THE PATTERN AND DRIVERS OF URBAN EXPANSION IN GREATER LAGOS FROM 1984 TO 2006

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ABSTRACT

Urban expansion has been identified as a major cause of global climatic and environmental changes, which are predicted to accelerate in the 21st century with unknown and potentially serious implications to life and the environment. Accurate and up-to-date information about urban expansion in terms of changes in urban area is needed for sustainable urban planning. Lagos is one of the fastest growing cities in the world and may experience the most serious implication of this change in the whole of West Africa. Lagos has witnessed great urban sprawl in recent times, annexing nearby villages and spreading fast into the neighbouring states. This growth and physical expansion is virtually undocumented and adequate planning to prevent great consequences of this development is therefore impossible. In this work, LandSat imagery (1984, 2001, and 2006) was processed and overlaid on the Lagos State administrative map in a GIS environment. Changes in linear expansion were recorded from a 1Km X 1Km grid while areal changes were recorded from a grid of 25Km X 20Km imposed on the map. Results of the linear changes in a few selected locations and the results of the areal changes in all the cells are presented. The result shows a fast growth of urban expansion in Lagos from 1984 to 2001 and from 2001 to 2006. The result was discussed and inferences were drawn on the drivers of urban expansion in Lagos.

Keywords: Urban, Expansion, Images, GIS, Land Use

INTRODUCTION

The growth and physical expansion of urban settlements which has occurred significantly all over the world in recent times has taken on a more dramatic momentum in those areas that have come to be regarded as the Third World (Aina, [1]). Barredo and Demicheli [2] noted that "urban population and expansion is increasing in developing countries particularly Africa. Urbanization is increasing in both the developed and developing countries. However, rapid expansion of large cities, and the associated problems of unemployment, poverty, inadequate health, poor sanitation, urban slums and environmental degradation pose a formidable challenge in many developing countries. Rapid urban expansion especially in the last two decades has put enormous pressure on land in Nigerian cities. Most of these big cities are faced with the problem of rapidly deteriorating physical and living environment (Owei, [3]). The most notorious example of urban expansion in Nigeria is undoubtedly Lagos. Lagos is well known for its heavy traffic congestion particularly at the rush hours, which became the site for urban peddling of an amazing variety of

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goods, entertainment, innovation and crime. Scenes of Lagos city within a few years bears a remarkable difference which testifies to the fast rate of urban expansion of Lagos. This growth and physical expansion is attested to in the United Nations report which predicted that Lagos will be the third most populous city in the world by 2015 after Tokyo and Bombay (UN, [5]). Lagos has witnessed great urban sprawl in recent times, annexing nearby villages and spreading fast into the neighbouring states. This growth and physical expansion is virtually undocumented and adequate planning could not be done to prevent great consequences this development could bring. Interestingly, researches have been conducted on urban expansion in many cities of the world. Examples are Hilton Head Island, South Carolina, (Lin *et al*., [6]); urban growth of the Greater Toronto Area (GTA) from 1985 to 2005, (Rui and Ban, [7]); urban sprawl model for Bursa-Istanbul (Eryilmaz, *et al*. [8]); North Ningxia, China and Regional Hub City in Japan, (Yoshitaka *et al*, [9]). In these works, authors have attempted to determine the rate of urbanization of the selected cities.

Studies have also been conducted on urban expansion of various cities in Africa. For instance, Wu *et al*., [10], investigated the factors influencing urban land use in Nouakchott, Mauritania. They concluded that population growth is the only factor responsible for urban expansion in Nouakchott. Tewolde and Cabral [11] studied urban sprawl and its impact on other land in Asmara, Eritrea. The result of the study indicated that the built-up area has tripled in size between 1989 and 2009. In their own study of Land use in Nairobi, Mundia and Aniya [12] covers the period between 1976 and 2000. They concluded that urban expansion has replaced agricultural farmlands and other natural vegetation, thereby affecting habitat quality and leading to serious environmental degradation. In Lagos, Barredo and Demicheli, [2] in their study on urban sustainability issues in African countries focussed on urban expansion in Lagos. They described land use simulation for the city of Lagos using an improved version of CA model prototype. The work included a twenty-year simulation run until 2020. Other studies on urban expansion in Lagos includes Braimoh and Onishi, [13]; Olayiwola *et al*., [14] and Okwuashi, [15]. There are also other previous studies on urbanization of Lagos (Aina, [1] and Adalemo, [16]) that are concentrated on a theoretical review of patterns of land use in Lagos.

