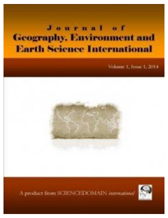

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Implication of Land Use Change on Flood Vulnerability in an Urban Watershed of Ibadan, Southwest, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author OOIO designed the study, managed the literature searches and performed the geospatial and statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author ATS proof read and managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

This study identified the relationship between land use land cover changes (LULC) and flood vulnerability (FV) in a watershed using geospatial data. Using the supervised classification method and post classification change detection technique, nature, extent and rate of land use land cover change were examined from 1972 -2013 with a view of assessing flood vulnerability on land use changes. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Digital Elevation Model (DEM) and Landsat multispectral medium resolution satellite image (Landsat) (30 m) covering Ibadan for the years 1972, 1984, 2000 and 2013 were acquired. The AsterDEM was used to delineate the urban watershed of Ibadan while the Landsat imageries were used to evaluate spectral and spatial changes in the LULC of the study area within the 41 years' period under consideration. Analytical hierarchical process was used to standardize and integrate identified

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factors (slope, soil, drainage, LULC, elevation) contributing to flood which were assigned weight and overplayed in the principle of pairwise comparison. The flood vulnerability (FV) sensitivity index was developed using the multi criteria decision analysis model. The study also examined the relationship between LULC and FV. The results showed that LULC in the watershed experienced increase in built up areas by 9.4% (1972), 14.1% (1984), 15.3% (2000) and 40.2% (2013) while waterbody experienced decrease of 2.8% (1972), 0.2 (1984), 0.1% (2000) and 0.1% (2013). Highest flood vulnerability was recorded in 2013, followed by 1984; while 1972 had the least flood vulnerability. The flood vulnerability on built up, light vegetation, bare soil and water body increased by 15.66%, 12.56%, 21.24%, 34.42% for 1984 and 57.16%, 9.16%, 83.68%, 0.78% for 2013 respectively. Results revealed that rapid changes in land use play a significant role in intensifying flood risk in the urban watershed. This study concluded that change in LULC is increasing drastically in the watershed. Implication of this is that if human activities are not properly controlled and if a well-planned and effective land use policy is not put in place within the watershed, vulnerability of the area to flood disaster may assume an unprecedented dimension.

Keywords: GIS; LULC; watershed; vulnerability; flood.

1. INTRODUCTION

Flood is a complex event caused by a range of human vulnerabilities which is viewed from the perspective of the physical, spatial or locational, and socio-economic characteristics of a region, inappropriate development planning, urbanization and climate variability [1-3]. In addition to the high flows caused by urbanization, the increased runoff also contains increased contaminants [4]. This flood issue has attracted the attention of many scholars who focused on different aspects of flooding ranging from impacts of flooding [5-7]; Urban flood study [8-10]; Flood management [2,11,12]; Flood Modelling [13,14].

Flood consequences around the globe are becoming too frequent and threaten sustainable development in human settlements because of rapid urbanization resulting in land use change, inadequate provision and maintenance of drainage systems, the location of people on marginal sites, and the physical characteristics of an area [15] and Ibadan is not an exception. This regular occurrence of flood has become a periodical challenge in Ibadan [10]. The city experiences recurrent and periodical environmental problem which has made the prevention of the regular floods in the city an enormous task. Floods occurrence were recorded in Ibadan in 1955, 1960, 1961, 1963, 1964, 1969, 1978, 1980, 1985, 1997, 2002, 2005, 2010, 2011, 2012, 2013 [16-20]. Specifically, the occurrence of flood in Ibadan is higher in Ogunpa and Kudeti whose catchments (watersheds) were flooded in 1955, 1960, 1961, 1963, 1969, 1978 and 1980 [21]. Even though there are agencies saddled with the responsibility of preparing for mitigation against, reduction of and recovery from disaster and to provide early warning systems, such as the Nigerian Emergency Management Agencies (NEMA), there is still increasing incidents of flooding in Odo ona river (2011) and Apete (2012, 2013, 2014) of Ibadan. Several reasons abound to explain the regular occurrence of floods in Ibadan over the years. Chief of these are the prevalence of heavy rainfall, climate change, poor sewage management and disposal [22]. This is compounded by poor urban planning control as shown by the unplanned layout and public apathy to environmental sanitation which aggravates regular occurrence of flooding in Ibadan. Reports from several studies on flood that have been carried out which revealed that the major emphasis has been on the quantitative aspect [23-30]. Also, studies have been carried out on land use and land cover in so many diverse ways [31-37]. The work of Aderogba [38] emphasised quantitatively the magnitude and criticality of the phenomena with their attendant challenges. There has been inadequate attention given to geospatial considerations which are needed to help users understand the spatial dimensions of flood vulnerability and its effects on land uses in the urban watershed of Ibadan. The integration of satellite remote sensing and GIS is an effective approach for analyzing the direction, rate, and spatial pattern of land use land cover change, hence, this study.

1.1 Study Area

The study area is Ibadan, the capital city of Oyo State located in southwest of Nigeria (see Fig. 1). It is located within Latitudes 7° 16' N and 7°34’N and Longitudes 3° 44’E and 4°02 ‘E. It has 11 Local Government Areas (LGAs) namely Ibadan

