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Mapping Spatiotemporal Dynamics of Akure Industrial Layout for Sustainable Development

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ABSTRACT: This research aimed at mapping the spatiotemporal dynamics of the Industrial Layout located in Akure Ondo State Nigeria. The dataset used are the administrative map of Ondo State, Akure Industrial Layout Boundary,various Landsat imageries of 32m resolution which are Thematic Mapper (TM) of 1986 & 1991, Enhanced Thematic Mapper Plus (ETM)+ of 2002, Operational Land Imager / Thermal Infrared Sensor (OLI/TIRS) of 2014, 2017, 2020; and Worldview 3 image 2020 of 1.24m resolution. The Landsat data were used to extract the different Land use/Land cover (LULC) within the study area. GPS receiver and Worldview 3 image were used to obtain the coordinates of the different LULC classes, which aided in the classification of image, and also for accuracy assessment of the classified image. All the Landsat standard data products were processed, to ascertain that they are free of radiometric and geometric errors using the Level 1 Product Generation System (LPGS) and extracted to obtain the landsat image bands. The extracted Landsat images (bands) were used in the processing and calculating the Normalized Difference Vegetation Index (NDVI) and calculation of LULC changes. Evaluation the accuracy of the results produced from the land cover classification was carried out by comparing the results of ground coordinates with the coordinates obtained from a higher resolution image (Worldview 3 image) in order to determine the accuracy of the land cover classification in the study area. The trend of changes of land cover in these areas was assessed and also, the prediction for the future condition both in terms of development was determined based on the results obtained from the initial results. Results from various maps produced and numerical data generated showed that Akure Industrial Layout was mainly dominated by shrub and grass land in 1986 and has in 34 years experienced transformation of 604% in the built environment (18% /year), 119% of Bareland (3.5%/year), and -29% of Grassland (0.9%/year), -66% of Shrub (2%/year). The forecast of the probable spatial extent for the years 2025 and 2030 were estimated to be 175.3Ha and 214.8Ha respectively, which shows there will be a continuous increase in the future development in Akure Industrial layout. The research recommended a proactive action from the government and end-users that will ensure a sustained manageability of the layout.

KEYWORDS: Development, Dynamics, Industrial, Layout, Spatiotemporal

1. INTRODUCTION

Land is fundamental to all economic activities. The supply and employment of land is central to the pattern and process of economic regeneration and restructuring [2]. Traditionally, the land was used mainly for agriculture, but the conversion of land to non-agricultural land use has been on widespread due to wide expansion of urban settlements and the construction of roads and stand-alone industrial sites due to the increase in population and the growth of industrial economy [4,11,14 and 15] observed in their different views that land use is the function or functions that humans apply to the land available to them which have impact directly on our environment. According to [2] and [11], these environmental and human dynamics and their interactions takes place on the land and are mediated by land. They are constantly changing and their changes come with impacts and effects that are sometimes beneficial and most times detrimental to the environment and man [6],[10]. [11], [15] and [16] posited that it is the detrimental effects that have been of concern because of their negative influence on the welfare and well-being of man. Land use / land cover (LULC) has been considered as one of the important bio-physical parameters and have significant effect on local environmental change, particularly increasing anthropogenic temperature [18], [17]. As the impacts of anthropogenic climate change have become