In this study, expansion was determined in two ways. The first is a linear expansion determined along a predefined grid line at interval of 1Km x 1Km. The second was a determination of areal expansion, where the study area was divided into regular cells of 25Km X 20Km. The expansion of built up area was computed for each cell in each epoch. Therefore the growth of urban environment (changes that have taken place in the conversion of other uses of land, for instance agriculture, forests etc to urban land use which leads to the expansion of urban area into its suburbs) is the focus of this study for the following reasons:

- There is an unprecedented growth in the physical expansion of Lagos to its suburbs in the last few decades.
- This expansion is not adequately guarded or controlled by any government policy or regulations.
- Mapping the growth will provide the relevant knowledge and understanding of the pattern and rate of growth
- Future pattern of growth can be predicted

- Adequate planning for monitoring the growth can be possible.
- From the outcome of this exercise, it is possible to allude to the principal causes of urban expansion in Lagos

THE STUDY AREA

Lagos is located in the south –western part of Nigeria. It served the dual purpose of being the commercial and administrative headquarters of Nigeria until the mid 1990s when the administrative headquarters of Nigeria was moved to Abuja. Lagos is located at latitude $6^0$27′N and Longitude $3^0$24′E. This falls just above the equator on Africa continent. The metropolitan Lagos has an area of 137,460 hectares and spreads over (3345 sq km). The islands are connected to each other and to the mainland by bridges and landfills. Lagos has a very diverse and fast-growing population, resulting from heavy and ongoing migration to the city from all parts of Nigeria as well as neighboring countries. According to Nigerian National Population Commission (NPC), its metropolitan area was about 9 million people in 2006. The study area in this study includes the whole of Lagos state of Nigeria and the regions it has expanded to in the neighbouring Ogun State. These regions are four local government areas of Ogun state which includes Ado-Odo/Ota, Ifo, Shagamu and Obafemi Owode. Figure 1 shows the study area.

Figure 1: Map of the study area (source: Author's compilation)

METHODS

Data Acquisition

In this study, we used three LANDSAT imageries of 1984, 2001 and 2006. A regional map of Lagos was obtained from the Office of the Surveyor General of Lagos state. The administrative map of Ogun state was also acquired from the office of the Surveyor General of Ogun State. From the map, local governments in Ogun state that shares boundary with Lagos state and have experienced uninterrupted expansion of Lagos were carved out with Lagos.

TABLE 1: SOURCES OF DATA

S/N	DATA	SOURCE
1. 2. 3	Landsat Image 1984 Landsat Image 2000 Landsat Image 2006	Global Land Cover Facility, University of Maryland.
4	Administrative and local government maps of Lagos state	Office of the Surveyor General of Lagos State
5	Administrative and local government maps of Ogun state	Office of the Surveyor General of Ogun State

Landsat images of the study area for 1984, 2001 and 2006 were acquired for the purpose of this study. The images were superimposed on the administrative map of the study area from where the study area was clipped from the image. Based on prior knowledge of the study area for over 20 years and a reconnaissance survey using previous maps of the study area and additional information from previous research in the study area, a classification scheme was developed for the study area. The images were processed using six land use classes. The land classes used for this study are given in table 2. Having identified regions of interest for the land use types, the images were classified. The resulting land use maps were converted to shape files and imported into the ArcGIS environment. These maps were then compared with the images used in creating them. This comparison and with the apriori knowledge of the study area from ground truthing, necessary corrections were effected on areas where the result disagree with the actual ground situation. Different layers were created for the various land use classes. Layers were created for the land use classes and these layers were grouped under the built up areas, bare soil, waterbody, wetland, mangrove and vegetation.

