American Journal of Science and Learning for Development
Volume 5, Issue 3 | July-2026
ISSN: 2835-2157

Article

Effect of Urban Expansion on Air Quality in Uyo Metropolis and Its Environs

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Abstract: This study focused on assessing the effects of urban expansion on air quality in Uyo Metropolis and its environs. To achieve its aim, 20 villages were sampled for the study. Survey design approach was adopted, and study data was from both primary and secondary sources. The data products used were Landsat TM imagery of 1986 and 2023, map of the study area and air quality data. A random sampling technique was used in administering 669 questionnaires to the sampled size in the 20 selected villages. Air quality data were collected in twenty points. The Landsat TM imageries were put into ArcGIS environment for bands composite, ground trothing was also carried out to ensure the accuracy of the data. Digital image analysis was carried out through K-mean unsupervised classification using ArcGIS, and three land cover classes were identified in the study area. The extent and yearly level of change were extracted from the land covers of 1986 and 2023. The findings showed that, there was land cover change with a shift from agriculture (farmland) and natural vegetation to built-up urban areas. The annual change rate was 18.84 km² per year, indicating a rapid urban expansion. The study found three levels of air quality in the study area, which were good, moderate and unhealthy for sensitive group. Population was seen as dominant factor that influenced urban expansion in the study area. Based on these findings it was recommended that sustainable and integrated urban planning that prioritizes green spaces, promotes efficient public transportation, and enforces zoning regulations that control industrial emissions should be adopted and implemented.

Keywords: Urban Expansion, Air Quality, Effect, Urbanization, Population

Citation: Udoibeh, N. J & Ekpo, S. M. Effect of Urban Expansion on Air Quality in Uyo Metropolis and Its Environs. American Journal of Science and Learning for Development 2026, 5(3), 50-63.

Received: 08th Mar 2026
Revised: 21th Apr 2026
Accepted: 02th May 2026
Published: 20th Jun 2026

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1. Introduction

The continuous global growth in population and economy has made the formation of urban agglomerations a defining trend in global urbanization [1]. Controlling and measuring the spread of urban agglomerations remains one of the critical challenges of our time [2]. Urban growth, caused by population increase and economic development has become a defining feature of the world nowadays. As cities continue to expand and evolve, the effects on environmental quality have become increasingly evident. The swift growth of urban areas carries significant consequences for the natural environment, affecting ecosystems, air and water quality as well as biodiversity. Acknowledging the effects of urban spread on environmental quality is essential for designing viable strategies and policies to control negative impacts and create more sustainable urban environments [3].

Urbanization has witnessed unprecedented growth and changes in our environment in the past few years, especially in developing nations. The attractiveness of urban centers for employment opportunities, better infrastructure, and access to services, has triggered a massive movement of people into cities. Consequently, urban areas have expanded horizontally, through the conversion of natural landscapes into built environments, and vertically, with high-rise buildings. This expansion regularly comes at the expense of critical ecosystems, including forests, wetlands, and agricultural lands, which are vital for maintaining environmental balance [4].

One visible outcome of urban expansion on environmental quality is the decline in air quality. Increased industrial activities, vehicle emissions, and the concentration of human settlements in towns than villages contribute to high levels of air pollution. Urban areas often suffer from higher concentrations of particulate matter, chemical oxides, and volatile organic compounds, leading to adverse health effects for residents and contributing to climate change [5].

From the mid-twentieth century upward, the pace of growth in cities across the world rose sharply, mostly in developing nations [6]. This growth brought about series of uncertainties and extensive debates for years to come [7]. Urbanization is considered a core force and stands as one of the foremost challenges confronting global climate change and sustainable development [8].

Over the past fifty decades, developing nations have recorded swift and remarkable growth in urban areas, mostly attributed to industrialization and transformations [9]. The speed of urban growth in African nations confirms the rate of migration from rural regions to cities and a steady natural population rise through increased births. Of the two primary contributors to urban population growth, natural increase plays greater role in some countries, while rural-to-urban migration is more significant in others [10]. It was noted by Cincotta and Engelman (1997) that certain cities are growing at rates two or three times faster than the overall national population, indicating substantial migration into such cities.

Hardly can any Nigerian city be proud of consistent water and electricity supply, affordable housing for all, properly managed waste disposal, adequate healthcare services, or reliable public transportation in place. Rather than providing comfort and serving as centers of civilization, urban centers have become environment marked by hardship [11]. The challenges associated with this form of unplanned urbanization include, high unemployment rates, environmental deterioration, inadequate urban services, poor housing conditions, deteriorating infrastructure, limited access to key resources and elevated levels of social vices [12].

The nature and pace of urbanization in Nigeria have attracted considerable attention [13]. Nigerian cities have expanded significantly with an urban growth rate of over 2% per annum [14]. This has resulted in a swift, largely uncoordinated expansion of Nigerian cities [15]. Most researches have shown how unplanned urban land uses compounded urban ataxia like; air pollution, congestion, urban sprawl and others [16].

Uyo, the administrative capital of Akwa Ibom State in Nigeria, has witnessed considerable urban expansion in recent years. With its burgeoning population, expanding commercial and industrial sectors, and improved transportation networks, Uyo has experienced substantial transformations in its urban fabric. However, the implications of these changes on the city's air quality have not been extensively explored.

Normal air quality is a crucial component of environmental health, contributing to the well-being of urban residents. As urban expansion occurs, the increased emissions from vehicles, industries, and energy consumption can lead to the generation of atmospheric pollutants. Therefore, understanding the effects of urban expansion on air quality in Uyo and its environ is of

paramount importance in designing effective mitigation strategies to safeguard public health and promote sustainable development.

Study Area

Uyo Urban lies within Latitudes 4°50'N and 5°7'N and Longitudes 7°45'E and 8°05'E. It shares boundaries with Ibiono Ibom and Itu local government areas to the north,

Ibesikpo Asutan, Nsit Ibom, and Etinan local governments to the south, Uruan local government area to the east, and Ikono in Uyo local government area to the west [17].

Population

The primary driver of physical expansion in Uyo has been population growth. The city's population rose from 743 persons in 1931 to approximately 74,000 in 1981. According to the 1991 census, Uyo recorded a population of 188,877 persons, and by 2006, this figure had further increased to 436,606 [18].