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increasingly evident, the issue of responsibility for these impacts has come to the fore as opined by [6]. Determinants of land use and land cover (LULC) changes according to [14] are important for understanding and formulating urban development policy. These determinants from the view of [6], [8] and [9] also guide government, and other stakeholders in making suitable land development strategies. [4], [13], 15] and [18] unequivocally affirmed that changes in land use and land cover often result in complex interactions of various landscape functions affecting social and economic activities. Therefore, it is expected that different land use changes occur because of different processes of development and are determined by different factors such as favorable socio-economic, political, and physical factors. The prominent urban land uses are residential, commercial, industrial and transportation; and it has been argued that residential takes the largest percentage of about 60% of any urban land use, industrial use has been assigned 10% of the city land use according to [2]. Industrialization in developing countries like Nigeria is a government development policy rooted in both national and regional development plans [2]. [9] and [10] observed over the years, that industrial development has played very important role in the improving the economic condition of the countries across the globe such as: Increase in employment; Raise in standard of living of citizens; Increase in government revenue due to collection of taxes like excise duty and income tax; Increase in social welfare as it increases the revenue of the government which is spent on the welfare of the people; Increase in investment, as industrial development increase the income of the people, and with the rise in income, rate of savings and rate of investment rises, which is compulsory for achieving the rapid growth rate. The revolution in industrialization globally has however caused severe consequences to man and his environment [9]. The impacts of industrialization are key to the development of nations across the globe. Industrialization has contributed greatly to man existence, by offering man high standard of living, solving various technological problems, and enhanced quality of life [10]. But, the negative impacts according to [10],[7] and [8] are very important to be given considerable attention, especially to safeguard the health of the populace from air contaminants like nitrogen oxides, carbon monoxides, sulphur-oxides, and other particulate matter with volatile organic compounds, which are associated with environment effects such as smog, acid rain and regional haze, which can cause health effects like respiration illness to the residents living around the industries . According to [8], the selection of an industrial site involves a complex array of critical factors involving economic, social, technical, and environmental issues, which are important to plan and monitor the industrial process in a systematic manner, and industrial parks are usually located on the edges of, or outside, the main residential area of the city [11,15] in order to reduce environmental impact of industrial land uses, such as air, water and land pollution, leading to illness and loss of life all over the world [5,16]. This study was carried out to investigate the extent of development in the Akure Industrial layout to aid its sustainable manageability.

1.1 The Study Area

Akure Industrial layout is located in the Northern part of Akure South Local Government Area in Ondo State Nigeria (Figure 1). It lies within latitudes and longitudes (7° 17' 24" N, 5° 09' 43"E), (7° 17' 06"N, 5° 10' 39"E), (7° 16' 40" N, 5° 10' 39"E), and (7° 16' 39" N, 5° 09' 54"E).

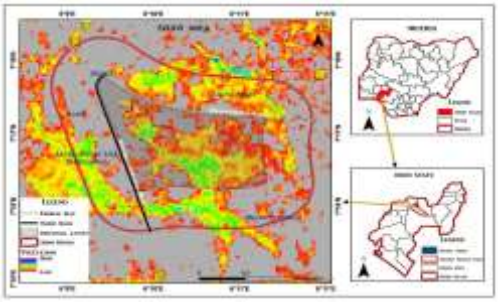

Figure 1: Map of the study area: Nigeria showing Ondo State (with the study area inset)

The study area is bounded by Akure-Ilesha expressway from the North to the East, and also bounded by Olusegun Obasanjo way from the North to the west, with a spatial extent of about 158 hectares. Akure Industrial layout and its environs (500m buffer) has an elevation ranging from 340m to 375m above the mean sea level. The average annual temperature is 25.3°C. The rainy period of the year lasts for 10 months of the years, with an approximate annual rainfall of 1455mm (Climate-Data, 2020).

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2. MATERIALS AND METHODS

Data and materials adopted and used for this research were gathered from disparate sources. The primary data collected were the sample/ground coordinates of different land cover types (Built environment, bare land, grass land and shrub) within the study area. The secondary data obtained were; Ondo state administrative map, LANDSAT satellite images covering the study area: Operational Land Imager (OLI)/ Thermal Infrared Sensor (TIRS) and Thematic Mapper (TM), worldview 3, as shown in Table 1

Table 1: The Adopted Data and their Attributes

Data	Source	Year	Resolution /Scale
LANDSAT Operational Land Imager / Thermal Infrared Sensor (OLI/TIRS)	United State Geological Survey (USGS)	2020 2017 2014	30 m
LANDSAT Enhanced Thematic Mapper Plus (ETM)+	United State Geological Survey (USGS)	2002	30 m
LANDSAT Thematic Mapper (TM)	United State Geological Survey (USGS)	1991 & 1986	30 m
Worldview 3 image	Google Earth	2020	1.24 m
Administrative map	Office of the Surveyor General of Ondo State		1:1,300,000
Akure Industrial Layout Boundary	Office of the Surveyor General of Ondo State	-	1:10, 000
GPS coordinates	Field Survey	2020	-