TABLE 2: LAND USE CLASSES USED FOR THE STUDY

S/N	CLASS	Description
1	Built up	All residential, commercial and industrial areas, villages settlements and transportation infrastructure
2	Mangrove	Mangrove forests
3	Vegetation	Trees, shrub land and semi natural vegetation, decidous, caniferous and mixed forests, palms, orchads, herbs, climbers, gardens and grasslands.
4	Water Body	River, permanent open water, lakes, ponds, canals and reserviors.
5	Bare soil	Fallow land, earth and sand land infillings, construction sites, excavation sites, solid waste landfills, open space and exposed soil.
6	Wetland	Marshy, waterlogged and areas suceptible to seasonal flooding.

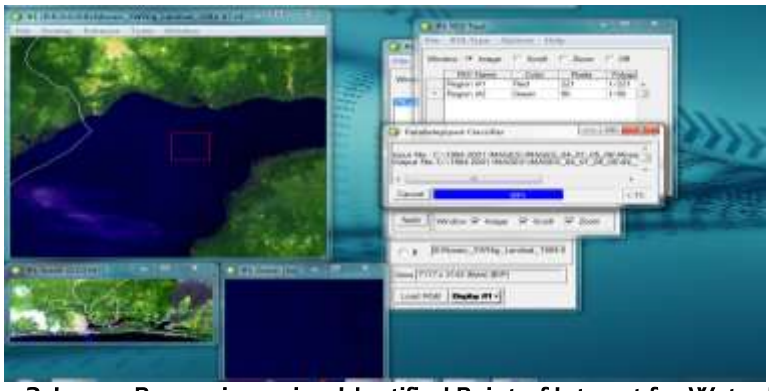

Figure 2: Image Processing using Identified Point of Interest for Water body

Figure 3: Water Body Overlaid on the Image to Identify error in the Classified Water body.

RESULTS

The land sue maps which are the results of the image processing are shown in figures 3 to 6.

