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Assessment of Rate of Land-Use/Land Cover Change Detection in Uyo Capital City of Akwa Ibom State, Nigeria.

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ABSTRACT

The study examined the changes detected in the land use/land cover of study area from 1986, 2004 and 2022. Data used were from Satellite imageries for the three epochs: 1986, 2004, 2022 and were subjected to unsupervised classification analysis and showed four land use classes modified after Anderson (1976) as: Built up, Farmlands, Disturbed Forest and Forest. A review of the growth rates in land use/land cover elucidates an exponential growth of the built-up land use class defined by the function: $Y = 1.92 \times (1.0625)^x + 4.1$; while the other land use classes are showing varying rate of depletion with its attendant implications on biodiversity, health, groundwater and surface temperature. It is recommended that the state creates a database to monitor this rate of change and its implications on Health, Groundwater quality and Biodiversity, etc. The study also revealed the rate and trend of urban growth which is essential in real estate planning.

Keyword: Land Use/ Land Cover, Built-up Land use class, Exponential Function

Aims Research Journal Reference Format:
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1. INTRODUCTION

Land use and Land cover are fundamental earth surface coverage attributes which are shaped by geology, evolution, hydrology, climate and anthropogenic activities; however, in our quest for livelihood and development these attributes differ at a range of space–time scales (Latifovic, Pouliot, and Olthof, (2017) Qadir and Singh, (2018)). Land use changes (LU) are the anthropogenic structures, infrastructures, activities or uses land is put into; with or without its natural cover (Singh, Venkatramanan, and Deshmukh, 2022). Land Use change is necessitated by man's desire for development and modernization which result in urban growth, where urbanization is defined as a process which incorporates increased population, industrialization or infrastructural growth and the imperative for socio-economic phenomenon (Liping, Yujun, and Saeed, 2018). Land use change has also been used to show the growth rate of different land use classes or the depletion rate of our biodiversity.

It is for these reasons and more that it is recommended that annual land use change updates be carried out at a scale of 0.25–1km, and five-year updates at 10–30m spatial resolution (CEOS Report, 2017).Land use activities include all actions by man that shape our primordial landscape in our quest for development and livelihood; viz: residential areas, industrial site, landfill site, markets dump sites, mechanic village, farmlands inputs, cemetery, abattoirs, Hospital dump sites, Roads, mining sites, means of transports, and other infrastructures as an imperative for socioeconomic wellbeing (Liping, et al 2018). However, wittingly or unwittingly, all those human activities generate pollutants which are dump directly or indirectly on land. Seto, Fragkias, Güneralp, Reilly, (2011) noted that urbanization is one of the most irreversible human impacts on the biosphere, which leads to a loss of agricultural land, threatens biodiversity, contamination and ultimately affects the local climate.

Yang, Zhang, Xu, & Luo, (2020) added that with the rapid development of urbanization and industrialization, China's metropolitan areas have experienced dramatic transitions of land use, which has had a profound impact on the eco-environment. Accordingly, analysis of the dynamics of regional Production–Living–Ecological (PLE) spaces has become an important entry point for studying land use transition and its eco-environmental effects. And result showed land use deterioration from P-L, E-P and E-L land use changes classification system based on PLE land functions. Also, it is a double-edged sword for the sustainable development of the eco-environment considering disordered transitions and unreasonable land use which may lead to a series of issues on the deterioration of ecological environments and the decline of ecosystem service function (Hanaˇcek, Rodríguez-Labajos, (2018); Lawler, Lewis, Nelson, Plantinga, Polasky, Withey, Helmers, Martinuzzi, Pennington, Radeloff, (2014). Hence, under the global backdrop of achieving the Sustainable Development Goals (SDGs) related land use and ecosystem quality.

Objective:
To carry out analysis of the different land-use / land cover changes in the study area using landsat images of 1986-, 2004- and 2022.