Source (Author)

The Landsat data were used to extract the different Land use/Land cover (LULC) within the study area. An integration of GPS receiver and Worldview 3 satellite image were used to obtain the coordinates of different LULC ground points, which aided in the classification of image, and also for accuracy assessment of the classified image. All the acquired Landsat images were processed to obtain their image bands. The extracted images (bands) were used in the processing of Normalized Difference Vegetation Index (NDVI) calculation, LULC. All the Landsat standard data products were processed, to ascertain that they are free of radiometric and geometric errors using the Level 1 Product Generation System (LPGS). Different Landsat bands were used for the calculation of the Normalized Difference Vegetation Index (NDVI). The NDVI equation was inputted into the raster calculator of the ArcGIS 10.5 10.5 software to produce raster surface showing NDVI. Then different LULC types were then generated using the NDVI threshold for LULC. The NDVI values (-1 to +1) were reclassified based on the LULC threshold for land cover types using the reclassify tool in the ArcGIS 10.5 environment.

Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas, build up area, road network. Values from 0.1 to 0.2 correspond to grassland. Grassland and Shrub land ranges between 0.2 and 0.5. Lastly, high values ranging from 0.5 to 1 indicate temperate and tropical rainforests. According to [1], the effect of industrial activities may extend from 500m to 2000m away from the industrial axis. 500m buffer zone (500m corridor from the

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boundary of Akure Industrial Layout) was adopted for this for this study, so that the buffer zone would not extend into the effect of another major land use close the study area, which is an educational land use (Federal University of Technology, Akure). The buffer zone was created. The boundary shape file (.shp) of the Study Area (500m buffer zone) was then used in sub-setting or clipping the derived images of the various index based algorithm, using ArcGIS 10.5 software in order to focus on the study area only. Accuracy assessment was performed on LULC generated from NDVI, which assisted in the calculation of the percentage of the image that was correctly classified when compared to the ground truth data.

3. RESULTS AND DISCUSSION

Land Use/Land Cover (LULC) classes were used to map and monitor the development that have been occurring within Akure Industrial Layout and its environs at 500m corridor for different epochs (1986, 1991, 2002, 2014, 2017 and 2020) are shown in Figures 2 to 4. Table 2 shows aerial coverage of each Land use/cover (LULC) types in Hectares derived from time series images of the study years, in order to determine the dynamics in the development of the area.