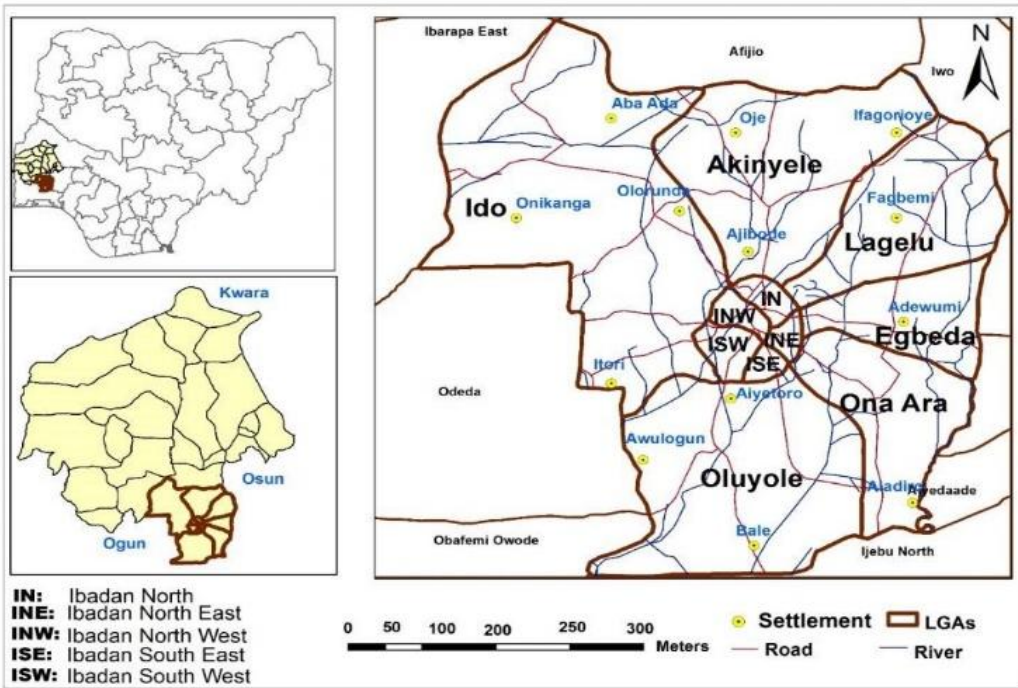


Fig. 1. Ibadan, Oyo State, South West Nigeria

North, Ibadan North – East, Ibadan North- West, Ibadan South- East, Ibadan South-West, which are the Ibadan Urban centres and Akinyele, Egbeda, Ido, Lagelu, Ona Ara and Oluyole area as the Ibadan Sub Urban Areas. Its population was estimated to be about 2, 550,593 in the 2006 Population census carried out and projected population for 2010 to be 2, 893,137 using growth rate of 3.2% [39].

It has a tropical wet (lengthy) and dry (short) season with an elevation range from 150 m in the valley area to 237 m above sea level on the major north-south ridge. The total area is 1,190 sq. mi (3,080 km^2). Most areas of the city are covered by rainforest and derived savanna.

2. MATERIALS AND METHODS

2.1 Data Acquisition and Analysis

The Digital Elevation of Ibadan (see Fig. 2) was obtained from Aster image and rivers (see Fig. 3) were digitized from the Topographic map which was overlaid on the DEM of Ibadan comprising the 11 Local Government Areas to delineate the urban watershed of Ibadan. The flow accumulation, direction, slope, stream segmentation and catchment aggregation and polygonization were carried out.

Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) DEM image with 30 m resolution was used for watershed delineation. Multi Spectral Scanner (MSS) (4 Bands), Thematic Mapper (TM) (7 bands), Enhanced Thematic Mapper (ETM) (7 Bands) and Landsat 8 Operational Land Imager (OLI) (12 bands) spectral band satellite imageries (Path 191, Row 55) for the year 2013, 2000, 1984 with a spatial resolution of 30 m and 1972 with a spatial resolution of 28 m but was resampled to 30 m. The ASTERDEM and the Landsat Imageries were acquired from National Aeronautics and Space Administration [40] and [4] respectively. A false color composite was carried out using band 432 due to the peculiarity of the bands for urban, light and thick vegetation study. However, interpretation may get difficult when we combine different bands of data to produce what is known as false color composites [41] but this was addressed using field knowledge and historical information of the study area.

These were used for estimating the Land use/Land cover dynamics of the area. A supervised classification was carried followed by post classification for accuracy assessment using Kappa coefficient which is one of the most popular measures for the interpretation of error

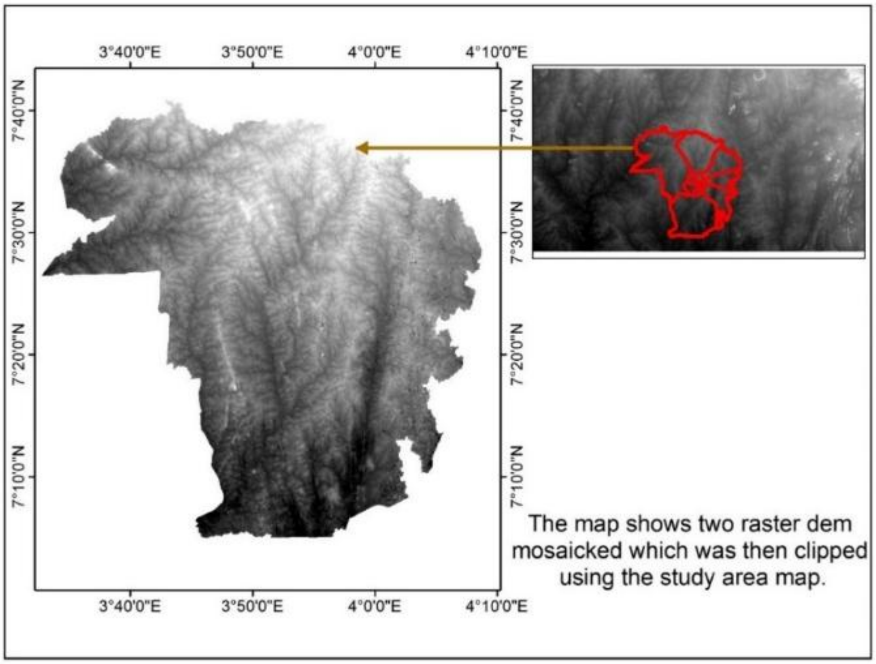


Fig. 2. DEM view of Ibadan

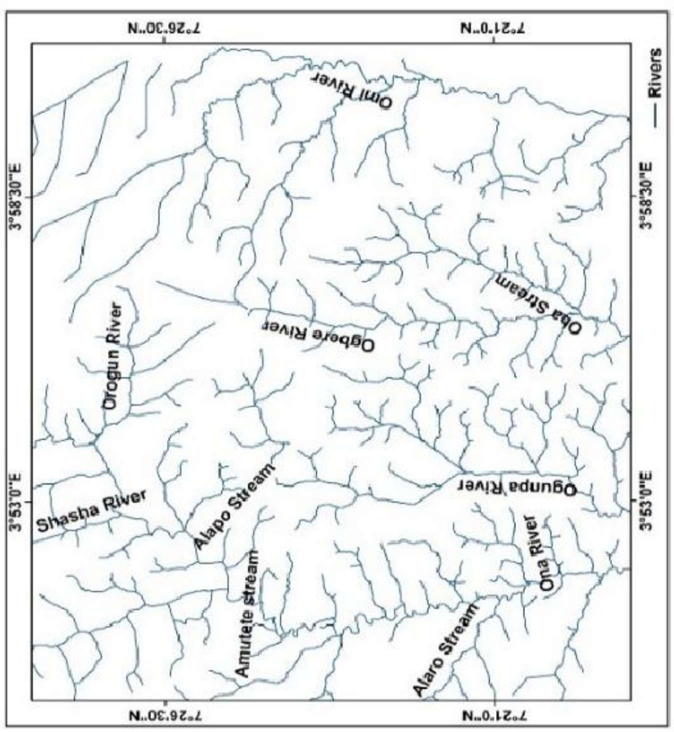


Fig. 3. Some parts of drainage network of Ibadan

matrix. It is a discrete multivariate technique used in accuracy assessment [42], after classification has been carried out. Topographic maps acquired from the achieve of Space

Applications and Environmental Science Laboratory Unit of Obafemi Awolowo University covering the area extent of Ibadan was used to extract the river (drainage networks), topological features, place names, settlements, roads, contours and vegetation types amongst others. The soil map was also acquired from the ministry of agriculture for extracting information about the various types of soils, composition and drainage/infiltration property using literatures and field survey /observations. In the study area, dendrite and parallel drainage pattern are recognized with various watersheds.