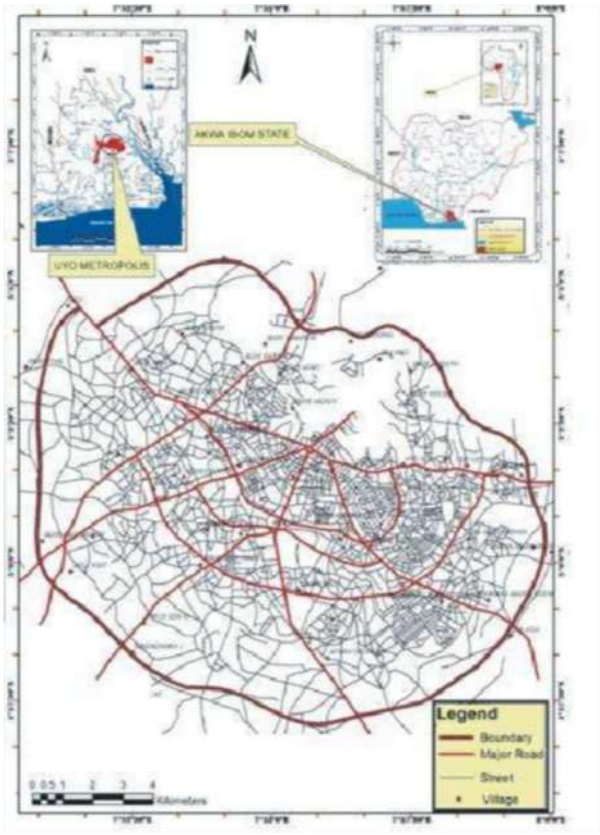

Figure 1: Map of Uyo Metropolis
Source: Ministry of Lands and Town Planning, Akwa Ibom State

Review of Related Literature

Urban expansion denotes the outward growth of cities, mostly involving the change of agricultural or natural green spaces into built-up environments [19]. It is the physical manifestation of urbanization, involving the extension of urban areas into previously non-urban areas through the development of infrastructure, construction of buildings, and the establishment of human settlements [20].

Air quality describes the state of the air in terms of the presence of pollutants, contaminants, and other harmful substances. It is a critical aspect of environmental health, as the quality of the air breathed directly affects human well-being. The sources of air pollution are varied and may be either natural or artificial. Natural sources is through volcanic eruptions, wildfires, and dust

storms, while human-made sources encompass industrial emissions, vehicle exhaust, power generation, and various activities involving the burning of fossil fuels.

Air pollution has harmful effects to human health and brief exposure to polluted air can trigger respiratory problems, aggravate existing conditions such as asthma and allergies, and cause irritation of the eyes, nose, and throat. Prolonged exposure to air pollution has been associated with cardiovascular problems, lung cancer, and death [21].

Rate of Urban Expansion

Urban expansion is a worldwide occurrence marked by the accelerating growth of cities and the encroachment of urban development into adjoining rural landscapes. It refers to the growth of cities in terms of their physical boundaries and population size

[22]. Nigerian towns and cities have grown substantially, with urban growth consistently above two per cent per annum [23]. Tracking the pace of urban expansion is vital for sound urban planning, long-term sustainable development, and addressing environmental degradation. It is a significant global trend driven by population growth, rural-urban migration, economic development and infrastructure investments. The rate of urban expansion has been accelerating over the past few decades, leading to various social, economic, and environmental implications.

Rural-urban migration is another key driver of urban expansion, as people often move from rural areas to cities in search of better living condition. This influx of migrants puts pressure on cities to accommodate the growing population, resulting in an unplanned expansion of urban areas.

Economic development also plays a crucial role in urban expansion. Cities are often centers of economic activity, attracting investment, industries, and businesses.

Infrastructure development is closely linked to urban expansion. The construction of transportation networks, housing, and public utilities contributes to the growth of urban areas. Governments, investors and urban planners invest in infrastructure to support the growing population and meet the demands of urbanization. The speedy rate of urban expansion is associated with both positive and negative consequences. On the positive side, cities offer various benefits such as better job prospects, improved access to education and healthcare, cultural diversity, and enhanced social opportunities. Urban areas can act as engines of economic growth, innovation, and development.

However, rapid urban expansion also poses challenges. It often leads to increased pressure on resources such as potable water, power, and housing. The demand for housing and other infrastructures can outpace supply, leading to housing shortages and informal settlements. Urban expansion can also result in increased pollution, traffic congestion, and strain on public services and utilities. Additionally, it can contribute to the loss of agricultural land and natural habitats [24].

Chen et al.) conducted a comprehensive study on urban expansion patterns and rates in China. Their research focused on the factors influencing the rate of urban expansion, considering population growth, economic development, and government policies. They found that rapid urbanization, driven by industrialization and rural-to-urban migration, caused expansion of cities in China. Their study emphasized the need for proactive urban planning and land management strategies to control the rate of urban expansion and prevent associated environmental degradation [25].

Shalaby and Khattab () focused on the rate of urban expansion in part of the Middle East and North Africa. They explored mostly on the socio-economic and environmental factors influencing urban growth in this specific context. Their study highlighted the role of oil wealth, population growth, and political stability in driving urban expansion in the MENA region. The authors recommended comprehensive urban planning strategies that will addressed social disparities, protect natural resources, and secure sustainable development amid rapid urbanization [26].

Hansen et al.() utilized spatial analysis using remote sensing techniques to assess the universal rate of urban expansion. Their research highlighted the significant increase in urban land cover and the consequent loss of natural ecosystems. The study emphasized the importance of monitoring and managing urban expansion to mitigate its adverse effects on biodiversity, climate change, and ecosystem services. The authors proposed the integration of remote sensing data and spatial planning tools to prove the legitimacy of their findings [27].

Urban expansion is a complex phenomenon influenced by various factors like demographic growth, economic conditions, public policy, and advances in technology. The reviewed literature emphasizes on the need for proactive and sustained urban planning strategies for effective urban expansion management. Inclusive land-use policies, integrated approaches, and the consideration of social, economic, and environmental dimensions are crucial for mitigating the adverse impacts of rapid urbanization and promoting sustainable development [28].

To manage the rate of urban expansion, governments and urban planners need to adopt sustainable and inclusive approaches. This includes comprehensive urban planning, efficient land use policies, investment in infrastructure and public services, promotion of affordable housing, and environmental conservation measures. By addressing these challenges, cities can strive for balanced and sustainable growth while maximizing the benefits of urbanization for their residents [29].