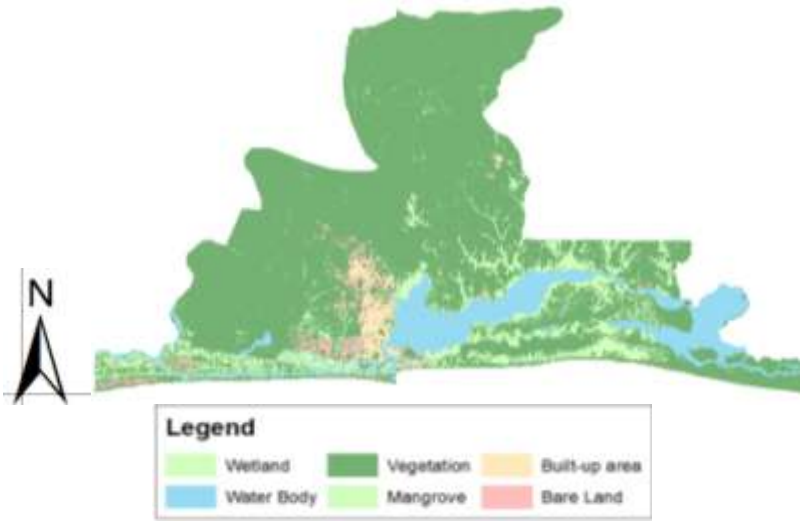

Figure 4: Land Use Map of the Study Area in 1984

Figure 5: Land Use Map of the Study Area in 2001

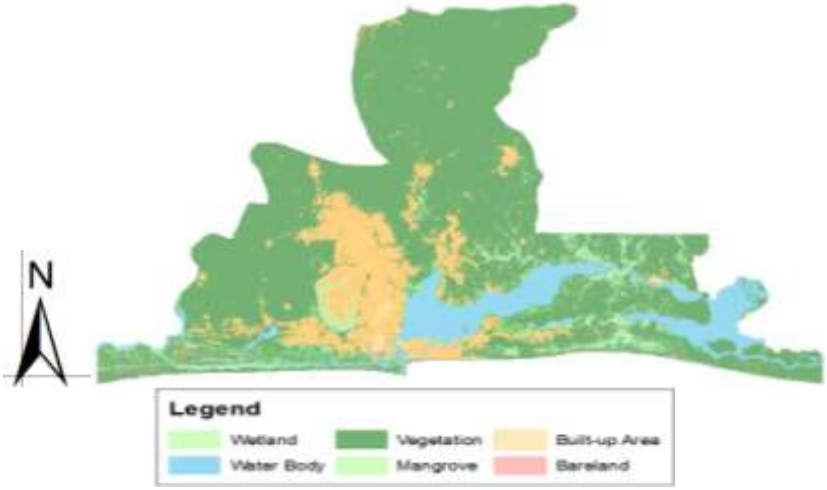

Figure 6: Land Use Map of the Study Area in 2006

Lineal Growth

In order to determine the linear changes in urban expansion, grid cells of 1km interval was imposed on the land use maps and the changes in urban expansion location along a grid line was determined.

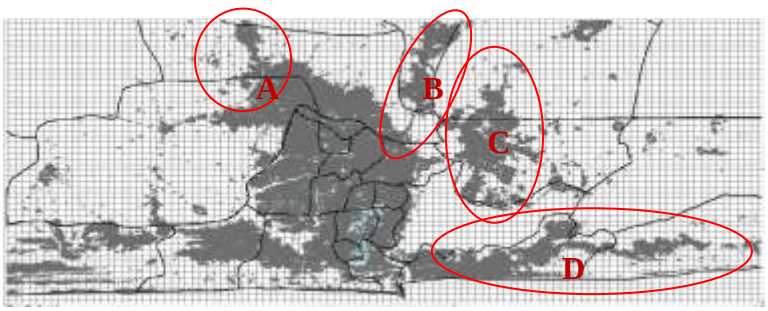

Figure 7: I kilometer gridded lines imposed on the built up class of the study area

The result obtained from this exercise is huge and because of the limitation of space, results for selected locations in the North South direction where linear changes are more than 500 metres between two epochs are presented. The locations selected for analysis is determined based on the areas that experienced more expansion as seen from the land use maps. Although, expansion occurred in almost all areas of the region under study, the areas highlighted in red in figure 7 labelled A to D above experienced greater expansion compared with others. This can be confirmed from the land use maps in figures 4, 5 and 6. The area marked A comprises of Alimosho local government of Lagos State, Ifo and Ado/Odo Ota local government of Ogun state. From our results, Alimosho experienced tremendous expansion between 1984 and 2001. After 2001, most of the land available for development in the area are already outside of Alimosho Local Government and hence, oustide of Lagos State. Ifo and Ado/Odo Ota Local Governments both expenrienced more expansion in 2001 to 2006 than Alimosho Local government. The result of expansion for Ifo Local Government is presented in table 4.

The area marked B in figure 7 above comprise of only Obafemi Owode Local Government in Ogun State. It is necessary to note that from field survey, most of the people living in the area are working in Lagos metropolis. As may be seen in land use maps above, development was noticed in the area only on the 2001 map. This suggests that those development were not in place in 1984. It is also necessary to note that the developed area in B is detached from the urban expansion in Lagos. The reason is because the undeveloped area between Lagos urban and area B is a flood plain usually flooded annually during the raining season especially when Oyan river that releases water to the plain overflows its boudaries. The region is also marked by a very long bridge built over the plain along the Lagos Ibadan Express way. The same pattern of seperation is noted between Lagos urban and Area C.

Table 3: Urban Expansion in Alimosho Local Government (N/S direction)

Parallel of Departure	2001 EXP (N) m	2001 EXP (S) m	2006 EXP (N) m	2006 EXP (S) m
532000	276.396	1026.621		
531000	7350.191	4789.789	0	9.017
529000	518.297	3568.353		268.842
529000	8339.622	4525.052	61.109	
527000	2305.48	4402.231	38.041	0
527000	5862.765	12899.822	848.52	26.848
526000	2176.662	1082.366		0
525000	2857.333	993.276	51.772	0

Table 4: Urban Expansion in Ifo Local Government (N/S Direction)

