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ASSESSING THE EFFECTS OF CHANGING LAND USE AND LAND COVER ON THE FLOOD EVENTS IN IBAJI LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA

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Abstract

The study Assessing the Effects of Changing Land Use and Land Cover on Flood Events in Ibaji Local Government Area, Kogi State, Nigeria seeks to investigate the relationship between land-use changes and the increasing frequency and severity of floods in the region. The primary objective is to assess how urbanization, agricultural expansion, and deforestation contribute to flood events by examining changes in land use and their hydrological impacts. The study emphasizes the need for understanding the role of land-use changes in shaping flood patterns to develop effective flood management strategies in flood-prone areas. The materials and methods used in this study include both primary and secondary data sources. Primary data was gathered through field surveys and land-use practices. Secondary data consisted of satellite imagery (Landsat 8 and ASTER DEM), topographic maps, and existing literature on flood patterns and land-use trends. GIS tools such as ArcGIS, Idrisi Selva, and ILWIS 3.3 were used to classify and analyze land-use changes between 2002 and 2021, focusing on categories such as farmland, vegetation, built-up areas, and water bodies. The analysis revealed significant land-use changes over the study period. Vegetation cover decreased from 572.8 km² (41.6%) in 2002 to 223.1 km² (16.2%) in 2021, while built-up areas expanded from 335.9 km² (24.4%) to 443.3 km² (32.2%), and farmland increased from 320.8 km² (23.3%) to 459.9 km² (33.4%). These changes have led to increased surface runoff, reduced water infiltration, and a higher frequency of flooding. Based on these findings, the study recommends implementing sustainable land management practices and integrating flood risk management into urban planning to mitigate the adverse effects of land-use changes and reduce flood vulnerability in Ibaji.

Keywords: Floods, Land-use, Land-Cover, Sustainable, Changes

1. Introduction

Various definitions have attributed flooding to anthropogenic factors (Offiong and Eni 2007) though it is generally accepted that rainfall is the dominant cause of flooding worldwide (Abowei and Sikoki, 2005). The effects of floods are wide this includes abnormally high stream flow that overtops the natural or artificial banks of a stream (Nkekiet.al, 2013) too much water in the wrong place (Ishaya, 2009) a natural hazard which occurs as an extreme hydrological event (Smith, 2001) and the flow of water above the carrying capacity of the channel. Generally, floods happen on flat or low-lying

areas with hydraulically smooth or saturated surfaces (Chimaet.al, 2010). Floods are environmental hazards caused by both natural and countries where the prevailing coping strategy is resilience (Muoghalu & Okonkwo, 2000; Smith, 2001).

Floods are part of the hydrological cycle and a natural hydrological feature of most river systems (Campion and Venzke, 2013). In recent years, however, flood events have drastically increased both in terms of frequency and severity due to a variety of reasons such as climate change (Liu, et al., 2018) and urbanization (Hollis, 1975; Zhang et al. 2008), hence, flood events

are regarded mostly in negative terms. Floods have not just become the most frequent natural hazard worldwide (Jongman, et al., 2012), it appears to be one of the deadliest natural disasters and often kills the most people, for instance, in 2016, flood killed the most people (4731), (Guha-Sapir, et al., 2016). According to Loster (1999), a ten-year comparative study of the world's great flood disasters from 1950 to 1998 showed a three-fold increase in the number of flood events, while the economic losses from flood events from the 1990's were ten times as high as in the 1950's, amounting to \$250 billion globally. Further, UNISDR (2015) notes that since 1995, floods have accounted for 47% of all weather-related disaster and that flood affects Asia and Africa more than other continents, for example, 560,000 people were affected by floods on average each year between 1995 and 2004.

Di Baldassarre et al. (2010) notes that in the last decades, there has been an increased incidence of severe flooding due to a variety of reasons, however, the capacity of most of the affected parties to anticipate and mitigate flood damages is very poor. While flood affects every part of the society, the most vulnerable groups are usually the indigent (Chan and Parker, 1996) and marginalized who enjoy little protective mechanisms against disasters, especially in the developing nations where the main source of income is agriculture. People can experience the same type of hazards and yet have different degrees of vulnerability as a result of variations in exposure, sensitivity and adaptive capacity. According to Harvey et al. (2014), exposure to floods, for instance, may differ depending on the location of households in relation to floodplains, steep slopes, low-lying areas or ravines and in most cases; poorer households are those that inhabit these high-risk locations. Disasters do not just disrupt the livelihood of the poor; it leads to the poor incurring severe losses and such losses may take time to recoup. Majority of Sub-Saharan Africa farmers are mostly dependent on rain-fed agriculture and have limited capacity to mitigate, adapt or cope with the effects of extreme climatic events such as flood which greatly impedes production. Studies such as Adhikari et al. (2014), Elum et al. (2016), Thorlakson and Neufeld

(2012) and Hertel and Rosch (2010) have indicated that smallholder farmers are highly vulnerable to climatic extremes such as floods because they generally are the least able to cope with disaster, live in the most at-risk areas and have little resources to help reduce their level of risk.

Land use is characterized by "the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions) to produce, change or maintain it" (FAO, 1999). Studies such as Foreman et al. (1997) and Naqvi et al. (2014) have recognized Anthropogenic factors as the driving forces behind the degree and direction of change upon the earth's surface (Although anthropogenic-induced land cover change and modifications have been going on for 48 millennia, however, current rates, extents and intensities of land use/land cover change are far greater than ever in human history, causing unprecedented perturbation in environmental processes at different spatial scales (Zhu, et al., 2012). Globally, the influence of land-use changes on flood risk is now a central feature of flood-management discussions (APFM, 2016). According to Taofik et al. (2017) the hydrological response of a drainage basin (described as the conversion capability of rainfall to runoff) is mainly governed by the basin morphometric properties, soil characteristics and land use pattern, while Ajibade et al.(2010) notes that land use pattern has effects on interception whereas morphometry decides the distribution of runoff excess. Several studies have been carried out to understand the relationship between land-use changes, hydrological responses and flood events (Ramesh, 2013). Various studies such as Alexakis et al. (2014), Wang et al. (2014) and Thanapakpawin et al. (2007) have established that land cover plays a key role in controlling the hydrologic response of watersheds in a number of important ways, such as, leaf area index and evapotranspiration (Mao and Cherkauer, 2009), soil moisture content and infiltration capacity (Fu, et al., 2000), surface and subsurface flow regimes including base-flow contributions to streams and recharge (Tu, 2009), surface roughness, (Feddesma, et al., 2005) runoff (Selby, 1972, Burch, et al., 1987) as well as soil erosion through complex interactions among

vegetation, soils, geology, terrain and climate processes (Nejadhashemi, et al., 2011). According to Dwarakish and Ganasri (2015), water and energy balances are significantly influenced by land cover pattern via its effect on transpiration, interception, evaporation and infiltration.

There are several other studies that show that changes in land use have influenced the hydrological regime of various river basins (Van et al. 2012; Getahun and Van Lanen, 2015; Pervez and Henebry, 2015; Chithra et al. 2015). In addition, Pati (2014) argues that vegetation plays an important role in infiltration and slows the movement of runoff, allowing more time for water to seep into the ground. The surface soil layer in a forest or a pasture generally has greater infiltration capacity than a compacted soil surface and changes in land cover from woodland to agricultural land also lower the infiltration rate of the soil. Conversion of forest, to agricultural areas usually comes with a vast increase in impervious surface, which can alter the natural hydrologic condition within a watershed. Agricultural expansion has been confirmed to increase the rate of runoff (Kwaad and Mulligan, 1991; Martyn et al. 2000; Clements and Donaldson, 2002) due to soil compaction and associated reductions in soil infiltration capacity. Urbanization leads to significant changes in surface cover, which influence the hydrological properties of an area. According to Zabret and Šraj (2015) urbanization reduces the infiltration of precipitation into the soil, so that both surface water runoff and the velocity at which water travels increases drastically which eventually lead to larger and more frequent incidents of local flooding. Furthermore, flood hydrology of watershed shows an intimate relationship with land-use. Land use change potentially has a very strong effect on floods as humans have heavily modified natural landscapes (Rogger, et al., 2017), therefore, any changes in the land use, such as urbanization across a catchment area, may trigger a sequence of flood occurrences. As the watershed becomes more developed, it also becomes hydrologically more active, changing the flood volume, runoff components as well as the origin of stream flow. In turn, floods that once occurred infrequently during pre-development periods have now become more

frequent and more severe due to the transformation of watershed from one land use to another (Coutu and Vega, 2007). O'Connell et al. (2007) notes that, in the context of land-use changes, "flooding is generated when landscape runoff delivered to the channel network exceeds its capacity to convey runoff to the catchment outfall, leading to the inundation of rural and/or urban riparian/floodplain areas". Additionally, Bruijnzeel (1993) notes that it is the shift from subsurface flow to overland flow dominated storm-flows, which often accompanies land clearing due to effects of soil compaction and burning that produces strongly increased peak flows. According to DER (1999), urban development changes hydrological regime, resulting in a new annual and seasonal hydrologic balance, causing frequency distribution changes of peak flows, magnitude and duration of high flows, and magnitude and duration of low flows. Further, development, depending on its size and location in a watershed, alters the existing hydrologic balance by increasing surface flow volumes up to 43%, reducing subsurface flows to 32%, and reducing evapotranspiration rates to 25% (DER, 1999). This results in major changes to the local hydrology. An increased stream flows due to changes in surface topography result in more rapid drainage and increases in the amount of hydrologically active areas within a watershed. (DER, 1999). These areas also increase in size, in comparison to their predevelopment size, due to reductions in depression storage capacity and in the retention capacity of the site's existing natural vegetation. Also, increases in impervious ground covers contribute to increasing volumes of runoff. These changes coupled with shorter times of concentration result in sharp modifications to the shape of the resulting hydrograph.

Flooding is a destructive and frequently occurring phenomena across the world. Accurate and recent flood plain maps are therefore needed to enhance public safety. Ibaji Local Government is one of the most vulnerable flood-prone areas in Nigeria. For the local, state and Federal government, the management and control of flood hazards in the area is of great importance. Several studies have been carried out using geospatial techniques and field survey for flood

vulnerability assessment, among which are: Nwilo *et.al.* 2012, modeled flood vulnerability of the flood plains of Adamawa State using GIS and cellular framework approach; Ikusemoran *et.al.* 2013 assessed flood vulnerability of the flood plains of Benue Basin; Ojigiet *et.al.* 2013 used geospatial technique in mapping flood disaster in the central part of Nigeria; Mohammed and Iyortim 2013 assessed the vulnerability of river Kaduna downstream of the Shiroro dam using remote sensing and GIS techniques; Happy *et.al.* 2014, assessed flood vulnerability in Kubwa, Abuja using GIS; Ifatimehin *et.al.* 2009, assessed flood vulnerability in Gwagwalada town using GIS and Remote Sensing. Lately, researchers have used a suite of satellite-based geospatial datasets with cost-effective detection methods to assess flood hazards in ungauged regions, but to date, the estimation of current and predicted flood effects is poor in Ibaji Local Government. In this regard, a comprehensive approach was used in investigating the land use and land cover (LULC) impacts on the flood occurrence in the area.

Furthermore, there is a generally low level of knowledge and understanding of how hydrological responses in the basin affect flood events, characteristics and behavior in the study area. The aim of this study is to assess the effects of changing land use and land cover on the flood events in the study area.

2. Material and Methods

Study Area

The study area is Ibaji Local Government Area of Kogi State, Nigeria. It is located between Latitude $06^{\circ} 52'00''\text{N}$ $06^{\circ} 87'00''\text{N}$ of the equator, and Longitude $06^{\circ} 48'00''\text{E}$ $06^{\circ} 80'00''\text{E}$ of the Greenwich meridian. It is located in eastern part of Kogi state (Figure 2.1) and covers approximately 1,377 km^2 . It is bordered by Edo state to the west by the river Niger, and Delta state to the south. The Headquarter of Ibaji local government is Onyedega.

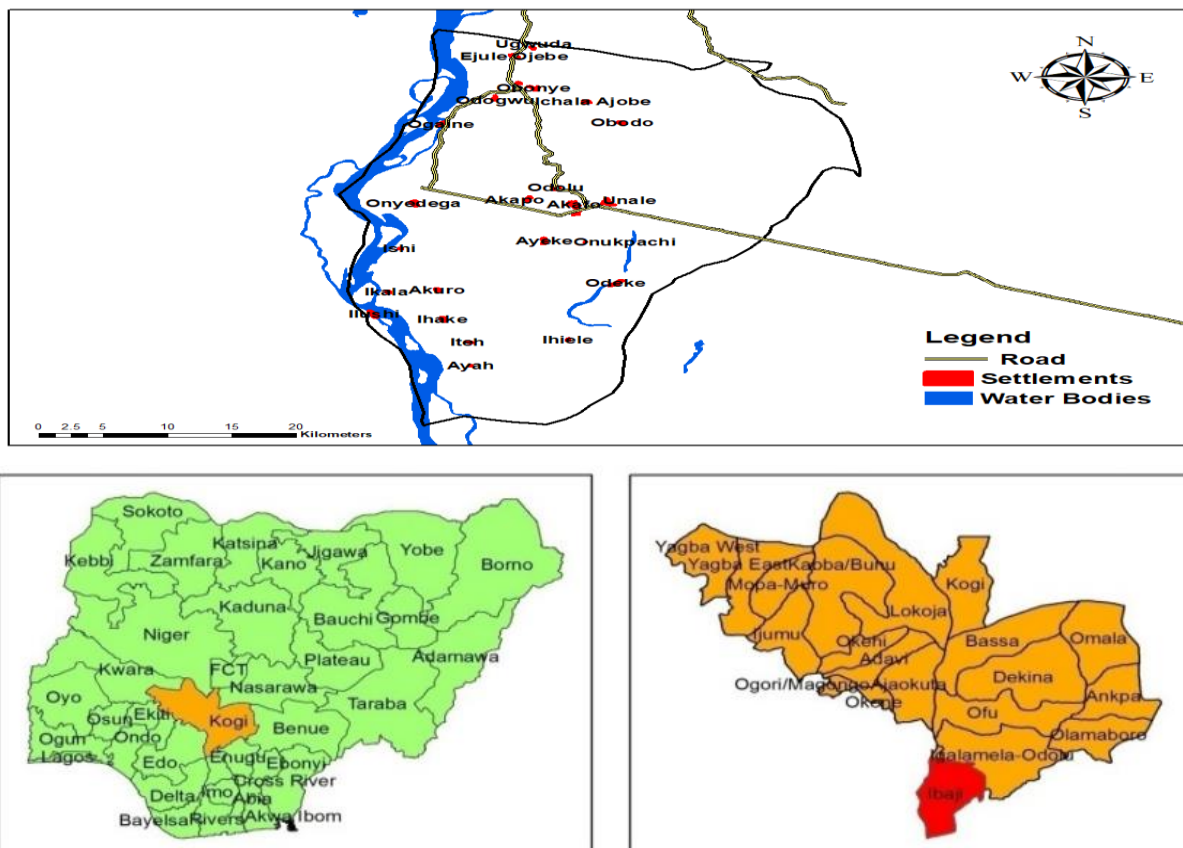


Figure 1: The Study Area

Reconnaissance Survey

A two weeks exploratory survey was conducted in the study area to get familiar with the terrain and the people and this informed the choice of data and methodology used in this research. The administrative maps, satellite image along with a native field assistant serves as a guide.

Source of Data

The data sources for this study were drawn from both primary and secondary sources.

a. Primary Sources

This involves direct measurements and investigations as well as questionnaire administration on the field. This research employs the use of field survey/questionnaire administration, personal observation and interview with respondents drawn from various sampled neighborhoods.

b. Secondary Sources

These are data generated from documents of various kinds and retrieved from the original sources. They include reports, Journals, statistical handbooks, text books. Published and unpublished thesis/dissertation. The Secondary data used in this research includes; Satellite Imagery, Topographic maps, Textbooks, Internet materials, Research journals and thesis (both published and unpublished).

Data Types

The data types used in this research as well as the hardware and software include the following:

- (a) **Satellite Imagery.** The satellite imagery utilized in this research includes, Aster Digital Elevation Model (DEM), 2002 and LANDSAT Imagery of 2002, 2012 and 2022 respectively. The two-satellite imagery were obtained from the official website of Global Land Cover Facility (GLCF) and Glovis.
- (b) **Ground Positioning System (G.P.S):** A Garmin 97 hand help GPS was used for the ground trothing and coding of various points of references (GPS Coordinates).
- (c) **Topographic Map:** Topographic maps of the study area was used and aid the production of a new digitized map of the area. It was

obtained from the National Centre for Remote Sensing (NCRS) Jos.

- (d) **Softwares Used:** The softwares used in this study includes; Idrisi Selva, ILWIS 3.3 and ArcGIS 10.1 were used for all GIS analysis involving spatial and attribute data, map productions and calculations and general model development and implementation. Microsoft word and Excel were used in result presentation and general write up.

(e) Land Use/Cover (LU/C) Classification

Land cover information is an important data set for characterizing and monitoring flood prone areas within a watershed as it reveals the correlation between imperviousness and changes in natural landscape. Land use map of the area was derived from landsat 8 imagery using supervised classification method in Idrisi Selva. Training sites were selected using the digitize tools, signatures was created using maksiz algorithm which was used in the final classification using Maximum likelihood algorithm. The land use/cover were categorized into five(5) classes as follows:

- i. **Farm land:** are cropland.
- ii. **Vegetation:** In a general sense, vegetation is an assemblage of plant species and the ground cover they provide. Their classification is based on the dominance of species in a community. Vegetation can be broadly classified as woodland, shrub or grassland.
- iii. **Built-up Area:** This comprises mostly of buildings, streets, highways, parking lots, sidewalks etc. they are sometimes referred to as impervious surfaces since they disallow water from infiltrating into the ground. According to Marvin *et al* 2007, increases in impervious surfaces, and accompanying phosphorous, sediment, and thermal loads, can have profound negative impacts on water resources. Hence Percent impervious surface area has emerged as a key factor to explain and generally predict the degree of impact severity on streams and watersheds. Motivated by the importance of impervious surfaces,

many researchers from various disciplines have attempted to estimate the amount and distribution of urban impervious surfaces (Rama *et al*, 2007). In these studies, satellite imagery has been very helpful as it could successfully characterize different land-cover and land-use types (Yang, 2006).

- iv. **Surface Water body:** These are open surface water bodies such as reservoirs, dams, rivers, streams and lakes
- v. **Sand deposit/Bare land:** bare soil is basically sand or soil not covered with grass wood chips, artificial turf or similar covering. In other words, bare soil is a soil surface devoid of any plant.

Statistical Data Analysis Methods

The Spatial analyst tool in ArcGIS 10.1 was used in extracting the areas covered by various land use, TWI, TPI and elevation in the study area

3. Result and Discussions

Land use and Land Cover Analysis

This section presents the results of the land cover change analysis. The land-use/land-cover changes between 2002 and 2021 were analysed using Landsat images and GIS image processing tools. The 2002, 2012 and 2021 land use maps are presented in Figures 2, 3 and 4 respectively.

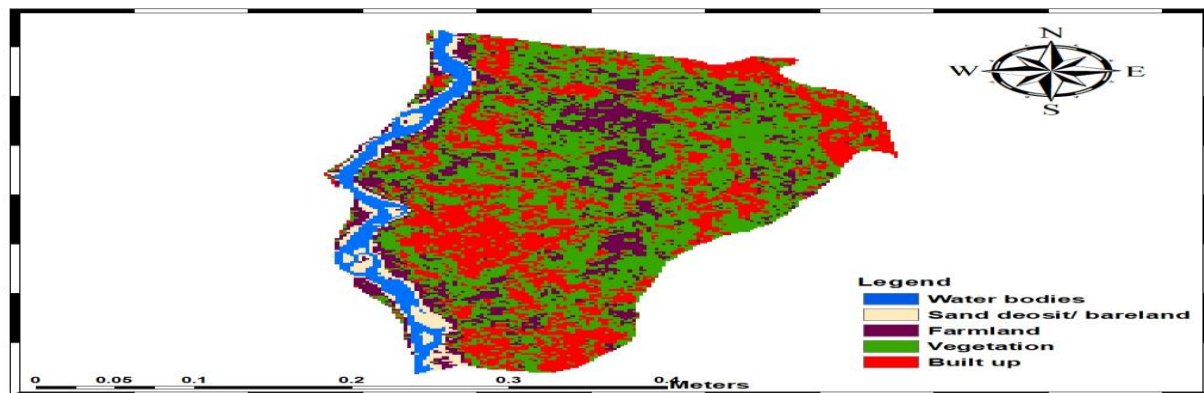


Figure 2: Land use/cover classes 2002

Source: Author Analysis (2024)

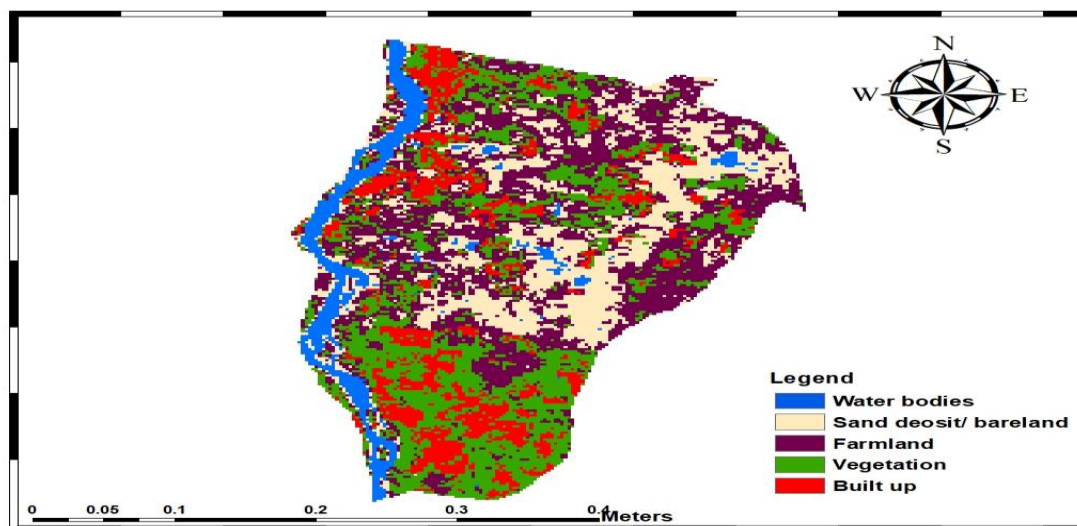


Figure 3: Land use/land cover map 2012

Source: Author Analysis (2024)

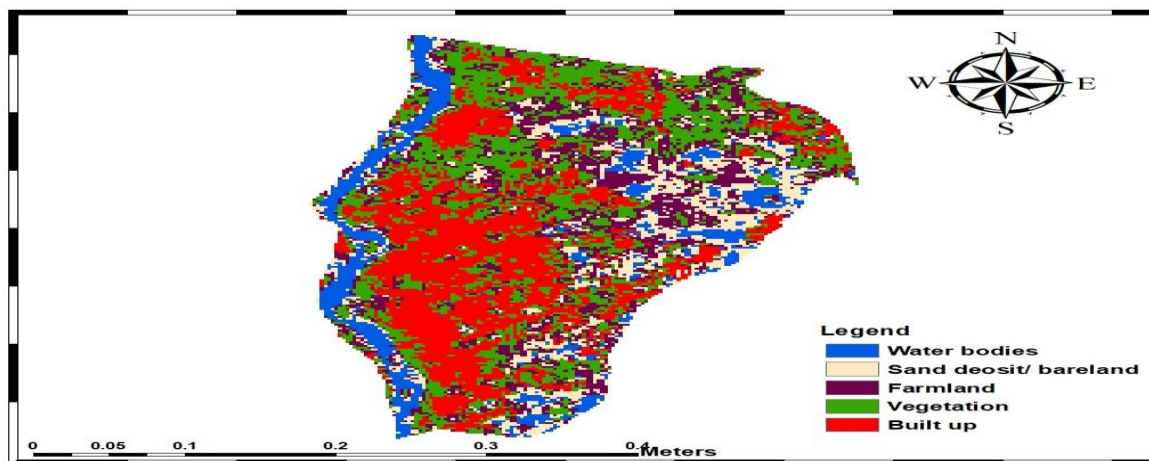


Figure 4: Land use/ land cover map 2021
Source: Author Analysis (2024)

Table 1: Areal Extent of Land use and Land Cover Classes

S/N	Land use Class	2002 (AreaKm ²)	%	2012 (Area Km ²)	%	2021 (Area Km ²)	%
1	Water bodies	17.92	1.3	71.604	5.2	56.457	4.1
2	Sand Deposit/Bareland	129.44	9.4	155.601	11.3	194.157	14.1
3	Farmland	320.84	23.3	414.477	30.1	459.918	33.4
4	Vegetation	572.83	41.6	347.004	25.2	223.074	16.2
5	Built up	335.98	24.4	388.314	28.2	443.294	32.2
	Total	1377	100	1377	100	1377	100

The results show that built-up area increased from 335.9km² in 2002 to 388.3km² in 2012 and 443.2km² in 2021. Farmland increased from 320.8km² in 2002, 414.4km² in 2012 and 459km² in 2021. Bareland increased consecutively across the study epochs from 129.4km² in 2002 to 155.6km² in 2012 and 194.1km² in 2021 while Vegetation cover declined throughout the study epochs from 572.8km² in 2002, 347km² in 2012 and 223km² in 2021. This is similar to findings in a study by Ochege and Okpala-Okaka (2017), in which forest area in South-eastern Nigeria declined by 44% between 1984 and 2014, while built-up area increased by 10.98% within the same period. The pattern also generally accords with that of Enaruvbe and Atafo (2016) which shows a decline in forest area, from 9522 km² to 5076 km² and 34.13% increase in agricultural area i.e., from 9796 km² to 13,140 km² from 1987 to 2013. The spatial distribution of changes

revealed that most of the deforested areas/agricultural areas are located in close proximity with built up areas. This goes to show that the expansion of built-up area and agricultural lands is taking place simultaneously and in close proximity. Different studies show that the situation in the study area is not a peculiarity. Several studies in Africa have shown similar pattern, for example, according to Mengistu (2009), studies that have been carried out in different parts of Ethiopia indicated that agricultural lands have expanded at the expense of natural forests and shrub lands. In a study of land use change in Ghana, Adjei et al. (2014) shows that between 1986 and 2008, the basin lost 18.0% of the total forest cover. Koneti et al. (2018) also observed a similar pattern in a study in India, the results of their study revealed that the overall LULC in the basin showed a reverse trend for the forest cover and cropland classes, i.e., decreasing

forests and increasing agricultural areas. Another study by Twisa and Manfred (2019) of land cover change in the Wami River Basin, Tanzania, shows that 11% of the forest converted into cultivated land within 16 years. There are, however, studies that have shown the opposite pattern, e.g., studies by Andualem et al. (2018) indicated that there was a dramatic land use land cover change over 11-year period of time in Upper Rib watershed and there was an increase of forest from 3.8% to 5.35% within a decade. Another study by Emenyonu et al. (2015) in the Western Niger Delta of Nigeria revealed that agricultural lands in the area reduced from 24.6% to 17.24% within 22 years, (1986 to 2008). The research findings revealed that land use change could be a significant factor in explaining the observed changes in streamflow in the area. The changing proportions of these land-use types within the study area can have drastic effects on discharge and response to storms in the area. The large amount of the conversion of forest to agricultural areas in the study area revealed by the land use change analysis provides an important factor that may have contributed to the increased flood frequency in the study area. In particular, the expansion of agricultural land and built-up areas provides plausible contributory factors that may adversely impact hydrological processes and subsequently increase stream flow and hence increase the risk of flooding in the study area.

4. Conclusion

The study concludes that changes in land use and land cover, as evidenced by measurable declines in vegetation cover from 572.8 km² (41.6%) in 2002 to 223.1 km² (16.2%) in 2021, have significantly increased flood risks in Ibaji Local Government Area, Kogi State. Concurrently, farmlands expanded from

320.8 km² (23.3%) to 459.9 km² (33.4%), and built-up areas grew from 335.9 km² (24.4%) to 443.3 km² (32.2%) over the same period. These changes disrupted the natural hydrological processes, increasing surface runoff and reducing soil infiltration. Such shifts have not only intensified the frequency and severity of flooding but also led to adverse impacts on agriculture, infrastructure, and livelihoods in the region.

The study further emphasizes the necessity for sustainable land management to address these challenges. It recommends reforestation to restore vegetation, controlled urban development, and innovative farming practices to enhance soil stability and water infiltration. Policymakers are urged to use the quantitative data provided—such as the (194.2 km²) increase in bare land (from (129.4 km²) in 2002 to 194.1 km² in 2021)—to craft targeted interventions that mitigate flood risks. By leveraging these insights, stakeholders can implement informed strategies that balance development with environmental conservation, ensuring sustainable livelihoods and reduced flood vulnerability for Ibaji's residents.

5. Recommendations

- i. **Enforce Land Use Regulations:** Authorities should enforce strict land-use controls, promote sustainable farming, and implement reforestation to reduce environmental degradation and flood risks.
- ii **Integrate Flood Risk Management in Urban Planning:** Urban planning authorities should include flood risk management in development policies, regulate urban expansion, and use geospatial tools to guide sustainable growth and mitigate flood impacts.

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