Level of Air Quality

The level of air quality is the degree of pollution, or purity of the air in a particular location. It is typically assessed based on the percentage of pollutants present in the air. Air quality levels are commonly classified into categories or indices to provide information about the overall air quality and potential health impacts. One widely used Air Quality Index (AQI), which provides a standardized measure of air quality and its associated health effects ranging from 0 to 500, with specific breakpoints dividing the range into different categories [30].

Anenberg et al. () focused on the impacts of excess nitrogen oxide discharge from motor vehicles on air quality and its associated health effects. The study quantifies the benefits of implementing mitigation strategies to reduce Nitrogen oxide emissions, emphasizing the importance of controlling pollution sources for improved air quality [31].

Zhou et al. (), focused on urban expansion and its effect on air pollution. Their findings emphasized the association between urban growth and increased levels of air pollutants. like particulate matter, nitrogen dioxide, and volatile organic compounds. They found that the expansion of industrial and transportation infrastructure with changes in land use patterns contributed to elevated pollution levels in urban areas. The authors clamoured for prompt implementing of air quality management strategies, promoting clean technologies, and optimizing urban design to control the side effects of urban expansion on air quality [32].

Urban Expansion and the Effect on Air Quality

Urban expansion as a significant global phenomenon has numerous environmental impacts, including air quality degradation. Over the years, researchers have extensively studied the effects of urban expansion on air quality to understand the complex relationships and develop effective strategies for mitigating the associated problems.

Zhang et al. () examined the correlation between urban expansion and air quality in China using satellite data to quantify urban expansion and analyze its influence on regional air pollution levels. The results highlighted the significant contribution of urban expansion to deteriorating air quality in China [33].

Li et al., () utilized remote sensing and GIS techniques in their findings to measure the influence of urban expansion on air quality. The authors demonstrated the correlation between

urbanization patterns and air pollution levels, advocating for sustainable urban development to mitigate air pollution.

Chen et al. () investigated urban expansion and the impact on air pollution in China, using panel data analysis. The result showed positive correlation between urban expansion and air pollution, emphasizing on the significance of environmental considerations in urban planning and management.

Yu et al., () explored the challenges posed by urban expansion on human health and air quality in Shanghai, the findings revealed negative effects of urbanization on air pollution levels and highlighted the need for effective pollution control strategies to safeguard public health.

Di et al., () investigated in their study, the relationship between air pollution and mortality rates in the Medicare population. The study highlighted the significant health risks posed by air pollution, which can be exacerbated by urban expansion and increased human activities in urban areas.

Seto and Fragkias () specifically addressed the conversion of mangroves to aquaculture ponds, the study highlighted the broader issue of urban expansion and its impact on air quality.

Ramachandra and Shwetmala () discussed the ecological and socio-economic aspects of urbanization, including its influence on air quality. It provided an overview of the impacts of urban expansion on various environmental parameters, advocating for sustainable urban planning to reduce air pollution.

Requia et al., () studied the global correlation between air pollution and cardiovascular disease mortality. While not specifically focused on urban expansion, it underscored the detrimental health effects of air pollution, which is often exacerbated by urbanization and increased human activities in urban areas.

This body of research identifies the key relationship between urban expansion and air quality, particularly in rapidly developing regions like Uyo metropolis. While there is some understanding of the general trends and challenges, significant knowledge gaps remain, particularly in the areas of comprehensive data collection, specific pollutant studies, policy impact assessments, health impact research, and community involvement. Addressing these gaps is essential for prudent management of air quality in Uyo metropolis amidst ongoing urban expansion.

2. Materials and Methods

Survey design method was applied in this study. Information were gathered through interviewing, surveying, and direct observation.

The data for this study were collected primarily using direct field observation and questionnaire. The data comprised information on socio-economic and demographic factors of urban expansion and its consequences. Secondary data were satellite imagery of 1987 and 2023. The sample size used for the study was generated using 'Taro Yamane's formula after population was projected to 2023. Sample size was 669 as was derived through calculation.

Taro Yamane's formula as follows: $n = \frac{N}{1 + N (e)2}$

Where, n = sampled population, N = Population of the study area, e = level of significance (0.05)

1 =is a constant.

$$n = \frac{545745}{1+ 545745 (0.05)2} = \frac{545745}{1+ 545745x\ 0.0025} = \frac{545745}{1+ 814.44} = \frac{545745}{815.44} = 669.26$$

n = 669

3. Results and Discussion

It therefore means that a total of 669 persons were sampled to represent the entire sampled population (545745) under study. The 669 questionnaires were divided into the twenty (20) selected villages. The numbers of respondents in each of the village were calculated based on their population, by dividing each village's population by the total population of all the twenty villages, and then multiplied by the total number of questionnaires (669) (see Table 1). Questionnaires were then administered by the various size of sample population found in each of the villages. A random sample technique was then used in administering the questionnaire in all the villages, to avoid bias and equal opportunity of being selected.

Table 1: Sampled Villages and Population

S/N	Villages	1991 Population	Projected (2023) Population	Sample Population
1	Uyo	86025	221084	454
2	Atan Offot	3387	8704	18
3	Afaha Oku	4127	10,606	22
4	Ndue otung Oku	375	963	2
5	Use Offot	3674	9442	19
6	Nsukara Offot	2566	6594	14
7	Effiat Offot	4179	10,740	22
8	Ikot Akpe	368	945	2
9	Itiam Etoi	3227	8293	17
10	Mbiabong Ikot Antem	1232	3166	7
11	Ifa Atai	2104	5407	11
12	Mbierebe Obio	1350	3469	7
13	Afaha Ube	1770	4548	9
14	Ekit Itam II	1552	3988	8
15	Ikot Ambang	1235	3173	7
16	Mbribit Itam	1110	2852	6
17	Use Ikot Ebio	640	1644	3
18	Ikot Oku Ikono	2122	5453	11
19	Nung Oku	2360	6065	12
20	Aka Offot	3362	8640	18
TOTAL			**325776**	**699**

Source: Researcher's compilation (2023)

Figure 2: Map of Uyo Urban Showing Sampled Villages Source: Author (2023)

The rate of Urban Expansion

The followings were revealed in Table 2, Figure 3, and 4

In 1986, the area covered by built-up structures was 34.452 km², which accounted for 18.41% of the entire landmass. By 2023, the area developed significantly and expanded to 105.9975 km², representing 56.63% of the total land area. This indicates substantial urban expansion and development over the given period. In 1986, farmland covered 97.7823 km², making up 52.3% of all land area. In 2023, the farmland area decreased to 50.3298 km², accounting for 26.89% of the total land area, indicating a decrease in agricultural land as a result of urban expansion.