Parallel of Departure	2001 EXP (N) m	2001 EXP (S) m	2006 EXP (N) m	2006 EXP (S) m
543000	5043.758	327.544	91.37	
542000	2929.058	327.544	1136.396	
538000	5504.51	718.773	271.278	
535000	4379.807	827.957	72.84	
534000	4653.257	860.662	479.018	551.929
531000	7350.191	4789.789	0	9.017
527000	5862.765	12899.822	848.52	26.848
526000			1559.682	
525000	4364.993	1012.2	545.846	

Table 5: Urban Expansion in Obafemi/Owode Local Government (N/S Direction)

Parallel of Departure	2006 EXP (N) m	2006 EXP (S) m
549000	2065.695	19.454
547000	967.878	4392.406
547000	5086.295	187.74
546000	219.555	1025.03
545000	1154.574	1057.331
545000	133.963	1154.573

Table 5 shows the expansion recorded between 2001 and 2006. We also observe that within a period of only 5 years, expansion recorded are in Kilometres with a line recoding above 5 kilometres. This expansion is indeed very fast. The area marked C in figure 7 comprises of Ikorodu Local Government. It has experinced fast growth and has extended by 2006 to the Shagamu local government area of Ogun State. Expansion to the south has been alted by the Lagos Lagoon. It however continues to grow in other directions.

Table 6: Urban Expansion in Ikorodu Local Government (N/S Direction)

Parallel of Departure	2001 EXP (N) m	2001 EXP (S) m	2006 EXP (N) m	2006 EXP (S) m
570000	0	0	2856.209	121.287
569000		204.964	13.955	1057.039
567000	1318.571	0	148.137	0
561000			1042.284	32.693
559000			72.532	906.941
558000	983.827	1263.502	116.056	92.409
555000	2694.83	588.748	851.365	
555000	318.906	3208.585		96.885
554000	3648.386	1422.801	3838.598	
551000				1730.069

Areas where rapid expansion were experienced between 2001 and 2006 were not so much developed between 1984 and 2001. This suggests that expansion migrated to where land is available.

The area marked D in figure 7 comprises of Eti Osa and Ibeju Lekki Local Governments. Expansion in this area is more prominent in the East-West direction. This follows the pattern of the road in the area and the restriction posed to expansion in the North-South direction by the Atlantic Ocean and Lagos Lagoon. Land is not available in this area as it is in the other areas we have considered. Besides, this area is the most wanted by the rich ones living in Lagos. Landed property is about five times costlier than other areas. Yet, the expansion recorded is still very tremendous.

Table 7: Urban Expansion in Eti Osa and Ibeju Lekki Local Governments (N/S Direction)

Parallel of Departure	2006 EXP (N) m	2006 EXP (S) m
582000	705.38	1400.871
581000	202.372	581.39
580000	85.17	936.36
579000	113.007	1744.77
578000	167.635	1320.326
573000	453.304	484.602
572000	715.284	748.81

Table 8: Urban Expansion in Eti Osa and Ibeju Lekki Local Governments (E/W Direction)

Parallel of Departure	2001 EXP (E) m	2001 EXP (W) m	2006 EXP (E) m	2006 EXP (W) m
715000			1165.256	122.605
714000	1020.695	373.791	84.819	
714000			2300.078	181.027
713000			6631.245	2444.959
712000			4008.764	308.638
711000	6547.018	0	3339.503	0
717000			261.262	2773.889
716000			3429.051	154.09

Area Growth

The study area was divided into 25 regular cells of 25Km by 20 Km intervals. The following factors were borne in mind for the subdivision operation.

- The terrain of Lagos which is a mixture of land lagoons and creeks
- The growth pattern recognized from the land use maps (developed and developing areas)
- The administrative map and divisions in Lagos
- Areas with similar neighbourhood indices grouped in a cell
- The geometry of Lagos i.e. it extends more in the east-west direction than in the north south direction.