Study Area:
Uyo Capital City lies between latitudes 4°58'N and 5°04'N and longitudes 7°51'E and 8°01'E. In the northern part it is bounded by Ikono, Itu and Ibiono Ibom Local Government Areas (LGAs). The city extends by a radius of approximately 10kilometers from the city center with an area coverage of about 214.31square kilometers. Uyo capital city is a made up of all the villages in Uyo local government area and few villages in the neigbouring LGAs that falls within the 10km radius of the Uyo capital city. The annual rainfall in Uyo has maintained a steady pattern during the first twenty years of the study from 1985 to 2004.

However, during the last decade of the study from 2005 to 2014, the rainfall pattern shifted abruptly over the 3000mm mark and has virtually remained in that region since then, except for 2009 when it dropped below the 3000mm mark. The population of the study area is made up of the population of Uyo Local Government area plus the population of the adjoining villages from other Local Government Areas, projected from the 1991 National population census report to 2022. Between 1965 and 2022, the number of people living in Nigeria increased at an average rate growth rate of over two percent (Sasu, 2022).

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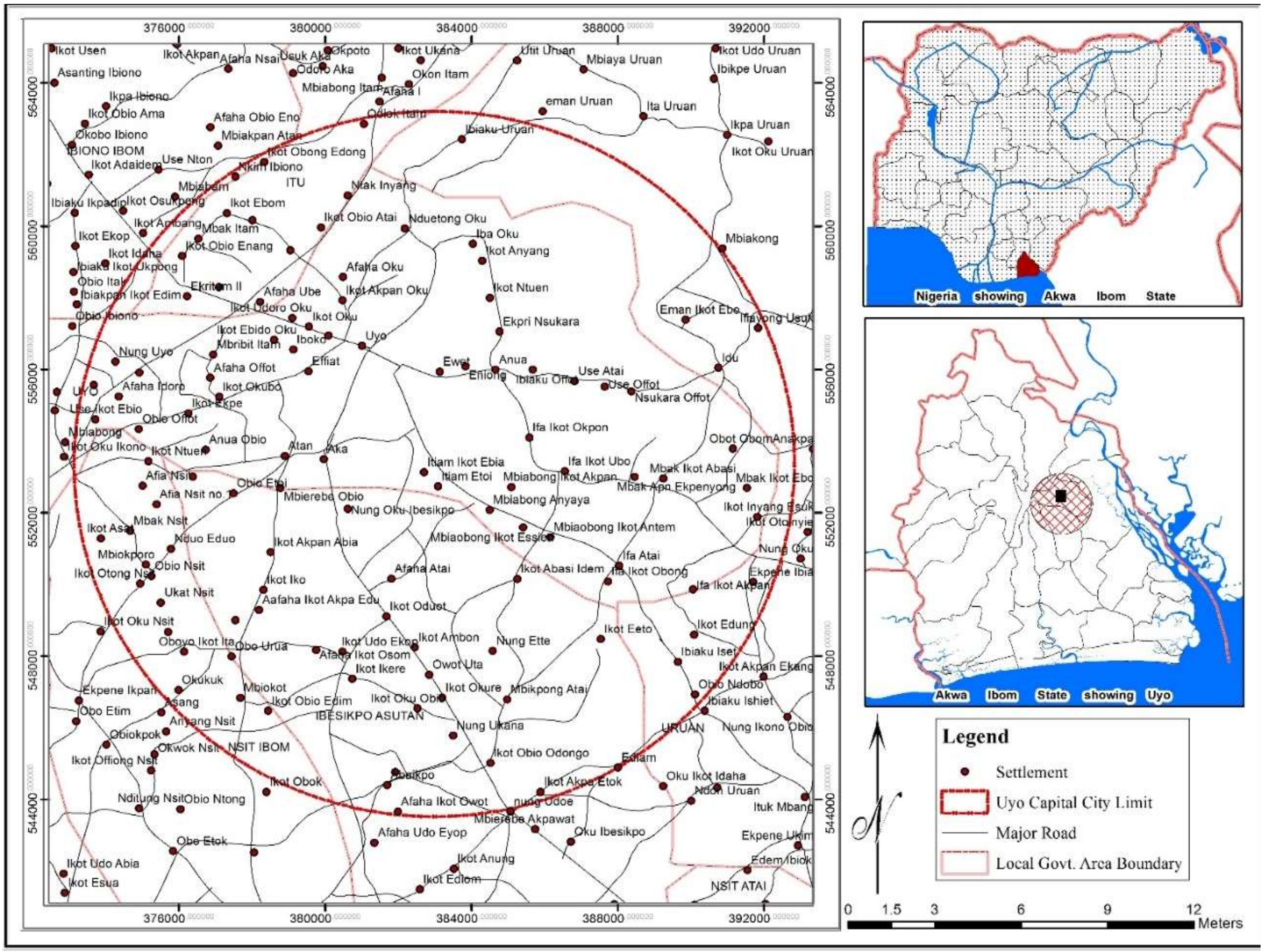

