IMPACTS OF BUILT-UP EXPANSION ON LAND USE AND LAND COVER IN BAUCHI METROPOLIS, BAUCHI STATE, NIGERIA.

ANDREW A.
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT, UNIVERSITY OF ABUJA, FCT, ABUJA.

ADENLE A. A.
DEPARTMENT OF GEOGRAPHY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

OJOYE S
DEPARTMENT OF GEOGRAPHY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

&

SULE I. M
DEPARTMENT OF GEOGRAPHY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

Abstract

This research analyzed the impacts of built-up expansion on LULC in Bauchi metropolis, Bauchi state, Nigeria. Specifically, the study examined the LULC change between 1990-2020, and the extent of Built-up expansion between 1990 to 2020. Landsat ETM+ satellite imageries of 1990 and 2010 and Landsat OLI satellite imagery of 2020, were used. The imageries were processed using Arc GIS 10.7. Transition Change Analysis was carried out using IDRISI Selva 17.0 Edition version. The result obtained from the transition analysis revealed that, water bodies contributed about 9.11 sq.km to built surfaces between 1990 and 2010 and additional 5.18 sq.km between 2010 and 2020. Vegetation contributed about 10.91 sq.km between 1990 and 2010 and 29.20 sq.km between 2010 and 2020. Bare surfaces contributed about 9.45 sq.km to built-up surfaces from 1990 to 2010 and another 0.90 sq.km from 2010 to 2020. Rock areas contributed about 9.19 sq.km to built-up between 1990 and 2010 and another 1.06 sq.km from 2010 to 2020. There is need for Bauchi State Government to equip the relevant planning authorities involved in decision making with adequate data to ensure broad based decisions.

Keywords: Built-up expansion, LULC, Transition, Bauchi Metropolis.

Introduction

Urbanization has significantly risen in the last three to four decades, especially in emerging nations (Kumi-Boateng et al., 2015). The urbanization trend in Sub-Saharan Africa has been characterized by an average yearly growth rate of around four percent over the last twenty years (Henderson et al., 2017). Humans have modified almost 75% of the Earth's natural landscape in the last millennium (Winkler et al., 2021; Grafius et al., 2020; Dadashpoor et al., 2019). The rising demand for urbanized land hastens alterations in landscape patterns and has adverse impacts on the environment and human beings (Vliet, 2019; Fan et al., 2018; Zhang et al., 2020). In 2018, the global built-up land area amounted to 797,100 km^2, as reported by Gong et al. (2020). According to Wihbey (2017), it is projected that this figure would rise to around 3 million km^2 by 2050. Furthermore, the worldwide per capita built-up land area has grown and surpassed

the pace of population growth (McGarigal et al., 2018).

The rapid expansion of urban areas, to the detriment of other land use and land cover (LULC), is unparalleled and has resulted in farm displacement, resulting in the loss of arable land and damage of habitats. Urban expansion in the modern world is influenced by various factors that are difficult to monitor on a large scale. These factors include land-use policy, foreign financial flows, transportation costs, and the informal sector (Angel et al., 2011). The primary indication of human alteration of the environment through various urban land use activities is the constructed environment. This encompasses transportation, residential, industrial, institutional, commercial, and recreational land uses (Ifatimehin and Ufuah, 2007). The consequences of uncontrolled urban expansion, in terms of population and area coverage, include environmental pollution from traffic gridlocks, concentration of industries, and inadequate refuse disposal systems. This leads to environmental degradation, loss of natural habitat and species diversity, and increased health risks for humans due to heat, noise, and crowding. It is therefore crucial to evaluate the swift transformations taking place in cities in order to improve these difficulties.

The rapid and uncontrolled growth of towns and cities in emerging countries is mostly caused by the movement of people from rural to urban regions (Jahan, 2012). The increase in the number of people coming to Bauchi city was made worse by the changes in the social, economic, and political aspects of the city. This was not only due to improvements in infrastructure like electricity and clean water, but mainly because of the perceived job opportunities, especially for people who used to live in rural areas (Usman and Mohammed, 2012). Remote sensing and geographic information systems (GIS) have been recognized as effective scientific instruments for investigating and monitoring land use and land cover (LULC), as well as mapping built-up regions (Bhatti and Tripathi 2014; Zaitunah and Sahara, 2021). The study examined the effects of urban development on land use and land cover (LULC) in Bauchi metropolis, Bauchi state, Nigeria, using these tools.

Materials and Methods

The Study Area

Bauchi metropolis, the capital of Bauchi State and the primary traditional emirate, is located in the North Eastern geopolitical zone of Nigeria. The location is situated within the longitudinal coordinates of 9°48' 0" and 9°52'30" East of the Greenwich Meridian, as well as the latitudinal coordinates of 10°16' 30" and 10°21' 0" North of the Equator. Located at an altitude of 616m, it is situated on the northern boundary of the Jos Plateau. The geography of Bauchi metropolis is predominantly level in the central area (Usman and Mohammed, 2012). According to the Bauchi State Urban Development Board, the Bauchi Urban area has a radius of approximately 120 km and consists solely of the Bauchi local government region.

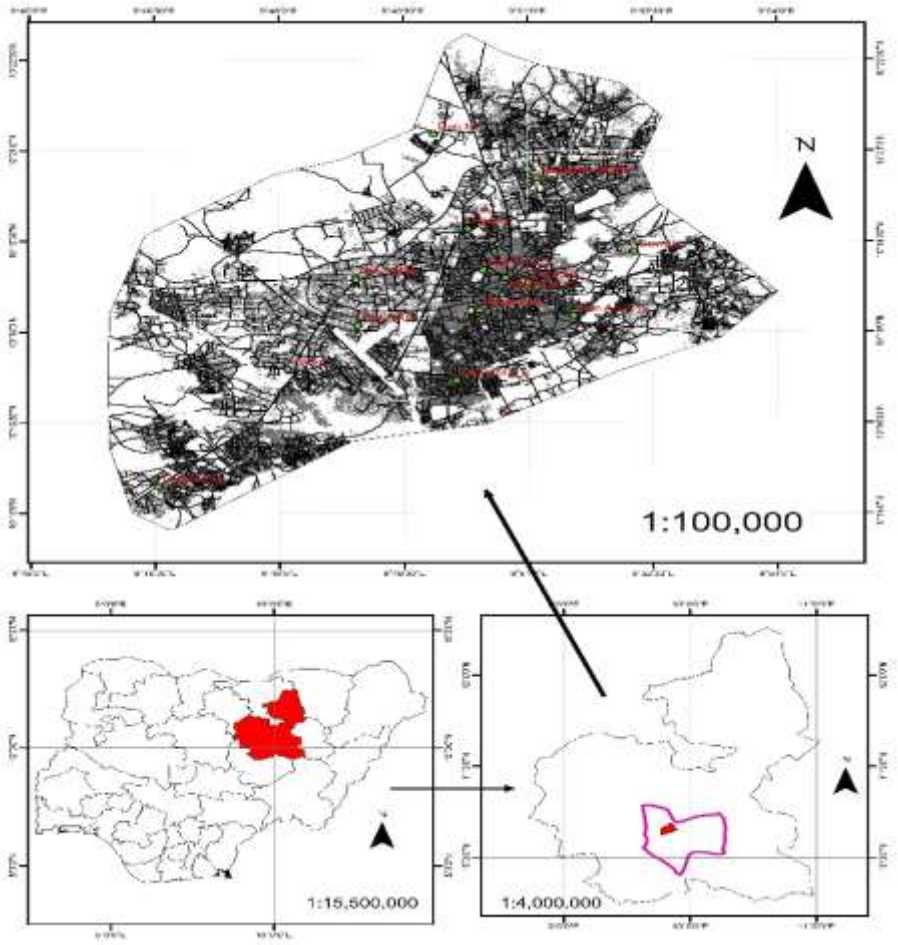


Figure 1: Bauchi metropolis
Source: Authors' Analysis (2023)

Nature and Sources of Data

The primary data used for this research were Landsat ETM+ satellite imageries of 1990 and 2010 and Landsat OLI satellite imagery of 2020, obtained from USGS. The study area lies on path 187 Row 54 on world referencing system. Other documented sources of data include: journals, thesis and other relevant secondary documents.

Method of Data Analysis.

The analysis was done with Arc GIS 10.7 and IDRISI for windows 17.1 Selva edition software. Arc GIS was used in calculation of the area in square kilometres of the resulting LULC types for each study year and subsequently comparing the result, while IDRISI was used in determining the transition that has taken place from LULC changes into urban expansion. The extent to which urban expansion influences LULC changes in the area was determined by Land Change Modeller (LCM) change analysis through transition map which showed all the transition from all other LULC into built-up between classified imageries of 1990-2010, 2010-2020 and 1990-2020, and identified how much urban land has increased over the years at the expense of other LULC (see Figure 2 for a flow chart of the study).

