GIS BASED ANALYSIS OF URBAN SPRAWL IN ENUGU URBAN FROM 2000 TO 2020

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Abstracts:
In this study, a quantitative measurement of sprawling pattern of urban growth in Enugu Urban from year 2000 to 2020 was carried out with GIS technology. Enugu is a post-colonial urban settlement that emerged as a result of discovery of coal seams along Udi hills in commercial quantity in 1905 and subsequent mining in 1909. Geographic Information System (GIS) was applied to identify and capture five categories of landuse land cover (LULC) changes for 30years in ten years' intervals of 2000,2010 and 2020 covering an area of 242.874km$^{2.}$ The major landuse landcover were, water bodies/wetlands, forest, farmlands, built-up area, and bare soil. From year 2000 to 2020, there was a tremendous increase in physical development of infrastructures and decreasing land use for farmlands and forest. A comparative study of GIS maps in 2000, 2010, and 2020 manifested a significant change in land use land cover pattern in the study area. The built-up area covered 82.682 square kilometers representing increase from 15 percent in 2000 but changed to 110.559km^2 in 2020 showing over 100 percent increase in built up area while farmlands and forest declined from 80% to 32%. Cumulative Shannon Entropy was calculated which gives 0.922 for year 2000, 0.913 for year 2010 and 0.938 for year 2020. Shannon entropy reading of over 0.9 indicated that Enugu Urban is under a chaotic urban development or sprawl desiring urgent attention in form of renewal and infrastructure upgrade while development of new town is recommended as a sustainable solution.

Keywords: Informal Settlement, Growth by accretion, Urban Sprawl, Physical Planning, Slum

1. Introduction.

Urban growth and land use/ landcover (hereafter LULC) changes in fast-growing cities in the developing countries has drawn considerable attention from researchers in Urban and Regional Planning. Population growth through immigration and natural births demand for construction of new residential, commercial, utility, and transport infrastructures. They also require conversion of forests, farmlands, and bare soils, causing LULC changes and urban sprawl. Urban sprawl has its threshold limits. At the lowest end of the spectrum, a city remains uniform and vulnerable to change while rapid unplanned urban sprawl exceeding its maximum threshold limit creates chaos and deterioration in the quality of urban utility services.

Brueckner (2000), in his study of urban sprawl in developing countries stated that in some cities, especially in countries located in southern part of Asia and sub-Saharan Africa, slums due to urban sprawling growths are not just few marginalized neighbourhoods holding small concentration of population but are widespread, and are home to a large part of urban population. These settlements and unique enclaves are sometimes called "slum cities", ghettoes, informal settlements and squatter settlements. Not only are the developing countries living in a rapidly

urbanizing world, they are also experiencing an unprecedented urbanization of poverty and urban growth by sprawling, a growth devoid of proper physical planning (Ravallion, Chen and Sangraula, 2007). Though several studies have been carried out on rural-urban migration, urbanization and urban sprawl especially in the poverty stricken countries of the developing nations (Risbud, 2017; Aruna, 2008; Kuffer and Barros, 2017), there is dearth of literature on detailed analysis of the extent of sprawl and the consequent emerging patterns of incremental growth without any referral master plan as a guide.

According to United Nations Human Settlements Programme (2012), about 33 percent of the urban population in the developing world, or about 863 million people, lived in unplanned areas and slums. In 2012, the proportion of urban population living in such unplanned areas and slums was highest in Sub-Saharan Africa (62%), followed by South Asia (35%), Southeast Asia (31%) and East
Asia (28%). The UN-Habitat (2012) also reported that about 43 percent of urban populations in these developing countries were slum dwellers while 78 percent of those living in the areas described as least developed countries were basically slum dwellers leaving only 22 percent living in planned urban areas. These have called for an innovative approach to urban studies and fast tracking of unplanned urban growth with GIS technology.

This research paper is therefore, to fill the knowledge gap by quantifying the level of sprawling, the extent poor physical planning and associated sprawling patterns of urban growth has affected the Enugu Urban through the use of modern GIS technology.

2. Literature Review.

The term "urban sprawl" was believed to have been first used in an article in 1955 as a negative comment on the state of urbanized London's outskirts (London Times, 1955 as reported by Gregory L, 2020). According to Gregory (2020), *London Times* (1955) specifically defined sprawl as the "straggling expansion of an indeterminate urban or industrial environment into the adjoining countryside." In their words, diffusion is too mild to use, but in bursting its bounds, the city actually sprawled and made the countryside ugly, uneconomic in terms of services with doubtful social value. There is perhaps no current topic more central to the study of urbanism than urban sprawl. Ever since then, definitions of sprawl continued to vary among urban researchers. Researchers in the field do acknowledge that the term lacks precision. For instance, Batty, Besussi, Elena and Chin (2013), defined sprawl as uncoordinated growth: the expansion of community without concern for its consequences, in short, unplanned, incremental urban growth which is often regarded as uncoordinated and unsustainable.

However, Bhatta, Saraswati, and Bandyopadhyay (2010), wrote that despite the dispute over the precise definitions of sprawl, there is a general consensus that urban sprawl is characterized by unplanned and uneven pattern of growth, driven by multitude of processes and forces leading to inefficient resource utilization. Urban sprawl mainly refers to the unrestricted growth in many urban areas of housing, commercial development, and roads over large expanses of land, with little concern for orderly urban planning, that is to say rapid urban growth devoid of proper physical planning.

