban Growth Analysis in Akure Metropolis. *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH*, *5*(04), 89-93. Retrieved November 5, 2022. Available at http://www.ijstr.org/

16. Ijaware V. A., & Titilade, A. S. (2022). Spatial Assessment of Open Defecation in the Core Area of Akure Metropolis, Ondo State, Nigeria. *African journal of Land Policy and Geospatial Sciences*, 5(4), 683-695, Retrieved December 26, 2023, Available at https://doi.org/10.48346/IMIST.PRSM/ajlp-gs.v5i4.31482.

17. Kliest, J., Fast, T., Boley, J., Wiel, H., & Bloemen, H. (1989). The relationship between soil contaminated with volatile organic compounds and indoor air pollution. *Environment International*, 15, 419-425, Retrieved December 24, 2023, Available at https://doi.org/10.101016/01604120(89)90057-3

18. Komolafe, A. A., Adegboyega, S. A., Anifowose, A.Y., Akinluyi, F. O., & Awoniran, D. R. (2014). Air Pollution and Climate Change in Lagos, Nigeria: Needs for Proactive Approaches to Risk Management and Adaptation. *American Journal of Environmental Sciences*, *10*(4), 412-423. Retrieved November 27, 2022, Available at https://doi.org/10.3844/ajessp.2014.412.423

19. Koko, A. F. Yue, W. Abubakar, G. A. Hamed, R. & Noman Alabsi, A. (2021). Analyzing urban growth and land cover change scenario in Lagos, Nigeria using multi-temporal remote sensing data and GIS to mitigate flooding. *Geomatics, Natural Hazards and*

Risk, 631-652. Retrieved September 23, 2023, Available at https://doi.org/10.1080/19475705.2021.1887940

20. Macrotrends. (2022). *Akure, Nigeria Metro Area Population 1950-2023*. Akure, Nigeria Metro Area Population 1950-2023 - Macrotrends. Retrieved June 29, 2023, from http://www.macrotrends.net

21. Macrotrends. (2022). *Nigeria Population Growth Rate 1950-2022 | MacroTrends*. Macrotrends. Retrieved November 4, 2022, from https://www.macrotrends.net/countries/NGA/nigeria/population-growth-rate

22. Macrotrends LLC. (2022). *Ondo, Nigeria Metro Area Population 1950-2022*. macrotrends. Retrieved October 24, 2022, from https://www.macrotrends.net/cities/22012/ondo/population'>Ondo, Nigeria Metro Area Population 1950-2022.

23. Mahmood, H. Alkhateeb, T. T. & Furqan, M. (2019). Urbanization, Oil Price and Pollution in Saudi Arabia. *International Journal of Energy Economics and Policy*, *10*(2), 477-482. Retrieved October 10, 2022, Available at https://doi.org/10.32479/ijeep.8914

24. Maria, J. A., & Mitchell, A. T. (2018) Built-up expansion between 2001 and 2011 in South America continues well beyond the cities. *Environ. Res. Lett.* (13). Retrieved December 24, 2023, Available at https://doi.org/10.1088/17489326/aad2e3

25. Megahed, Y. Cabral, P. Silva, J. & Caetano, M. (2015). Land Cover Mapping Analysis and Urban Growth Modelling Using Remote Sensing Techniques in Greater Cairo Region—Egypt (w. Kainz, Ed.). *International Journal of Geo-Information*, (4), 1750-1769. Retrieved October 15, 2022, Available at https://doi.org/10.3390/ijgi4031750

26. Nigerian Investment Promotion Commission. (2023). *About Ondo State*. Retrieved January 2, 2023, Available at https://www.nipc.gov.ng/nigeria-states/ondo-state/

27. Ojo, O. O. Shittu, A. A. & Adebolu, T. J. (2019). Landuse Pattern and Landcover of Akure Forest Reserve and Its Environs. *International Journal of Environment and Climate Change*, *9*(12), 852-861. Retrieved Novemeber 28, 2022, Available at https://doi.org/10.9734/IJECC/2019/v9i1230166

28. Omonona, A. O. Ajani, A. F. & Koledoye, O. J. (2019). Heavy metals Contamination in Soil and Water Samples in Omo Forest Reserve, Nigeria. *Africa Journal of Biomedical Research*, *22*, 207-214.Retrieved Novemeber 23, 2022, Available at https://ojshostng.com/index.php/ajbr/article/download/2263/1595