In 1986, the area covered by vegetation was 54.9189 km², representing 29.3% of the total land area. By 2023, the vegetation area had decreased to 30.8259 km², accounting for 16.47% of the total land area. This indicates a decline in natural vegetation cover, potentially due to urbanization. The total land area remained constant at 187.1532 km² for both 1986 and 2023. The data highlighted the transformation of the landscape, with a shift from agriculture and natural vegetation to built-up metropolis. The major change is the substantial increase in the built-up area, indicating rapid urban growth and development.

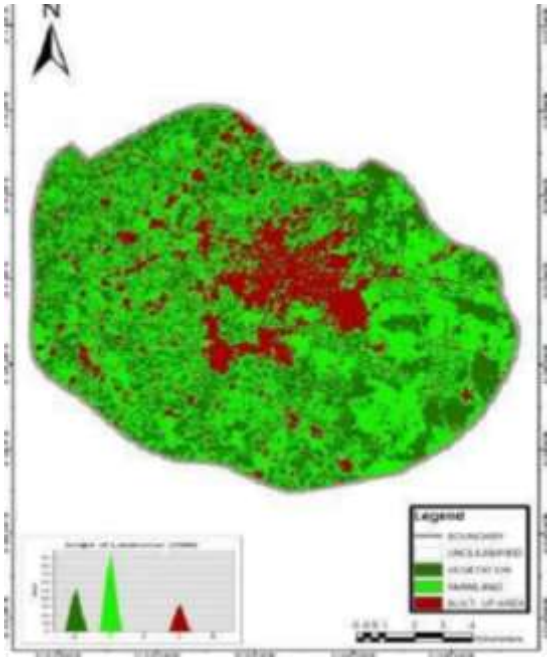

Figure 3: 1986 Land cover Map of Uyo Metropolis Source: USGS (2023)

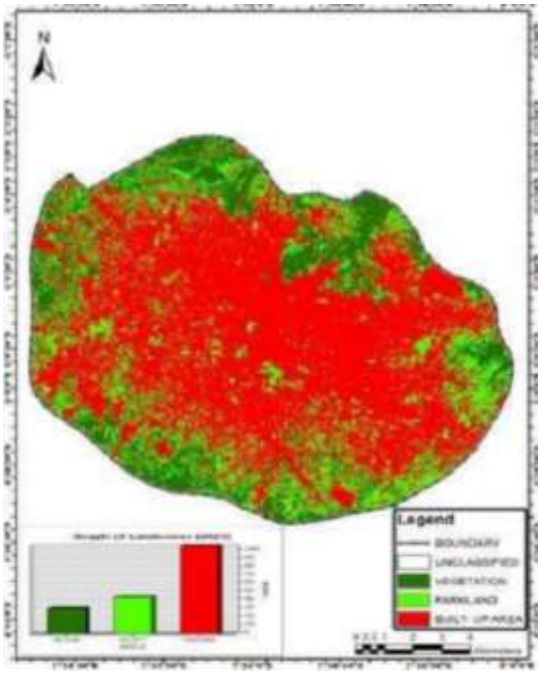

Figure 4: 2023 Land cover Map of Uyo Metropolis Source: USGS (2023)

Table 2. Land Cover Changes (1986 to 2023)

S/N	Landcover Classification	Landcover in 1986 (km²)	Percentage 1986	Landcover 2023 (km²)	Percentage 2023
1.	Built-up Area	34.452	18.41	105.998	56.64
2.	Farm Land	97.782	52.25	50.330	26.89
3.	Vegetation	54.919	29.34	30.826	16.47
Total		187.153	100.00	187.153	100.00

Source: Author's Field Survey, (2023)

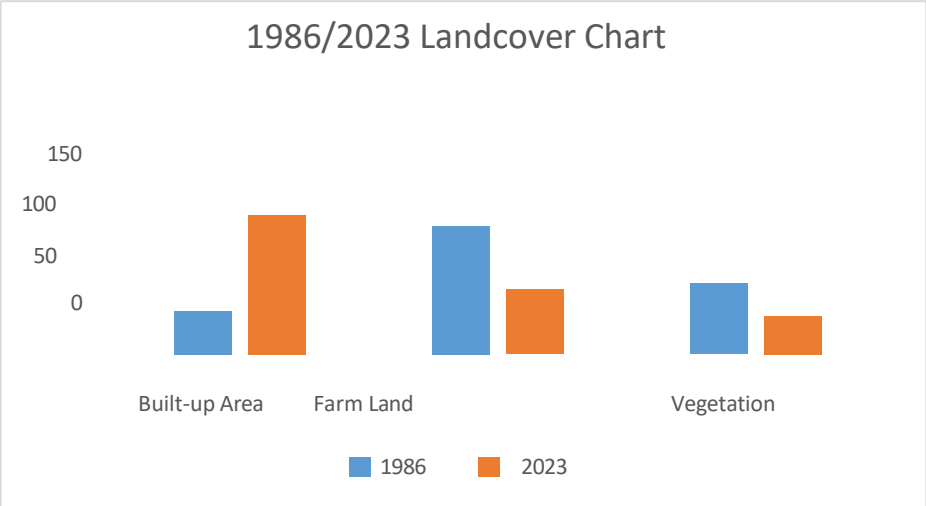

Figure 5: 1986/2023 Landcover Chart

Level of air quality in the study area as was observed and recorded in two(2) days, Mornings and Evenings for comparison.