In the words of Arena (2008), the concept of urban sprawl dwells on emergence of a situation of unauthorized and unplanned development, normally at the fringe or peripheral areas of cities especially haphazard and piecemeal construction of homesteads, commercial areas, local industrial areas and

other non-conforming land uses, generally along the major lines of communications or roads adjacent to specified city limits. Once this phenomenon of urban development is observed, it is often described as Urban Sprawl (Bosselman, 1998). Urban sprawl is the growth of a metropolitan area through the process of scattered development of miscellaneous types of land use in isolated locations on the fringe, followed by the gradual filling-in of the intervening spaces with similar land uses. Prodhan, Pravakar & Perera Rangith (2008) stated that such haphazard developments create slums, unauthorized colonies, piecemeal commercial development, intermixes of conforming and non- conforming uses of land coupled with inadequate services and facilities. The rising concern over the presumed consequences of urban sprawl – traffic congestion, the loss of open space, high public service costs and property taxes, and inflated vehicle-miles travelled and greenhouse gas emissions – has made urban sprawl a topic of widespread popular interest (Kelly Clifton, Reid Ewing, Gerrit-Jan Knaap & Yan Song, 2008).

According to Jumin, Jayanthi, Juchul, Susan, Robert, Chandra and Kara Kockelman (2018), Urban Sprawl is described as area expansion of urbanized area without organized physical planning while Urban Growth is general increase in the physical size of urbanized area, whether planned or unplanned. This conceptual definition by Jumin Song *et al* (2018) brought to rest the long controversy on the actual meaning of urban sprawl and will be adopted throughout this study as the basic conceptual framework. The concept clearly explained urban growth as distinct from urban sprawl.

Urbanisation has been associated with significant global economic and social transformations. Also, the dynamic change from rural to urban land use is so fast that the resultant need and complex uses coupled with shortage of land have led to the speculation and increase in land values (Alabi, 2007). Urban and metropolitan living were linked with higher levels of literacy and education, better health, lower fertility and a longer life expectancy, greater access to social services and enhanced opportunities for cultural and political participation (UNDESA, 2015).

While noting that urbanisation often evokes images of overcrowded cities,concentrations of poverty and environmental degradation, the World Bank (2009) cautions against seeing urban growth mainly from the negative point of view only. Instead, it is suggested that the debate and studies in urbanism should be about the efficiency and inclusiveness of the processes to transform rural economies to urban ones, and how policy can best mitigate the issues that arise at different stages of urbanisation which gap this study seeks to fill. This has become necessary, as it has been more than established that the advantages of urbanisation far out weighted the disadvantages. Ruralisation is an index of poverty and under development. People of many classes and religions live and work together in cities, which create better understanding and harmony and help to break most of the stubborn traditional social and cultural barriers that created difficult to manage community problems leading to anti-growth in modernism culture.

The UN-Habitat (2020) warned in her report that the world will likely urbanize further in the next decade, from 56.2% in year 2020 to 60.4 % by 2030. Surprisingly, the report went further to state that ninety-six per cent (96%) of the projected urban growth worldwide will occur in the less developed regions of East Asia, South Asia and Africa with three outstanding countries—India, China and **Nigeria**—accounting for over thirty-five per

cent (35%) of the total increase in global urban population from 2018 to 2050. It is important to note that this challenge of urban growth by sprawling without properly guided physical planning, has become an important issue on sustainable human settlement development and management (Gyuse, 2020; Dumashie, 2011and UN-Habitat,2020). In Enugu, there is rapid urban expansion and sprawling without proper physical planning to ccommodate future expansion (Agu et al, 2016).

Most of the previous research studies on urbanisation, urban slums, housing conditions, informal and peri-urban settlements centered mostly on rate of rural–urban migration, housing and urban infrastructure challenges, slum growth, regeneration and renewal, with only very few attempting to measure in quantitative terms the extent of urban sprawl so as to explain most of the emerging challenges facing the dwellers in Enugu Urban. Urban growth pattern seems to have adopted growth by sprawling and reactionary urban redevelopment and renewal instead of predicted planned physical growth devoid of slums and preponderant urban crisis.

urban made up of three local government areas, namely Enugu North, Enugu South and Enugu East council areas. Map of

The conclusion derived from this fresh reality is that the major trends in the world's cities are indispensable and has been transforming from year to year, during which the urban landscape were undergoing significant shifts. Whereas past decades may have needed to deal with rural poverty and neglect, which were the major challenges remaining in that time, the name of the current game is how to make cities more productive, more manageable, and more conducive to the aspirations of increasing urbanized populations through proper physical planning.

3. The Study Area.

Enugu Town, the administrative capital of Enugu State is located on latitude 6^0 25'30.63'' and 6^0 40'38.61" North and longitude $7^0$25'30.74'' and 7^0 36'0.71" East on the globe. It is arguably the most important town in South Eastern Nigeria having been the colonial administrative headquarters of Southern Nigeria in 1929, Regional Headquarters of Eastern Region, Headquarters of old East Central State and old Anambra State and presently the capital of Enugu State. The study area is Enugu Enugu State showing the study areas shaded among the seventeen local government areas of Enugu State were shown in figure 1.