Digital Elevation of Ibadan was obtained from Aster image and rivers were identified on the Topographic map which was overlaid on the DEM of Ibadan. Malczewski [43-46] opined that the choice of criterion that has a spatial reference is an important and profound step in multi-criteria decision analysis. Hence, the criteria/factors considered in this study we chosen due to their significance in causing flood in the study area through field survey and as identified in many other past and recent works [47-51]. The factors considered are the flow accumulation, slope, soil, elevation, drainage density, and land use (classified) which was chosen based on an analysis of existing studies and knowledge.

2.2 Multi Criteria Decision Analysis (MCDA) for Flood Vulnerability (VL)

First, the evaluated criterion was reclassified and assigned value at their level of importance Second, Multi Criteria evaluation approach using a MCDA in a GIS environment were used in finding and modelling flood vulnerability in the urban watershed. This involves determining how each factor affects the flood vulnerability according to degree of importance and demonstrating the effect of different criteria weights on the spatial pattern of the identified vulnerable areas. Fig. 4 provides detailed methodological flowchart of the study.

3. RESULTS

Ibadan was delineated into a watershed with 32 sub catchments (see Fig. 5a). A total of 32 catchments were delineated as urban watershed of Ibadan in Oyo state. The rasterized sub-catchment was further polygonised which generated a labelled catchment by coding and some settlements in the catchments were identified. This coding assisted in knowing the rate of change in each of the catchments. The Projected DEM was used to derive the percentage slope of the watershed as described in Fig. 5b.

3.1 Land Use Land Cover (LULC) Analysis

The LULC classification for 1972 from MSS satellite image (Fig. 6a) showed that majority of the study area had dense vegetation accounting for 197,069.9 ha (72.4%), water, bareland/soil, light vegetation, and built up accounted for 7,562.5 ha (2.8%), 17,468.4 ha (6.4%), 24,335.5 ha (8.9%), and 25,681.1 ha (9.4%), respectively. The total Area covered is 272,117.4 ha (100%) The land use /land cover classification for 1986 from TM satellite image (Fig. 6b.) showed dense vegetation accounting for 140,387.2 ha (51.6%) while water, bareland/soil, light vegetation and built up amounted to about 408.78 ha (0.2%), 14,809.0 ha (5.4%), 78,203.0 ha (28.7%), 38,309.7 ha (14.1%) respectively. The total Area covered is 272,117.4 ha (100%)). Most portion of the area remains dense vegetation during this period. Furthermore, land use / land cover (LULC) classification for 2000 from ETM+ satellite image (Fig. 6c) shows dense vegetation accounting for 37,947.6 ha (13.9%) while water, bareland/soil, light vegetation and built up amounted to about 251.7 ha (0.1%), 88722.1 ha (32.6%), 103498.8 ha (38.1%), 41568.4 ha (15.3%) respectively. The total Area covered is 272,117.4 ha (100 %) Most portion of the LULC class remains built up and dense vegetation during this period. Categorically, LULC classification for 2000 from OLI satellite image (Fig. 6d) presented dense vegetation accounting for 39031.1.6 ha (14.3%) while water, bareland/soil, light vegetation and built up amounted to about 293.8.7 ha (0.1%), 11079.4 ha (4.1%), 112356.8 ha (41.3%), 109356.4 ha (40.2%) respectively. The total Area covered is 272,117.4 ha (100%). There is a drastic change from dense vegetation to built-up and light vegetation in a progression form (see Table 1).

The change detection was made based on the classified maps of 1972 and 1984. When 1984 LULC was compared with 1972 land use/ land cover classification, there was a change that shows decrease or increase in particular land use land cover. The LULC categories that show increase are built up and Light vegetation which accounted for 12628.6 ha (4.7%) and 53867.5 (19.8%) 5,546.2 ha (1.9%) respectively. On the other hand, the LULC categories like dense vegetation, bare soil/land and water declined to

56682.7 ha (20.8.7%), 2659.4 ha (1%) and 7153.7 ha (2.6%) respectively (Table 2). When the 2000 LULC classification was compared with 1984 LULC classification, there were changes that showed decrease or increase in particular LULC. The LULC categories, which showed increase are light vegetation, bare soil/land and built up accounting for 25295.8 ha (9.4%), 73913.1 ha (10.8%) and 3258.7 ha (1.2%) respectively. On the other hand, the LULC categories like dense vegetation and water showed decreasing pattern which amounted to 102440 ha (-37.7%) and -28.4 ha (0.4%); respectively (Table 3). Furthermore, when the 2013 LULC classification was compared with 2000 LULC classification, there were changes that showed decrease or increase LULC. The LULC categories, which showed increase are built up and dense vegetation accounting for 67787.6 ha (24.9%) and 8858.2 ha (3.2%) respectively. On the other hand, the land use /land cover categories like light vegetation, bare soil/land and water showed decreasing pattern which amounted to 10142 ha (3.7%), 77642.7 ha (28.5%) and -86.6 ha (0%) respectively (Table 4).

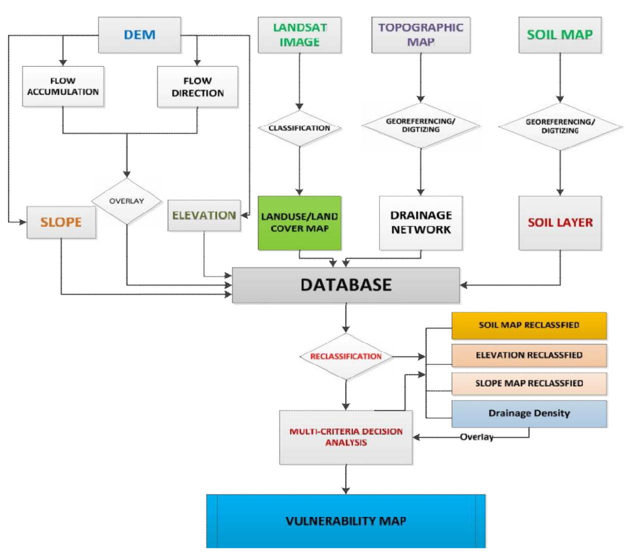
Table 1. LULC classes, their corresponding areas for 1972