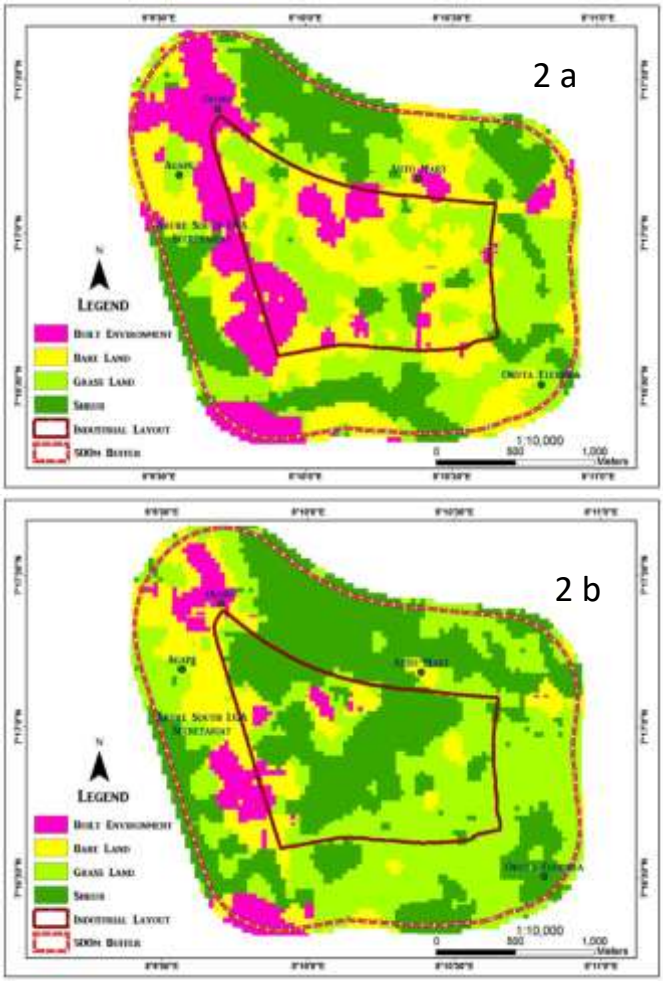

Figure 2: Map showing the development in the year (a.1986 and (b. 1991)

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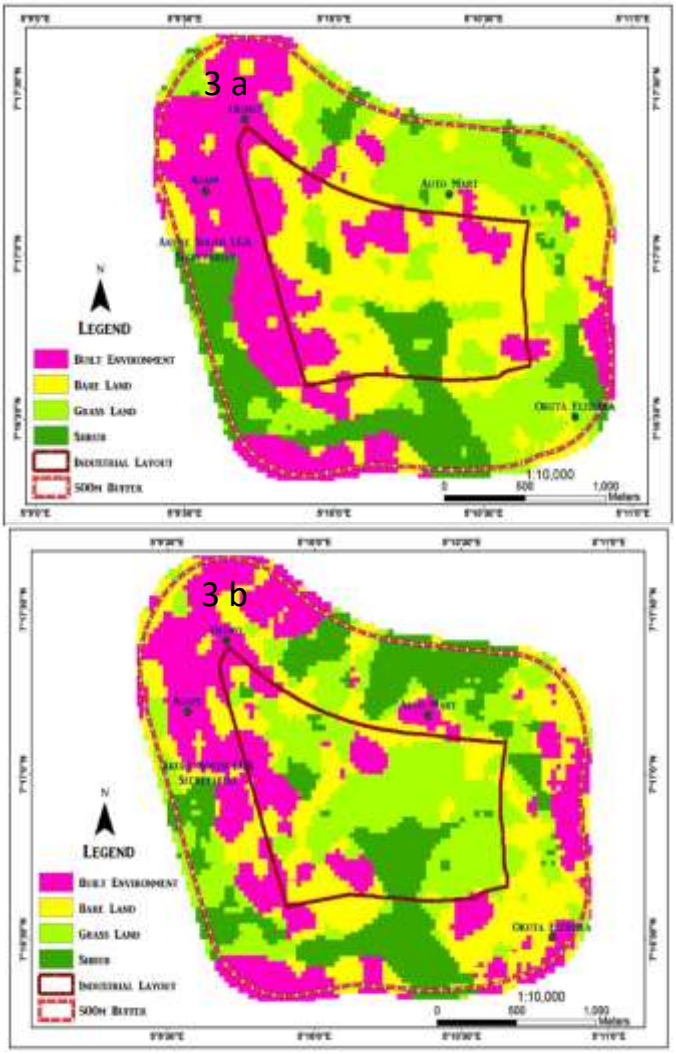
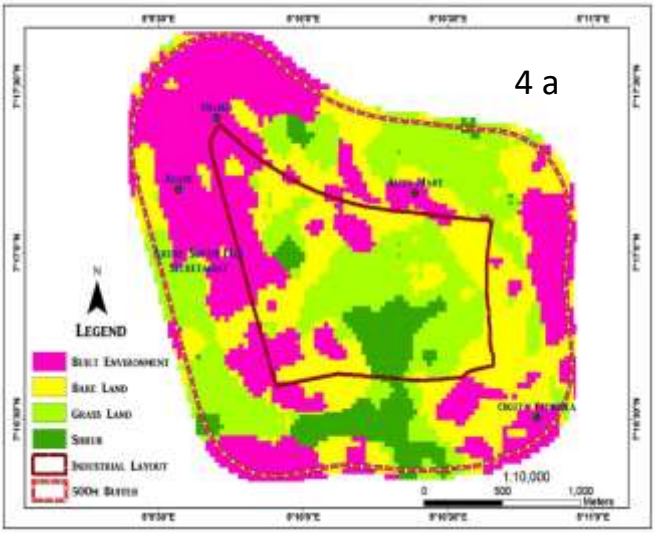