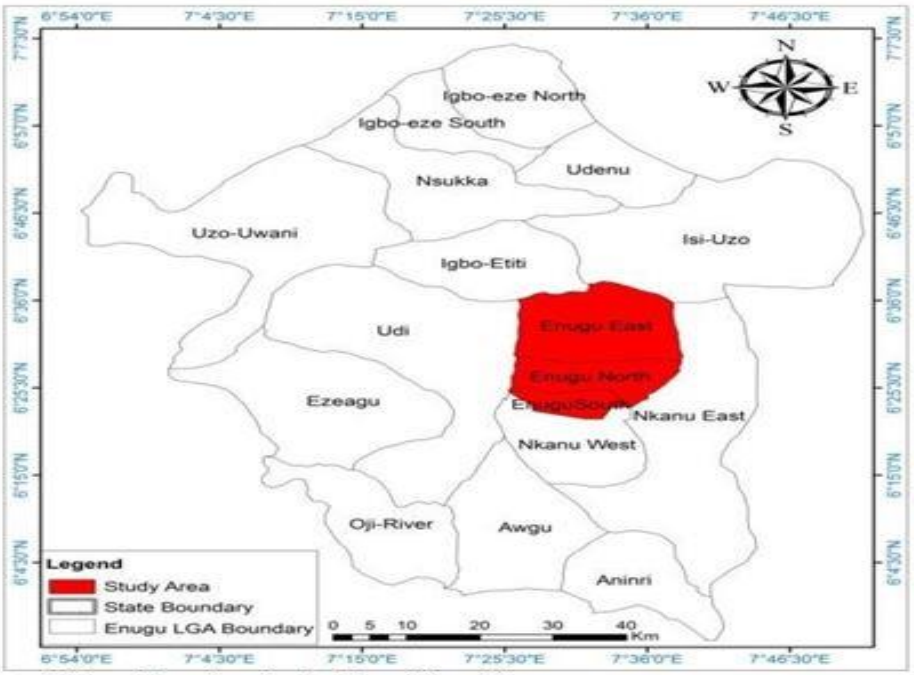


Figure 1: Map of Enugu State showing Enugu Metropolis.
Source: Survey Division, Enugu State Ministry of Lands Town Planning.

Settlements and study areas were located were shaded. Enugu town is franked in the west by Udi hills, a long range of folded sedimentary escarpment which started from Basanga range in Benue state through the length of Enugu State to Okigwe plains. The ridge ranging from 600m to 800m above sea level stretches towards the north, east and south of Udi hills. The hillside is made up of clay and reddish-brown gravel silt mainly from the wasting slopes. The underlying bedrock is shale and coal seams that project from the dipping plain to the angle of east- west orientation. The discovery of these coal seams in commercial reserves by the British explorers in 1905 gave birth to the present Enugu town called Coal city. Enugu is located within the tropical climate zone with diminishing influence of the maritime. Enugu used to experience about 8 months of rainy season and 4 months of dry season which last from December to March. The rainy season has been increasing in the duration and intensity due to the present global warming.

Enugu Urban fondly known as Coal City has grown to be an important tourist centre in Nigeria. The town is endowed with a lot of tourist resources, facilities and potentials. These exist in natural features such as lakes, hills, falls, springs and cultural festivals as well as such man-made features like hotels, telecommunications and transportation outfits, galleries and monumental or archaeological collections. Some of these potentials are developed, others are yearning for development. Some of the existing tourist events in Enugu include the New Yam Festival and associated masquerade displays.

4. Methodology.

This study deployed extensively the use of Geographic Information System (GIS) to map the landuse and land cover (LULC) changes from year 2000 to 2020. This study of LULC changes made an analysis of a large amount of spatio-temporal data that were traditionally

collected through analogue ground-based field surveys. Due to rapid improvements in remote sensing technologies, spatial coverage, repetitive observations, and efficient data-processing capabilities, has encouraged urban researchers and city planners to use remote sensing data to examine the spatio-temporal LULC changes and urban sprawl. The identification of LULC changes using remote sensing data in the study area involved methods of pre-classification and post-classification of the changes. The pre-classification method processes a set of multi-temporal remote sensing images to create maps identifying areas of change or no-change in LULC without going further in classifying the nature of changes. The post- classification method then goes further to compare two classified temporal remotely sensed images to produce maps that showed the changes within and between LULC classes over the time frame. Considering the existence of complex, overlapping, and inaccessible LULC patterns in the study area, and lower accuracy level likely to be achieved, an unsupervised classification using the Iterative Self-Organizing Data Analysis Technique Algorithm (ISODATA) was used to achieve better accuracy in LULC classification. The resulting classes were combined and reclassified into five major urban land cover categories (Table 1). Finally, extent of urban sprawl was calculated by integrating Shannon's entropy and GIS tools. Shannon's entropy (En) was used to compute the density of urban development in order to measure its degree of concentration or dispersion among n zones. In this study eleven (11) zones were used at 500m intervals.

(i) Urban Sprawl in Enugu from Year 2000 to Year 2020.

The Geographic Information System (GIS) was used to identify and capture five categories of landuse land cover (LULC) in ten years' intervals of 2000, 2010 and 2020 covering an area of 242.874km2as follows: water bodies/wetlands, forest, farmlands, built-up area, and bare soil.

1. Built-Up Area; All types of manmade structures: residential, industrial, agricultural commercial and services; transportation and utilities; built-up.
2. Forest; Trees, natural vegetation, grassland and other vegetation land covers.
3. Farmlands; Cultivated and arable fields, gardens, play grounds/ornamented parks.
4. Bare Soil; Areas with no vegetation cover, sand, open space, and bare lands.
5. 5 Water Bodies/Wetlands; Reservoirs, swampy/marshlands, ponds, streams, and rivers.

4(ii). Urban Sprawl in Enugu as at Year 2000.

