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NATURE OF LAND USE/LAND COVER IN KUBANNI DAM CATCHMENT AND AREAS LIABLE TO FLOODING DOWNSTREAM OF KUBANNI DAM ZARIA, KADUNA STATE, NIGERIA

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ABSTRACT
This study examined the nature of Land Use/Land Cover in Kubanni Dam Catchment and Areas Liable to Flooding Downstream Of Kubanni Dam Zaria, Kaduna State, Nigeria.The disastrous floods in Nigeria, in 2012, 2022 and the recent flood in northern parts of Nigeria which are linked to climate change indicated that the threat is a global reality. The research used landsat imageries covering years 1990, 2000, 2010 and 2020 for land use, land cover (LULC) change analysis supervised classification, maximum likelihood algorithm was used for the classification of the satellite in ages in ArcGIS 10.3 environment. Result from the landuse/landcover change analysis showed that there is an expansion in built-up areas from 35.572 km^2 in 1990 to 53.741km^2 in 2020 and vegetation declined from 6222km^2 in 1990 to 58.171km^2 in 2020. Results also showed that the size of farm lands has declined from 6.222km^2 in 1990 to 5.433km^2 in 2020. The result further showed that the total are a liable to flooding is about 5.477km^2. The result obtained from the characterization of LULC showed that wetland under cultivation was largely land use liable to flooding (40.8%) in the study area, followed by built-up (37.68%) while bare land, forest and shrub land are the least in the study area. Result of LU/LC change in the study can be concluded that there is built-up expansion in the study area

KEYWORDS: *Landuse/Landcover, Flooding, Kubanni Dam*

INTRODUCTION

Floods are among the leading threats to people's livelihoods and affect development prospects worldwide (Jevrejeva et al., 2018), this is especially true of developing countries where infrastructure systems, including drainage and flood protection, tend to be less developed and where climate impact adaptation and the ability to cope with impacts are low, hence floods often cause unmitigated damage and suffering

(Winsemius et al., 2016). For areas in coastal zone, usually considered as flood prone area or settlements around major river channels the impact of floods is worst as 70% of population in the zone depend on climate-sensitive subsistence occupations. The disastrous floods in Nigeria, in 2012, 2022 and ongoing flood in northern parts of Nigeria which are linked to climate change illustrate that the threat is a global reality. In 2012, Nigeria experienced its worst flooding in over 40 years, because of heavy rainfall across the country, for many days, and due to release of excess water from Lagdo Dam in northern Cameroon. The incidence affected 32 states, 24 severely. The floods occurred from July to October that year, affecting more than 7 million people and causing economic damages estimated at $500 million (World Bank Group, 2024). The Post Disaster Need Assessment (PDNA) Report following 2012 flood revealed that the total damage caused by the disaster amounted to $16.9 billion, representing 1.4% of real GDP growth in that year (NHSA, 2020, Nigeria, 2021). In another study GERICS, (2015) reported that the severe flooding in 2015 affected one million people and resulted in damages of approximately $25 million. According to National Emergency Management Agency, more than 2 million others were counted as internally displaced persons (IDPs), while more than 5,000 people were physically injured and 5,900 houses destroyed (NEMA, 2013). The most severely affected states were Benue and Niger states, because of their riparian communities (Agada and Nirupama, 2015). The European Commission Joint Research Centre (European Commission Joint Research Centre, 2018) cites the National Emergency Management Agency (NEMA) as having reported that heavy rains across Nigeria caused the rivers Niger and Benue to overflow. The report states that 12 states were affected, with a National Disaster being declared in four states, viz., Anambra, Delta, Kogi and Niger states. The flooding affected 441,251 persons, and more than 100 dead were recorded. Between the years 2011–2020, Nigeria recorded about 1,187 deaths connected to flooding, 15% of Africa's deaths by flooding within the same period (Umar, and Gray, 2022). The cost of damage to properties was $904.5 million, which comprised 21% of property damage in Africa from flooding (Centre for Research on the Epidemiology of Disasters, 2021). In 2022, it was also reported that about 33 of Nigeria's 36 States and the FCT was flooded, farmlands across the country were submerged, and roads were cut off at some point, limiting fuel access in some states and after the water receded, 600 people were reported died, and Some 1.3 million people had been displaced, with more than 200,000 homes destroyed (Ogar, 2023). Just recently, Borno State in the north east of Nigeria was hit by devastating floods. The flood was caused by the collapse of the Alau Dam, which is associated with excess water from rainfall.The devastating floods have submerged entire residential areas, displaced tens of thousands of people, and forced zoo animals to escape into the streets. Reports shows that at least 30 people have died in the floods (Nimi, 2024). Authorities also reported that people are affected, of which over a million were displaced. Damaged septic tanks and flooded graveyards are also reported all of which have implications for water contamination and diseases out-break. Coupled with changing climate, land-use and land cover modification were implicated in increased frequency and magnitude of flooding. Studies have found that increasing population creates competing demands on land use that negatively impact the environment by reducing the permeability of the soil, which reduces the stability of the soil itself and its ability to maintain its structure under water pressure

(Caldas et al., 2018; Guadilla-Sáez et al., 2020; Janizadeh et al., 2021; Acuña-Alonso et al., 2024).

In Nigeria, there is extensive literatures indicating significant increase in the use of residential land, open land, rice fields, and wetlands (water bodies) and different infiltration rates that contribute to the variation of flood zone hazards (Ashaolu, et al., 2019, Ali et al., 2021, Ezebube et al., 2023). For a sustainable flood risk management, research has found that most countries in developed world relies not only on infrastructure development, but also on governmental and non-governmental actors applying legal, economic and communicative water management instruments (Akter et al., 2018). Hence, key to mitigating flood risk lies in establishing governance in flood management and this include, integration of land use and water issues, which would lead to more sustainable and viable land and water management (Hartmann & Driessen, 2017, Winter & Karvonen, 2022). The Kubanni drainage basin has undergone modifications over the years and the effects include increasing flood frequency, hence the need to study changing pattern of LULC in Kubanni drainage basin and effect on downstream of the basin.

The Study Area

The study area is located within the Kubanni drainage basin between Latitudes 11º06' to 11º07'N of the Equator and Longitudes 7º38'-7º44'E of Greenwich Meridian. The study area is located within two LGAs, namely; Zaria and Sabon Gari in the northwest of Zaria in Kaduna State. However, the specific area under study lies downstream of the Kubanni Dam to the confluence with the Galma River, Zaria. The climate of Kubanni basin is typical of climate in Zaria and Environs. It is described as A_w climate with distinct wet and dry seasons (Hore, 1970). The Characteristics of the climate are determined by oscillations of two contrasting air masses; tropical maritime and tropical continental air masses. The tropical maritime originates from Gulf of Guinea and ushers in rainy season. The tropical continental originates from Sahara deserts and ushers in the dry cold and dusty season called the harmattan that occasionally limits visibility and reduces solar radiation (Hore, 1970). The area is underlain by Pre-Cambrian rocks which lie in the mobile zone between the West African and Congo Cratons. These Pre-Cambrian rocks consist of migmatites, gneisses and North South trending meta-sedimentary rocks, intruded by a series of granitic and mafic-ultra- mafic rocks of late Pre-Cambrian to early Palaeozoic age as McCurry (1973) report evidence of complex structural patterns such as joints and faults, form largely by invading granitic plutons in the Basement belonging to the widely distributed Pan-African magmatic suite present. Kubanni River has its source from the Kampagi hill, in Biye, near Zaria. It flows in southeast direction through Ahmadu Bello University and joins river Galma at the confluence north-west of ABU Main campus in Sabon Gari. Kubanni basin system is ephemeral, intermittent and assumes a dendritic pattern which is deeply incised by numerous systems of gullies (Ologe, 1971& Bello, 1973). The most prominent land use practice in the study area is agricultural land use which are cultivation and animal husbandry. This is because the economic base of virtually all rural and semi urban settlement in northern Nigeria is agriculture and it is subsistent. The use of land for agricultural activities is influenced by several factors such as land per resident ratio and location of soil quality. As the land per resident ratio increases (population density increases) the percentage of land in fallow decreases due to increase in farming activities. The increase in intensity in land use as population density increases creates problem in maintenance of soil fertility.