Fig. 1 Map of the Study Area

2. MATERIALS AND METHOD

Data for land use/ land cover changes inventory: Data sets for this objective were sourced from the United States Geological Survey (USGS) acquired remotely as Landsat satellite imagery for 1986, 2004, 2022. The topographic Map of the Study Area from Uyo Capital Development Authority was also used, both as secondary data. These data were used on GIS applications to determine the inventory of land use/land cover change detected in the epoch and reveal and measure changes in land use/land cover in the area. The Study area boundaries were digitized using ArcGIS 10.3 application tool set and overlapped onto the remotely sensed imageries of three epocs: 1986, 2004 and 2022 and were analysed in the GIS application for classification of the land use/ land cover change detected modelling using unsupervised classification. This method has been applied by several researchers for the same purpose.

Advances In Multidisciplinary & Scientific Research
AIMS Research Journal
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The extraction of the Mask process was heralded by the administrative map of Akwa Ibom State was geo-referenced using ArcGIS 10.5 and the Study area (Uyo metropolis and environs) digitized from the administrative map and transformed from Geographic Coordinate System (GCS) to Projected Coordinate System, World Geodetic System (WGS) 1984, Universal Transverse Mercator (UTM) Zone 32 and orthorectified. The imageries were processed using the Erdas Imagine 15 to carry out unsupervised land use/ land cover change classification in the Area Of Interest (AOI) by applying Layer Stacking, followed by Image mosaic to create the AOI. The AOI spectral pixel were further enhanced through contrast stretching and spatial filtration to improve the delineation of the different land use/ land cover classes.

The classification schemes were developed for the study after Anderson (1976) modified. The modification of the classes was done based on the land use/ land cover types that were identified during the classification. Approximately four (4) land use/ land cover classes were classified for the analysis namely; Built up, Farmland, Disturbed Forest, and Forest. The Area Coverage for the different classes were generated in hectares. The Table 1 shows the area of the different land use classes in Hectares. The Accuracy Assessment using confusion matrix generated for 1986, 2004, 2022 Landsat 7 images. Overall accuracy (%) 79.24 82.41 96.64 Kappa Coefficient 0.782 0.894 0.947 Confusion matrix' of Story and Congalton (1986), and 'Kappa' analysis of Lea and Curtis (2010) were followed for the overall accuracy assessment and evaluation of images of 1986, 2004, 2018.

3. DISCUSSION OF FINDINGS:

Land use/Land Cover change inventory from 1986, 2004 and 2022: The result of land use/ land cover change detected in the study area, analysed using satellite imagery with the aid of GIS applications to produce land use/ land cover change inventory in the study area, revealed the following land use classes modified after Anderson (1976):

Table 1: Details of Analysis of Land Use/ Land Cover for 1986, 2004 and 2022.