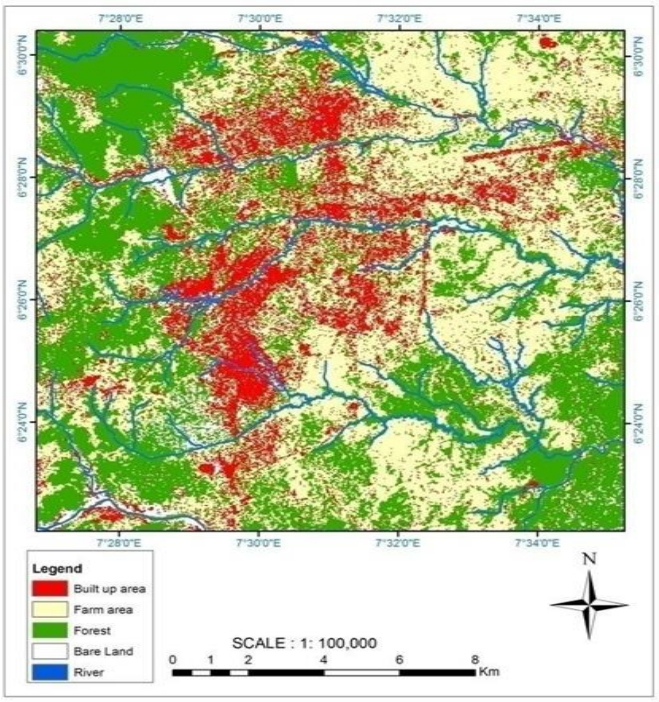


Figure 2: Landuse land cover Map of Enugu in 2000.
Source: GIS map of Enugu accessed on 2021,15/08:18.00.

Table1: Statistical table of LULC of Enugu, 2000

ID2000	Classes	Count	Area (Km2)	(%)
1	Built up Area	41570	37.413	15.4
2	Farm Land	111914	100.723	41.47
3	Forest	105578	95.02	39.12
4	Bare Land	10191	9.172	3.78
5	Water Body	607	0.546	0.22
Total		**269860**	**242.874**	**100**

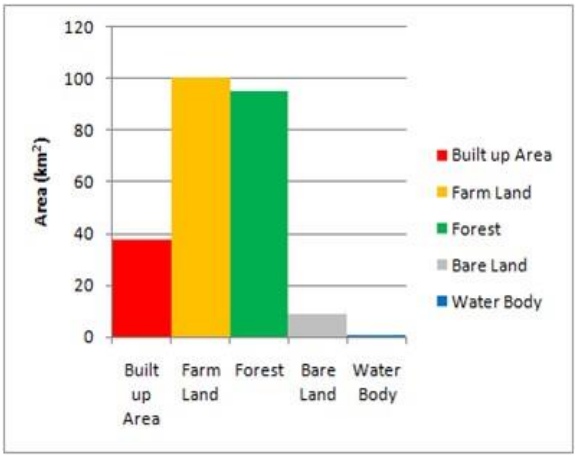


Figure 3: Histogram of LULC of Enugu 2020
Source: Calculated from Figure 2 and table 1

From figure 2 showing the built-up areas in Enugu as at year 2000, out of 242.874 square kilometers of Enugu land area, only 37.413 square kilometers representing 15.4 percent of the present Enugu urban were built up and covered with physical structures. Up to 80 percent of the whole landmass was covered by farmlands and forests at equal proportion. Farming and other agricultural activities formed the major landuse activities. Most of the pre-existing native villages and migrant farm settlements located at distance were fully occupied by itinerant farmers who provided adequate food for sale in the township creating an excellent sustainable city.

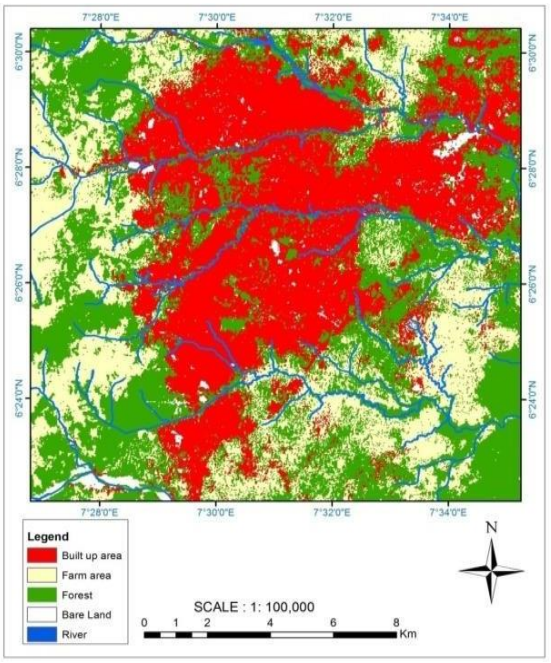


Figure 4: Landuse land cover Map of Enugu in 2000. **Source:** GIS map of Enugu accessed on 2021,15/08:18.00.

Table 2: Statistical table of LULC of Enugu, 2010

ID_2010	Classes	Count	Area (Km^2)	(%)
1	Built up Area	91869	82.682	34.04
2	Farm Land	70706	63.635	26.2
3	Forest	57902	52.112	21.46
4	Bare Land	4677	4.209	1.73
5	Water Body	44706	40.235	16.57
Total		269860	242.874	100

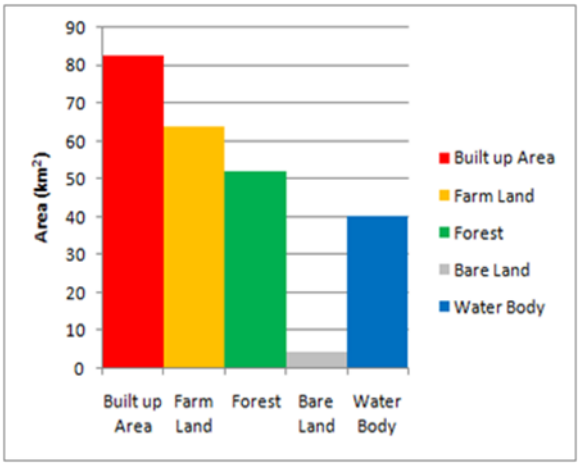


Figure 5: Histogram of LULC of Enugu, 2000.
Source: From Table 2.