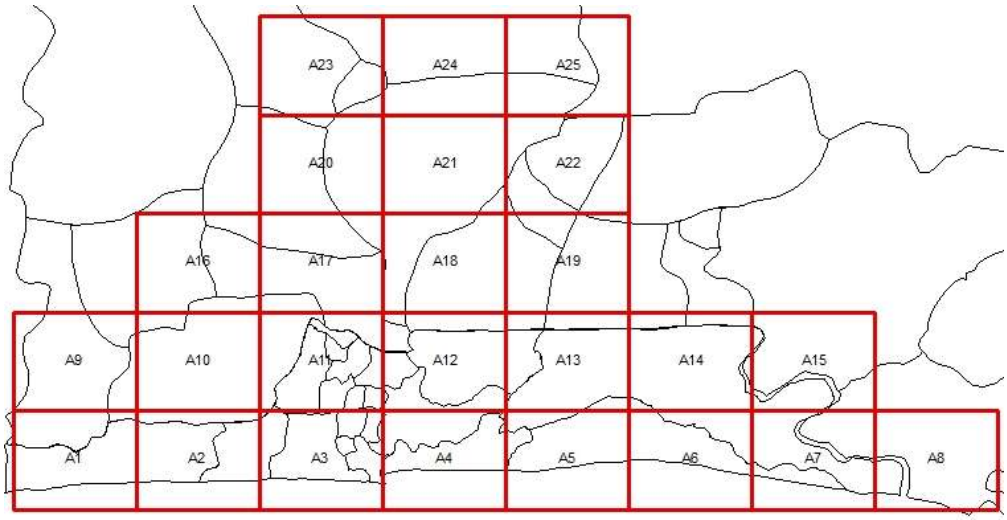

Figure 8: Lattice Design for the Study Area

The built up area, which accounts all areas occupied by human activities was computed and the result is as shown in table 9.

Table 9: Urban Growth in Greater Lagos between 1984 and 2006

Cell	Area 1984 (Km^2)	Area 2001 (Km^2)	Area 2006 (Km^2)
1	0.6021	4.783994	4.830667
2	4.697329	49.0528	60.0754
3	105.2305	173.8161	197.294
4	19.26649	62.42364	97.56706
5	0.614876	6.368239	27.33072
6	0.0009	0.0765	1.973375
7	1.236008	4.248406	18.40428
8	0.378632	0.564864	1.039502
9	0.003683	1.872008	2.167326
10	0.0738	9.084887	10.50763
11	106.7631	308.7893	355.8743
12	10.42039	74.34912	118.6505
13	1.796189	5.280906	7.168655
14	2.939915	10.16673	13.66019
15	Insignificant		
16	0	0.433783	1.647776
17	1.972143	56.94113	74.46343
18	0.917473	15.79584	42.02823
19	6.014471	17.17334	19.5626
20	0.193671	2.243751	3.169578
21	0.0783	3.622121	4.647838
22	0.008949	0.016164	0.090858
23	0.56228	4.706962	8.187682
24	0.0027	0.612318	0.829347
25	0.0009	0.952023	1.00494