SN.	Land Use/ Land Cover Classes	1986 (Area in Hectares)	% Coverage 1986	2004 (Area in Hectares)	% Coverage 2004	2022 (Area in Hectares)	% Coverage 2022
1.	Built-up	6,022.08	15	9,789.53	24.4	21,113.28	52.7
2.	Farmland	10,468.26	26.1	13,879.65	34.6	8,546.40	21.3
3.	Disturbed Forest	11,628.00	29	11,895.86	29.7	7,376.13	18.4
4.	Forest	11,973.87	29.9	4,526.97	11.3	3,056.40	7.6
	Total	40,092.21	100	40,092.01	100	40,092.21	100

From Table1, the land use/ land cover classes represent the detected land cover class produced using unsupervised classification in the study area. The total surface area is 40,092.21ha. The Table 1 also shows the percentage coverage of the land use classes in each epoch.

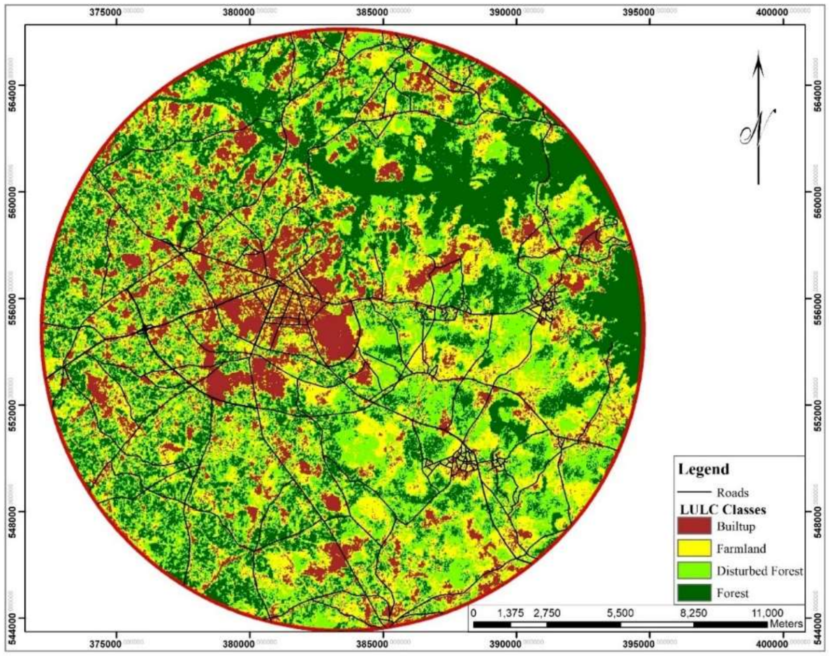

Fig. 2 Land Use/ Land Cover Image Map of Uyo Capital City 1986
Source: Researcher - Extracted from Landsat 7 TM Imagery 1986.

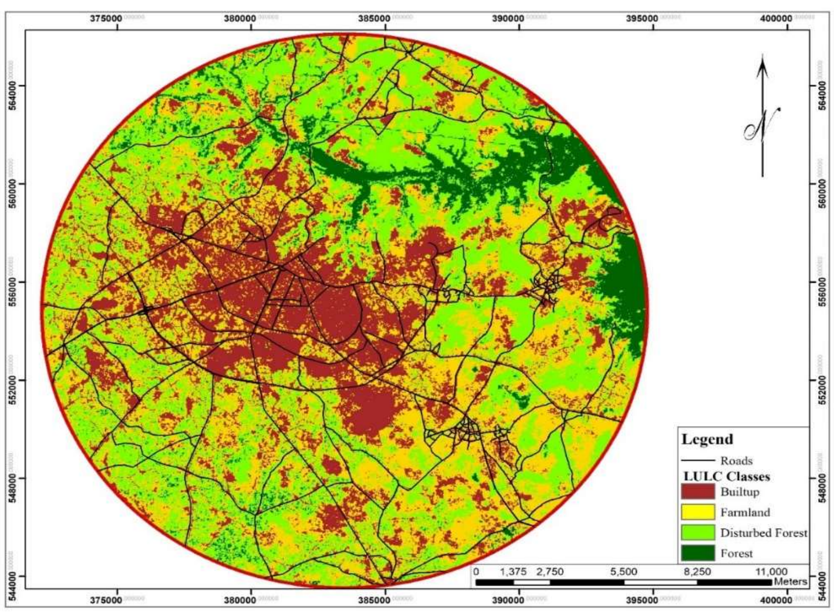

Fig.3 Land Use/ Land Cover Image Map of Uyo Capital City 2004
Source: Researcher - Extracted from Landsat 7 TM Imagery 2004.