From year 2001 to 2010 there was a tremendous increase in physical growth in terms of infrastructure as shown by rising trend in housing development. When the GIS apparatus was adjusted to capture the landuse as at year 2010, the result as shown in figure 4 indicated an outstanding change in the built up area of Enugu urban. A comparative study of figure 4 and 2 manifested a significant change in land use land cover pattern in the study area. The built-up area covered 82.682 square kilometers representing increase from 15 percent to over 34 percent. The rise is remarkable showing over 100 percent increase in built up area while farmlands and forest declined from 80% to 47%. The bar charts in figures 3 and 5 vividly showed a remarkable change in the LULC.

4(iv). Urban Sprawl in Enugu as at Year 2020.

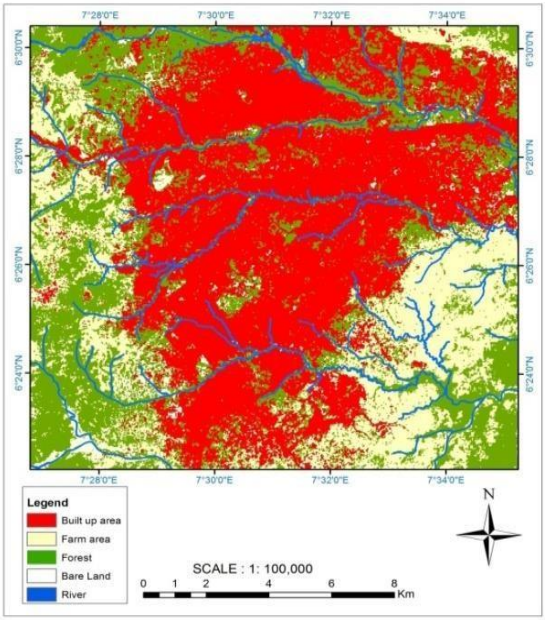


Figure 6: Enugu Landuse Landcover 2020.
Source: GIS map of Enugu accessed in 2021,15/08:18.00.

Table 3: Statistical table of LULC of Enugu, 2020

2020	Classes	Count	Area (km2)	(%)
1	Built up Area	122843	110.559	45.52
2	Farm Land	52750	47.475	19.55
3	Forest	34804	31.324	12.90
4	Bare Land	8964	8.068	3.32
5	Water Body	50499	45.449	18.71
Total		269860	242.874	100.00

Source: From Figure 6.

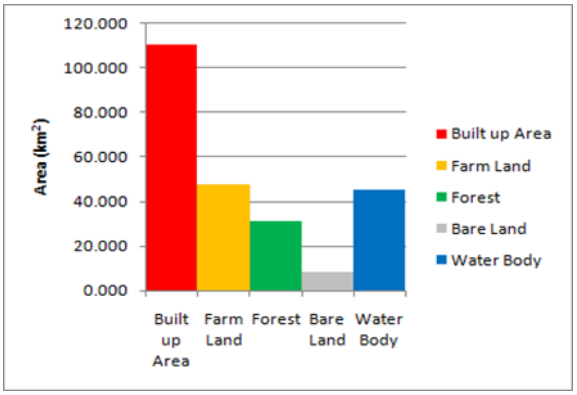


Figure 7: Histogram of LULC of Enugu, 2000
Source: From Table 3.

There was a persistent increase in built up areas as noticed in the GIS map of 2020. The satellite imagery showed intensive coverage of land surface by more built up infrastructures (see figure 6 and 7). In fact, the built-up areas were in a hot chase on the farm lands. The urbanised area increased from 82.6km^2 to 110.6km^2. The bar chart in figure 7 showed that the built-up area increased to cover up to 45.5% of Enugu land mass while farmlands and forest declined to less than33% of the land mass.

4(v). Extent of Urban Sprawl in Enugu from Year 2000 to Year 2020.

To perform the Shannon's entropy analysis, the three classified maps were first reclassified into two categories: built-up and

non-built-up areas. Then *i*th numbers of concentric circles or buffers are drawn from the center of the city. A total of 11 concentric buffer rings, each at 500 m apart, were drawn around the city centre to cover the entire study area. The density of the built-up area was calculated for each ring or circle. Finally, the relative entropy values were calculated for each year by using the formula:

$$E_n = \sum_{i}^{n} pi \frac{\log\left(\frac{1}{ni}\right)}{\log(n)}$$

Relative entropy values closer to 0 indicate uniformity and compact or high density urban development that makes the city vulnerable to change; whereas entropy values close to 1 indicate low density urban development and a high degree of urban sprawl causing chaos in providing urban infrastructure and utility services; entropy values in the middle between two extremities indicate an organized urban development. Entropy values for each buffer ring were plotted against the buffer distance, and mapped for each of three years to detect the spatial pattern of urban sprawl over time. To map and identify the zones of uniform, organized and chaotic urban sprawl in the study area, the entropy value of each buffer zone was added to obtain a cumulative entropy value which ranges between 0 at center most buffer ring to the maximum at the 11th ring. The cumulative entropy value was then divided into three equal intervals: buffer zones with values ranging between 0.0–0.33 would be the zones of uniformity; those between 0.33–0.66 would be the zones of organized urban development; and those above 0.66 would indicate zones of chaotic urban development. Change of entropy between two time periods indicate the magnitude, direction, and nature of urban sprawl. Therefore, changes in entropy values were computed by subtracting the entropy value of the base year from that of the terminal years.