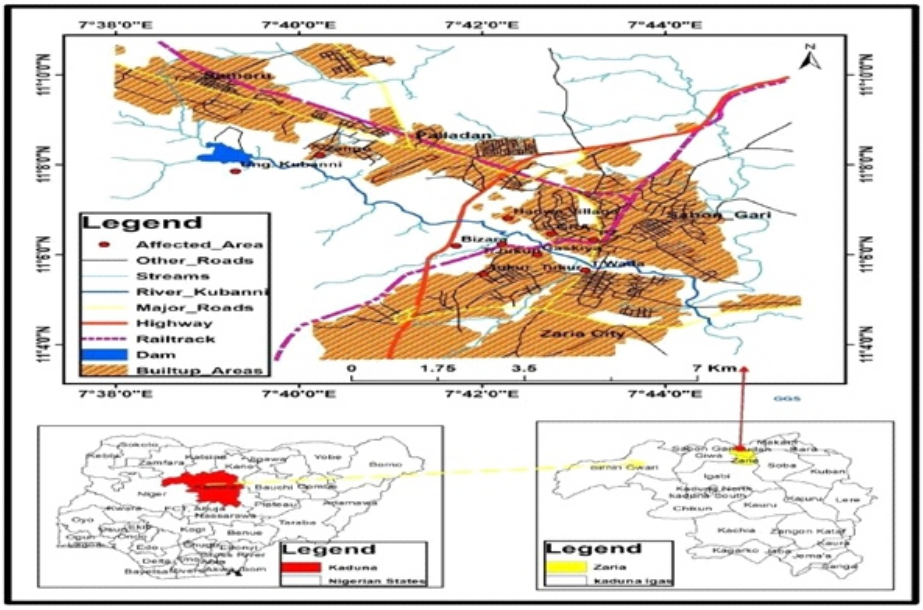

Figure 1: The Study Area showing downstream of Kubanni Dam extracted from Google Map 2022.

Materials and Methods

Datasets and Sources

The study used both primary and secondary data. Landsat OLI TIRS image and Landsat ETM+ images spanning from 1990, 2000, 2010 and 2020 were obtained from USGS GloVis (http://www.glovisusgs.gov) free of cost.This set of data was used to assess LU/LC change in a GIS environment and determine the land use that is vulnerable to flood disaster. Sufficient numbers of GPS coordinates using spatial reference system of NGS 84/UTM Zone 32N were collected in the field to train the maximum likelihood algorithm for proper supervised classification of 1990, 2000, 2010 and 2020 Landsat Imageries. Some of the collected GPS coordinates were also used for the ground trothing during accuracy assessment. A high-Resolution Satellite imagery Quick bird data (60cm resolution) 2017 was used to extract relevant features for risk and vulnerability analysis. Google Earth including its "show historical imagery" function was also used in assisting classification and accuracy assessment of Landsat images of the study area and extract different features on the ground. Direct field observation was carried out during the reconnaissance survey to get information about possible LULC classes in which the study area can be classified into. It was used to verify the data obtained through change detection. Topographic map Zaria sheet 102 1969 was used to delineate the flood plain (downstream).

Data Analysis

The processing and analysis of Landsat Images and all the other GIS data was done using ERDAS imagine 2015, Arc GIS 10.3, while all the numerical data was analyzed using MS Excel. More so, to simulate the unsteady flow throughout the downstream of the Kubanni River from the Kubanni Dam to the downstream boundary about 12km from the Dam GIS Software was adopted. Once all the geometric data are entered in to HEC-RAS, it required that unsteady flow data must be entered to undertake the unsteady flood simulation. Unsteady flow data considered in this study included boundary conditions at all of the external boundaries of the system, as well as any desired internal locations, and set the initial flow and storage area condition at the beginning of the simulation. Generally unsteady flow data required are

boundary condition and initial condition. Different types of boundary conditions were used in HEC-RAS hydrological modelling and they include the Flow Hydrograph, Stage Hydrograph, Stage and Flow hydrograph, Rating Curve, Normal Depth, Lateral Inflow hydrograph. In this study, the unsteady flow data used as a boundary condition is the Probable Maximum Flow (PMF), Inflow Hydrograph and Normal depth. The PMF Inflow Hydrograph was used as an upstream boundary condition. After all the geometric and unsteady flow data were entered, the unsteady flow calculations were performed.

Results and Discussion

Table 1 showed the LU/LC changes in statistics of Kubanni dam floodplain (1990 to 2020). In Figures 2, 3, 4 and 5 are maps showing 1990, 2000, 2010 and 2020 characterization of LU/LC in River Kubanni floodplain.

Table 1: LU/LC Change Statistics of Kubanni Dam Floodplain (1990-2020)

Year	Water Body km^2(%)	Vegetation km^2 (%)	Farmland km^2 (%)	Build-up km^2 (%)	Bare land km^2(%)
1990	0.690/0.585	75.570/64.010	6.222/5.270	35.572/30.131	0.005/0.004
2000	0.690/0.585	70.570/59.775	6.312/5.347	40.462/34.272	0.026/0.022
2010	0.680/0.576	65.001/55.057	5.323/4.509	47.021/39.828	0.035/0.029
2020	0.660/0.559	58.171/49.272	5.433/4.602	53.741/45.520	0.055/0.046

***Source**: Author's Analysis, 2021.*

Table 2 showed that in 1990 water body occupied 0.690km^2 of the study area, vegetation 75.570km^2, farmland 6.222km^2, built-up 35.572km^2 and bare land 0.005 km^2. In 2000 water body occupied 0.690 km^2, vegetation 70.570 km^2, farmland 6.312 km^2, built-up 40.462 $km^2$and bare land 0.026 km^2. In 2010 water body occupied 0.680 km^2, vegetation 65.001 km^2, farmland 5.323 km^2, built-up 47.021 km^2 and bare land 0.035 km^2. In 2020 water body occupied 0.666 km^2, vegetation 58.171 km^2, farmland 5.433 km^2, built-up 53.741 km^2 and bare land 0.055 km^2. The results of LU/LC change in the study area shows that there is an expansion in built-up area from 35.572km^2 in 1990 to 53.741km^2 in 2020 and vegetation land use has reduced in size from 75.570 km^2in 1990 to 58.171km^2 in 2020. Also, farmland land use has reduced from 6.222km^2 in 1990 to 5.433 km^2 in 2020.

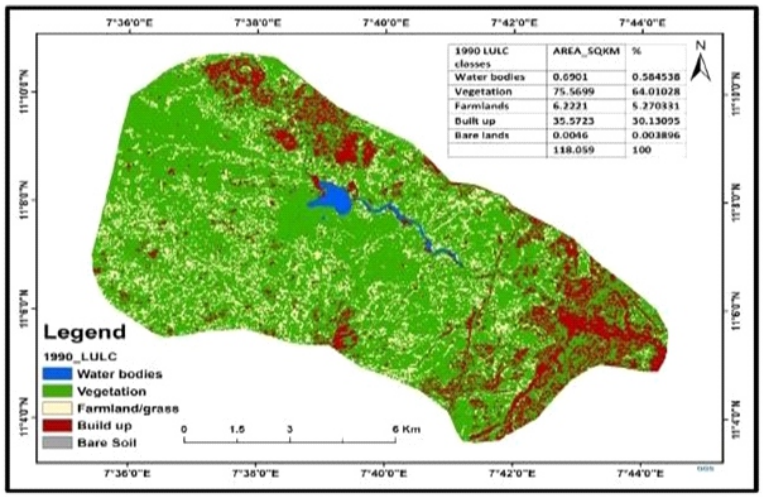

Figure 2: 1990 Land use/land cover Characteristics of Kubanni Dam Floodplain ***Source:** Author's Analysis, 2021.*

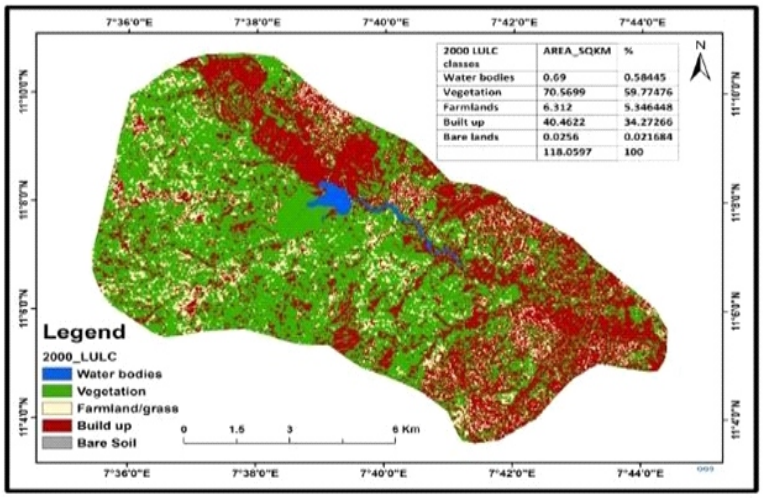

Figure 3: 2000 Landuse/Landcover Characteristics of Kubanni Dam Floodplain ***Source:*** *Author's Analysis, 2021.*

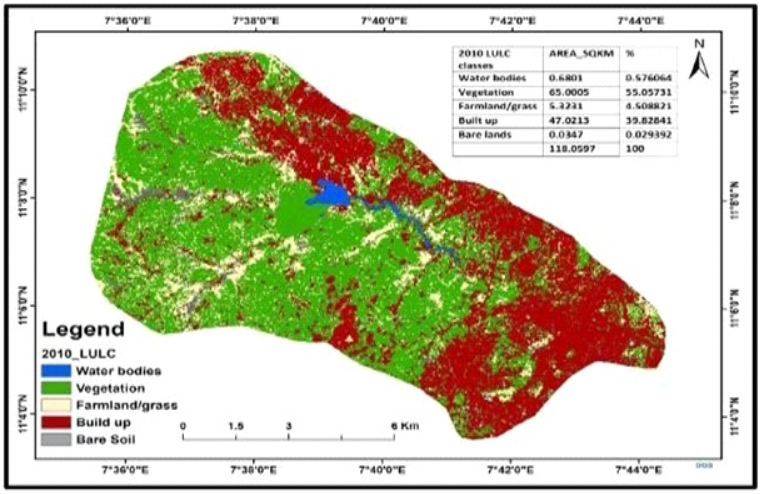

Figure 4: 2010 Landuse/Landcover Characteristics of Kubanni Dam Floodplain ***Source:*** *Author's Analysis, 2021.*

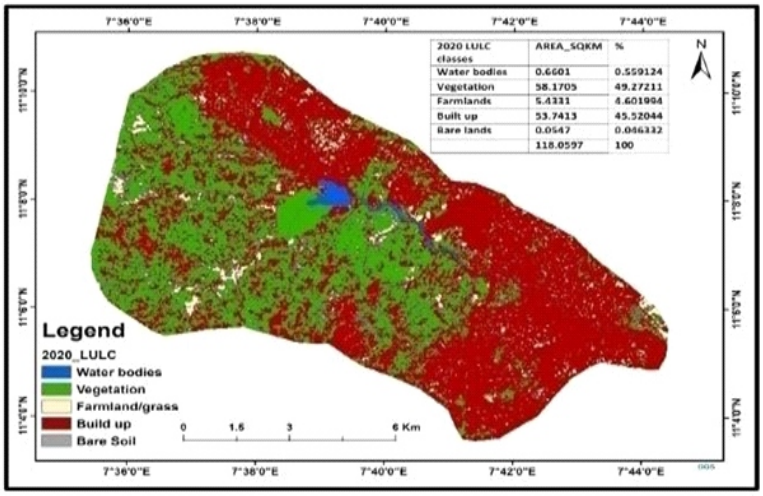

Figure 5: 2020 Landuse/Landcover Characteristics of Kubanni Dam Floodplain ***Source:*** *Author's Analysis, 2021.*

Land use/land cover change has been recognized as a key driver of hydrological processes such as surface runoff, evapotranspiration, sediment transportation and base flow in floodplains (Zhao et al., 2012; Garg et al., 2017). Dynamic changes in land cover, especially an increase in built-up area and decrease in vegetation area, increased the susceptibility of the basins and floodplains to flooding as impervious surfaces are relatively more likely to generate surface runoff (Adnan et al., 2020). Bearing this in mind, it can be said that the four tributaries of the Kubanni dam because of the increase in impervious surface resulting from the increase in built-up in the study area would experience increase in stream flow and sediments that could increase discharge into the Kubanni dam which could lead to a dam breach. Also, another implication of increased built-up expansion on floodplain as observed by Oyatayo et al., (2013) results in massive wetland and vegetation loses as well as increased impervious surfaces throughout the town. The consequences of expanding built-up expansion on floodplains and basin is that some inhabitants of Tudun Jukun, Grace Land, Tudun Wada, PZ area, Sabon Gari, Aviation are exposed to high flood risk because they have encroached on floodplains and built houses on land that is not suitable for that purposes. This confirms the findings of Neller (1988) and Oyatayo et al., 2013 which are supportive of the fact that development in watershed and floodplains adversely affect ecosystems in these watersheds and floodplains which causes the stream channels in such watershed to be very unstable, exhibiting extensive deposition of sandbars, expansion of floodplains reduced channel capacity to regulate stream flood and increased run-off stream flow. In the long run, these urban dwellers are exposed to increasing flood risk due to the fact that these settlements have encroached on the floodplain and equally because of changing landforms in the basin.

The results of the unsteady flow simulation shows that strong 3-D effects are generated in the regions of strong curvature of the river channel, near sudden constrictions and obstacles, and during the times the mean flow direction varies significantly over the flow depth. Such effects cannot be captured by the 2-D model with recalibration, pointing toward the need to use 3-D models for detailed flood mapping hence, its use in this research. Figure 6 shows the flood inundation map of areas downstream of Kubanni dam should there be a dam break. The flood inundation map shows the extent of flood inundation as a result of a potential breach of Kubani dam. The result shows that the total area liable to flooding is about 5.477km^2. The result also shows that the floodable area increased in extent from the dam breach outlet to the downstream outlet of the basin. Most of the areas in the downstream of the dam are highly vulnerable because of the flat terrain especially between Tudun Wada, Sabon Gari, and lower sector of Gyellesu to the confluence of the Galma River. This corroborate the findings of Canovas et al., (2020) in Kashmir, India that used a millennium record of past floods in Kashmir based on historical and tree-ring records to assess the probability of 2014 likely flood events in the region. The findings revealed that the inclusion of historical records increased flood hazard level in the region. Although Canovas et al., (2020) used historical data as predictive inputs; this study used GIS modeling yet the result provide clear picture of likely inundated areas in the event of flood owing to dam breach.

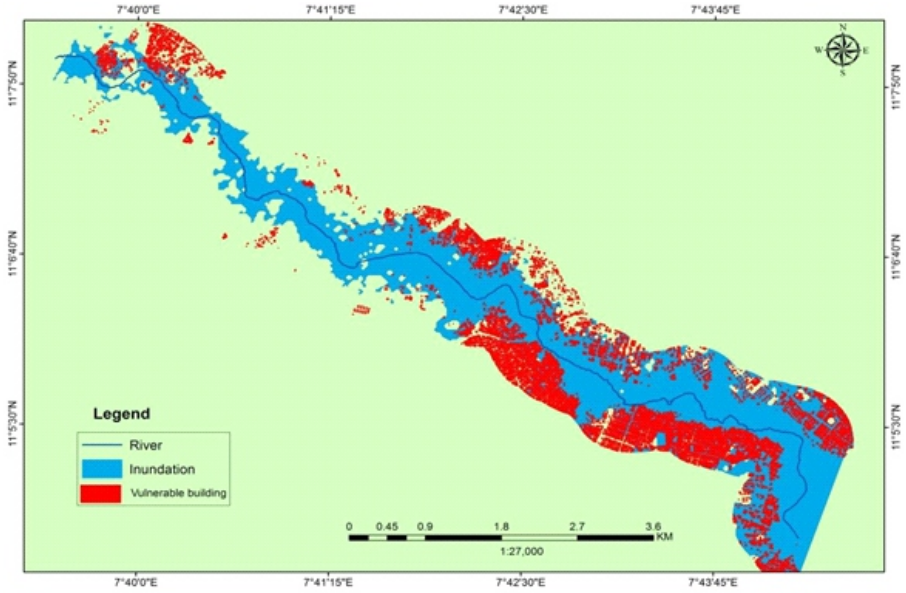

Figure 6: Area inundated by a potential Dam breach in the Kubanni Basin
Source: *Author's Analysis, 2019.*

Giving the compact nature of land use and urban intensification continuously occurring in Zaria, the area inundated is quite a large expanse of land. No doubt the inundated areas in the event of Dam breach portend a great risk to Zaria in terms of people, flora, infrastructure, aesthetics and other aspects of the environment. This finding shows the essence and need for preventive and proactive measures to forestall such breach giving the fact that anthropogenic activities that precipitate dam breach are at increasing rate around and within the Kubanni basin. The land use and land cover liable to flooding is presented in Table 2 and Figure 7.

Table 2: Land use/land covers Liable to Flooding in the Kubanni Dam Area

Land Use/Land Cover	Area (Km^2)	Percentage
Built-up	3.490	37.68
Bare land	0.200	2.16
Farmland	1.606	17.34
Forest	0.024	0.26
Shrub land	0.157	1.70
Wetland	3.786	40.87
Total	5.477	100

Source: *Author Analysis, 2019.*

It could be seen that the total built up area liable to flooding is about 38%, bare-land is 2.16%, farmland is 17.34%, shrub land is 1.69%, and forest is 0.26% while the wetland area is 40.87%. It could be seen that wetland cultivation (40.87%) was the most widespread land use liable to flooding followed by built-up (37.68%) and farmland (17.34%), bare-land, forest and shrub land occupy the least land use area in the downstream of Kubani dam. This result shows that there is concentration of human activities in the area and a possible dam breach will have significant consequences on these human activities. Lives may be lost, crops destroyed, economic activities and livelihoods disrupted. Flood vulnerability assessment showed that 71% of the study area is liable to flooding.

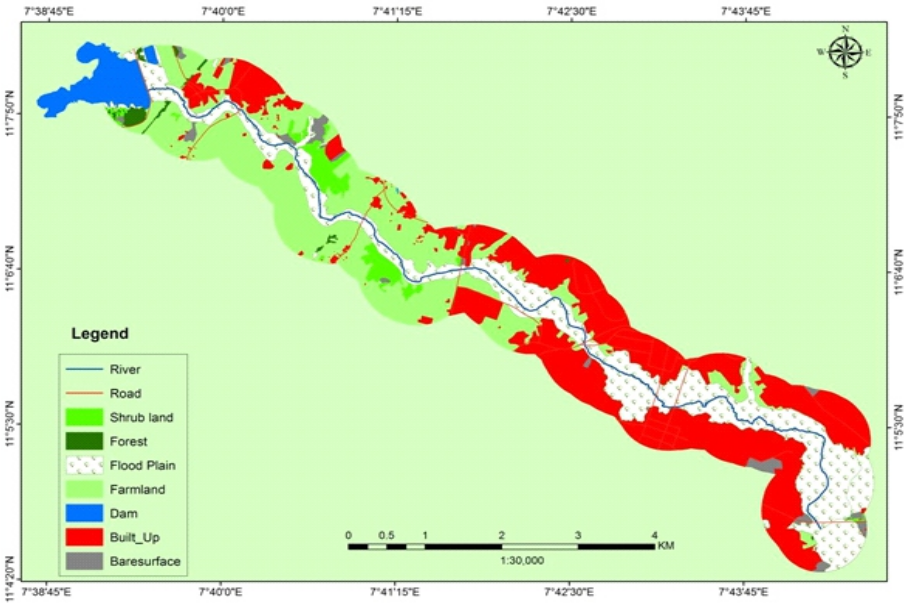

Figure 7: Land use/Land cover map ***Source:*** *GIS Analysis, 2019.*

Conclusion and Recommendations

Result of LU/LC change in the study can be concluded that there is built-up expansion in the study area (from 35.572km^2 in 1990 to 53.741km^2 in 2020) and vegetation landuse has reduced in size from 75.570km^2 in 1990 to 58.171km^2 in 2020 flooding is about 5.477km^2 more, so the floodable area increases in extent from the dam breach outlet to the downstream outlet of the reservoir majority of the areas downstream of the dam is highly vulnerable because of the flat terrain especially between Tudun Wada, Sabon Gari, down Gyallesu to the confluence of the River Galma. The study recommends that regulatory agencies such as Kaduna State urban planning and development Agency should be alive on their responsibilities on checkmating the buildings on the Kubanni river flood plain.

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