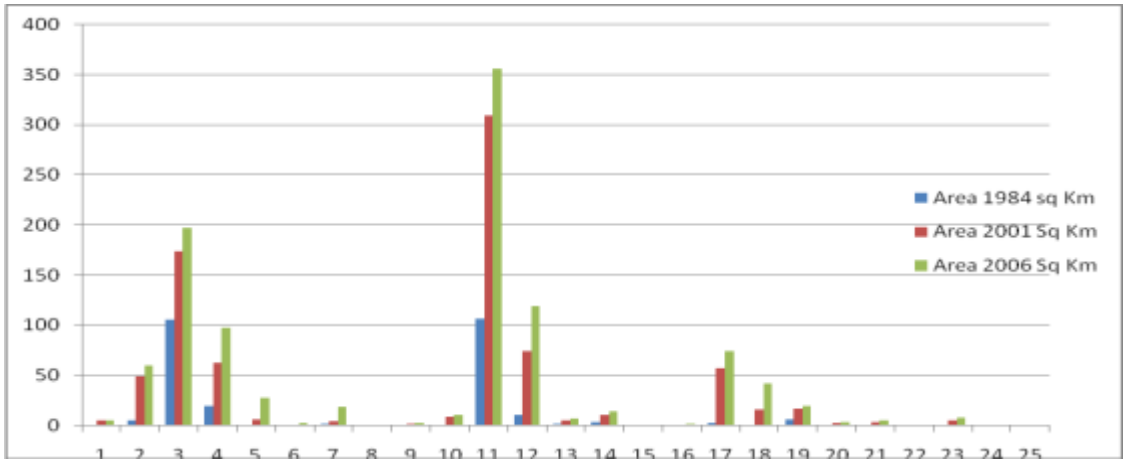

Figure 9: Chart showing area of bulit up land in each cell from 1984 to 2006

As can be observed in all the cells, there is a steady growth of built up area from 1984 to 2006. It can also be observed that urban expansion is growing from dense urban areas to sparse urban areas. One can then conclude that the growth will continue in the subsequent years. This brings us to the real fact that Lagos has already emmerged as a megacity and since the growth continued steadily throuhout the period examined and will most likely continue to grow, we then have to make room for this megacity. It is known the world over that city growth can hardly be stopped, the growth can however be sustainably controlled. The control can be achieved through a careful study and understanding of the trend and pattern growth.

Drivers of urban expansion in Greater Lagos

Authors in urban expansion uses identified drivers to model urban expansion from where the contributon of each driver is derived. Result of such model helps in making useful decisions on which driver could be altered and how, so as to plan and implement a sustainable development. Although, different drivers (which includes population, income potential, neighbouhood indices etc.) had been used in modeling Lagos expansion (e.g Braimoh and Onishi, 2007), we discussed in this paper only those drivers that could be alluded to from the results of our image processing.

Road: It is important to note that in all the land use maps produced for different epochs, Lagos city growth is prominent where there is road. Examples are regions A, B, and D in figure 7 which have the presence of Lagos Abeokuta Road, Lagos Ibadan road and Lekki Epe road. Another region that has witnessed signifant growth though not presented in this paper is Lagos Badagry corridor. All these examples revealed that road is a majour factor in urban expansion.

Land Availability: It can also be observed from the land use maps that areas where there is vegetation unmixed with so much wetland and water got developed in subsequent epoch. Areas A, B, C and D are all areas where pure vegetation land is available. It is only in region D that we have vegetation sandwiched by the Atlantic ocean and the Lagoon. Even at that, the development is clusterred around the road linking Epe, which coincidentally is the area wiyhin the region that has availability of Land.

Land Value: It could be inferred that the areas that witnessed significant growth have their land values relatively low. According to report published by Ukabam (2010), land value in Lagos metropolis is relatively low in such areas as Abule Egba and Ipaja (which falls within region A) and Ajah (which is In region D). Although his work did not cover the regions B and C, authors field investigation revealed that land value in these regions are not higher than the those of A and D.

Proximity to CBDs: It may be difficult to conclude that CBD affect expansion in Lagos if Lagos is considered to have only one CBD which unaguably can be referred to as Lagos Island. Many of the regions identified to be growing very fast are somehow far from Lagos Island. If however, Lagos is considerred to have multiple CBDs as proposed by authors such as Ukabam (2010) and Braimoh and Onishi (2007), then we can conclude that expansion is affected by CBDs. For instance, if Ikeja is

considerred as one of the CBDs in Lagos, then we can infer that it is affecting the growth in regions A and B. Region D could therefore be said to be affected by the duo of Lagos Island and Victoria Island.

CONCLUSION

The results of this study shows that Lagos is expanding at a very rapid rate. Its expansion is indescriminate of the administrative boundaries as it can be seen from 2001 land use map that the region called "Lagos" has expanded beyond the boundaries of Lagos State. This is the main reason for the Lagos Megacity Project being undertaken by Lagos and Ogun States. The presentation of the results both in lineal and areal makes the expansion more appealing and understandable. We also observed that areas that are growing very rapidly could be most probably have been influenced by road network, land availabilty, land value and proximity to CBDs. It will be very important to take drastic steps towards ensuring the expansion that can be sustainable. If the pattern of growth recorded within the study period is maintained, Lagos will soon merge with other nearby cities such as Abeokuta, Ibadan, Shagamu and Ijebu Ode. With the picture of this merger in mind, how prepared is the government of Lagos, Ogun and Oyo states, and infact Nigeria as a country for this possible merger, what will be the effect of this merger on local and global environment? The government of Nigeria and the states affected should be prepared to address this problem quickly and by so doing, we will be making room for the Lagos megacity.

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