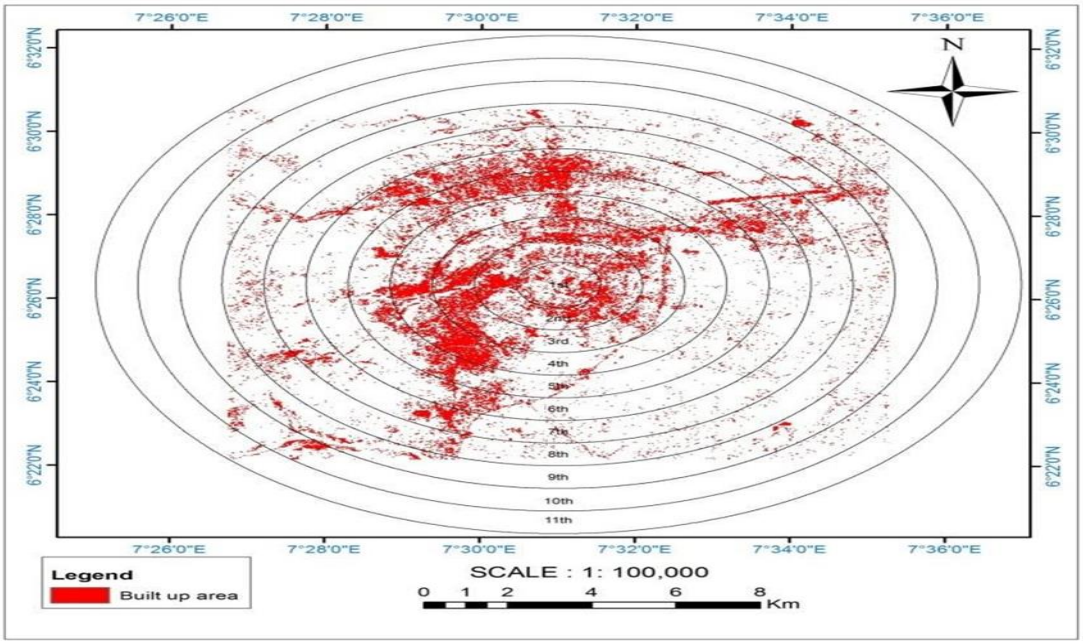


Figure 8: Enugu Built up Area, Year 2000

Table 4: Calculation of Sprawl year2000

ID Zone 2000	Area (built up area) inSkim 2000	Area (Zone)in sqkm	% of built-up	built up den	PDENi	1/PDENi	log(1/PDENi)	Log 11	Entropy
1st	1.103	3.141	35.127	0.351	0.181	5.531	0.743	1.041	0.140
2nd	3.802	9.424	40.338	0.403	0.208	4.817	0.683	1.041	0.148
3rd	5.619	15.708	35.771	0.358	0.184	5.432	0.735	1.041	0.141
4th	5.320	21.991	24.192	0.242	0.125	8.032	0.905	1.041	0.117
5th	6.192	28.274	21.900	0.219	0.113	8.872	0.948	1.041	0.111
6th	5.523	34.557	15.983	0.160	0.082	12.156	1.085	1.041	0.093
7th	3.596	40.840	8.806	0.088	0.045	22.064	1.344	1.041	0.063
8th	3.065	47.123	6.503	0.065	0.033	29.878	1.475	1.041	0.051
9th	1.967	53.406	3.682	0.037	0.019	52.768	1.722	1.041	0.034
10th	1.075	59.690	1.800	0.018	0.009	107.926	2.033	1.041	0.020
11th	0.152	65.973	0.231	0.002	0.001	842.768	2.926	1.041	0.004
Total	**37.41**	**380.13**	**194.33**	**1.943**	**1.000**	**1100.24**	**14.60**	**11.46**	**0.922**

Source: GIS from Figure 8.