29. Omorogieva, O., Imasuen, O., Isikhueme, M., Ehinlaye, O., Anegbe, B., & Ikponmwen, M. (2016). Hydrogeology and Water Quality Assessment (WQA) of Ikhueniro and Okhuahe Using Water Quality Index (WQI). *Journal of Geography, Environment and*

Earth Science International, 6, 1-10. Retrieved December 24, 2023, Available at https://doi.org/10.9734/JGEESI/2016/25615

30. Olamiju, I. O. Eke, E. E. & Oyinloye, M. A. (2018). Analysis of the urban expansion for the Akure, Ondo State, Nigeria. *International Letters of Social and Humanistic Sciences*, *75*, 41-55. Retrieved February 25, 2022, Available at https://doi.org/10.18052/

31. Oparinde, A., Aturamu, O., Ojo, T., and Kulogun, E. (2020). Agricultural commercialization and food security nexus among maize farming households in Akure South Local Government Area of Ondo State, Nigeria. *Journal of Scientific Research and Reports,* 26(8), 79-87. Retrieved December 18, 2023, Available at https://doi.org/10.9734/jsrr/2020/v26i830297

32. Ohwo, O., and Abotutu, A. (2015). Environmental Impact of Urbanization in Nigeria. *British Journal of Applied Science & Technology*, *9*(3), 212-221. Retrieved October 10, 2022, Available at www.sciencedomain.org

33. Onyenechere, E., Uwazie, U., Elenwo, E., & Ibe, F. (2021). Influence of Urban Informal Activities on Pollutant levels in Water and Soil of Some Cities in Northern Nigeria. *Chemistry Africa*, 1-19. Retrieved at December 24, 2024, Available at https://doi.org/10.1007/s42250-021-00266-4

34. Owoeye, J. O. & Akinluyi, F. O. (2018). Geospatial analysis of land cover change and urban sprawl trend in Akure Region, Nigeria. *MOJ Ecology & Environmental Science*, *3*(1), 26-31. Retrieved November 28 2022, Available at https://doi.org/10.15406/mojes.2018.03.00062

35. Owoeye, J. O. (2019). Accessing Urban Growth Dynamics and Depletion of Agricultural Land Use in Akure Region, Nigeria. *Land Science*, *1*(1), 43. Retrieved November 23, 2022, Available at https://doi.org/10.30560/1s.v1n1p43

36. Oyinloye, M. A. (2013). Geospatial Analysis of Urban Growth–The case of Akure, Nigeria. *American Journal of Social Issues and Humanities.*, *3*(4), 200-212.

37. Patra, S., Sahoo, S., Mishra, P., & Mahapatra, S. C. (2018). Impacts of urbanization on land use /cover changes and its probable implications on local climate and groundwater level. *Journal of Urban Management*, *7*, 70-84. Retrieved October 10, 2022, Available at https://doi.org/10.1016/j.jum.2018.04.006

38. Ritcher, M. S. (2020). Revisiting urban expansion in the continental United States, *Landscape and Urban Planning*, 204, Retrieved December 24, 2023, Available at https://doi.org/10.1016/j.landurbplan.2020.103911

39. Shaharoona, B., Al-Ismaily, S., & Al-Mayahi, A. (2019). The role of urbanization in soil and groundwater contamination by heavy metals and pathogenic bacteria: A case study from Oman. *Heliyon Journal*. https://doi.org/10.1016/j.heliyon.2019.e01771

40. World Bank Group. (2021). *Nigeria: Ensuring Water, Sanitation and Hygiene for all*. The World Bank. Retrieved October 24, 2022, from https://www.worldbank.org/en/news/feature/2021/05/26/nigeria-ensuring-water-sanitation-and-hygiene -for-all

41. Xie, C., Huang, B., Claramunt, C., & Chandramouli, C. (2005). Spatial Logistic Regression and GIS to Model Rural-Urban Land Conversion. *PROCESSUS Second International Colloquium on the Behavioural Foundations of Integrated Land-use and Transportation Model: Frameworks, Models and Applications.* Retrieved February 23, 2022, Available at https://www.researchgate.net/publication/228904456_Spatial_logistic_regression_and_GIS