Figure 3: Map showing the development in the year (a. 2002 and (b. 2014)



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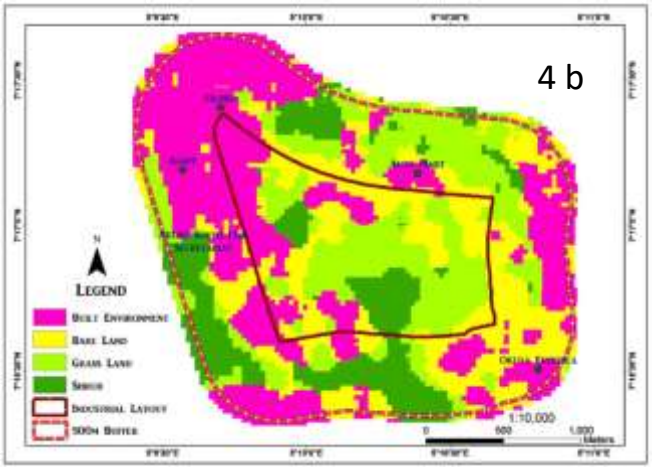
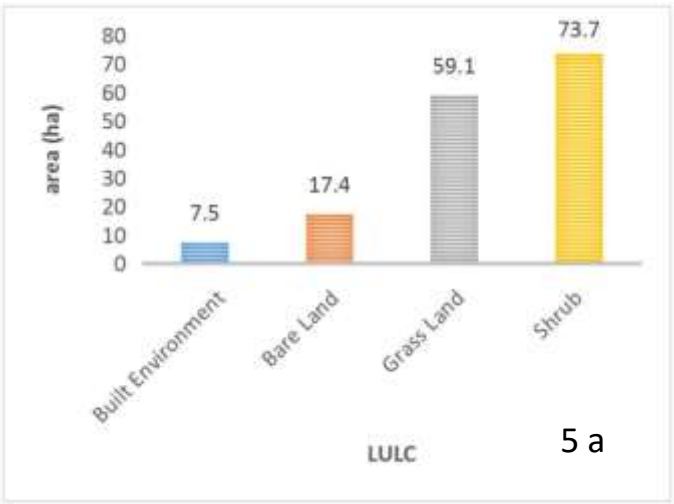


Figure 4: Map showing the development in the year (a. 2017 and (b. 2020)

Table 2: Time series changes in the LULC types within Akure Industrial

Land Use/ Land Cover	1986 (Ha)	1991 (Ha)	2002 (Ha)	2014 (Ha	2017 (Ha)	2020 (Ha)
Built Environment	7.5	14.1	28.8	42.2	48.8	52.8
Bare Land	17.4	27.9	33.5	38	40.1	38.1
Grass Land	59.1	50.4	45.3	48.8	46.5	41.9
Shrub	73.7	65.3	50.1	28.7	22.3	24.9
TOTAL	157.7	157.7	157.7	157.7	157.7	157.7

From Table 2 it was observed that, in the year 1986, Akure Industrial Layout was mainly dominated by shrub and grass land (vegetation), in which shrub covered 73.7ha and grass land covered an area of 59.1ha. The built environment covered 7.5ha while bare land occupied 17.4 ha. These scenario is shown graphically in Figure 5a