TABLE 3 DAY ONE (1) (MORNING)

AIR QUALITY AND FIELD METEOROLOGY RECORD

		Morning Air Quality Parameters					Morning Meteorology				
Sample Code	**Sample Points**	**$PM_{2.5}$**	**PM_{10}**	**NO_2**	**SO_2**	**CO**	**Temp. (°C)**	**RH (%)**	**Press. (kpa)**	**WD**	**Wind speed**
AQ1	Ikot Ekpena rd. by Udi str.	100	200	0.05	0. 1	9.0	25	61	1010.7	160 NE	0.3
AQ2	Aka Idak eyop junction	40	90	0.05	0.03	2.0	24	75	1009.6	219 SE	0.43
AQ3	By Ikpa rd traffic light	60	87	0.03	0.04	2.0	23	55	1009.4	40 NE	0.4
AQ4	Uyo village rd. dump site	40	60	0.042	0.04	1.0	24	86	1010.5	48 ENE	025
AQ5	Ring 3 roundabout by Nwaniba	42	93	0.042	0.05	1.0	25	54	1010.8	330 NW	0.5
AQ6	Ekpri Nsukara Junction	86	200	0.03	0.06	6.0	26	53	1010.2	240 SW	0.4
AQ7	By mechanic village	112	97	0.05	0.061	2.0	23	93	1010.4	49 NE	0.93
AQ8	Ikot Akpe market	40	92	0.03	0.05	1.0	24	79	1010.4	67 NW	0.25
AQ9	By 4lanes traffic light	84	81	0.042	0.052	2.0	23	53	1008.8	140 SE	0.4
AQ10	Ring 3 roundabout by Oron Rd.	44	89	0.042	0.06	1.0	24	78	1010.8	8N	0.59
AQ11	Ifa Atai big junction	50	83	0.02	0.05	4.0	24	51.5	1010.3	320 N	0.4
AQ12	Mbierebe junction	38	202	0.01	0.03	3.0	23	53	1008.4	270 W	0.3
AQ13	Itam Junction	120	120	0.05	0.04	6.0	24	78	1010.2	136 SE	0.32
AQ14	AKTC park	48	89	0.01	0.04	2.0	23	79	1010.5	148 SE	0.50
AQ15	Ikot Ambang market	50	180	0.01	0.05	1.0	23	67	1009.2	60 ENE	2.66
AQ16	Idoro rd. by VVF rd.	50	81	0.02	0.06	2.0	24	77	1009.7	177 SE	1.95
AQ17	Pepsi junction By Idoro rd.	40	96	0.01	0.061	4.0	23	53	1010.7	140 SE	0.4
AQ18	Ikot Oku Ikono junction	120	200	0.05	0.05	8.0	25	62	1010.2	90 NE	0.3
AQ19	Nung Oku junction	45	100	0.06	0.052	3.0	24	78	1010.9	170 SE	0.68
AQ20	Aka junction	56	97	0.1	0.03	2.0	24	56.5	1008.4	160 SE	0.4

Source: Author's Field Survey, 2023

TABLE 4 DAY ONE (1) (EVENING)

AIR QUALITY AND FIELD METEOROLOGY RECORD

		Evening Air Quality Parameters							Evening Meteorology		
Sample Code	**Sample Points**	**$PM_{2.5}$**	**PM_{10}**	**NO_2**	**SO_2**	**CO**	**Temp. (°C)**	**RH (%)**	**Press.**	**WD**	**Wind speed**
AQ1	Ikot Ekpena rd. by Udi str.	174	337	0.07	0.2	13.0	30	65	1009.3	40NE	1.32
AQ2	Aka Idak eyop junction	84	162	0.054	0.06	4.0	29	56	1009.9	163 ENE	0.95
AQ3	By Ikpa rd traffic light	72	101	0.08	0.062	4.0	27	60	1009.5	236 SE	0.27
AQ4	Uyo village rd. dump site	56	84	0.052	0.061	3.0	27	61	1009.1	150 N	0.12
AQ5	Ring 3 roundabout by Nwaniba	58	153	0.056	0.072	3.0	27	62	1009.0	82 SW	1.18
AQ6	Ekpri Nsukara Junction	120	246	0.094	0.116	8.0	28	79	1009.5	370NE	0.25
AQ7	By mechanic village	114	131	0.0.6	0.115	4.0	28	77	1009.9	219 SE	0.44
AQ8	Ikot Akpe market	84	100	0.052	0.082	5.0	28	67	1009.2	60 ENE	2.66
AQ9	By 4lanes traffic light	126	139	0.063	0.083	2.0	27	79	1009.8	177 SE	1.94
AQ10	Ring 3 roundabout by Oron Rd.	80	143	0.05	0.092	3.0	28	76	1009.4	88 NE	0.68
AQ11	Ifa Atai big junction	56	83	0.06	0.082	2.0	27	83	1006.3	70 E	0.36
AQ12	Mbierebe junction	61	282	0.054	0.05	1.0	28	80	1006.8	152 SSE	0.52
AQ13	Itam Junction	134	268	0.088	0.062	6.0	28	78	1009.3	370NE	0.24
AQ14	AKTC park	87	187	0.07	0.06	4.0	28	75	1009.6	219 SE	0.43
AQ15	Ikot Ambang market	80	284	0.05	0.072	3.0	27	80	1006.3	70 E	0.36
AQ16	Idoro rd. by VVF rd.	64	91	0.06	0.10	4.0	29	80	1006.8	152 SSE	0.52
AQ17	Pepsi junction by Idoro rd.	56	116	0.062	0.11	6.0	28	74	1006.4	154 WSW	1.18
AQ18	Ikot Oku Ikono junction	136	332	0. 08	0.06	10.0	28	73	1006.4	106 NE	0.44
AQ19	Nung Oku junction	80	118	0.07	0.062	3.0	27	77	1009.7	177 SE	1.95
AQ20	Aka junction	83	125	0.1	0.061	4.0	27	65	1009.3	150 N	0.14

Source: Author's Field Survey, 2023

TABLE 5. DAY TWO (2) (MORNING)