LULC type	Area in 1972 (ha)	(%)LULC 1972	Area in 1986 (ha)	(%)LULC 1986	Area in 2000 (ha)	(%)LULC 2000	Area in 2013 (ha)	(%)LULC 2013
Built Up	25681.1	9.4	38309.7	14.1	41568.4	15.3	109356.4	40.2
Water	7562.5	2.8	408.8	0.2	380.4	0.1	293.8	0.1
Dense Vegetation	197069.9	72.4	140387.2	51.6	37947.6	13.9	39031.1	14.3
Light Vegetation	24335.5	8.9	78203.0	28.7	103498.8	38.1	112356.8	41.3
Bareland/Soil	17468.4	6.4	14809.0	5.4	88722.1	32.6	11079.4	4.1
Total	272117.4	100	272117.4	100	272117.4	100	272117.4	100

Overall Accuracy: 91.3079% Kappa Coefficient = 0.8794 (1972)
Overall Accuracy: 93.5897% Kappa Coefficient = 0.9053 (1986)
Overall Accuracy: 94.3682% Kappa Coefficient = 0.9109 (2000)
Overall Accuracy: 96.1101% Kappa Coefficient = 0.9399 (2013)

Table 2. LULC Changes (1972 - 1984)

Land cover type	Area in 1972 (ha)	(%) land cover in 1972	Area in 1984 (ha)	(%) land cover in 1984	Changes between 1972-1984	
					(ha)	(%)
Built Up	25681.1	9.4	38309.7	14.1	12628.6	4.7
Water	7562.5	2.8	408.8	0.2	-7153.7	-2.6
Dense Veg	197069.9	72.4	140387.2	51.6	-56682.7	-20.8
Light Veg	24335.5	8.9	78203.0	28.7	53867.5	19.8
Bareland/Soil	17468.4	6.4	14809.0	5.4	-2659.4	-1
Total	272117.4	100	272117.4	100		



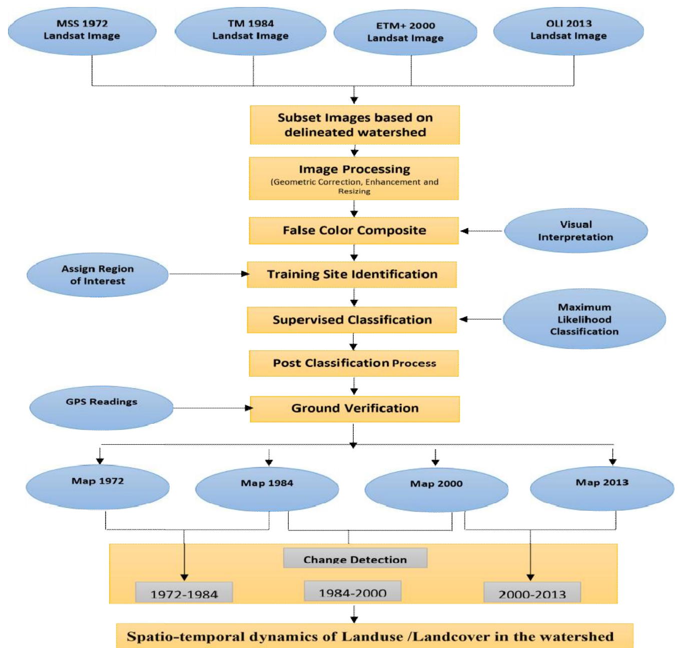


Fig. 4. The methodological flowchart of the study

Table 3. LULC Changes (1984 – 2000)

Land cover type	Area in 1984 (ha)	(%) land cover in 1984	Area in 2000 (ha)	(%) land cover in 2000	Changes between 1984 -2000 (ha)	(%)
Built Up	38309.7	14.1	41568.4	15.3	3258.7	1.2
Water	408.8	0.2	380.4	0.1	-28.4	0.4
Dense Veg	140387	51.6	37947.6	13.9	-102440	-37.7
Light Veg	78203	28.7	103498.8	38.1	25295.8	9.4
Bareland/Soil	14809	5.4	88722.1	32.6	73913.1	10.8
Total	272117.4	100	272117.4	100		