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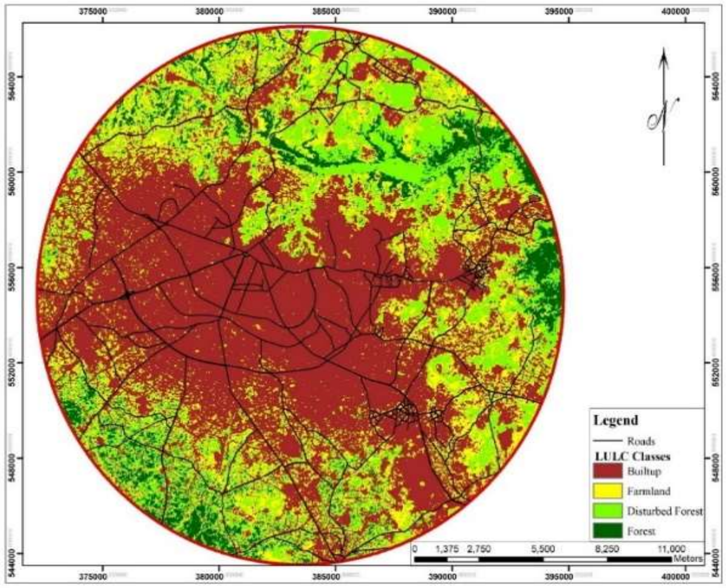

Fig.4: Land Use/ Land Cover Image Map of Uyo Capital City 2022
Source: Researcher - Extracted from Landsat 7 TM Imagery 2022.

From the Figures 2, 3, and 4 above, it is shown that the brown patches in the map represent the Built-up class. Other land use classes are colour-coded as Yellow for Farm land, lemon for Disturbed Forest and Dark Green for Forest as can be seen from the maps' legend. The different land use classes are presented as covering land sizes radially from core to the periphery. The sizes in Hectares (ha) of the different land use classes are here presented in the Table 2 and Figure 5 present a bar chart visualizing the different class sizes with the different epoch.

Table 2: Percentage change in land use between 1986 and 2004, 1986 and 2022, 2004 and 2022

S/N	Land use classes	1986	2004	2022	% change btw 1986-2004	% change btw 1986-2022	% change btw 2004-2022
1	Built-up	6,022.08	9,789.53	21,113.28	+63%	+251%	+116%
2	Farmland	10,468.26	13,879.65	8,546.40	+33%	-18%	-38%
3	Disturbed Forest	11,628.00	11,895.86	7,376.13	+2%	-37%	-38%
4	Forest	11,973.87	4,526.97	3,056.40	-62%	-74%	-32%
	Total	40,092.21	40,092.01	40,092.21			