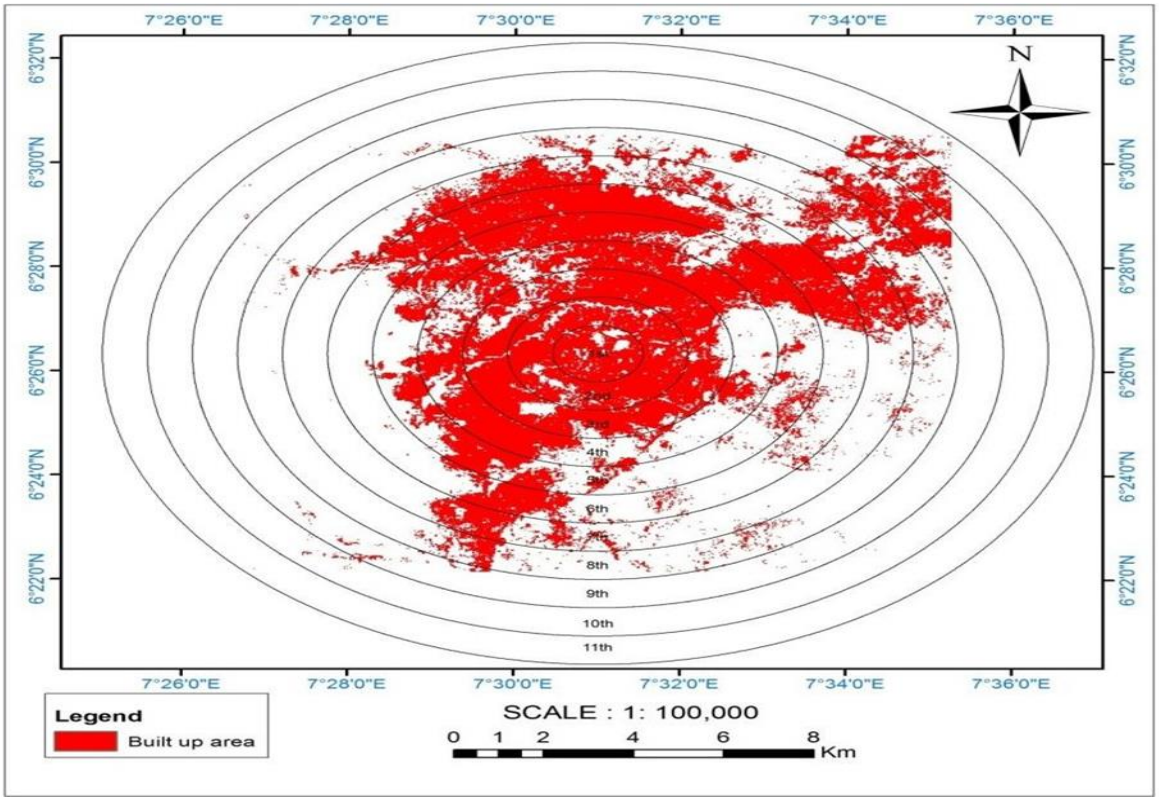


Figure 9: Enugu Built up Area, Year 2010.

Table 5: Calculation of Sprawl in Year 2010.

ID Zone 2010	Area (built up area) in Sqkm 2010	Area (Zone) in sqkm	% of built-up	built up den	PDENi	1/PDENi	Log (1/PDENi)	Log 11	Entropy
1st	2.597	3.141	82.661	0.827	0.190	5.261	0.721	1.041	0.143
2nd	8.060	9.424	85.528	0.855	0.197	5.085	0.706	1.041	0.145
3rd	12.527	15.708	79.752	0.798	0.183	5.453	0.737	1.041	0.141
4th	11.885	21.991	54.043	0.540	0.124	8.047	0.906	1.041	0.117
5th	13.910	28.274	49.199	0.492	0.113	8.840	0.946	1.041	0.111
6th	13.583	34.557	39.306	0.393	0.090	11.065	1.044	1.041	0.098
7th	10.134	40.840	24.814	0.248	0.057	17.527	1.244	1.041	0.074
8th	5.179	47.123	10.990	0.110	0.025	39.574	1.597	1.041	0.042
9th	2.820	53.406	5.280	0.053	0.012	82.372	1.916	1.041	0.024
10th	1.773	59.690	2.970	0.030	0.007	146.413	2.166	1.041	0.015
11th	0.215	65.973	0.326	0.003	0.001	1333.870	3.125	1.041	0.002
Total	**82.68**	**380.13**	**434.87**	**4.349**	**2.238**	**1663.51**	**15.11**	**11.46**	**0.913**

Source: GIS from Figure 9

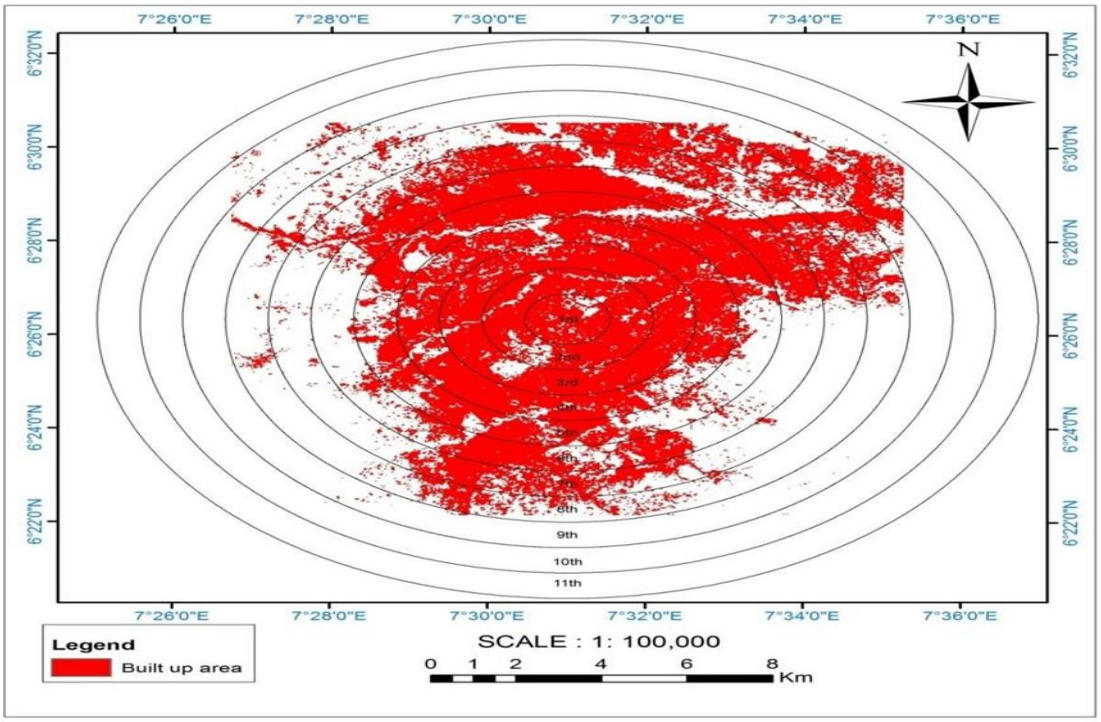


Figure 10: Enugu Built up Area, Year 2020.