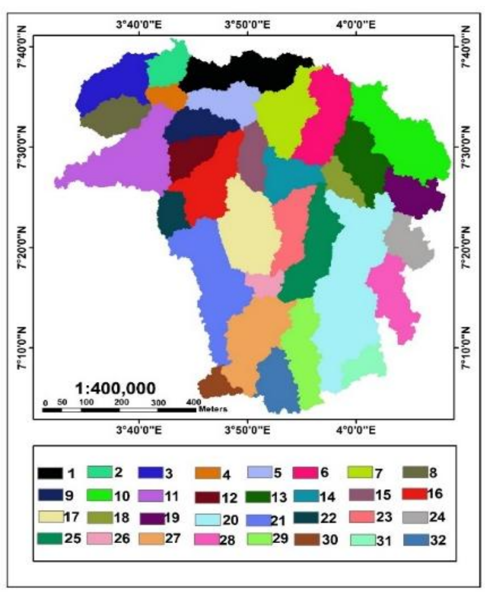


Fig. 5a. The sub-catchment delineated

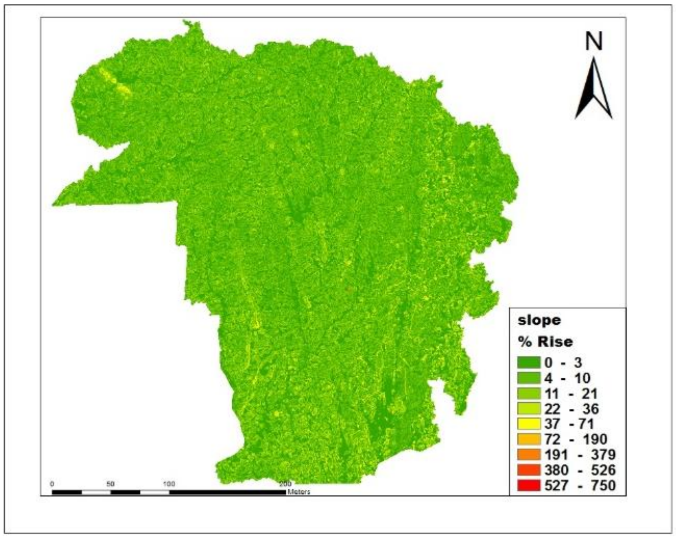


Fig. 5b. Slope of the watershed

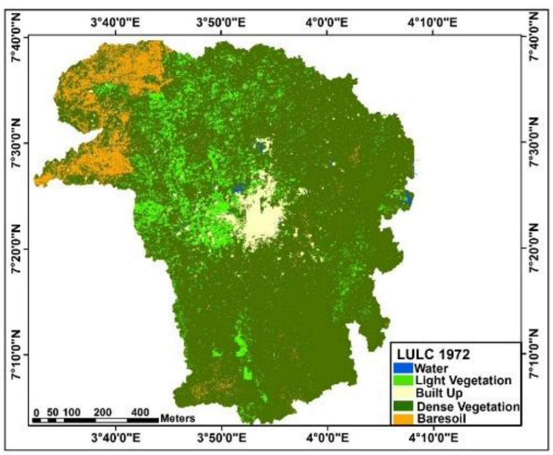


Fig. 6a. LULC classification for 1972

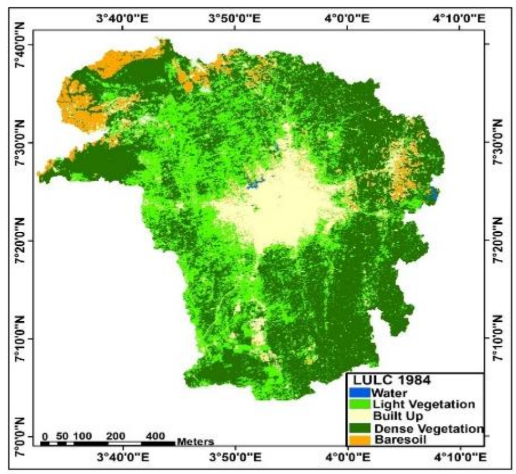


Fig. 6b. LULC classification for 1984

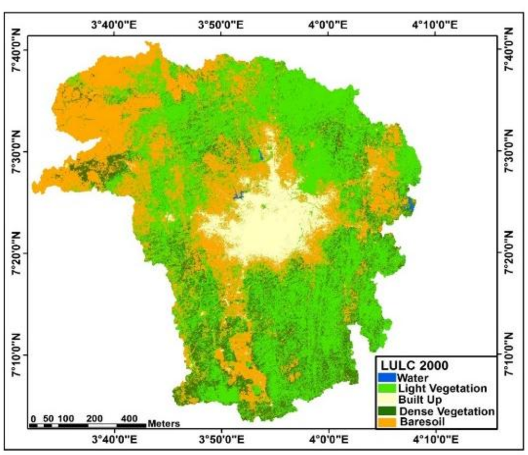


Fig. 6c. LULC classification for 2000

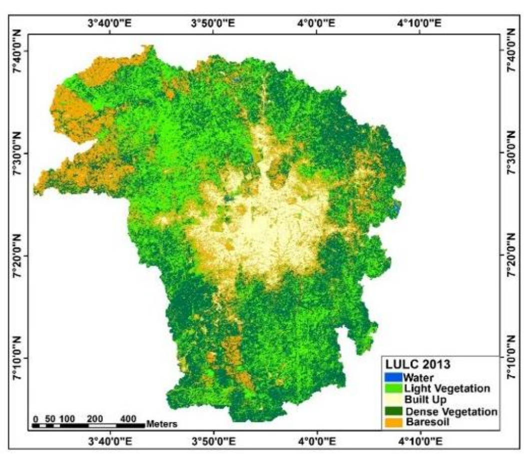


Fig. 6d. LULC classification for 2013

Table 4. LULC Changes (2000 – 2013)

Land cover type	Area in 2000 (ha)	(%) land cover in 2000	Area in 2013 (ha)	(%) land cover in 2013	Changes between 2000-2013 (ha)	(%)
Built Up	22568.4	8.3	109356	40.2	86788	31.9
Water	380.4	0.1	293.8	0.1	-86.6	0
Dense Veg	37947.6	13.9	39031.1	14.3	1083.5	0.4
Light Veg	122499	45	112357	41.3	-10142	-3.7
Bareland/Soil	88722.1	32.6	11079.4	4.1	-77642.7	-28.5
Total	272117.4	100	272117.4	100		

Table 5 shows the progression of change from 1972 to 2013. There was a steady increase from the year 1972 (9.4%) – 2013 (40.2%) in the built up area. However, the year 2000 (15.3%) experienced a minute transitional change in built up areas when compared with that of built up changes in the other three years. This could be attributed to concurrent flooding that happened in the 80s and the 90s as reported and analyzed from the field data and literature.

There was increment in the size of the vegetated areas of the study area from 1972 (8.9%) – 2013 (41.3%) which resulted from deforestation. The forested areas were inversely proportional to the vegetated areas as there was decrement from 1972 (72.6%) – 2013 (14.3%). This showed that the tree cover which reduced the rate of infiltration to the ground and thereby preventing flooding has experienced drastic change due to factors such as ineffective land use practices, increase in level of immigration and population growth and increase in the demand for more facilities and amenities as identified from the field survey and this could be attributed to continual removal of forest to cater for agricultural purposes and urbanization.

The bare land of the study area was gradually reducing in size from 1972 (6.4%) – 1984 (5.4%) resulting from urbanization. Unfortunately, there was a sudden increase in its size in 2000 (32.6%) which resulted from the flooding that also negatively affected the built up areas. This flooding also negatively affected the forested areas by removing the tree cover and turning them to vegetated areas thereby increasing their size in that year.

3.2 Extent and Rate of Change in LULC Dynamics from 1972-2013

The major land use of urban-built up surface had an increasing positive trend of change in its areal extent from 1972 to 2013 while water body decreased continuously in the four periods. There has been also an observable unstable increasing and declining trend of change in the other land cover classes of dense vegetation, light vegetation and bare land/soil. This implies a dramatic urban expansion and change in the morphology of the size and extents of the watershed. The changes in the areal extent of the water surfaces was believed to be related to the huge urban expansion.

Land use /land cover change (LULCC) analysis carried out shows an increase in built up area over time. Urbanization is attributed to many factors but mainly attributed to population growth in an area because of rural-urban migrations. The progression of change from 1972 to 2013 showed a steady increase from the year 1972 (9.4%) – 2013 (40.2%) in the built-up area (Table 6). Findings show that the year 2000 (15.3%) experienced a minute transitional change in built up areas when compared with that of built up changes in the other three years (1972, 1984 and 2013) which was because of the flooding that happened in the 80s and the 90s as reported and analysed from the field survey. The water bodies were of the maximum in the year 1972 which drastically experienced continuous decrease from 1984 to 2013. This was noticed to have resulted from people's encroachment into the areas covered by water bodies; making them more vulnerable to flood. There was increment in the size of the vegetated areas of study from 1972 (8.9%) – 2013 (41.3%) which is attributed to uncontrolled tree felling for building erection. The forested areas were inversely proportional to the vegetated areas as there was a decrease from 1972 (72.6%) – 2013 (14.3%).

3.3 Periodic Flood Vulnerability

The vulnerability of the catchment to flood shows that in 1972, the total area vulnerable to flooding is lower when compared to 1984, while in 1984 to 2000 it is higher and in 2000-2013 there was an increase. Different catchments in the watershed are experiencing all, one or two of the three vulnerability levels as presented in the flood vulnerability maps. Results shows the total area occupied by the high vulnerable areas for 2013, 2000 and 1984, moderate vulnerable areas for 2013, 2000, 1984 and low vulnerable areas for 2013, 2000 and 1984 respectively.

3.4 Flood Vulnerability and Catchment Level

Furthermore, the vulnerability result was used to identify and describe the catchment level of vulnerability to flooding. The result of this analysis was studied in line with the field observation of the various issues and occurrences of flood. This showed most of the catchments identified to have experienced flooding at one time or the other and are also vulnerable to flooding. Catchment 32, 23 and 17 were highly vulnerable for 1972, catchment 32, 30, 29, 31 and 27 1984 were highly vulnerable, 3, 8, 23 and 33 for 2000 and catchment 3, 8, 11, 17, 23, 32, 30, 29, 26 and 27 for 2013 respectively (Table 7).

3.5 Flood Vulnerability and Land Use Land Cover (LULCC) from 1972-2013

LULCC changes also play a vital role in increasing the vulnerability of the area. The study establishes the locations and magnitude of the LULC dynamics between 1972 and 2013, ultimately leading to implications for flood risk on affected areas. The result identified a continuous decline from low level of vulnerability to high level of vulnerability on the LULC as described in Fig. 7a, 7b, 7c and 7d. There is a pattern of increase in vulnerability on built up, Light vegetation, bare soil and waterbody accounting for 8993.60 ha (94.77%), 2364.18 ha (9.73%), 14121.80 ha (81.05%), 419 (77.59) for year 1972 and 26700.57 ha (57.16%), 9560.65 ha (9.16%), 3697.19 (83.68), 1.29 ha (0.78%) for the year 2013 respectively.

The result also shows that as a land use changes, it affects its level of vulnerability such as dense vegetation. As other areas take over dense vegetated areas, the total area become low and this is also observed with water while areas like built up and bare soil which are increasing in areas are becoming more vulnerable. The LULC shows figures and image changes, all in form of the reduction in vegetation cover and forested canopy in the area which in effect is exposing the area to increase in surface runoff and possible overflow of low lying areas. The physical properties of the area also contribute to the increase or decrease in surface runoff and generally, its vulnerability to flooding. The land use through the four years showed that built up and bare land are the most affected and this pose a serious threat to flood risk. However, other vegetated areas around the built up area are also vulnerable to flooding.

Further analysis revealed the vulnerable LULCC (Built up, light vegetation, dense vegetation, baresoil /land and water) in each of the sub catchments and categorized into high, moderate and low vulnerable areas. There is a pattern of increase in vulnerability on built up, Light vegetation, bare soil and waterbody accounting for 8993.60 ha (94.77%), 2364.18 ha (9.73%), 14121.80 ha (81.05%), 419 (77.59) for year 1972 and 26700.57 ha (57.16%), 9560.65 ha (9.16%),

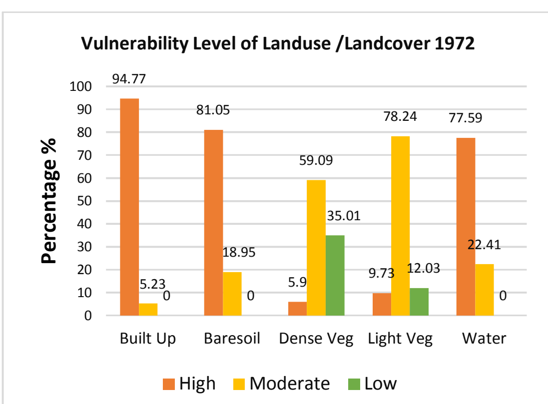


Fig. 7a. Flood vulnerability on LULC 1972

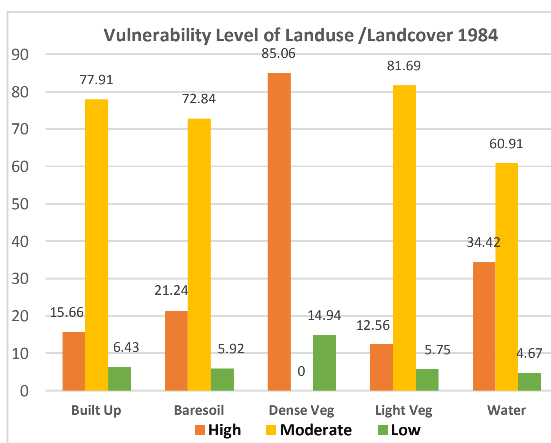


Fig. 7b. Flood vulnerability on LULC 1984

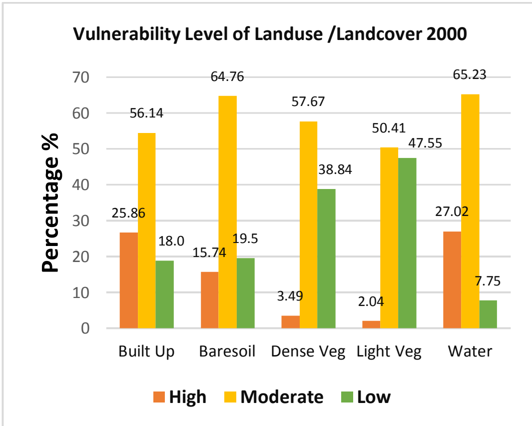


Fig. 7c. Flood vulnerability on LULC 2000

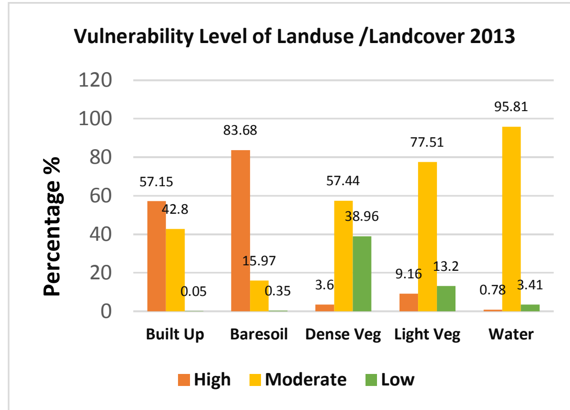


Fig. 7d. Flood vulnerability on LULC 2013

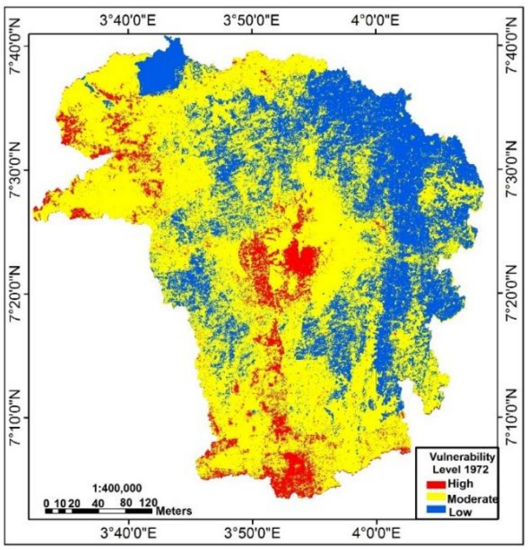


Fig. 8a. Flood vulnerability for 1972

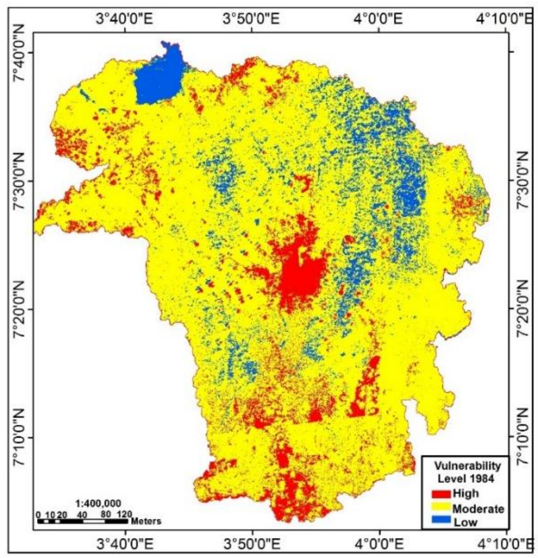


Fig. 8b. Flood vulnerability for 1984

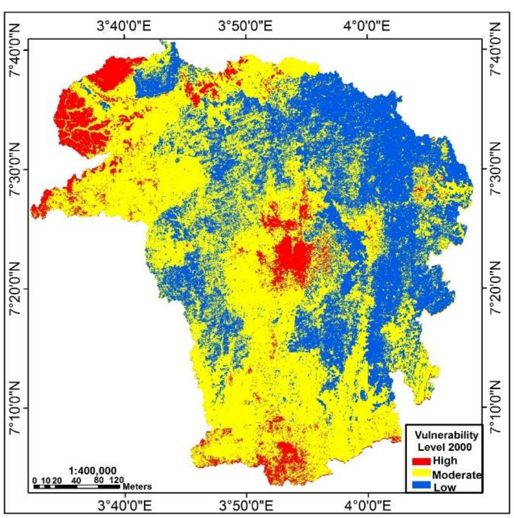


Fig. 8c. Flood vulnerability for 2000

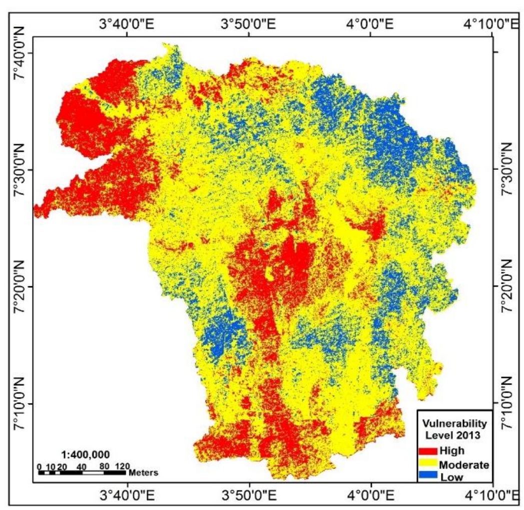


Fig. 8d. Flood vulnerability for 2013

3697.19 (83.68), 1.29 ha (0.78%) for the year 2013 respectively (Fig. 8a, b, c, d and 9a, b, c, d). Water having moderate vulnerability is accounted to high soil erosion in the upstream and sediments and dissolved substances cumulatively called river load deposited in the river channels and on adjacent flood plains in downstream of the major rivers. All these indicate that the rate of erosion and soil loss in the upstream is high due to lack of abstraction of flood water [52]. However, the changes between 1984 and 2000 was not so alarming when compared with other years which is attributed to the flood disaster experienced consistently in the 1980s and 1990s but there was a drastic increase from 2000 as reported from the analysed field data and this change in built up area has then been continuous till date. The results calculated for the Landsat images of the study area for 1972, 1982, 2000 and 2013 clearly explains this effect.

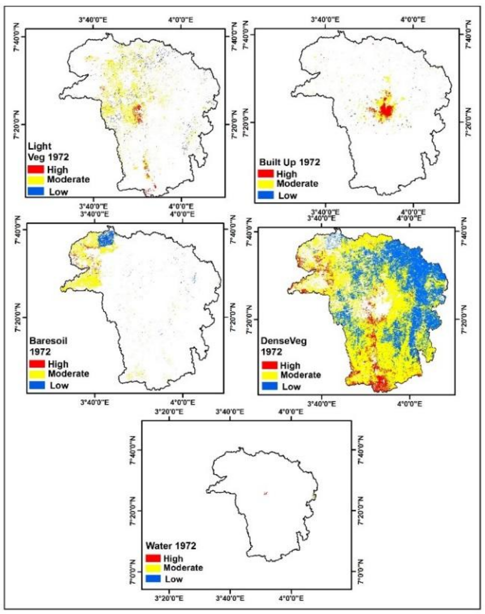


Fig. 9a. Flood VL of LULCC in 1972

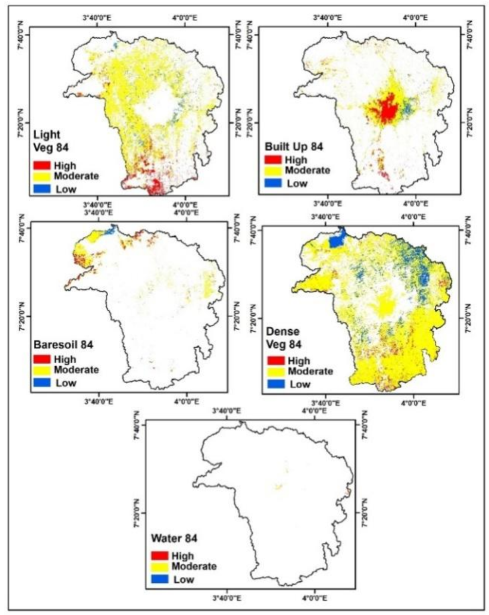


Fig. 9b. Flood VL of LULCC in 1984

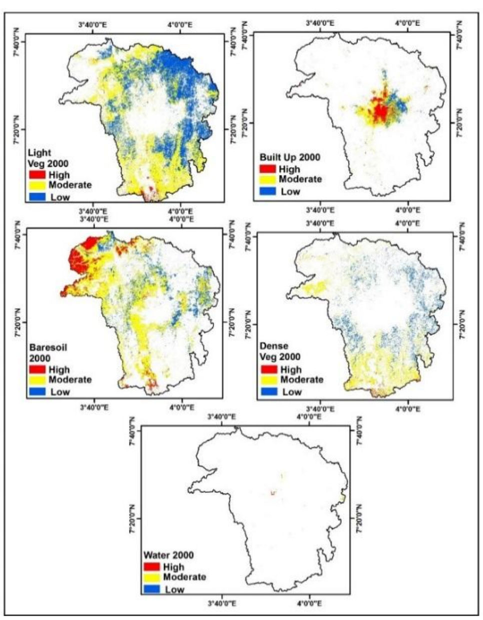


Fig. 9c. Flood VL of LULCC in 2000

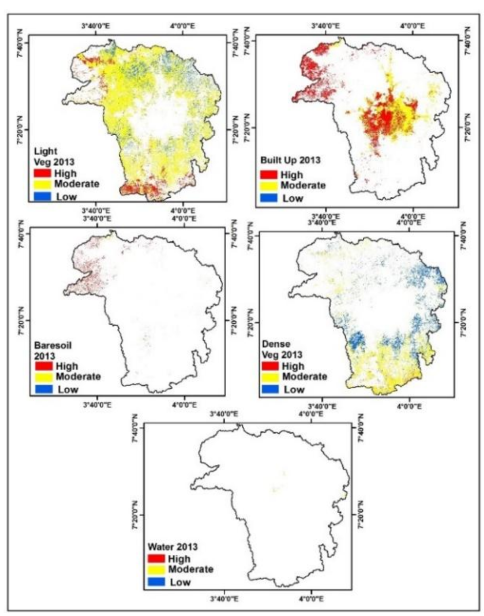


Fig. 9d. Flood VL of LULCC in 2013

Table 5. Area statistics and percentage of the LULC progression change from 1972-2013

LULC type	1972		1984		2000		2013	
	Area (ha)	%	Area (ha)	%	Area(ha)	%	Area(ha)	%
Built_up	25681.1	9.4	38309.7	14.1	41568.4	15.3	109356.4	40.2
Water	7562.5	2.8	408.8	0.2	380.4	0.1	293.8	0.1
Dense Veg	197069.9	72.4	140387.2	51.6	37947.6	13.9	39031.1	14.3
Light Veg	24335.5	8.9	78203.0	28.7	103498.8	38.1	112356.8	41.3
Baresoil	17468.4	6.4	14809.0	5.4	88722.1	32.6	11079.4	4.1
Total	272117.4	100	272117.4	100	272117.4	100	272117.4	100

Table 6. Overall amount, extent and rate of land cover change (1972-2013)

LULC types	1972-1984			1984 -2000			2000 – 2013		
	Change (Δ /ha)	Extent of Δ (%)	Rate of Δ (%/yr)	Change (Δ /ha)	Extent of Δ (%)	Rate of Δ (%/yr)	Change (Δ /ha)	Extent of Δ (%)	Rate of Δ (%/yr)
Built Up	12628.6	0.49	3.899e-5	3258.7	-0.411	2.611e-5	67788	3.855	4.442e-5
Water	-7153.7	-0.95	1.322e-4	-28.4	-0.069	-7.415e-2	-86.6	-0.228	2.633e-3
Dense Veg	-56682.7	-0.29	5.081e-6	-102440	-0.730	-7.845-e1	1083.5	0.029	2.677e-5
Light Veg	53867.5	2.21	4.11e-5	25295	0.566	1.278e-5	8858	-0.083	8.184e-6
Baresoil/ land	-2659.4	-0.15	5.716e-5	73913.1	4.991	6.753e-5	-77642.7	-0.875	8.627e-5

Table 7. Level of vulnerability in each of the sub catchments

Vulnerability level of catchment	1972	1984	2000	2013
High	17, 23, 32	17, 23, 26 and 32	3, 8, 23 and 33	3, 8, 11, 14, 17, 18, 23, 26, 27, 29, 32, 30 and 31
Moderate	1,3, 4, 5, 7, 8, 9,11, 12, 14, 15, 16, 18, 20, 21, 22, 25, 26, 27, 28, 29, 30 and 31	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22,24,25,27,28, 29, 30 and 31	1, 4, 9, 11, 12, 15, 16, 17, 18, 21, 22, 25, 26, 27, 28, 29, 30 and 31	1, 2, 4, 5, 6, 7, 9, 12, 13, 15, 16, 19, 20, 21, 22, 24, 25, 27, 28,
Low	2, 6, 10,13,19, 24	2	2, 5, 6, 7, 10, 13, 14, 19, 20, 24,	10,

4. DISCUSSION

The conversion of agricultural land use and farm lands into residential and industrial lands mainly around towns and cities encourages urbanization; thereby resulting in rapid land use and land cover changes [37,53,54]. The result of analysis by Salami and Akinyede [34] confirmed a decline in vegetation cover in the southwestern part of Nigeria from 59% in 1986 to 25% in 2004 which might have encouraged more impermeable surfaces that increase the rate of runoff. The results of such changes in the urban areas impact on the natural landscape, river morphology, drainage system and LULC of the area as well as increasing the frequency of water induced hazards [55,56,57].

Land use change intensifies flood risk and the implication of this is that ineffective land use practices increase the vulnerability of the natural environment to disaster [58]. For instance, the common practice of indiscriminate dumping of solid waste in drainages in the study area hinders the free flow of water along the channels of the rivers, most especially along the Ogunpa and Kudeti river channels [49]. In the study, the high vulnerable areas were found to have flat areas in terms of slope which also confirms some of the findings of [59,49,47]. The results also revealed that most of the watershed are flat areas. The implication is that such watershed may experience serious urban floods when there is high rainfall [60]. The situation is compounded by climate change in the area, resulting in higher intensity of daily rainfall in the watershed and increased vulnerability to flooding. Climate change is a growing concern in both developed and developing countries. It would not be so worrisome if the variations in climatic conditions were not so significant causing environmental changes that are alarming [61]. The obvious explanation for such variations is in the misuse of the environment through human activities that manifested in changes in atmospheric chemistry leading to abnormalities in climatic parameters such as temperature, evapotranspiration, rainfall and precipitation [62,61]. With respect to the soil infiltration, the watershed has fairly well drained soils with porous profiles except for the Jago association, hence, minimal water logging is excepted based on the infiltration properties of the soils in the watershed indicate [63,22].

5. CONCLUSION

Even though land is recognised to provide the basic means of livelihood improvement [64] and a natural capital that yields products utilized by human populations [31], this does not mean it should be misused without proper management regime. The continuous and drastic changes in LULC in the urban watershed is becoming alarming and the results of this study reveal that human activities are encouraging urbanization in a way that encourages disaster such as flooding. In such a changing urban environment there is need to put in place effective land use policies, strategies and practices to control human activities, protect the natural environment from uncontrolled development to provide a safe and sane environment for living. There is need to pay utmost attention to the watershed of Ibadan either in parts or holistically in terms of controlling anthropogenic activities aggravating flood risk. In order to achieve one of the Millennium Development goals (MDGs) involving sustainable environment, there is need to reduce and if possible eliminate flood disaster records that is increasing day by day. This is only achievable if there is effective land use planning in the area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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