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Land Use Change Detection and Evaluation in a Watershed: The Implications for Ofu River Water Quality in Anyigba, Kogi State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This paper examined visible land use changes in Ofu River watershed. Supervised and unsupervised classification of land use types were adopted. Geographical Information System (GIS) software, ArcGIS was used handling and analyzing geographic information by visualizing land use change characteristics or spatio-temporal variability of land use in the study area. The results shows built-up in 2000, 2010, 2020, and 2030 projection were analyzed to be (18.931km^2, 30.891km^2, 81.280km^2 and 112.455km^2) respectively, water body (7.491km^2, 7.491km^2, 7.450km^2 and 7.428km^2), wetlands (105.637km^2, 81.713km^2, 61.590km^2 and 39.564k^2), scattered agriculture (1381.057km^2, 1,460.415km^2, 1,58.560km^2 and 1,662.313km^2) and vegetated land (415.428km^2,

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348.033km^2, 209.660km^2 and 106.783km^2) respectively. Tested hypothesis revealed that $p< .05$. This study recommends proper monitoring of land uses and workable land use policies be put in place in the study area.

Keywords: Land use change; change detection; Ofu watershed; river water quality.

1. SETTING THE CONTEXT

Globally, the critical modifications of Land Use Land Cover could be related to unending population growth [1-3]. This is linked with intense agricultural development and expansion of residential area. The wise use of land resources determines sustainability of the environment and human welfare [4]. The bid to understand and detect spatiotemporal changes in both forms and functions of land within watersheds in recent times has become preeminent and a tool for planning and infrastructure development. Changes in land use and land cover due to urbanization, industrialization and agriculture activities will adversely affect ecosystem and its water quality at all scales. Knowing the spatial dimension, distribution and identifying water pollution sources are also vital elements in implementing effective water resource management and protection of rural water bodies. Land use types and land cover changes critically impact the hydrological cycling of pollutants and affect the quality of the receiving water significantly [5]. Land use and land cover change types (LULCCT) has been considered an important research area for global environmental change and sustainable development [6].

Land use in general term is a series of practices on the land, implemented by individuals in order to obtain benefits from its amassed resources [7]. Land use change has a noticeable or major effect on the ecosystem including the aquatic environment such as rivers, streams and lakes, [8]. Agricultural lands, forests, grassland and wetlands have been changed in forms and functions to built-up areas to accommodate in so many communities with excess population [7]. Urban growth and expansion increase impervious surfaces on land which can alter natural hydrologic processes and pose direct and indirect threats to the integrity of the streams and watersheds. Land use change does not only affect stream water quality; it also affects stream water quantity. Currently, it is one of the major causes of global environmental change [8]. Water pollution is a common environmental problem as a result of land use changes [9]. In the words of Misganew, Desta, Tsirsit [10] reported that drinking water quality if fundamental to human physiology and health.

Humans are increasingly altering the state of the earth's systems causing strong impact on the processes within and between the biosphere, hydrosphere and atmosphere [11]. Global environmental change that resulted from anthropogenic activities in no small measure impact river water quality and biogeochemical cycles. The humid tropics covered 1/5 of the global land surface and rivers in this region generates the greatest fraction of global runoff [12]. River water quality is related to the catchment land use and land cover type [13]. The impacts of land use land cover change on rivers water quality are remarkably enhanced in the tropics due to biotic factors, such as higher biomass, and more productive tropical forests [14]. Abiotic factors, such as higher precipitation, intense and frequent flooding and warmer temperatures [15] has great ecological consequences. Land use land cover changes in the tropics are driven by logging, pasture/ranching, urbanization, agriculture, and burning of vegetation [16]. Generally, LULCC in the tropics increase nitrate, phosphorus (PO_4^-), ammonium (NH_4^+), electrical conductivity in bodies of water (including $Na^{+,}$ Mg^{2+}, $Cl^{-,}$ K^+, and Ca^{2+}) 16].

Sustainable Development Goals Articles No. 6 and 15 looks at "Clean water/Sanitation and Life on earth". Human life depends on earth as much as the water in its spatial spread, quality and quantity for our sustenance and livelihood. Changes in land use/cover also have an impact on water resources through their contribution to processes like the introduction of invasive fauna and flora species into water and siltation [17,18]. Land uses such as agriculture and built up areas have been shown to influence soil moisture and climatic processes such as temperature and precipitation [19]. Water resources are often at the Centre of urban development but, as the city expands, the environmental pressure on its water resources increases [20]. Clean water and safe water are critical and crucial resource for the improvement and maintenance of human -health and wellbeing [21].

Anthropogenic activities in close proximity to water sources have always impacted the water quality since land and water ecosystems are connected by surface runoff, stream networks, and ground water systems [22-24].

Deforestation and other factors such as the presence of agricultural land use adjacent to water resources, can affect the overall water quality by increasing sedimentation and nutrient loading in water bodies [25-27]. Land use and land cover change (LULCC) can significantly alter pristine ecological settings, which can in turn have important impacts on downstream coastal ecosystem by promoting marine eutrophication and hypoxia [28].

Heavy metals in water due to several anthropogenic activities can have several health implications. Lead poisoning can cause variety of health challenges, including developmental issues in children, such as learning difficulties and slowed growth. In adults, it can cause kidney damage and high blood pressure. Mercury exposure can harm the nervous system. Cadmium ingestion leads to kidney disease while long exposure can lead to lung and prostate cancers.

Heavy metals can enter into water supplies through industrial and consumer waste, natural weathering of rocks and soils. Its impact on the environment and human health, and the difficulty of managing and mitigating its effects constitutes high health impacts, environmental effects, its naturally persistent and difficult to remove and a lot of the residents of the stud yarea lack adequate knowledge and appropriate awareness on the effects of heavy metals on human health.

2. METHODS AND INSTRUMENTATION

This study detected land use dynamics of Ofu River watershed, Nigeria. The objectives for this study included; identifying and classifying land use types, identify spatio-temporal variations, identify the types of fertilizers used within the watershed, detect annual growth rate among land uses, project land use change for 2030, compare heavy metals' concentration across sampling stations of Ofu water with WHO, EU and NSDWQ guidelines and to identify its ecological implications on water quality. Both supervised and unsupervised classification of land use types were adopted. Unsupervised classification method was used first to have an idea regarding the overall land use types and land cover cluster pixels. Supervised classification method was then used with maximum likelihood classification algorithm. Five (5) land use types were identified for the Ofu River catchment. RS/GIS were used to measure the dynamics of land use land cover change types in the study area so as to determine the spatial and temporal changes in land use of Ofu River Basin. The land-sat images described was used to investigate LULC in the study area's watershed between 2000-2010, 2011-2020 and 2021-2030. The images were analyzed with the image processing software Geomatica version 2013, a widely used image processing software package, which is often used to perform LULC classification of remotely sensed data. Remote sensing was used for monitoring changes in land use and land cover (LULCC) observation and its impact on the entire environment including water bodies. It offers varieties of benefits to LULC study and an opportunity to access even remote areas. Instrument for data collection was questionnaire administration while nature of data included those on remote sensing and GIS, types of fertilizers used within the watershed. Sources of data included the primary and secondary sources. Sample size for this study was determined using simple random sampling technique.

This study tested the hypothesis that say "land use change types has no statistically significant effects on water quality of Ofu River." Related literature exists on land use change detection globally; Richard, [5], Yunfeng et al [6], Zakariya et al [7], Kumar, [29], Kiros [30] and Kathyheyan 2021. In this regard, Ofu River watershed has not been extensively studied to evaluate the overall land use types, its growth rate spatiotemporally, projected growth of land use changes for the year 2030 and its effects on environmental resource like water, hence the need for this study.

Table 1 shows the geographical description of the sample stations, altitude and dominating land use types of the study area. Agala Ogane has the highest elevation above mean sea level (299m) closely followed by Agbenema (262m). The least altitude in the selected sample sites is Ojofu (249m) above mean sea level. This implies that the sample stations are diverse in terms of elevation levels. This also means that the elevation of each of the sampling points differ

Table 1. Geographical Description of the Sampling Stations

Sampling codes	Name	Latitude of sample site	Longitude of sample site	Major Land use type	Altitude
S1	Ojofu (Control)	7^0 31’39.43’’E	$7^0$10’3.59’’N	Built-up/Forest	249m
S2	Agbenema (Experimental)	7^0 9’40’’E	$7^0$3’46’’N	Built-up/Agriculture	262m
S3	Agala-Ogane (Experimental)	7^0 31’35’’E	$7^0$8’33’’N	Built-up/Agriculture	299 m
S4	Akponogwu (Experimental)	7^0 31’ 15.57’’E	7^0 7’ 6.62’’N	Built-up, Refuse dump/Agriculture	254m

Source: Field Survey, 2023.

and influences the settlements and land use types differently. This goes a long way to affect flow of runoff in each of these stations. The table also reveals the land use activities in the study area (Table 1). The dominating land use type of the study area is agriculture (crop growing/ animal husbandry) and built-up land (Fig. 1).

3. DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

Table 2 reveals the intensity of any land use type at any given location at a time. Juxtaposing 2000 and 2020 data, it was revealed that there have been increase in the built-up area and scattered agriculture and wetland. In 2000, built-up area was 1,893.076ha but increased to 3,089.053ha in 2010. Again, in 2020, it further increased to 8,128.024ha and by 2030, built-up area has been projected to increase to 11,243.498ha. This result could be as a result of urbanization and quest for settlement expansion due to increase in population. It is noteworthy that built-up land use type recorded the highest gain and this is evident according to Ifatimehin and Musa [31] that many buildings sprang up within Anyigba and its environs in respect to its new status as a university town. The implication of settlement expansion on the study area (S1-S4) is that as built-up area increases, open land is lost, pressure is increased on water bodies and runoff also increases with increased paved surfaces and roof tops all reducing water infiltration rate of the study area.

Based on the results as presented in Table 2, scattered agricultural practices occupied a land area of 1381km^2 in 2000, by 2010 it gained by 1460 (4.5km^2) in 2020, it further increased to 156.856km^2 agricultural land use type of the study area has been projected to occupy a land area of 1662.313km$^{2.}$ by 2030. There is a progressive increase also in land use gain by scattered agriculture in the study area. This indicates that as the population of the study area increases, quest for adequate food production increases also which may have led to continuous increase in land used for agricultural activities in the study area. The implication of this result is as population increases, food production ought to meet food demand leading to expansion in agriculture. As revealed, Land clearing, use of herbicides and application of fertilizers (organic and inorganic) by crop farmers can on the long run degrade Ofu River water quality.

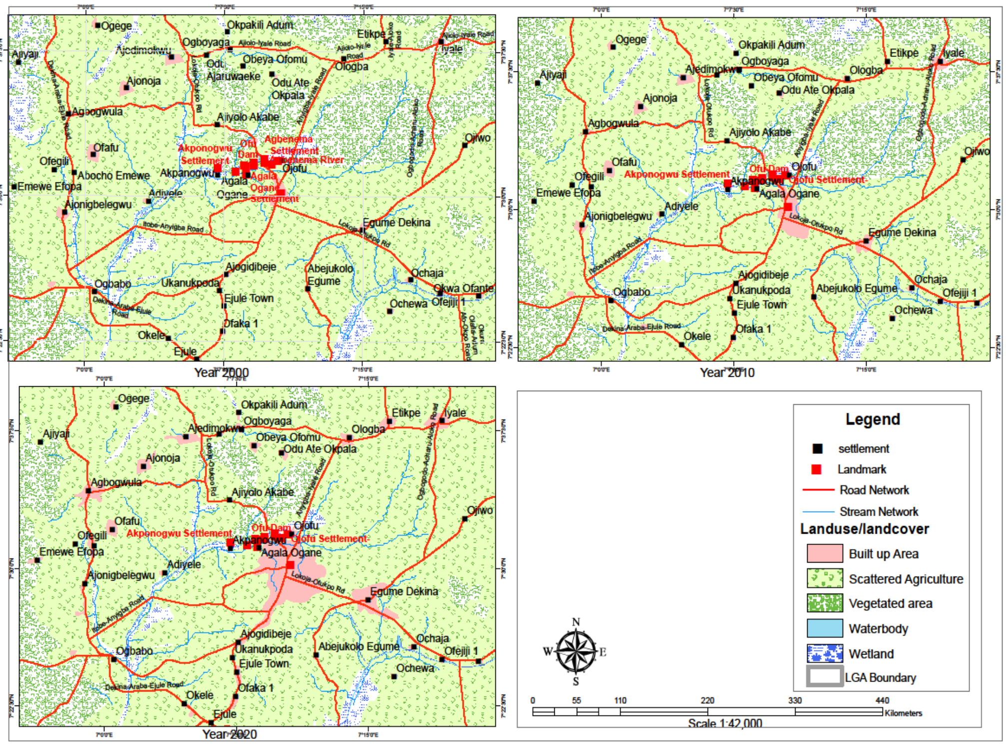

Fig. 1. Detected land use forms and functions of the study area
SOURCE: Field Survey, 2023.

Table 2. Land use forms and functions

S/n	Land use Land cover	Projected Year 2030(ha)	Projected Year 2030 (Km^2)	Year 2020(ha)	Year 2020 (Km^2)	Year 2010(ha)	Year 2010 (Km^2)	Year 2000(ha)	Year 2000 (Km^2)
1	Built up Area	11,245.498	112.455	8,128.024	81.28	3,089.053	30.891	1,893.076	18.931
3	Scattered Agriculture	166,231.323	1,662.313	156,856.119	1568.56	146,041.475	1460.415	138,105.710	1381.057
4	Vegetated Area	10,678.286	106.783	20,966.446	209.66	34,803.341	348.033	41,542.767	415.428
5	Waterbody	742.786	7.428	744.893	7.45	749.107	7.491	749.107	7.491
6	Wetland	3,956.421	39.564	6,158.833	61.59	8,171.338	81.713	10,563.656	105.637
	Total	192,854.315	1,928.543	192,854.315	1,928.54	192,854.315	1,928.543	192,854.315	1928.543

Source: Field Survey, 2023.

In contrast to the expansion of built-up land use type and scattered agriculture in study locations and as indicated by Table 2 vegetated area in year 2000 occupied 41.543 km^2, it decreased to 34.803km^2 in 2010 and further shrank to 20.966km^2 losing about 13.837km^2 in 2020. One of the most astonishing revelations in this study is the projection of the declining vegetal cover of the study area. In 2030, vegetal area has been projected to be only 10.678km^2 losing about 10.288km^2 which is a sign of a steady decline. The implication of consistent decrease in vegetated land use type of the study area is that surface runoff will increase, hydrological processes will be affected and some extreme weather conditions may be noticed in the study area in the time to come.

It was also noticed in Table 2 that the loss in water bodies in the study area was not significant. In 2000, water bodies in the study area occupied an area of 749.107km^2. In 2010, there was no gain nor loss in water bodies (749.107km^2) but 2020, there was a slight increase (0.786km^2) in water bodies in the study area. This slight increase could be as a result of creation of the mini earth dam on Ofu River and the flow of Abu-uja lake into Ofu River in recent times in the study area. Table 2 further shows a projected decrease in areal extent (2.107km^2) in the water bodies by 2030. This scenario of water bodies' loss in the study area may be due to man -environment interaction which would have culminated into loss of vegetation cover, resulting in higher evaporation and reduced evapotranspiration which will distort several micro-climatic events such as temperature, precipitation in duration, time and frequency in the study area. this finding supports Rudsky et al [32]. The researchers reported that several land form types and classes occur in several places. In a study conducted, it was discovered that continuous decrease in vegetation will always lead to increased runoff which affects the available surface water resources.

As presented in Table 3, the land use matrix for the study area indicated that between 2000-2010 built- up land use was 81.280 km^2, between built-up land and scattered agriculture was 1568.56 km^2 land use gain. However, built-up and vegetated land was 209.66km^2. The table further explains that between scattered agriculture and vegetated land scattered agriculture grew by 468.33 km^2. Between Scattered agriculture and water body, water body declined by 0.01 km^2. Between vegetated area and built-up land use, built-up land use between 2000-2010 gained 415.433 km^2 but between vegetated area and scattered agriculture's gain in 2010 was 255.13 km^2. No gain nor loss was recorded between vegetated land uses between 2000-2010. In 2010 between vegetated area and water body there was a minimal gain of 0.63 km^2.

As revealed by land use matrix results presented in Table 4, between 2000-2010, built-up land use gained over water body by 7.49 km^2 between water body and scattered agriculture was 0.01 km^2 but between water body and vegetated area in 2010 was 2.77 km^2 and between 2000-2010, water body and wetland were 8.21 km^2. Between 2000-2010, built-up land use gained over wetland by 105.64 km^2 but between wetland and scattered agriculture was 285.57 km^2 however, between wetland and vegetated area in 2010 was 2.15 km^2 land use gain. The matrix shows that as a land use increases, it affects other land uses negatively which by extension also has negative impact on the environment.

Table 3. Land use matrix of the study area (2000-2010) (ha)

		2010				
	LC types	**Built up Area (Km^2)**	**Scattered Agriculture (Km^2)**	**Vegetated Area (Km^2)**	**Waterbody (Km^2)**	**Wetland (Km^2)**
2000	Built up Area	81.28	1,568.56	209.66	7.45	61.59
	Scattered Agriculture	1.381.06	0.00	468.33	0.01	0.21
	Vegetated Area	415.43	255.13	0.00	0.63	1.57
	Waterbody	7.49	0.01	2.77	0.00	8.21
	Wetland	105.64	285.57	2.15	3.87	0.00
	Total	192,854.32	192,854.32	192,854.32	192,854.32	192,854.32

Source: Field Survey, 2023.

Table 4. Land use types and their annual growth rate

S/n	Land use Land cover types	Projected Year 2030(ha)	Projected Annual Rate of growth (ha/year)	Year 2020(ha)	Annual Rate of growth (ha/year)	Year 2010(ha)	Annual Rate of growth (ha/year)	Year 2000(ha)
1	Built up Area	11,245.50	311.75	8,128.02	503.90	3,089.05	119.60	1,893.08
2	Scattered Agriculture	166,231.32	937.52	156,856.12	1081.46	146,041.48	793.58	138,105.71
3	Vegetated Area	10,678.29	-1,028.82	20,966.45	-1383.69	34,803.34	-673.94	41,542.77
4	Waterbody	742.79	-0.21	744.89	-0.42	749.11	0.00	749.11
5	Wetland	3,956.42	-220.24	6,158.83	-201.25	8,171.34	-239.23	10,563.66
6	Total	192,854.32	0.00	192,854.32	0.00	192,854.32	0.00	192,854.32

Source: Field Survey, 2023.

As presented in Table 4, revealing the annual growth rates of land use types of Ofu River and its projected growth for year 2030, the rate of growth of built-up land use of the study area shows a progressive growth across S1-S4 respectively. The growth rate for year 2000 (119.60 ha/yr), 2010 (503.90 ha/yr), 2020 (311.75 ha/yr) and 2030 (11,245.30 ha/yr). This result indicates that the annual growth rates in built-up area will be unprecedented because it will encroach on other land use types. This will decrease vegetated land resulting in some environmental hazards such as soil erosion due to expanding bare surfaces as a result of loss of vegetation.

Table 4 also shows that scattered agriculture has recorded annual growth rates as follows: 2000 (743.58 ha/yr), 2010 (1081.46 ha/yr), 2020 (937.52 ha/yr) and 2030 (166,321.32 ha/yr). This result indicates that scattered agriculture in the study area has a high growth rate. This implies that food production will be enhanced as more lands are cultivated. Due to increase in agricultural land use type, existing non-agricultural lands will be converted to agricultural land use creating a continuous encroachment on all the land use types in the study area. For the vegetated area, 2000 (-673.44 ha/yr), 2010 (-1383.46 ha/yr), 2020 (-1,028.82 ha/yr) and 2030 (-10,678.29 ha/yr). it was clear from Table 4 as built-up land use and scattered agriculture expands in the study area; vegetated land use shrunk drastically. Indicating high rate of vegetal decline in the study area. Data on annual growth rate of water body shows that year 2000 (0.000ha/yr), 2010 (-0.42 ha/yr), 2020 (-0.21 ha/yr) and 2030 (-742.79ha/yr). This result implies that water bodies in S1 (Ojofu), S2 (Agbenema), S3 (Agala-Ogane), and S4 (Akponogwu) communities will manifest minimal decline in water body between 2000-2030. This means that activities that will lead to this decline must be reduced if not totally removed for sustainability of the existing water body.

As presented in Table 4 annual growth rate of wetland was constantly on the decline for the years under review: 2000 (-239.23 ha/yr), 2010 (-201.25 ha/yr), 2020 (-220.24 ha/yr), and 2030 (-3956.42 ha/yr). This is a clear indication of continuous decline in the growth rate of wetland in the study area. in a study conducted by Seckler et al. [33], the study discovered that as one land use type increases, some other land use decreases which has a tremendous impact on the ecosystem. Using descriptive statistics, the researchers further opined that in most places, built-up and agricultural land uses are the major landuse types that affect other land uses. This they further reported has unique effects on the environmental quality.

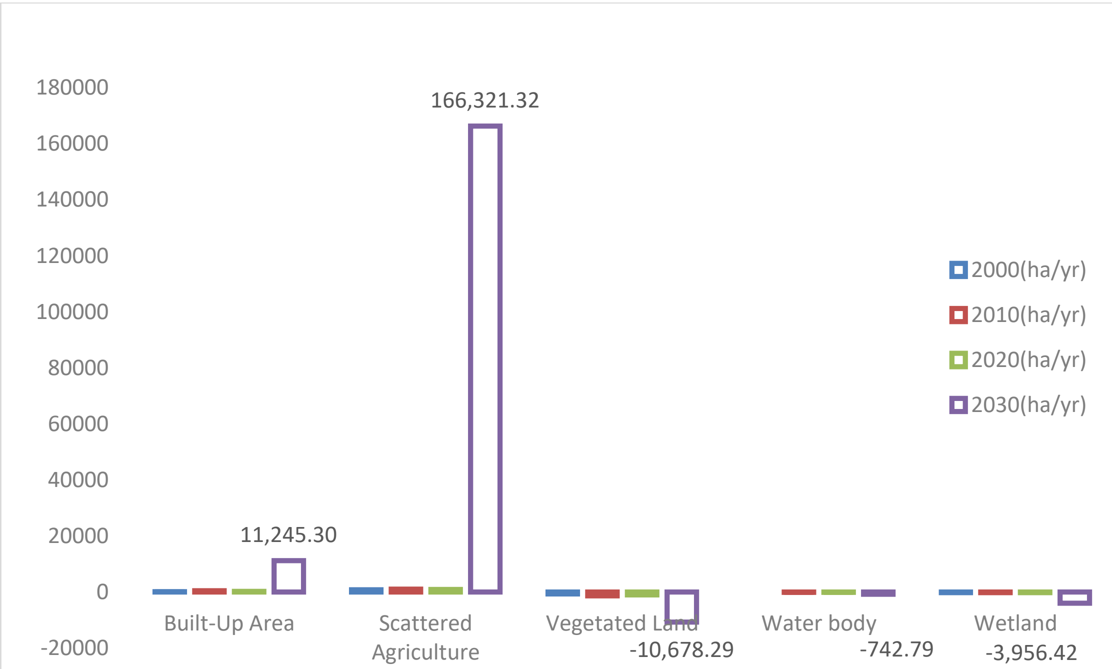

Fig. 2. Showing land use gains and losses for the Study Area
Source: Field Survey, 2023.

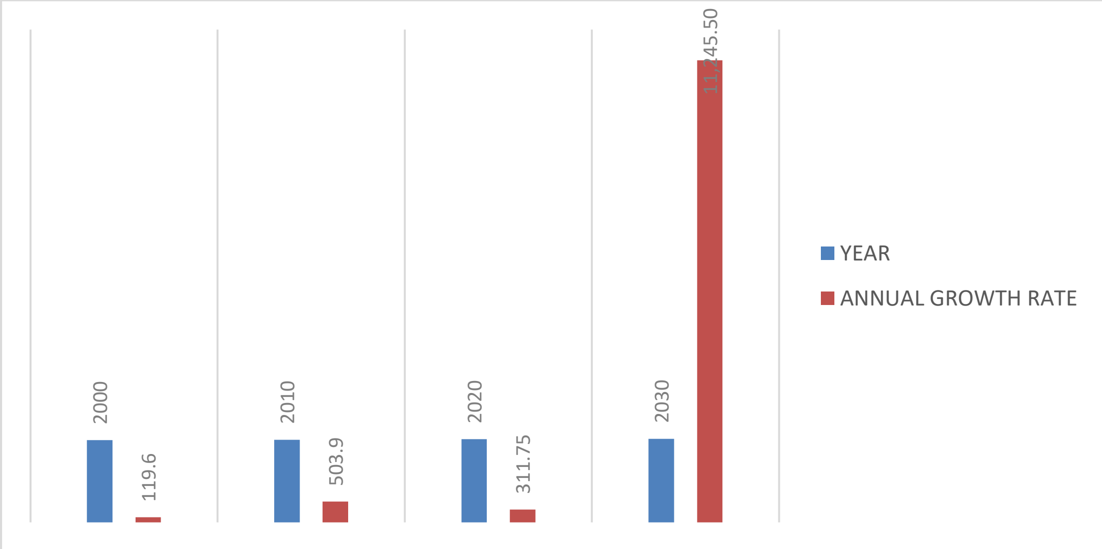

Fig. 3. Projected Land use Growth Rate for 2030.
Source: Sield Survey, 2023.

As presented in Figs. 2 and 3, revealing land use gains and losses and annual growth rates of land use types in the study area and its projection for year 2030, the rate of growth of built-up land use of the study area shows a progressive growth across S1-S4 respectively. The growth rate for year 2000 (119.60 ha/yr), 2010 (503.90 ha/yr), 2020 (311.75 ha/yr) and 2030 (11,245.30 ha/yr). This result indicates that the annual growth rates in built-up area will be unfamiliar because it will encroach on other land use types. This will decrease vegetated land resulting in some environmental hazards such as soil erosion due to expanding bare and impervious surfaces as a result of loss of vegetation.

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Several types of fertilizers exist based on the peculiarity of soil. Table 5 reveals the types of fertilizer used by farmers along the bank of Ofu River. The table also reveals that the most applied fertilizer is NPK (38.8%) closely followed by super phosphate with 19.4%, micro-nutrient fertilizer (1.94%) application rates in the study area. One of the most mobile elements in inorganic fertilizers is nitrogen. This element can move easily within the soil and could affect both surface and underground water sources. The result alludes that diverse forms of inorganic and organic fertilizers where been used on the farms along Ofu River watershed. This indicates that these organic and inorganic fertilizers could

Table 5. Types of Fertilizer Used on the Agricultural Lands

Sample id	Urea	Organic	NPK	SSP	Micro-nutrient	CMS	Total
S1 (Ojofu)	17(8,25%)	15(7.28%)	49(23.7%)	30(14.5%)	3(1.45%)	6(2.91%)	120(58.2%)
S2 (Agbenema)	4(1.94%)	3(1.45%)	16(7.76%)	4(1.94%)	-	12(5.82%)	39(18.9%)
S3 (Agala-Ogane)	2(0.97%)	4(1.94%)	11(5.33%)	3(1.45%)	1(0.48%)	7(3.39%)	28(13.5%)
S4 (Akponogwu)	-	13(6.31%)	4(1.94%)	3(1.45%)	-	-	20(9.70%)
Total	23(11.1%)	35(16.9%)	80(38.8%)	40(19.4%)	4(1.94%)	25(12.1%)	206(100.0%)

Source: Field Survey, 2023.

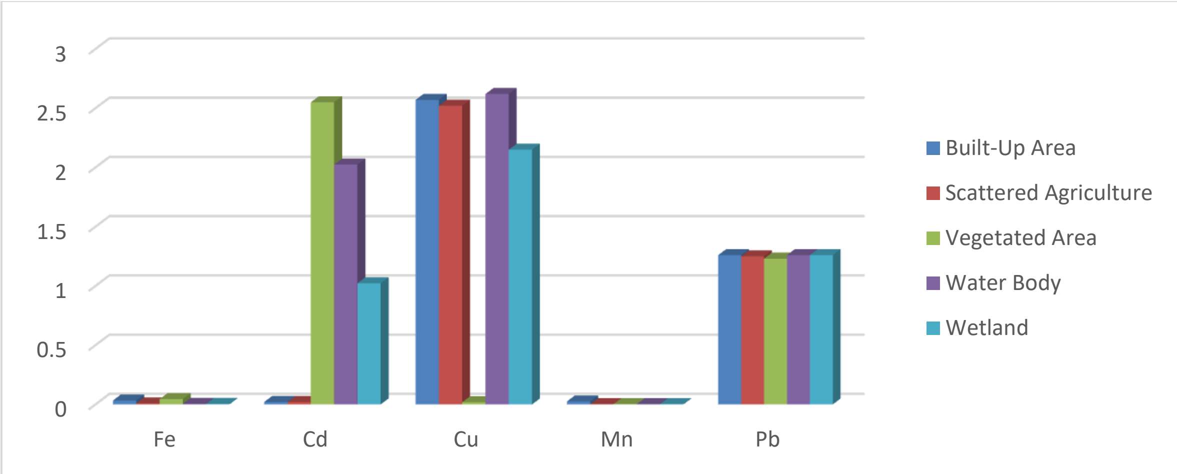

Fig. 4. Heavy Metals' concentration among different land uses at (S1) Ojofu
Source: Field Survey, 2023.

move in the soil and runoff into the river water thereby damaging the quality of Ofu River water due to the proximity of the farms to Ofu River water. In the words of Karthiheyan, Joseph and Muthuramalingan (2021), agricultural soils in many parts of the world are generally contaminated by heavy metal toxicity such as Cd, Cu, Zn, Ni, Ph. There are due to the long-term use of phosphate-based fertilizer in the study area. In the words of Jayash and Christine (2020), agricultural fertilizer use is widely acknowledged to be a leading cause of water pollution, yet no national estimate exists on the effect of fertilizer application on concentration of agricultural pollutants in the United States watershed.

Based on the result presented in Fig. 4, the iron concentration among the land uses at S1 (Ojofu) range from 0.73 – 0.46mg/L respectively with built-up land use having the lowest (0.0016mg/L0) while the land use type with highest iron concertation was agricultural land (0.46mg/L). Cadmium was highest in the wetland (0.021mg/L) but least in vegetated area (.73mg/L). This indicated that cadmium concentration among the soils of different land uses were low. The presence of cadmium could be as a result of natural and unpremeditated anthropogenic activities such as burning, and application of phosphate -based fertilizers activities in the study area. The current finding supported Kiros et. al [30], reported that of all sample of soils from all land uses studied, iron, manganese, Cadmium and lead were found in all the samples at different concentration levels above WHO allowable threshold Table 6 Heavy Metals Concentration (mg/L) in Water of Ofu River.

Table 6. Heavy metals' concentration among sampling units

S/no	Sample	Heavy metals concentration (mg/l)				
S/NO.	**SITES**	**Fe**	**Cu**	**Cd**	**Mn**	**Pb**
1	S1(Ojofu)	0.75	2.20	0.019	1.74	0.31
2	S2(Agbenema)	0.69	2.25	0.016	1.71	0.27
3	S3(Agala-Ogane)	0.64	2.25	0.015	1.75	0.27
4	S4(Akponogwu)	0.71	2.36	0.018	1.76	0.30
Guideline						
WHO		0.01	2.0	0.003-0.005	0.2	0.01
EU		0.01	2.0	0.003	0.2	0.01
NSDWQ		0.3	0.1	0.003	0.2	0.01

Source: Field Survey, 2023.

Samples were taken from the upper, middle and lower courses of Ofu River to test for heavy metal s' presence and concentration. The results of Table 6 indicates the outcome for heavy metal analysis of Ofu River water. The analysis of iron reveals that study location S1 (Ojofu) has concentration level of 0.75 mg/l^{-1} which is the highest level of concentration closely followed by location S4 (Akponogwu) with concentration level of 0.71mg/l^{-1}. The least concentrated sampling location was location S3 (Agala-Ogane) with concentration level of 0.64mg/l. The source of heavy metal in soil could be as a result of natural and anthropogenic activities around the river basin/watershed. After release from natural or anthropogenic sources, heavy metal (iron) contaminate natural water bodies reaching the water bodies through sediments or from within the river water. This also indicates that the iron concentration across the sampled points of Ofu River water is beyond the allowable limit by WHO, EU and NSDWQ guideline of 0.2mg/l and 0.3mg/l respectively. This reveals that Ofu River water is not fit for human consumption.

Copper is needed in the body because, copper aids in the growth and formation of bones, formation of myelin sheaths in the nervous system, it also helps in the incorporation of iron in hemoglobin, assists in the absorption of iron from the gastrointestinal track (GIT), and in the transfer of iron to the tissues of the plasma in the body. Increased level of copper is seen in acute infections as in chronic conditions such as cirrhosis, rheumatoid arthritis and in post-operative stages. Clinical disorders associated with Cu deficiencies anemia, bone disorders, neonatal ataxia, depigmentation and abnormal growth of hair, impaired growth and reproductive performance. Table 6, the concentration of copper in the sampled water from Ofu River Sample location (S4) Akponogwu has the highest copper concentration (2.36mg/l) while S1 (Ojofu) has the least concentration of copper (2.20mmg/l) with S2 and S3 (Agbenema and Agala-Ogane) having equal concentration rates of 2.25 mg/l respectively. The results indicated that copper concentration of the Ofu River water was beyond the WHO, EU and NSDWQ guidelines of 2.0mg/l. This shows that the copper level of Ofu River water is high implying that the Ofu River water without treatment is not fit for human consumption.

As shown in Table 6, the cadmium values recorded across the four (4) sampling locations range from 0.015mg/l to 0.019mg/l. The highest concentration of cadmium was found at S1 (Ojofu) with concentration level of 0.019mg/l while the least concentration was found at S3 (Agala-Ogane) with concentration level of 0.015mg/l. The allowable limits by WHO, EU and NSDWQ is 0.003mg/l and 0.005mg/l respectively. This result shows that the concentration of cadmium in Ofu River water is higher than the threshold allowed and such, the water is unfit for human consumption owing to the carcinogenic, non-biodegradable and bio-accumulation characteristics of the element.

As presented in Table 6 the total value for manganese range between 1.71mg/l to 1.76mg/l in the study area where sampling location (S2) Agbenema recorded the lowest concentration of manganese whereas the highest concentration (1.76mg/l) was detected at S4 (Akponogwu) but S1 and S3 (Ojofu and Agala-Ogane) recorded 1.71mg/l and 1.73mg/l respectively. All the sampling locations were beyond the allowable units of 0.2mg/l by World Health Organization (WHO). This indicates that without prior treatment, Ofu River water is contaminated and not fit for human consumption when manganese is considered.

Lead can be found in waterpipes, insecticides, in construction, gun bullets, x-ray and atomic radiation. Reproductive dysfunction by lead has distinct morphological and biochemical features such as disorganized epithelis, decrease sperm quality, altered sperm morphology and low androgen level. WHO and SON recommends that the concentration of lead in water should be 0.5mg/L and 0.1mg/L. However, from the lead values recorded in Table 6 among the four sampling locations, all sampling location on Ofu River water recorded concentration value that are above WHO, EU and NSDWQ limit of 0.01mg/l. The spatial distribution of lead (Pb) reveals that upstream station S1 (Ojofu) recorded the highest lead concentration of 0.31mg/l. The result reveals that S2 (Agbenema) and S3 (Agala-Ogane) had the least and equal levels of lead (Pb) concentrations (0.27mg/l). However, S4 (Akponogwu) has a concentration level of (0.30mg/l). The abundance of heavy metal (lead) in Ofu River water could be as a result of the nature of wastes generated within the area and mineral sediments formed by runoff. The existence of lead in Ofu River water could lead to neurological malfunctioning when consumed. To this end, the water of Ofu River is unfit for direct human consumption.

This study corroborated with Ismat, Saifeldin, Abubakr, Brima, Ibrahim, Sara and Ebraheem [34]**.** The study evaluated the impact of heavy metal concentration from municipal solid waste dumpsite on surface water and soils as well as leaves of native plants in Khamees-Musat city. The result showed that heavy metal concentration follows this order: Mn>Zn> Pb>Ni>Co while those in leaves followed the order: Mn>Cu>Cr>Zn>Cu>Pb>Cd indicating different levels of metal uptake in plants. The R-value of paired sample t-test for the concentration by each element in the surface water and soil samples indicate insignificant variation between heavy metal concentration in surface water and soil samples of the study area. In a study conducted by Kurma (2020), the research reported that the mean value of traced element was higher than WRW, USEPA and TRV thresholds indicating that severe contamination of the stream. In his study, the highest mean concentration of Pb was 264 mg/l which was detected in Dolo. The highest concentration of manganese was observed at D4 to be 290 mg/l which is much higher than the legal limits set by USEPA 3mg/l. In the same vein, the study further reported that the concentration of cadmium ranged from 323-421 with an average of 3446.6± 45.6mg/l at D4. At station 3, in his study, the higher concentration of manganese in the water was due to discharge of untreated wastes from chemical laboratories and construction remnants and deposition of household, municipal wastes, dust emission from automobiles exhaust fumes. The concentration of these traced element in surface water of the study area significantly inhibit the activities of microorganisms and posed a serious threat to the health of the environment and animals. It was also reported by Kiros, Gebreyahannes, Amanual and Samuel [30] in a study conducted at Kefta Humera Woreda, Tigray, Ethiopia. The researchers reported that iron was the only heavy metal in surface water and well water sampled for study. The result revealed that the concentration of iron measured in all surface and well water samples had iron concentration above the permissible limits of WHO and ESA for drinking water of 0.3mg/l. The higher value of iron from the study areas could also be from the natural sources. This may be due to weathering of minerals, soil type and sediments which are iron-rich materials naturally given to the environment. In the view of Jingyi, