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LAND USE/COVER CHANGE AND ITS IMPLICATION FOR FLOOD EVENTS IN BENUE STATE, NIGERIA

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ABSTRACT

The aim of the study is to analyse the implication of land cover change on flood events in Benue state, Nigeria over the period 1990-2020. Landsat TM (1990); Landsat ETM+ (2000, 2010); and Operational Land Imager (OLI) (2020) were used. The Landsat imagery dataset was sourced from the Earthexplorer platform from United States Geological Surveys (USGS). Changes in land cover were measured using time series of remotely sensed data (Landsat TM, ETM and OLI). This study adopted the Error Matrix approach in ArcGIS to assess the accuracy of the classification. From the analysis, it was observed that, there is a significant decrease in forest land cover with annual decrease 3.26% within the 30 years (1990 to 2020) while cropland and pasture land increased with annual rate of increase of 2.21%, built up area 2.13% Water 0.04%, bareland/sandbar with 11.51% annual rate of change. These land cover dynamics is capable of creating environment suitable for increased surface run off and subsequently flooding. This situation coupled with significant increase in rainfall trend (positive constant of 5.45), will mean increase in flood events (positive constant of 8.72) and vulnerability of people, settlement especially urban and human activities within flood prone areas in Benue state. The relationship between land cover change and flood events shows that there is significant influence of change in forestland cover, cropland/pasture, built up area, water body and bare surfaces on flood events in the area. This implies that changes in land cover is contributing significantly to flood generating mechanism which means that all things being equal, flood events in the area will continue to increase in terms of frequency, magnitude and its impacts on the area.

Keywords: Land use, Flood Events, Vegetation, Farmland, River Benue

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INTRODUCTION

Man's interactions with the environment have been identified as a key influence changing the earth's surface over time (Fasal, 2000; Ifatimehin and Ituah, 2007; Adeyeri and Okogbue, 2014). The nature and magnitude of flood events are influenced by changes in the earth's surface characteristics. The information on changing land-use within a region is vital for evaluating the hydrological impacts. The land on which we dwell has been drastically altered by human activities. Changes in land use and land use management, in particular, have an impact on the hydrology that determines flood events. Deforestation, urbanization, and other land-use activities can change the seasonal and annual distribution of stream flow, resulting in flood occurrences (Dunne and Leopold, 1978). During heavy and intense rainfall, changing land use from forested cover to crop/pasture land cover is known to increase the rate and total volume of runoff (Rowe, 2003; Panahi, Alijani, and Mohammadi, 2010; Tali, 2011; Lang 2018). Such changes in land use result in high peak flows as well as greater fluctuations in flows and water levels (Hamilton, 2001). Flood-related losses are increasing as a result of increased building along rivers and population concentrations near areas prone to flood disaster.

Land use and land cover play an essential role in flood occurrences because they affect surface landforms, which are vital in fluvial processes that generate floods. Floods, for example, are defined as a result of both geophysical and human factors (Davidson and Dawson, 1979). Floods are primarily an environmental danger that arise from a variety of fundamental reasons, the most common of which are climatological in origin, but which are frequently exacerbated by man's poor use or misuse of the physical environment (Ward, 1978; Oriola, 1994, 1998, Tali, 2011).

Anthropogenic land-use changes alter the size and timing of flood peaks (Rahman, Ningsheng, Mahmude, MdMonirul Islam c, Hamid Reza Pourghasemi, Ahmad, Jules Maurice Habumugisha, Washakh, Alam, Liu, Han, Ni, Shufeng, Dewan, 2021), as well as the magnitude and type of soil erosion. It has been discovered that afforestation and the promotion of sustainable forest management would significantly boost the water retention capacity of landscapes. The areas most vulnerable to damage by flooding are urban areas and thus, the urbanization of unsafe areas is responsible for recent dramatic flood disasters (Handmer, 2000). Change in land use exerts a significant influence on the relations of rainfall-runoff and/or runoff-flooding (Yang and Yu, 1998) and alter flood disaster accordingly.

Floods may be beneficial as well as harmful (Ali, 2018). Floods are the most contradictory of all severe phenomena, according to researchers (Jha, Lamond, Bloch, Bhattacharya, Lopez, Papachristodoulou, Bird, Proverbs, Davis and Barker, 2011 and Ferreina, Hamilton, Vincent, 2011). In light of this argument, Ologunorisa (2006) stated that flood is the most common natural hazard that causes the most damage while also providing the most benefits. Floods maintain the fertility of soils by depositing layers of silt and flushing salts from the surface layers. Floods provide water for natural irrigation and fishing, both of which are important sources of protein in many developing countries. Flood retreat agriculture, in which food crops are grown on the damp soil left after a flood, is frequently practiced in the tropics. The seasonal inundation of large floodplains in semi-arid West Africa is of crucial ecological and economic importance and is responsible for a larger agricultural output than the output associated with formal, highly capitalized irrigation systems (Adams, 1993). In a normal year, floods may bring these benefits without creating disasters (Smith, 1996). Floods also recharge underground water (Oriola, 2000).

Floods, on the other hand, cause havoc and catastrophic damage to the environment and people, especially in densely populated areas. The damages range from destruction of properties, roads and farmlands to displacement of persons and loss of lives (Oriola, 2000). Floods in Bangladesh killed 300,000 people in 1970, whereas floods in China killed 5 million people between 1860 and 1960. (Smith, 1996). In June, 1991, more than 5,000 people were killed in Afghanistan in perhaps the worst flash disaster in modern times (Ayodele, Suleiman, Alabi and Adesi, 2014)

In Nigeria, the 2012 flooding was adjudged as the most devastating in 40 years. According to the Nigerian Meteorological Agency (NIMET), the country lost a total of 2.9 trillion Naira in the disaster, equivalent to its 1.4% Gross Domestic Product (Ocheri, Ali and Eba, 2014). The catastrophe rendered millions of people homeless around the country, killed hundreds and swept away or damaged properties worth trillions of Naira. In fact the comprehensive Post Disaster Needs Assessment conducted from November, 2012 to March, 2013 by the Government with the support of the World Bank and Global Facility for Disaster Reduction and Recovery, United Nations Development Partners working through the relevant Ministries, Parastatals and Agencies put the estimated total value of infrastructure, physical and durable assets destroyed at $9.6bn. The total value of losses across all sectors of economic activity was estimated at $7.3bn. The combined value of these damages and losses was $16.9 billion. In all, 363 people were killed; 5,851 injured; 3,691,394 affected and 3,871,530 displaced (Ocheri*et al*, 2014).

In addition to the low-lying places which are naturally prone to flooding like Rivers, Oyo, Bayelsa, Lagos and other states in the Southern and Western parts of Nigeria, states which hitherto were considered out of the reaches of flooding experiences such as Gombe, Katsina, Borno, Kaduna, Kano, Kebbi, Jigawa, Plateau and Bauchi all counting their losses in terms of human and material devastations. The inundation of floods ravaged several areas in the country was further worsened by the release of water from the Cameroun's Lagdo Dam located in the Northern part of that country. It affected a total of 33 states in Nigeria. In Adamawa state alone, all the 23 local government areas were affected cutting across no fewer than 125 communities. The dams at Shiroro and Jebba also overflowed their bounds in Niger state killing many and washing away homes and properties as well as livestock in their wake (Ali, 2018)

The loss of natural land cover for human-modified land cover results in an increase of flood occurrences. Since 1980, Benue State has experienced loss of natural land cover such as forested and shrublands, and additions of more human development, notably urbanization, arable farming and grazing. The increase in human activities on the earth surface have decreased the permeability of lands, resulting in higher volumes of runoff, leading to more severe floods. Similarly, the increases in cropland and pastureland have increased both soil erosion and rainwater runoff, again ultimately causing an increase in flood events.

MATERIALS AND METHODS

Study Area

Benue state, with a land area of 30,955sq kilometre is located between Latitudes $6^{0}25^{1}$ and $80^{0}8^{1}$N, and Longitude $7^{0}47^{1}$ and $10^{0}00^{1}$E, on the eastern side of the middle belt of Nigeria. It is bounded to the north by Nassarawa, to the northeast by Taraba, to the south by Cross River, to the west by Enugu, andKogi. Along Nigeria's southeast border, there is also a short international border between the State and the Republic of Cameroon (Fig. 1). The Tiv, Idoma, Igede, Etulo, Abakpa, jukun, Nyifon, and Akweya are the most populous groups in Benue State. The Tiv are the largest ethnic group, occupying approximately 14 local government areas alongside the Etulo and Jukun; however,Idoma, Igede occupy the remaining nine local government areas, while other migrants such as the Igbo, Hausa, Yoruba, and other minor tribes in Nigeria live among them.

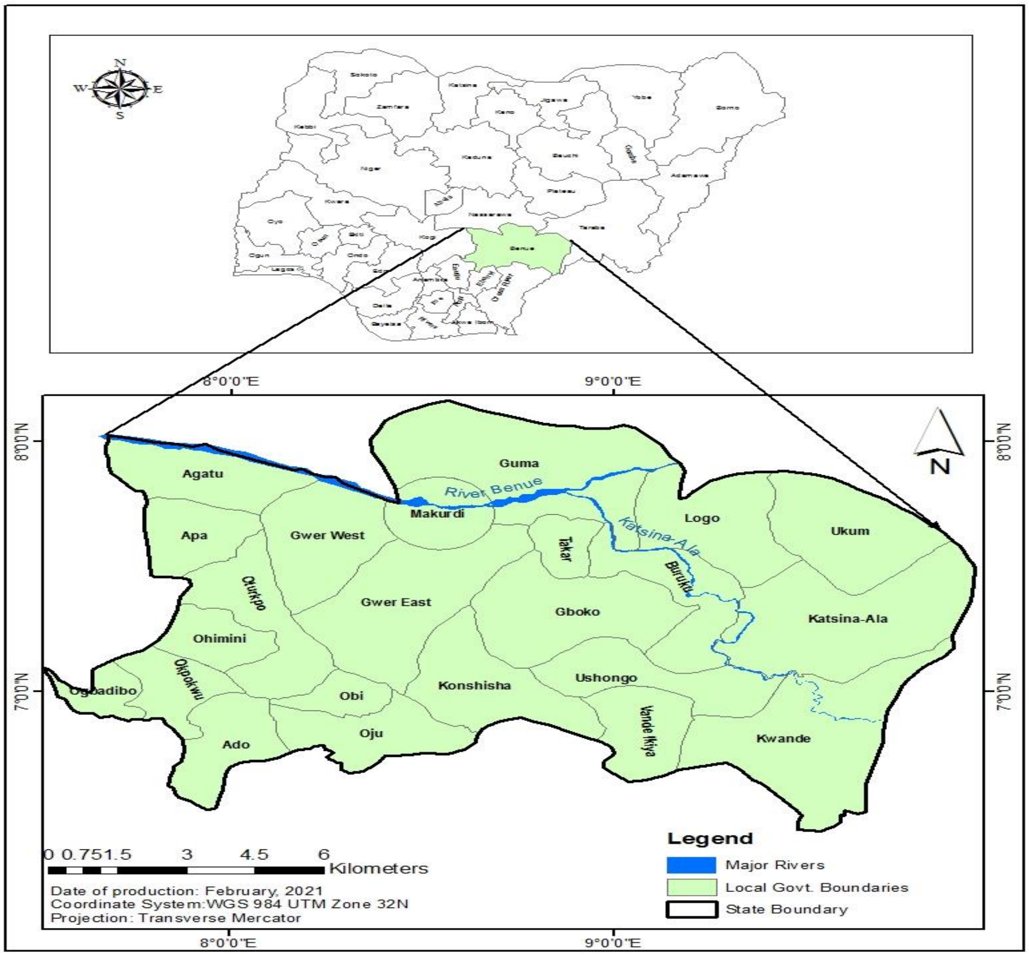

Figure 1: Benue state showing the Local government areas.

Experimental Design

Two types of data were collected and used for the purpose of this research; remote sensing data and topographic map. Satellite data comprising of Four-year multi-temporal imageries: Landsat TM (1990); Landsat ETM+ (2000, 2010); and Operational Land Imager (OLI) (2020) were used. The Landsat imagery dataset was sourced from the Earthexplorer platform from United States Geological Surveys (USGS). A topographic map of the state was used as a guiding map for extraction of study area satellite images for processing. Changes in land cover were measured using time series of remotely sensed data (Landsat TM, ETM and OLI). Table 1 gives a summary of the image characteristics for the dataset used. Dry season images of the four data sets were acquired from January to March in order to reduce the effects of clouds that are prevalent during the rainy season. Ancillary data included the ground truth data for the LU/LC classes and peak flow in major rivers of the state. The ground truth data was in the form of reference points collected using Geographical Positioning System (GPS), high resolution Google earth images were also used to aid in classification and overall accuracy assessment of the classification results.

Table 1: Satellite data used

S/No	Satellite imagery	Date	Resolution	Source
1	Landsat TM imagery	January, 1990	30m	USSG Earth Explorer
2	Landsat ETM imagery	March, 2000	30m	USSG Earth Explorer
5	Landsat ETM imagery	November, 2010	30m	USSG Earth Explorer
7	Landsat 8 OLI imagery	November, 2020	30m	USSG Earth Explorer

Table 2: Land cover types used in the Classification of satellite derived land cover types

Code	Land Cover	Description
1	Forest	High density of trees with little or no undergrowth. Dominated by tropical trees such as *Kyayasenegalensis, Magniferaindica,Daniella olivera, Isoberlinadoka* and P*arkiabiglobosa*
2	Farmland and Pasture	Environment dominated by grasses and herbaceous plants typically, spear grass and elephant grass *(Andropogongayanun)* often used for grazing livestock. It is used here collectively to also include agricultural land or mixed farming area that describes land that constantly shifts between farm and fallow land. Typically, the vegetation cover has been removed or modified and replaced by other types of vegetation cover of anthropogenic origin
3	Water body	Areas persistently covered by water typically lakes, dams and rivers
4	Bare Land	Land of limited ability to support biotic life and in which less than one-third of the area has vegetation cover. These areas typically have less than 4% vegetation cover such as exposed river sand land in-fillings sites, excavation sites, open space and bare soils.
5	Built-up Area	This comprises urban and rural built-up including homestead areas such as residential, commercial, industrial areas, villages, road networks, pavements and man-made structures.

Image pre-processing and classification

Pre-processing of satellite images before detection of changes is a very vital procedure and has a unique aim of building a more direct association between the biophysical phenomena on the ground and the acquired data (Coppin, Jonckheere, Nackaerts, Muys &Lambin 2004). Data were preprocessed in ERDAS imaging for band combination and sub-setting of the image on the basis of Area of Interest (AOI). The main objective of image classification is to place all pixels in an image into land use land cover classes in order to draw out useful thematic information (Boakye, Odai, Adjei &Annor 2008). Image classification was done in order to assign different spectral signatures from the LANDSAT datasets to different land use land cover. This was done on the basis of reflectance characteristics of the different land use land cover types.

Different color composites were used to improve visualization of different objects on the imagery. Infrared color composite NIR (4), SWIR (5) and Red (3) was applied in the identification of varied levels of vegetation growth and in separating different shades of vegetation. Other color composites such as Short Wave Infra-red (7), Near Infra-red (4) and Red (2) combination which are sensitive to variations in moisture content were applied in identifying the built-up areas and bare soils. This was supplemented by a number of field visits and use of goggle earth software that made it possible to establish the main land use land cover types. For each of the predetermined land use land cover type, training samples were selected by delineating polygons around representative sites. Spectral signatures for the respective land use land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A satisfactory spectral signature is the one ensuring that there is 'minimal confusion' among the land covers to be mapped (Gao& Liu, 2010) Maximum Likelihood Classifier Algorithm with decision rule was used for supervised classification by taking 100 training sites for five major land use land cover classes. The Maximum Likelihood Classification is the most widely used per-pixel method by taking into account spectral information of land cover classes (Qian, Zhou &Hou 2007). The delineated land use land cover classes were; built up areas, water bodies, farmlands, bare-lands and forest as described in Table 2.

RESULTS

The satellite images covering Benue state of Landsat TM 1990 to 2020 were digitally processed to obtain a dependable change table statistic. The decadal period of 1990, 2000, 2010 and 2020 were adopted to determine the magnitude of change over time and the dimension of land cover change over the period presented in Table 3.

Table 3: Landuse/Landcover statistics in Benue states for the years 1990 -2020

Landuse/Land cover	1990		2000		2010		2020	
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%
Cropland/Pasture	16925.7	54.41	21206.6	68.2	27179.3	87.37	28169.7	90.55
Built up Area	293.4	0.94	862.59	2.77	1893.24	6.086	2168.17	6.97
Bare land/Sandbar	59.08	0.19	114.85	0.37	30.44	0.098	263.06	0.85
Water body	170.27	0.55	128.28	0.41	108.86	0.35	190.56	0.61
Forest	13659.9	43.91	8796.19	28.3	1896.43	6.096	317.14	1.02
Total	31108.4	100	31108.4	100	31108.4	100	31108.4	100

Table 3 clearly shows a change in all the identified land uses/ land covers from 1990 to 2020. Specifically, there is a decrease in forest cover from 13659.9km^{2}representing 43.91% of the total land area in 1990 to 317.14km^{2}representing 1.02% of the total land area in 2020.Other land uses/ covers especially cropland/pasture increased from 16925.7km^2 representing 54.41% of the total land area in 1990 to 28169.7km^2 representing 90.55% of the total land area in 2020.This result is significant on its own based on the implication it has for surface runoff and subsequently flood events in the area. In addition, the results will be useful to support further analysis towards determining the implication of land use land cover change for flood events in the state.

The rate of forest cover change in Benue State from 1990 to 2020

The digitally processed images of Benue in 1990 and 2020 reveal a great change of forest land cover to other land covers in the study area. The information on the change of forest cover to other identified land covers is shown on Figure 2 and 3.

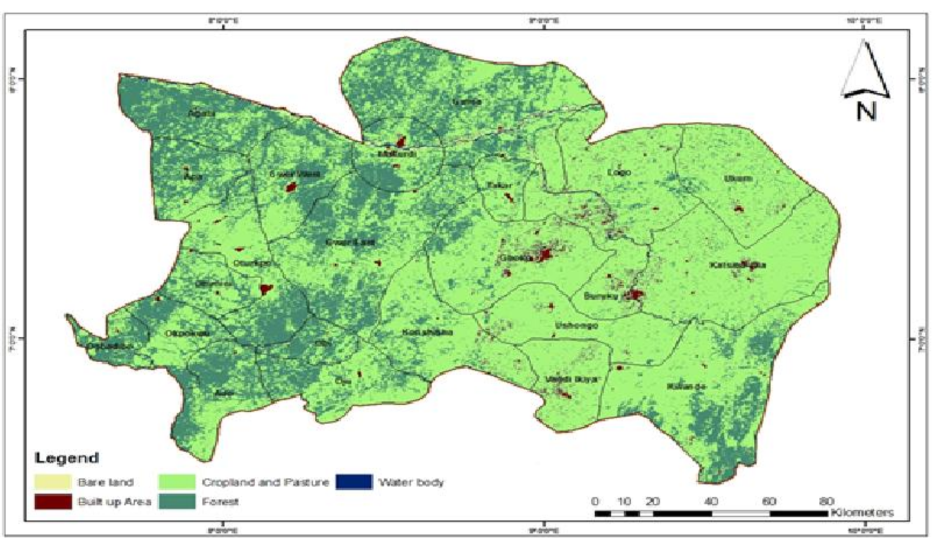

Figure 2: Landuse/ landcover of Benue state in 1990

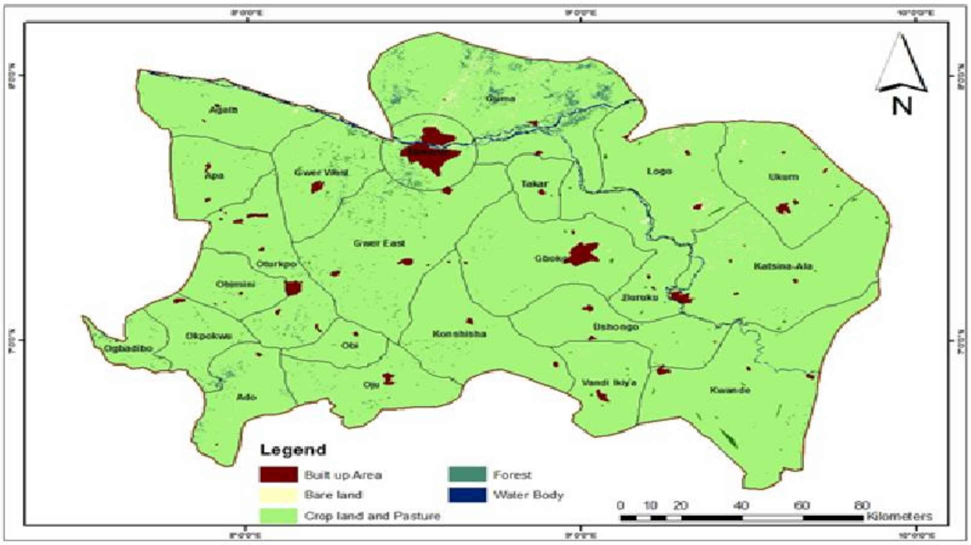

Figure 3: landuse landcover of Benue state in 2020

Rate of land use /land cover change in Benue state from 1990 - 2020

Information on Table 4 shows clearly that while there was percentage decrease in forest cover class, there was percentage increase in other land cover classes. It can be inferred that, there was decrease in forest landcover in favour of other land cover classes. Forest land cover decreased by 97.68% with 3.26% annual rate of decrease.

Table 4 shows that areas covered by other land cover increased considerably in the state. Cropland/pasture land cover/use increased by 66.43% with annual rate of increase of 2.21%, built up area land cover increased by 63.99% with annual rate of increase of 2.13%, while bare land cover increased by 345.26% with annual rate of increase of 11.51% from 1990 to 2020. This is evident on the level of increase in peak discharge in rivers presented on Figure 4

Table 4: Land use land cover change in Benue State from 1990 – 2020

Landuse/Land cover	Area (Km^2) in 1990	Area (Km^2) in 2020	Change in Area (Km^2) 1990-2020	% Change	Annual rate of change
Cropland/Pasture	16925.7	28169.7	11244	66.43	2.21
Built up Area	293.4	2168.17	1874.77	63.99	2.13
Bare land/Sandbar	59.08	263.06	203.98	345.26	11.51
Water body	170.27	190.56	20.29	11.92	0.40
Forest	13659.9	317.14	-13342.76	-97.68	-3.26

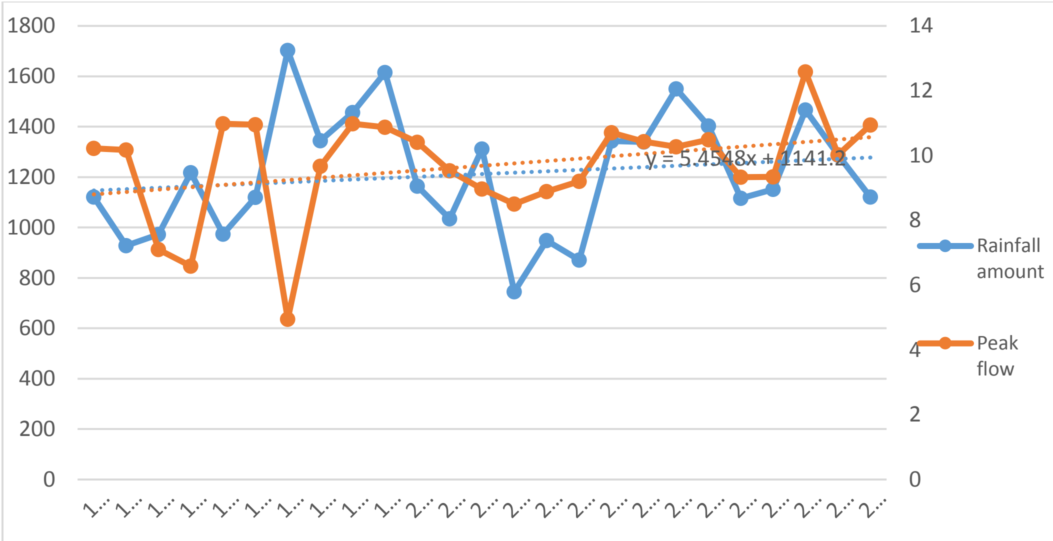

Figure 4: Trend of Rainfall and Peak Discharge in Benue state 1990-2020

Table 5: Multiple linear regression score showing the joint influence of LULC on flood event

Predictor Variable	R	R^2	F	ß	T	P-value
Constant					9.328	0.00
Peak flow (Flood event)	0.877	0.768	11.937	-	-	0.00
Cropland and pasture				0.358	3.078	0.01
Built up Area				0.387	2.639	0.01
Bare land surfaces				0.208	1.648	0.12
Water body				0.211	1.655	0.01
Forest area				-0.506	-3.065	0.01

The results presented in Table 5 shows that cropland/pasture, built up area, bare land surfaces, water body and forest area jointly influence overall flood events in Benue state (R=0.877, R^2=0.768, F=11.937, P<0.01). The result indicates thatchange in cropland/pasture, built up area, bare land surfaces, water body and forest area influence 76.8% of flood events in Benue state. On their independent influence on flood events, the results revealed that Forest cover area (ß=-0.506, t=-3.065, P=0.01) showed significant influence of 50.65% on flood events. This implies that 1 unit decrease in forest cove will lead to 50.7% increase in flood events in the area. The implication of this situation is that deforestation is contributing significantly to flood generating mechanism, and it has been established using geospatial analysis that forest cover is decreasing in Benue state at the rate 3.26% which is above the global deforestation rate. The results further revealed that built up area is the second land use / land cover that influences flood events (ß=0.387, t=2.639, P=0.01) influencing 38.7% of flood events. This implies that 1% increase will lead to 38.7% increase in flood events in the area. This result agrees with the findings of Tali (2011) and Lang (2018) that built up areas have significant influence on flooding. Other anthropogenic activities such as farming (Cropland /pasture land) (ß=0.358, t=3.079, P=0.01) influence35.8% of flood events. This finding collaborates the works of Yang and Yu (1998) and Rahman et al (2021) that change in land use especially from forest cover to cropland exerts a significant influence on the relations of rainfall-runoff and/or runoff-flooding and alter flood events accordingly.

DISCUSSION

From the analyses, forest land cover was observed to have decreased by 97.68% with 3.26% an annual rate of decrease, while other identified land uses and land cover increased. Settlement growth especially urbanization is a phenomenon experienced in this part of the world (Oyeleye, 2001). Settlement expansion is currently shrinking forest areas. This phenomenon in one way or the other creates paved surface and also encroaches on floodplains which increases surface runoff, flooding and impact on built up areas. Other processes such as loosening of the top soil by cultivation encourage the washing away of the topsoil by surface runoff. These eroded particles are deposited in water channel making them shallow. In turn, reducing the capacity of water channel to contain large volume of water and causing flooding.

Removal of forest cover primarily due to human activities such as settlement expansion/growth, farming activities, bare surfaces due to deforestation exposes the environment to adverse effects of rainfall. Even though views held by Ayoade (1988) and other scholars, that rainfall intensity, duration and amount are generally the major causes of flooding in the region. Other factors only aid the incidence as confirmed by other studies (Oriola, 2000, Ocheri and Okele, 2012, and Hula and Udoh, 2015, *Shabu, et al.*,2017; Musa, and Shabu2019). That is to say, when the protective cover is removed, surface runoff increases leading to flooding around natural and artificial drainage channels

The implication of land use and land cover change indicated that decrease in forest cover will mean increase in the flood generating mechanism while increase in built up areas, crop and pasture land and bare land surfaces will mean increase in flood triggers. This implies that 1% increase/decrease in cropland/pasture, built up area, bare land surfaces, water body and forest area will lead to 76.8% increase/decrease in flood events in the area. The situation agrees with the findings of Tali (2011) that decrease in forest cover means more and more influence on the environment. Deforestation, agricultural expansion and increasing built-up are putting tremendous pressure on the forest resources of the study area. Wood is the most important source of energy for the rural people. Increasing demand for fuel wood and timber results in the acceleration in the process of deforestation the area.

Conclusion and Recommendations

The loss of natural land cover such as forest cover to human modified land covers such as cropland/pasture, built up areas and bare land is seriously influencing the frequency and magnitude of flood events in the area. Human activities are currently shrinking forest areas and this creates paved surfaces which increase surface runoff and subsequently, increased flood frequency, magnitude and impact in areas prone to flooding. Based on the current trend in land use and land cover change, afforestation and reforestation of higher reacheswould reduce the problem of overland flow and it will also increase the lag time.

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