Table 6: Calculation of Sprawl in Year 2020.

Table 6: Calculation of Sprawl in Year 2020.

ID Zone 2020	Area (built up area) inSqkm 2020	Area (Zone)in sqkm	% of built-up	built up den	PDENi	1/PDENi	log(1/PDENi)	Log 11	Entropy
1st	2.659	3.141	84.638	0.846	0.160	6.238	0.795	1.041	0.133
2nd	8.153	9.424	86.512	0.865	0.164	6.103	0.786	1.041	0.134
3rd	14.159	15.708	90.140	0.901	0.171	5.858	0.768	1.041	0.136
4th	17.854	21.991	81.190	0.812	0.154	6.503	0.813	1.041	0.130
5th	17.602	28.274	62.256	0.623	0.118	8.481	0.928	1.041	0.114
6th	17.458	34.557	50.520	0.505	0.096	10.451	1.019	1.041	0.102
7th	15.577	40.840	38.142	0.381	0.072	13.843	1.141	1.041	0.086
8th	11.491	47.123	24.386	0.244	0.046	21.652	1.336	1.041	0.064
9th	4.217	53.406	7.897	0.079	0.015	66.862	1.825	1.041	0.028
10th	1.369	59.690	2.293	0.023	0.004	230.229	2.362	1.041	0.011
11th	0.019	65.973	0.029	0.000	0.000	18430.483	4.266	1.041	0.000
Total	**110.56**	**380.13**	**528.00**	**5.280**	**2.717**	**18806.70**	**16.04**	**11.46**	**0.938**

Source: GIS from Figure 10

5. Discussion of results.

Figure 2 to 10 and tables 1 to 6 displayed a comprehensive maps and data extracted from Enugu satellite map using the GIS apparatus. These were done at ten years' intervals for years 2000, 2010 and 2020. The map captured an area of 242.874km2 covering greater part of Enugu North, Enugu South and Enugu East Local Government Areas. In the maps, five classes of landuse land cover were identified namely (1) built-up area, (2) farmland,

(3) forest, (4) bare land and (5) wetland/water body.

In Shannon entropy interpretation 0.1- 0.33 are zone of concentrated urban development or minimal urban sprawl, 0.33- 0.66are zones of organised urban development or low urban sprawl while 0.66 and above belong to zone of chaotic urban sprawl or high level of urban sprawl. The cumulative Shannon entropy as calculated in table 4, 5 and 6 are 0.922 for year 2000. Then, 0.913 and 0.938 for years 2010 and 2020 respectively. Right from year 2000, the study area Enugu has surpassed the normal level of urban development but fall into the level of chaotic urban development or high-level urban sprawl.

The increasing intensity of the colour shadings from figures 8 to 10 showed vividly that the study area experienced a drastic change and intensity in land use/land cover over the last 30 years. Areas under built up increased while areas under agricultural land, vegetation, and open land decreased rapidly. Built-up area increased from 37.413km2 in year 2000 to 82.682km2 in 2010 representing over 100% increase while farmlands and forest decreased from 192km2 to 115km2. It indicated urban expansion at the cost of prime agricultural land. This is a serious factor for change in socio-economic status of Enugu urban. Open land has also been transformed into built up areas and this class of landuse has registered a decrease of 5km2 during the ten-year period. Other classes of landuse/land cover witnessed minor changes.

In 2020, built-up area covered an area of 110.559km2 out of total land area of 242.874km2 representing 45.52%. To be precise, if we adjust for difficult terrains and

water bodies/ wetlands/ flood prone areas, one can as well realise that percentage of built up areas has gone beyond 60% in general. Little wonder the residents have started experiencing increasing challenges of congestion in traffic, housing and high level of inadequacies in most other social amenities. The undeniable fact is that Enugu has been transforming from year to year, during which the urban landscapes were undergoing significant planned and unplanned shifts. Most of the urban settlements were dotted with slum areas and settlements that are not conducive for human habitation. The demand for urban land space for various land uses other than agriculture has been unprecedented leading to urban sprawl and unplanned urban invasion of the rural suburbs without physical planning. It was also discovered that in many instances the agricultural lands in the outskirts of cities were strongly customarily owned but weakly publicly managed. This may have given rise to easy short change of agricultural landscapes to urban sprawl. There is confusing ad mixture of traditional land ownership and what one may describe as weak and conflicting land and urban planning laws in Enugu.

Enugu urban has been found to be growing through uncoordinated piecemeal acquisition of lands and preparation of layouts at the outskirts of the cities by individuals, estate firms, communities, land speculators and government agencies creating an unsustainable urban growth and uncoordinated layouts in a process called incremental planning (Kharaman,2022).

6.Conclusion.

Calculating from the current planning standard where it is professionally advised not to develop over 35% of a plot of land in low density and 45% in high density areas, Enugu urban can be said to have been over developed. The Shannon entropy figure of over 0.90 showed that sprawling pattern is chaotic. It is therefore recommended that Enugu should undergo further research to find out the major causes of this chaotic urban development and likely challenges associated with the level of urban sprawl. Instead of continued development of new buildings and layouts in the chaotic enclave, massive infrastructure upgrade and development of new towns at 9th mile, Ituku/Ozara/ Agbogwugwu and Ogbeke/Ugwogo Areas should be encouraged.

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