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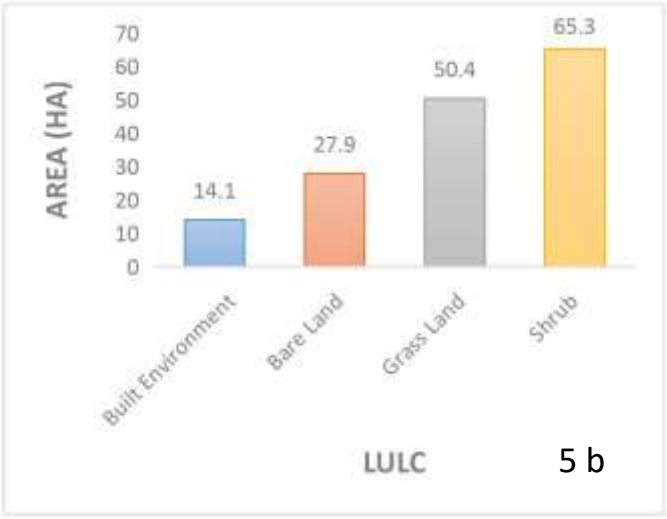

Figure 5: Area of coverage of LULC types within the study area in (a) 1986 and (b) 1991

In the year 1991 as shown in Figure 5b, development increased within Akure Industrial layout as built environment increased to 14.1ha and bare land increased to 27.9ha. Shrub and grass land, which are vegetation reduced to 65.3ha and 50.4ha respectively.

In the year 2002 as shown in Figure 6a further increase in the development in Akure Industrial Layout was experienced as built environment and bare land increased to 28.8ha and 33.5ha respectively, then the non-developed areas (Shrub and grass land) decreased to 45.3ha and 50.1ha respectively.

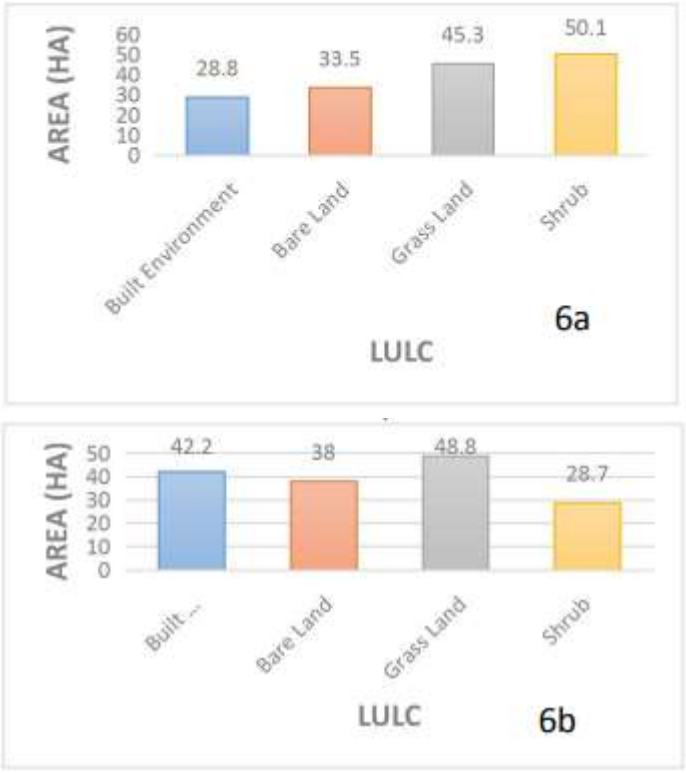

Figure 6: Area of coverage of LULC types within the study area in (a) 2002 and (b) 2014

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In the year 2014 (Figure 6b), further development occurred within the Akure Industrial Layout as built environment increased to 42.2ha, and bare land also increased to 38ha, then shrub reduced drastically to 28.7ha, while grass land increased to 48.8ha

Year 2017 as indicated in Figure 7a, was no exception in the further development of Akure Industrial Layout as the development indicators which is mainly built environment according to Ogunlade (2020c) had an increase in the spatial extent to 48.8ha, and bare land, which is also an indicator for development increased to 40.1ha.