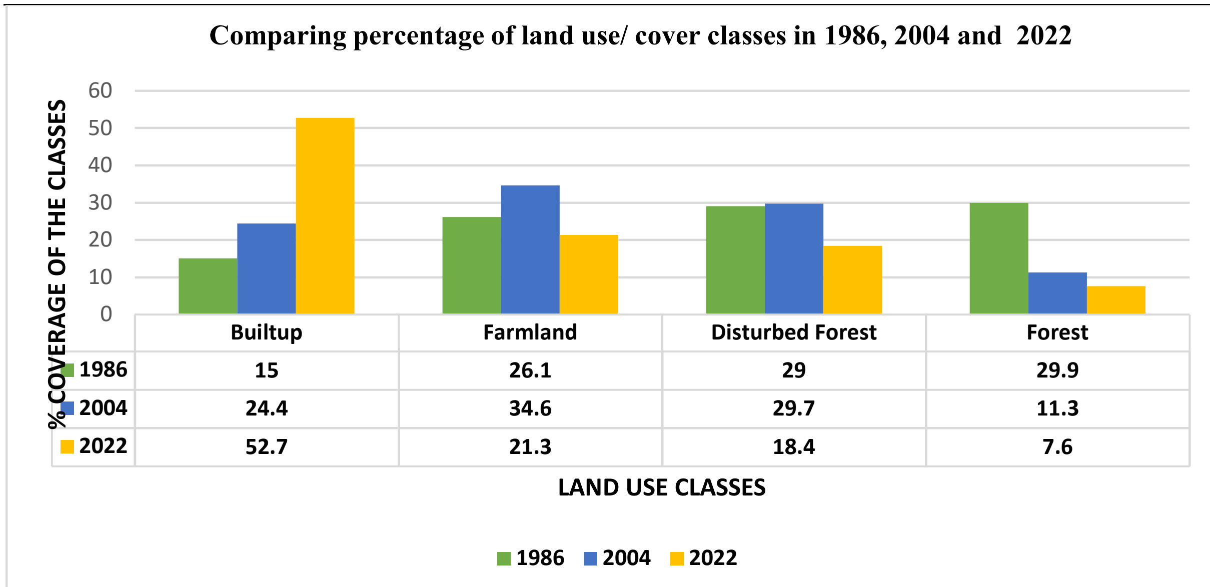

Fig. 5 Clustered Bar Chart Showing Land Use Classes

The clustered bar chart in Figure 5 is used to further present the land use/ land cover classes, with cluster of coloured-bars representing the land use / land cover class and each bars of the same colour represent specific epoch of study; i.e., Green -1986, Blue- 2004, and yellow – 2022. The first cluster of multiple-bars from the left of the Figure 5 represents the Built-up class; the second multiple bars represent the Farmland class; the third clustered bars depict the Disturbed Forest; While the fourth group of bars depicts the Forest land cover class.

Built up

The imagery of the first epoch (1986) processed revealed that the Built-up class occupy 6.0Ha and make up of 15% of the epoch. The data of the second epoch (2004) however showed increase in the built-up area from 6.0Ha in 1986 to 9.8Ha 18-years later. The built-up class in 2004 epoch therefore stretches to 24.4% of the study area. A further analysis of another 18years being 2022 epoch, elucidates a Built-up class that has expanded to 21.1ha and covers 52.7% of the study area. Further review of the analysed data revealed that between 1986 and 2004 the Built-up class changed by increasing by 3.9ha but by 2004 to 2022 in the same year interval, the Built up changed by a positive difference of 11.8ha. Also, between epoch 1986 to 2022 a total increase in Built-up area of 15.1ha; revealing a 251% growth from the 6.0ha in 1986 built-up land use class. This is area of land taken up by Built-up class. The first set of multi-bars in Figure 5 represent the Built-up class from different epochs. The length of each rectangular coloured segment represent the percentage coverage of built-up land use/ land cover class of the epoch in the study area. Ultimately, the bar chart displayed the Built-up area as occupying 15% in 1986, 24.4% in 2004 and 52.7% in 2022. Also, from the Table 2 above, the Built-up class for each epoch is extracted to form the table of function as shown in Table3, with the year 1986 assuming a starting point of zero and 2004 is 18 years after 1986 and year 2022 is 36 years from 1986.

Table 3 Axial display of area coverage of built-up area from 1986 to 2004 to 2022.

Axis	1986 BC Area (Ha)	2004 BC Area (Ha)	2022 BC Area (Ha)
Y	6,022.08	9,789.53	21,113.28
X	0	18	36

Since the built-up area is the crux of development and its impact on human health and environment, might be more fatal than other classes; we attempt to estimate the rate of land use change based on the observed area coverage of Built-up class in each epoch. The Area in hectares for Built-up class area coverage is the y axis while the period interval from 1986 to the date of measurement is the x axis ie period = 1986 – 2004 =18years

The above built-up class is assumed to grow exponentially and is defined by the general exponential function:

$Y = a.b^x + c$--eqn1
$6.02= a.b^0 + c$--eqn2
$9.79= a.b^{18} + c$ --eqn 3
$21.11= a.b^{36} + c$---eqn4

Rearranging and solving for all constants: a=1.9, b=1.06 and c=4.1 into eqn1 above.