AIR QUALITY AND FIELD METEOROLOGY RECORD

		Morning Air Quality Parameters					Morning Meteorology				
Sample Code	**Sample Points**	**$PM_{2.5}$**	**PM_{10}**	**NO_2**	**SO_2**	**CO**	**Temp. (°C)**	**RH (%)**	**Press. (kpa)**	**WD**	**Wind speed**
AQ1	Ikot Ekpena rd. by Udi str.	$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO	24	63	1010.5	160 NE	0.3
AQ2	Aka Idak eyop junction	110	250	0.06	0.1	10.0	23	75	1009.6	219 SE	0.43
AQ3	By Ikpa rd traffic light	60	100	0.04	0.04	3.0	24	88	1010.4	20 NE	0.68
AQ4	Uyo village rd. dump site	58	85	0.04	0.05	1.0	24	82	1010.5	160 SE	0.18
AQ5	Ring 3 roundabout by Nwaniba	36	65	0.046	0.05	2.0	23	93	1010.4	49 NE	0.93
AQ6	Ekpri Nsukara Junction	38	100	0.049	0.04	1.0	24	87	1010.6	550	0.50
AQ7	By mechanic village	80	220	0.06	0.086	5.0	24	86	1010.5	48 ENE	025
AQ8	Ikot Akpe market	110	98	0.0.42	0.085	2.0	23	93	1010.9	210 SW	0.32
AQ9	By 4lanes traffic light	50	95	0.03	0.06	2.0	23	94	1010.5	300 NW	0.89
AQ10	Ring 3 roundabout by Oron Rd.	86	85	0.035	0.06	2.0	23	92	1010.5	44 NE	1.63
AQ11	Ifa Atai big junction	60	90	0.04	0.07	2.0	24	81	1010.2	157 ENE	0.50
AQ12	Mbierebe junction	46	80	0.042	0.06	3.0	24	80	1010.1	79 NE	0.45
AQ13	Itam Junction	41	210	0.039	0.046	3.0	23	80	1007.3	146 SSE	0.75
AQ14	AKTC park	106	150	0.056	0.054	4.0	24	79	1007.3	210 SSW	0.06
AQ15	Ikot Ambang market	50	95	0.03	0.052	3.0	24	79	1007.5	43 NE	1.12
AQ16	Idoro rd. by VVF rd.	69	200	0.03	0.04	2.0	24	82	1007.8	193 SSW	0.18
AQ17	Pepsi junction By Idoro rd.	45	75	0.04	0.086	2.0	24	83	1007.1	336 SE	1.04
AQ18	Ikot Oku Ikono junction	35	80	0.04	0.04	3.0	25	62	1010.2	90 NE	0.3
AQ19	Nung Oku junction	125	250	0.06	0.05	9.0	24	78	1010.9	170 SE	0.68
AQ20	Aka junction	62	98	0.05	0.05	2.0	24	56.5	1008.4	160 SE	0.4

Source: Author's Field Survey, 2023

TABLE 6 DAY TWO (2) (EVENING)
AIR QUALITY AND FIELD METEOROLOGY RECORD

Sample Code	Sample Points	Evening Air Quality Parameters PM 2.5	PM 10	NO2	S02	CO	Temp. (°C)	RH (%)	Evening Meteorology Press.	WD	Wind speed
AQ1	Ikot Ekpena rd. by Udi str.	PM 2.5	PM 10	NO_2	SO_2	CO	28	78	1009.3	370NE	0.24
AQ2	Aka Idak ayop junction	164	287	0.06	0.2	12.0	28	75	1009.6	219 SE	0.43
AQ3	By Ikpa rd traffic light	64	152	0.044	0.049	3.0	28	76	1009.4	88 NE	0.68
AQ4	Uyo village rd. dump site	74	103	0.07	0.052	5.0	27	77	1009.7	177 SE	1.95
AQ5	Ring 3 roundabout by Nwaniba	60	79	0.048	0.052	2.0	28	67	1009.2	60 ENE	2.66
AQ6	Ekpri Nsukara Junction	62	146	0.049	0.082	3.0	26	83	1013.1	51 SE	1.42
AQ7	By mechanic village	126	244	0.064	0.09	9.0	26	83	1013.6	309 N	0.36
AQ8	Ikot Akpe market	116	130	0.04	0.089	4.0	26	81	1013.2	136 WSW	0.80
AQ9	By 4lanes traffic light	74	97	0.03	0.072	4.0	26	82	1013.0	120 SE	0.12
AQ10	Ring 3 roundabout by Oron Rd.	124	115	0.03	0.074	2.0	27	79	1013.4	15 NNE	0.53
AQ11	Ifa Atai big junction	64	138	0.04	0.082	2.0	26	83	1013.1	51 SE	1.42
AQ12	Mbierebe junction	60	86	0.035	0.072	3.0	28	80	1006.8	152 SSE	0.52
AQ13	Itam Junction	58	98274	0.04	0.04	3.0	28	78	1009.3	370NE	0.24
AQ14	AKTC park	148	238	0.082	0.05	8.0	28	75	1009.8	219 SE	0.43
AQ15	Ikot Ambang market	85	181	0.05	0.05	3.0	27	82	1006.3	70 E	0.36
AQ16	Idoro rd. by VVF rd.	81	264	0.04	0.082	2.0	29	84	1006.8	152 SSE	0.52
AQ17	Pepsi junction by Idoro rd.	69	97	0.04	0.09	4.0	28	74	1006.4	154 WSW	1.18
AQ18	Ikot Oku Ikono junction	61	132	0.05	0.089	7.0	28	73	1006.9	106 NE	0.44
AQ19	Nung Oku junction	131	282	0. 07	0.06	9.0	27	77	1009.6	177 SE	1.95
AQ20	Aka junction	63	120	0.08	0.074	4.0	27	65	1009.3	150 N	0.14

Source: Author's Field Survey, 2023

Level of air quality in the study area

Table 7; carries results of Air Quality Index (AQI) rating for ambient air quality (CO, SO2, NO2, PM_2 and M_{10}) these were calculated with the formula below:

$AQI_{pollutant}$ = pollutant data reading x 100

Standard

It revealed the result of the Air Quality Index rating for ambient air quality. The air quality for particulate matter2.5 across all the sampling locations in the study area were all between good, moderate, and unhealthy for sensitive groups (A, B, and C respectively).

On AQI rating, the air quality for NO_2 for most ofthe sampling locations in the study area was moderate (B) only the Ifa Atai sampling point (Ifa Big Junction) was good (A), while Ikot Oku Ikono, Nung Oku and Nsukara Offot sampling points were unhealthy for sensitive group (C). The CO variation across the sampling points revealed that the air quality was good (A) except in Uyo which was moderate (B).