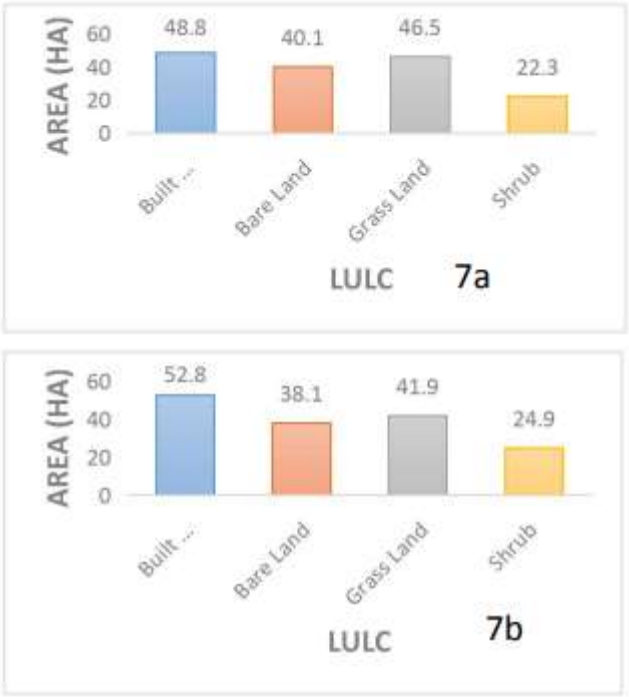

Figure 7: Area of coverage of LULC types within the study area in (a) 2017 and (b) 2020

The indicators for non-development which are shrub and grass land were further depleting (Ogunlade 2020b), as their spatial extents were 22.3ha and 46.5ha respectively. In the year 2020 (Figure 7b), the built environment has covered 52.8ha, bare land covered 38.1ha, grass land covered 41.9ha and shrub covered 24.9ha.

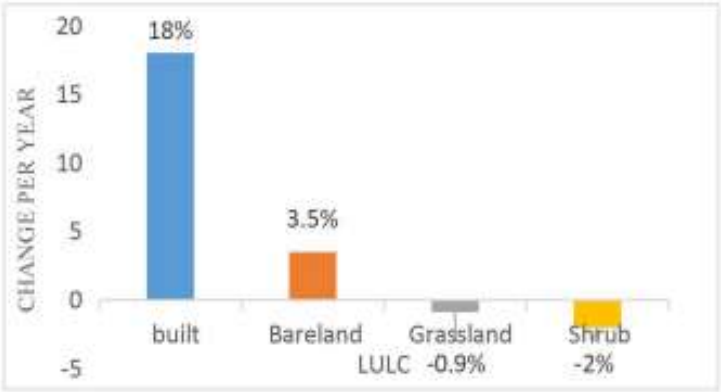

Figure 8: General LULC change per year

Generally, in 34 years from Table 2 and Figure 8, there has been a transformation of 604% in built environment (18% /year) 119% of Bareland (3.5%/year), -29% of Grassland (0.9%/year) -66% of Shrub (2%/year).

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3.1 The trend of built environment within Akure Industrial Layout between 1986 and 2020.

The trend of the spatial extent of built environment, which is the major indicator of the development was monitored over the study years. It was observed in Figures 5, 6 and 7 that the built environment in Akure Industrial Layout had increased over the years as the spatial extent increased from 7.5ha to 14.1ha between 1986 and 1991. It further increased from 14.1ha to 28.8ha from 1991 to 2002, 28.8ha to 42.2ha from 2002 to 2014, 42.2ha to 48.8ha from 2014 to 2017 and finally increased from 48.8ha to 52.8ha from 2017 to 2020. This trend is illustrated in Figure 9. These increase in the spatial extent in the built environment showed that development is increasing in the industrial layout, which means more industries are occupying Akure Industrial Layout. This development is also reflected in more of the built (environment in Akure Industrial Layout) LULC per year as compared to other LULC in Figure 9.

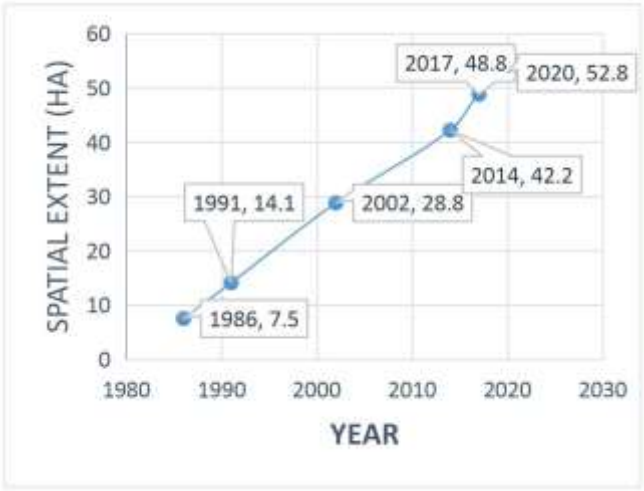

Figure 9: Trend of development in Akure Industrial Layout for the study years

3.2 Prediction of the future development in Akure Industrial Layout Environs

The forecast of the probable future development of the built- up was carried out using the trend projection method on Microsoft Excel to calculate the probable extent of development in the industrial layout in the years 2025 and 2030 (Table 3) by using the historical extent of development in Table 2 and depicting it graphically in Figure 10

Table 3: Probable future extent of development (Built Environment) in Akure Industrial layout

Year	1986	1991	2002	2014	2017	2020	2025	2030
Coverage	26.4	42	68.3	89.4	110.2	136.8	175.3	214.8

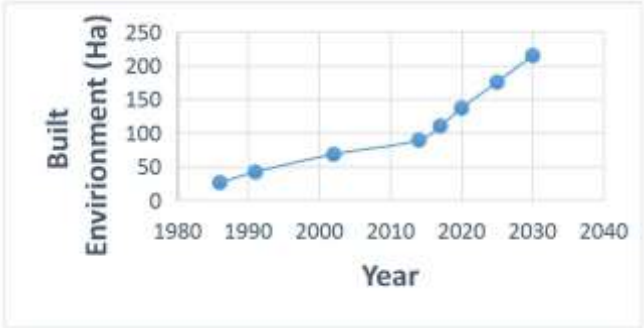

Figure 10: Probable future development in Akure Industrial Layout to the years 2025 and 2030

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From Table 3 and Figure 10 the probable spatial extent of development for the years 2025 is estimated to be 175.3Ha and in 2030 to be 214.8Ha. These shows there will be a continuous increase in the future development in Akure Industrial layout environs to the years 2025 by 35Ha per year and 2030 by 43Ha per year all things been equal. It is note worthy that this increase as observed by {11,12.13) will come with its attendant benefits such as more jobs, more industrial products, more people around and many socio-economic benefits. Also, the development will bring along some attendant problems such as pollution, industrial sprawl into other landuse and landcover, rise in the temperature and many other natural and anthropogenic problems [16,17]. This study is therefore bringing into the awareness of decision and policy makers, industrialist, environmental managers, planners etc, the reality of development in the study area and the likes all over the world. This will activate a proactive readiness to manage the possible aftermath as appropriate.

CONCLUSION AND RECOMMENDATION

The study have revealed that the industrial layout have experienced a significant transformation of the landcover types in each epochs and the study period in general. It has been observed that the built environment which is the indicator of development according to [7]and [11] has increased tremendously in the spatial extent from 7.5ha to 14.1ha between 1986 and 1991 to 28.8ha in 2002, 42.2ha in 2014, 48.8ha in 2017 and 52.8ha in 2020. A forecast into the year 2025 and 2030 revealed a possibility of increased development in the built environment of 175.3Ha in 2025 and 214.8Ha in 2030; and a continuous increase by 35Ha per year and by 43Ha per year respectively all things been equal. thus signifying a continuous increase of industries which the layout is designated for. It is thus recommended from the findings in this study that the state government and all end-users of the layout see that the growth in the built environment is be strictly industrial as designated except if the layout has fallen into the midst of residential areas due to continuous inevitable urbanization, in which case another layout will be provided at the outskirt of Akure metropolis to be designated solely for industrial landuse. This study should be adopted as a prototype for the sustainable manageability of similar layout.

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