$Y = 1.92 * (1.0625)^x + 4.1$--------------------------------------eqn5

The eqn5 above is the exponential function derived by the researcher relating the rate of growth of built-up class in Uyo capital city with change in time in the three epoch of 1986 to 2004 and 2004 to 2022.

Farmland Class

The Farmland class data, as presented in Table 1, covers 10,468.26ha and occupy 26.1% of the 1986 epoch and is identified with yellow colour on the map legend Figure 2, 3, 4. In the 2004 epoch, the farmland class increased to 13,879.65ha depicting 34.6 % of the Area. However, the farm size is reduced to 21.3% occupying 8,546.4ha in 2022. Farmland Class are rapidly being encroached by the Built-up class while the Farmland class is poaching into the Disturbed-Forest and the Forest classes. Apparently, the farmland grew from 1986 to 2004 by 3,411.45ha taking over this extra size from the disturbed forest and Forest class. However, the build-up class had taken new land cover of 3,767.45ha which is safe to say they were largely bare grounds and farmland by 3,767.45.

Hence in the period, the farmland had encroached more land but it is also depleted by the built-up area. Between 2004 to 2022, the Table 1 data showed that the farmland class has constricted by 5,333.25ha whereas Built-up area had encroached other land cover classes expanded by 11,323.75ha. Assuming that all new Built-up area came from Farmland it implies that agricultural practices are really being threatened by built up area as built-up area takes about 11,000 ha of Farmland remaining only 3,800 ha per se. This is of concern as the global hunger and climate change bite harder as more forest is depleted alternatively for farmland.

Disturbed Forest

The Disturbed Forest occupied 11,628ha covering 29% of the study area as at 1986 based on Table 1 and Figure 5. The land use class grow slightly to 11,895.86 in 2004 as shown in Table1 and Figure 2 and occupying 29.7% of the study area. The practice of bush fallowing system could encourage this; however, part of the Disturbed Forest is being threatened or taken over by Farmland class and Built-up Area. The coverage area of the Disturbed Forest declined in 2022 to 7,376.13 ha and occupying 18.4% as the Forest also declined while Farmland and Built-up class invade it for farming and residential spaces. Comparatively as shown in Table 2, the Disturbed Forest land use class grow by 2% between 1986 to 2004; then between 2004 to 2022 the land cover declined by -38%.

Forest Land Cover Class

The Forest land cover class as shown in Table 1 and Figures 2, 3 and 4 show a steady decline in area from 11,973.87 ha in 1986 to 4,526.97ha in 2004. Also, it further reduced its coverage to 3,056.40 ha there by creating declining percentage coverage area from 29.9% in 1986, to 11.3% in 2004 and 7.6% to 2022. Compared to its initial position in 1986 to the 2004, there was a decline of 62.4% and between 1986 to 2022 is 74.2%.

4. CONCLUSIONS:

The study investigated the land use/ land cover change in the study area which are changes largely caused by anthropogenic activities and the natural unchanged land cover. The changes detected are Built-up, Farmland, Disturbed Forest and Forest and seen to be continuous, persistent and dynamic in shaping the land use/ land cover changes in the three epochs of 1986, 2004 and 2022. Of the land use classes, the Built-up area is expanding exponentially and the land use change in the interval follow an exponential function:

$$Y = 1.92 * (1.0625)^{x} + 4.1$$

It is here recommended that there should be a policy frame work on land uses especially in terms of forest exploitation and depletion for residential purposes. Also, well planned sky rise buildings should be encourage in urban centers rather than opening up forests just to build residential areas. That investment in real estate should be regulated due to its huge impact on Agricultural land loss, Biodiversity loss as well as global warming.

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