Table 1: LULC classification scheme

Classes	Description
Built-up Area	Residential, commercial, industrial, villages.
Water Bodies	River, lakes and reservoirs.
Vegetation	Any species of plants(flora), forest.
Bare surface	Exposed soils, landfill and areas of active excavation and production.
Rock Area	Any type of rock identified

Source: Jensen (2005)

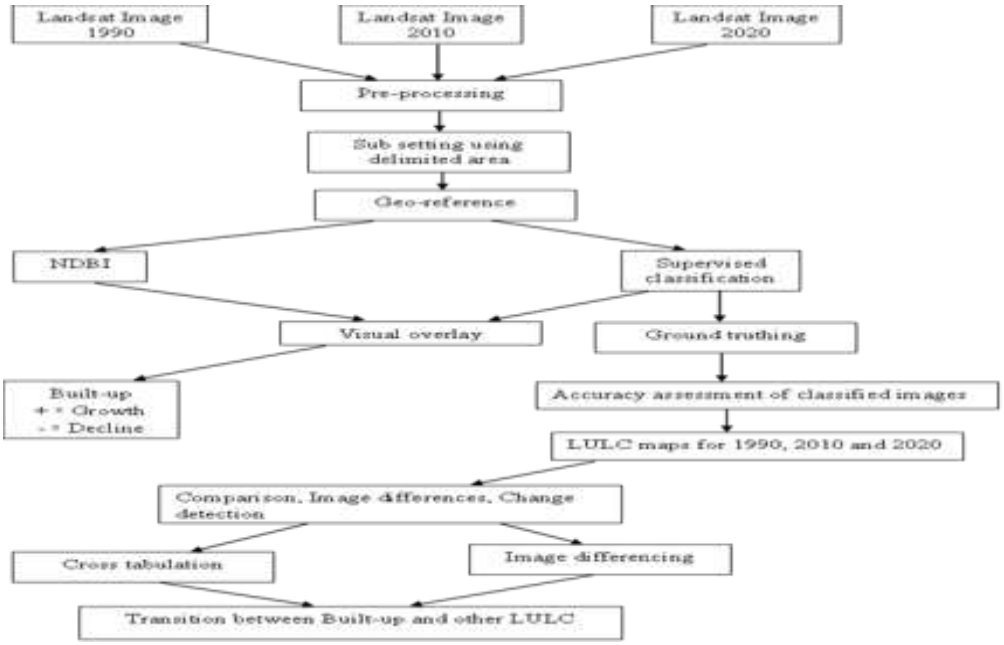


Figure 2: Flowchart of research methodology
Source: Authors' Analysis (2023)

Results and Discussion

Land Use Land Cover Classification

Table 2 shows the various LULC types and the proportion of the total area occupied by each. In the year 1990, built-up areas occupied the highest proportion of the total land, accounting for about 35.6% of the entire area, followed closely by vegetation with about 21.3%. Bare surfaces accounted for 17.3% in that same year, while rock area occupied about 14.2%. Water bodies occupied only 11.6% of the total land in the area in 1990. By the year 2010, built-up areas occupied the highest proportion of the total land, accounting for about 54.6% of the entire area, followed closely by vegetation with about 35.5%. Bare surfaces accounted for 1.3% in that same year, while water bodies occupied about 6.5%. Rocky areas occupied only 2.1% of the total land in the area in 2010. By 2020, built-up areas also occupied the highest proportion of the total land, accounting for about 73.8% of the entire

area, followed closely by rock areas with about 14.3%. Bare surfaces accounted for 7.3% in that same year, while water bodies occupied about 3.2%. Vegetation occupied only 1.4% of the total land in the area in 2020.

This implied that whereas built up areas decreased progressively from 42.56km2 (35.6% of the total area coverage) in 1990 to 88.45km2 (73.8% of the total area coverage) in 2020, water bodies decreased progressively from 13.81km2 (11.6% of the total area coverage) in 1990 to 3.86km2 (1.4% of the total area coverage) in 2020. Other land cover types also decreased considerably during the study period. This demonstrated urbanization impact on other LULC classes

Table 2: LULC distribution pattern between 1990, 2010 and 2020.