Table 7: Results of AQI rating for ambient air quality (CO, SO2, NO2, PM_2 and M_{10})

Sampled Code	Sampled village	AIR QUALITY INDEX (AQI) FOR POLLUTANTS PM 2.5	PM 10	NO_2	SO_2	CO
AQ1	Uyo	101.4 (C)	107(C)	100(B)	140 (C)	57 (B)
AQ2	Atan Offot	45.5 (A)	50.5(B)	70 (B)	44.5 (A)	15 (A)
AQ3	Afaha Oku	49.1 (A)	37.4 (A)	91 (B)	51 (B)	16 (A)
AQ4	Ndue otung Oku	35.7 (A)	28.9 (A)	78.3 (B)	52 (B)	11.5 (A)
AQ5	Use Offot	36.8 (A)	49.2(A)	81.6 (B)	61 (B)	11.5 (A)
AQ6	Nsukara Offot	76.5 (B)	92.6(B)	103(C)	88 (B)	34 (A)
AQ7	Effiat Offot	83.7 (B)	45.6 (A)	73 (B)	84 (B)	15 (A)
AQ8	Ikot Akpe	46 (A)	38.4 (A)	76.6 (B)	66 (B)	15 (A)
AQ9	Itiam Etoi	77.7 (B)	39.9 (A)	87.5 (B)	67 (B)	9.5 (A)
AQ10	Mbiabong Ikot Antem	46 (A)	45.64 (A)	60 (B)	76 (B)	11.5 (A)
AQ11	Ifa Atai	39.1 (A)	33 (A)	41.6 (A)	66 (B)	15.5 (A)
AQ12	Mbierebe Obio	36.8 (A)	96.9 (B)	71(B)	89 (B)	17.5 (A)
AQ13	Afaha Ube	94.1 (B)	77.5 (B)	115(C)	81 (B)	29.5 (A)
AQ14	Ekit Itam II	50 (A)	55.3 (B)	66.6 (B)	72 (B)	15 (A)
AQ15	Ikot Ambang	55.4 (B)	92.8 (B)	68 (B)	90 (B)	10.5 (A)
AQ16	Mbribit Itam	42.2 (A)	34.5 (A)	73 (B)	56 (B)	14.5 (A)
AQ17	Use Ikot Ebio	35.7 (A)	42.3 (A)	78.3 (B)	48 (A)	24 (A)
AQ18	Ikot Oku Ikono	94.8 (B)	106.2 (C)	108 (C)	98 (B)	45 (A)
AQ19	Nung Oku	46.1 (A)	43.6 (A)	105 (C)	90 (B)	15.5 (A)
AQ20	Aka Offot	51 (B)	44.4 (A)	58.3 (B)	71 (B)	16.5 (A)

Source: Author's Field Survey, 2023.

4. Conclusion

The study examined the rate of urban expansion in Uyo Metrpolis. The notable change was the increase in built-up area, it had significantly expanded to 105.9975 km², from 34.452 km², representing 56.63% of the total land area, with an annual change rate of 18.84 km2 per year, which shows that the study area is rapidly growing. The direction of change is upward, indicating that over the chosen period, more agricultural land and open spaces has been turned into built-up areas.

In examining the level of air quality, the study found remarkable decline in air quality in Uyo Metropolis as a result of rapid urban expansion. Increased vehicular emissions, commercial activities, and construction dust were observed as primary contributors to air pollution. Three

levels of air quality were identified within the study area, these were good, moderate, and unhealthy for the sensitive group. Spatial variations in air quality were also observed within the study area, with areas closer to major roads and commercial zones experiencing higher levels of air pollution compared to residential areas further away.

The study revealed that population growth, driven by migration and urbanization, is the most influential factor in urban expansion, followed by job opportunities. Availability of natural resources has a smaller impact in comparison.

Conclusion

The study has unequivocally demonstrated that urban expansion in Uyo Metropolis contributed to the deterioration in air quality. As the city expands, increased vehicular traffic, commercial activities, and constructions have polluted the atmosphere, especially the air, through the release of various gasses from motor vehicles. As such, urgent measures are needed to curb the trend.

Recommendations

`To address the pressing issue of declining air quality in Uyo Metropolis, the following recommendations are put forth:

1. Integrated Urban Planning: Uyo Metropolis should adopt integrated urban planning approaches that prioritize green infrastructure, sustainable transportation, and zoning regulations to reduce the side effects of urban expansion on air quality.
2. Air Quality Monitoring: Set up a comprehensive air quality monitoring team across the city to provide up-to-date information and data on air quality.
3. Emission Control Measures: Enforce stricter regulations on vehicle emissions, industrial emissions, and construction activities, accompanied by regular inspections to ensure compliance.
4. Public Awareness Campaigns: Sensitize and educate residents on the need for clean air and need to promote sustainable transportation choices.
5. Continued Research: Encourage ongoing research into the effects of air pollution in Uyo Metropolis and evaluate the effectiveness of implemented interventions to inform adaptive strategies.

By implementing these recommendations, Uyo Metropolis will be arm with resilient strategies of mitigating the adverse effects of urban expansion on air quality, safeguarding the health of its residents, protecting the environment, and ensuring sustainable urban development.

REFERENCES

[1] T. Agbola, "Urbanization, physical planning, and urban development in West Africa," in The Struggle for Land: Indigenous Insight and Industrial Imperatives in Developing Countries, F. N. Ndubisi, Ed. London, UK: Zed Books, 2005, pp. 193–234.

[2] A. Aliyu and L. Amadu, "Urbanization, cities, and health: The challenges to Nigeria – A review," Annals of African Medicine, vol. 16, no. 4, pp. 149–158, 2017.
[3] S. C. Anenberg, J. Miller, R. Minjares, L. Du, D. K. Henze, F. Lacey, and M. Brauer, "Impacts and mitigation of excess diesel-related NOx emissions in 11 major vehicle markets," Nature, vol. 545, no. 7655, pp. 467–471, 2020.
[4] I. M. Asuquo, "Land use detection in Uyo and environs in Akwa Ibom State using remote sensing and GIS (1986–2008)," M.S. thesis, University of Lagos, Lagos, Nigeria, 2010.
[5] G. Chen, Z. Li, L. Chen, and W. Lu, "Impact of urban expansion on air pollution in China: A panel data analysis," Science of the Total Environment, vol. 631–632, pp. 489–498, 2019.
[6] Z. Chen, Y. Zhuang, X. Xue, and Z. Tian, "Impact of urbanization on PM2.5 concentrations: Empirical evidence from 283 cities in China," Environmental Research, vol. 183, Art. no. 109219, 2020.
[7] R. P. Cincotta and R. Engelman, Economics and Rapid Change: The Influence of Population Growth. Washington, DC, USA: Population Action International, 1997.
[8] Cities Alliance, Liveable Cities: The Benefits of Urban Environmental Planning. Washington, DC, USA: Cities Alliance, 2007.
[9] B. Cohen, "Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability," Technology in Society, vol. 28, no. 1–2, pp. 63–80, 2006.
[10] D. Delia, R. Jones, and A. Smith, "The allure of urban centers: The impact of urbanization on natural landscapes," Journal of Urban Development and Environmental Balance, vol. 34, no. 2, pp. 123–145, 2021.
[11] Q. Di, Y. Wang, A. Zanobetti, Y. Wang, P. Koutrakis, C. Choirat, and J. D. Schwartz, "Air pollution and mortality in the Medicare population," New England Journal of Medicine, vol. 376, no. 26, pp. 2513–2522, 2017.
[12] C. D. Elvidge, K. E. Baugh, M. Zhizhin, and F.-C. Hsu, "Why VIIRS data are superior to DMSP for mapping nighttime lights," Proceedings of the Asia-Pacific Advanced Network, vol. 45, pp. 1–13, 2018.
[13] M. C. Hansen, P. V. Potapov, A. H. Pickens, and B. Adusei, "Global mapping of urban expansion using remote sensing and spatial analysis techniques," Remote Sensing of Environment, vol. 232, Art. no. 111261, 2019.
[14] Q. Huang, X. X. Lu, J. M. Sellers, and S. Zhao, "A global comparative analysis of urban form: Applying spatial metrics and remote sensing," Landscape and Urban Planning, vol. 176, pp. 112–125, 2018.
[15] International Human Dimensions Programme on Global Environmental Change (IHDP), Urbanization and Global Environmental Change: Opportunities and Challenges for Sustainability, IHDP Rep. No. 15. Bonn, Germany, 2005.
[16] L. Jiang and B. C. O'Neill, "Global urbanization projections for the shared socioeconomic pathways," Global Environmental Change, vol. 42, pp. 193–199, 2017.
[17] S. Li, Y. He, H. Xu, C. Zhu, B. Dong, Y. Lin, B. Si, J. Deng, and K. Wang, "Impacts of urban expansion forms on ecosystem services in urban agglomerations: A case study of Shanghai–Hangzhou Bay urban agglomeration," Remote Sensing, vol. 13, Art. no. 1908, 2021.
[18] X. Li, Y. Zhang, Y. Liu, L. Zhang, H. Wang, and Y. Xu, "Assessing the impact of urban expansion on air quality using remote sensing and GIS techniques," Environmental Pollution, vol. 278, Art. no. 116840, 2021.
[19] H. Nagendra, X. Bai, E. S. Brondizio, and S. Lwasa, "The urban south and the predicament of global sustainability," Nature Sustainability, vol. 1, no. 7, pp. 341–349, 2018.
[20] National Population Commission (NPC), National Population Census Handbook. Abuja, Nigeria, 2006.
[21] A. G. Onibokun and A. Faniran, Urbanization and Urban Problems in Nigeria. Ibadan, Nigeria: Nigerian Institute of Social and Economic Research (NISER), 2006.
[22] A. O. Oluwakoya, "A comprehensive assessment of transportation emissions in Nigeria: Trends, drivers, and impacts," The Proceedings of the Nigerian Academy of Science, vol. 16, no. 1S, pp. 61–71, 2024.
[23] I. Oyeleye, "Challenges of urbanisation and urban growth in Nigeria," American Journal of Sustainable Cities and Society, vol. 1, no. 2, pp. 235–251, 2013.
[24] T. V. Ramachandra and Shwetmala, "Ecological and socio-economic assessment of urbanization: A case study of Bangalore," Current Science, vol. 97, no. 6, pp. 861–872, 2009.
[25] W. J. Requia, M. D. Adams, A. Arain, S. Papatheodorou, and P. Koutrakis, "Global association of air pollution and cardiovascular disease mortality: A systematic review and meta-analysis," Environment International, vol. 114, pp. 226–239, 2018.
[26] A. Shalaby and M. Khattab, "The rate of urban expansion in the Middle East and North Africa (MENA) region: Socio-economic and environmental influences," Journal of Urban Studies and Planning, vol. 15, no. 4, pp. 321–338, 2020.

[27] United Nations Department of Economic and Social Affairs (UNDESA), World Urbanization Prospects 2018: Highlights. New York, NY, USA: UNDESA, 2019.

[28] United States Environmental Protection Agency (USEPA), Guidelines for Reporting of Daily Air Quality: Air Quality Index (AQI). Washington, DC, USA: U.S. Environmental Protection Agency, 2000.

[29] J. Uyanga, J. Artser, and N. Udoibeh, "Urban governance and infrastructure delivery," in Urban Crises and Management: Sustainable Planning Approaches, J. Uyanga and F. Ekong, Eds. Uyo, Nigeria: Department of Urban and Regional Planning, University of Uyo, 2018, pp. 50–76.

[30] Q. Wu, R. Guo, J. Luo, and C. Chen, "Spatiotemporal evolution and the driving factors of PM2.5 in Chinese urban agglomerations between 2000 and 2017," Ecological Indicators, vol. 125, Art. no. 107491, 2020.

[31] Z. Yu, L. Chen, L. Li, T. Zhang, L. Yuan, R. Liu, Z. Wang, J. Zang, and S. Shi, "Spatiotemporal characterization of the urban expansion patterns in the Yangtze River Delta Region," Remote Sensing, vol. 13, Art. no. 4484, 2021.

[32] C. Zhang, W. Wang, J. Li, J. Zhang, and X. Xu, "Urban expansion and its impact on regional air quality in China," Journal of Cleaner Production, vol. 244, Art. no. 118766, 2020.

[33] Y. Zhou, S. J. Smith, K. Zhao, M. Imhoff, A. Thomson, B. Bond-Lamberty, G. Asrar, X. Zhang, C. He, and C. D. Elvidge, "A global dataset of urban extent from nightlights," Nature Sustainability, vol. 3, no. 8, pp. 647–656, 2020.