CATEGORY	1990		2010		2020	
	Area (Sq.km.)	Percentage (%)	Area (Sq.km.)	Percentage (%)	Area (Sq.km.)	Percentage (%)
Built-up Area	42.5588	35.6	65.4863	54.6	88.4490	73.8
Water Bodies	13.9146	11.6	7.7515	6.5	3.8609	3.2
Vegetation	25.5640	21.3	42.6504	35.5	1.6477	1.4
Bare Surface	20.7424	17.3	1.5086	1.3	8.8105	7.3
Rock Area	17.0913	14.2	2.4724	2.1	17.1069	14.3
TOTAL	**119.8711**	**100**	**119.8711**	**100**	**119.8711**	**100**

Source: Authors' Analysis (2023)

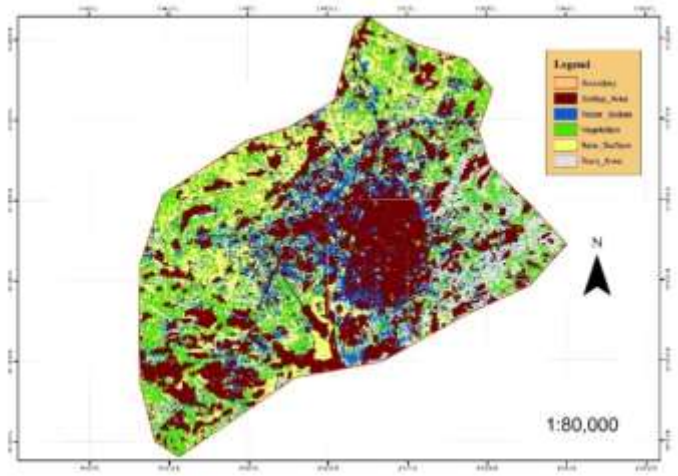


Figure 3: LULC of Bauchi metropolis 1990.

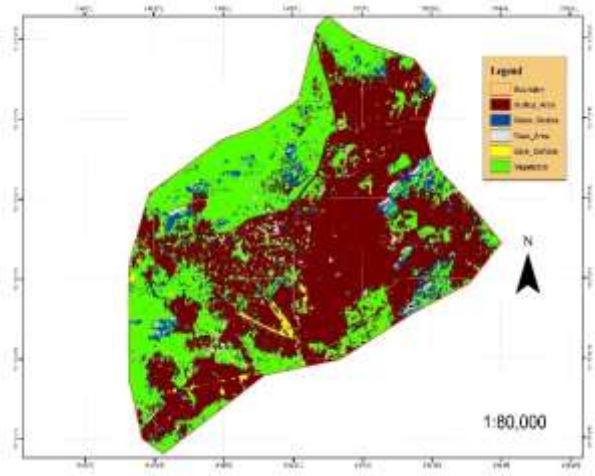


Figure 4: LULC of Bauchi metropolis 2010

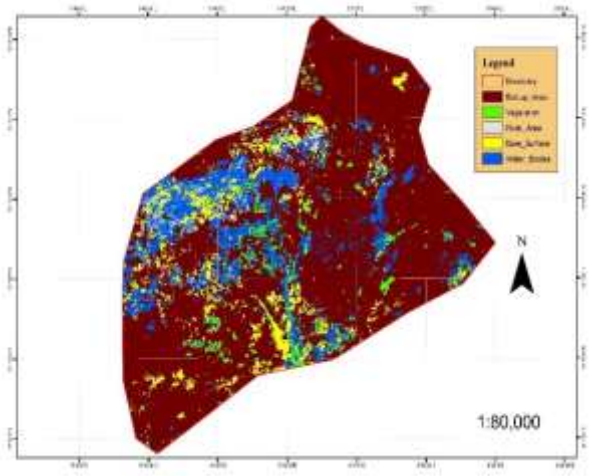


Figure 5: LULC of Bauchi metropolis 2020

Transition between LULC.

The transition place between the LULC classes within the study period is presented in Figure 6. It shows the extent to which LULC influences each other within the study period. The result revealed transitions between built-up and other LULC classes. Built-up area lost about 2.66 km^2 to water bodies between 1990 and 2010, and about 2.01 km^2 between 2010 and 2020. Built-up area also lost about 1.71 km^2 to rock area from 1990 to 2010 and a further 7.05 km^2 from 2010 to 2020. Built up areas lost about 0.48 km^2 from 1990-2010 and 4.08 km^2 from 2010-2020 to bare surfaces Furthermore, about 10.89 km^2 and 0.21 km^2 of built-up area was lost to vegetation from 1990-2010 and 2010-2020 respectively.

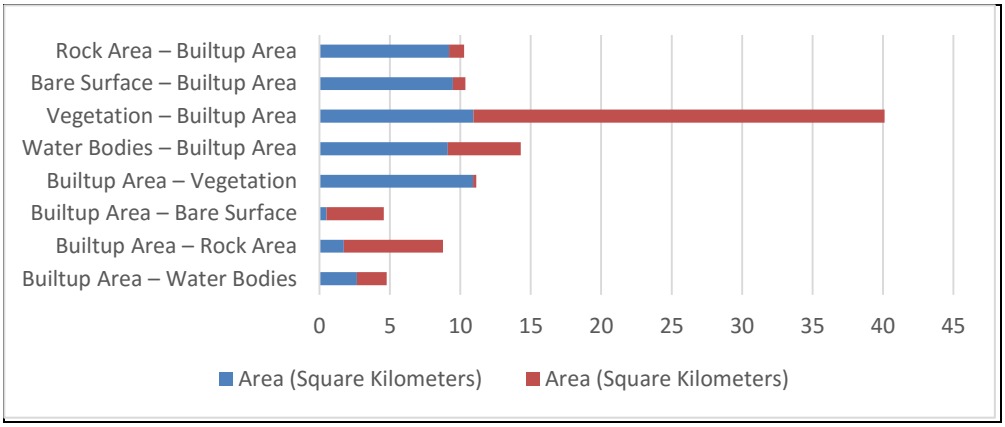


Figure 6: Transition between Built-up and other LULC

It is seen from the foregoing results obtained as shown in Figure 6 that other LULC classes changed into built-up surfaces, leading to urban expansion experienced within the study period. The figure revealed that water bodies contributed about 9.11 sq.km to built surfaces between 1990 and 2010 and additional 5.18 sq.km between 2010 and 2020. The conversion was minimal because of the fact that it's

unlikely for a substantial amount of water bodies to change into built-up but rather into bare surfaces when it dries up, cultivated or vegetated as confirmed by the results.

The result also revealed that vegetation contributed about 10.91 sq.km between 1990 and 2010 and 29.20 sq.km between 2010 and 2020. This is attributed to the fact that vegetation is cleared due to urban expansion for developmental purposes and it also affirms the fact that vegetation is decreased significantly from 2010 to 2020 at the expense of built-up areas. The result further revealed that bare surfaces contributed about 9.45 sq.km to built-up surfaces from 1990 to 2010 and another 0.90 sq.km from 2010 to 2020. This the fluctuations in bare surfaces over the span of the study period, leading to its reduction at the expense of urban expansion.

Rock areas contributed about 9.19 sq.km to built-up between 1990 and 2010 and another 1.06 sq.km from 2010 to 2020. This could be attributed to the large scale that quarrying for urban expansion in the area.

Based on the foregoing the study revealed the extent to which urban expansion influences LULC in the study area.

Computation of Normalized Difference Built-up Index (NDBI)

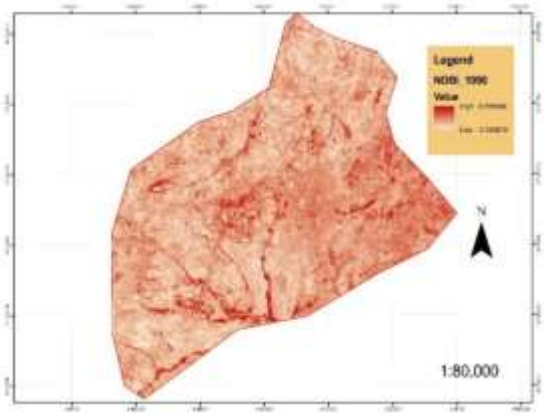
NDBI values of 1990 imagery (Table 3, Figure 7) indicated the highest and lowest built-up values 0.18 to -0.33. The maximum values revealed the densely built-up and barren areas, while the minimum values were displayed over the water bodies and vegetative areas. The maximum NDBI value of 0.57 recorded in 2010 (Table 3, Figure 8) was observed over built-up, while the minimum value of -0.335079 over the study area was recorded in 1990. The built-up index of 0.25 recorded in 2020 (Table 3, Figure 9) represented the highest value over settlements, sand, and barren lands. On the other hand, minimum values showed the NDBI -0.15 over water bodies, crop lands and other vegetation.

Table 3: NDBI values for 1990, 2010 and 2020

Indices	**1990**		**2010**		**2020**	
	High	Low	High	Low	High	Low
NDBI	0.184948	-0.335079	0.576466	-0.157596	0.255825	-0.156716

Source: Author's Analysis

Figure 7: NDBI of Bauchi metropolis 1990



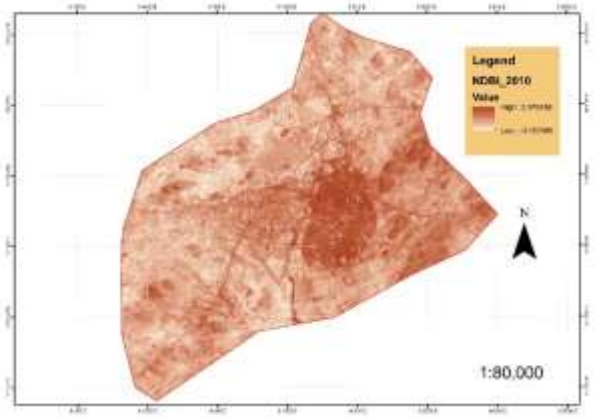


Figure 8: NDBI of Bauchi metropolis 2010

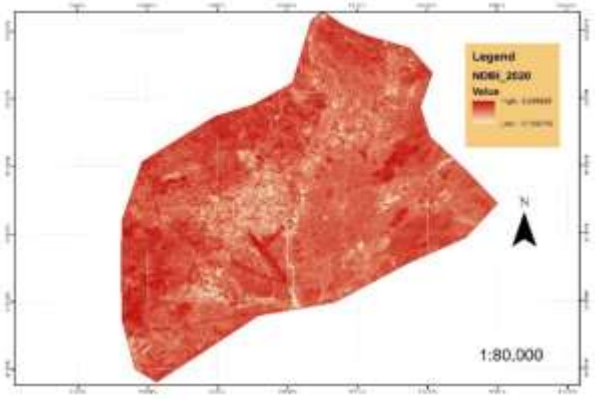


Figure 9: NDBI of Bauchi metropolis 2020

Conclusion

The use of geospatial analysis in this study revealed an increase in built up areas due to population growth, urbanization, economic development, land availability and government policies. The study has shown the extent to which other LULC changes are been transformed into built up which is an indication of urban expansion with its serious unforeseen consequences which need to be addressed.

This has imposed significant pressure on the environment and natural resources with serious implications on spatial organization within the area. Mapping land cover change using Landsat images provide crucial information for policymakers and planners in understanding urban growth consequences especially towards the environment. Thus, it represents greater importance of prioritizing policies and specific regulations for the regional development authority.

In view of the foregoing discussion, the state agencies that are charged with the responsibility of ensuring ordered development of Bauchi metropolis (survey, town planning) seem to have been outpaced by the rate of expansion. In response to this, the town planning department has to apply planning control measures such as development control and urban growth boundary in a stricter manner than before to control the development trend.

References

Angel, S., Parent, J., Civco, D., Blei, A., & Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. *Progress in Planning,* 75(2), 53–107. DOI: https://doi.org/10.1016/j.progress.2011.04.001

Bauchi. (2015). Encyclopedia britannica. Retrieved October 17, 2015 from www.brittanica.com/place/Bauchi-Nigeria.

Bhat, P. A., Shafiq, M., Mir, A. A. & Ahmed, P. (2017). Urban sprawl and its impact on landuse/land cover dynamics of Dehradun City, India. *International Journal of Sustainable Built Environment,* 6(2): 513-521.

Dadashpoor, H., Azizi, P., Moghadasi, M. (2019). Land use change, urbanization, and change in landscape pattern in a metropolitan area. *Sci. Total Environ*. 655, 707–719. https://doi.org/10.1016/j.scitotenv.2018.11.267.

Decoville, A., Schneider, M. (2016). Can the 2050 zero land take objective of the EU be reliably monitored? A comparative study. J. *Land Use Science* 11 (3), 331–349. https://doi.org/10.1080/1747423X.2014.994567.

Dewan, A. M., Yamaguchi, Y. & Rahman, M. Z. (2012). Dynamics of land use/cover changes and the analysis of landscape fragmentation in Dhaka Metropolitan. *Bangladesh Geojournal*, 77(3): 315–330.

Du, S., Shi, P. & Rompaey, A.V. (2013). The relationship between urban sprawl and farmland displacement in the Pearl River Delta. China Land, 3(34): 34–51.

Fan, J., Wang, Y.F., Wang, C.S., Chen, T., Jin, F.J., Zhang, W.Z., Li, L.J., Xu, Y., Dai, E.F., Tao, A.J., Zhou, K., Li, J.Y., Tang, Q., Chen, D., Guo, R. (2018). Reshaping the sustainable geographical pattern: A major function zoning model and its applications in China. *Earth's Future* 7 (1), 25–42. https://doi.org/10.1029/2018EF001077.

Fekede, W. (2002). Deficits in urban land management and informal responses under rapid urban growth, an international perspective. *Habitat International*, 24(2): 127-50.

Gong, P., Li, X.C., Wang, J., Bai, Y.Q., Chen, B., Hu, T.Y., Liu, X.P., Xu, B., Yang, J., Zhang, W., Zhou, Y.Y. (2020). Annual maps of global artificial impervious area (GAIA) between 1985 and 2018. *Remote Sens. Environ*. 236, 111510 https://doi.org/10.1016/j.rse.2019.111510.

Grafius, D.R., Edmondson, J.L., Norton, B.A., Clark, R., Mears, M., Leake, J.R., Corstanje, R., Harris, J.A., Warren, P.H. (2020). Estimating food production in an urban landscape. *Sci. Rep.* 10, 5141. https://doi.org/10.1038/s41598-020-62126-4.

Ifatimehin, O.O. & M.E. Ufuah, (2007). An analysis of urban expansion and loss of vegetation cover in Lokoja, using

GIS techniques. Zaria Geographer. *Journal of Environmental Studies and Human Development,* 17(1): 28-36.

Ishaya S., Ifatimehin, O.O. & Okafor, C. (2008). Remote sensing and GIS applications in urban expansion and loss of vegetation cover in Kaduna Town, Northern Nigeria. American-Eurasian *Journal of Sustainable Agriculture*, 2(2): 117-124.

Jensen, J. R. (2005). Introductory digital image processing: A remote sensing perspective. 3rd Edn., Bergen (NJ): Pearson Prentice Hall.

Liu, Y., Chen, J., Cheng, W., Sun, C., Zhao, S. & Pu, Y. (2014). Spatiotemporal dynamics of the urban sprawl in a typical urban agglomeration: A case study on Southern Jiangsu, China (1983–2007). *Frontiers in Earth Science*, 8(4): 490–504.

McGarigal, K., Plunkett, E.B., Willey, L.L., Compton, B.W., Deluca, W.V., Grand, J. (2018). Modeling non-stationary urban growth: The SPRAWL model and the ecological impacts of development. *Landscape Urban Planning* 177, 178–190. https://doi.org/ 10.1016/j.landurbplan.2018.04.018.

UNCHS-United Nations Center for Human Settlements, (1996). An urbanizing world: World global report on human settlements. New York: Oxford University Press.

Usman, H.A, Mohammed, B.U. (2012). Solid waste management in Bauchi, Nigeria (Obstacles and prospects). *Journal of Environmental Science and Resources Management,* 4, 96-107. Retrieved from www.cenresinpub.org

Vliet, J.V. (2019). Direct and indirect loss of natural area from urban expansion. *Nat. Sustainability* 2, 755–763. https://doi.org/10.1038/s41893-019-0340-0.

Wihbey, J. (2017). Boundary Issues: The 2016 Atlas of urban expansion indicates global densification. *City Scape* 19, 21–30.

Winkler, K., Fuchs, R.., Rounsevell, M., Herold, M. (2021). Global land use changes are four times greater than previously estimated. *Nat. Commun.* 12, 2501. https://doi. org/10.1038/s41467-021-22702-2.

Zhang, Y., Geng, W.L., Zhang, P.Y., Li, E.L., Rong, T.Q., Liu, Y., Shao, J.W., Chang, H. (2020).
Dynamic changes, spatiotemporal differences and factors influencing the urban eco-efficiency in the Lower Reaches of the Yellow River. *International Journal Env. Res. Pub. He* 17, 7510. https://doi.org/10.3390/ijerph17207510.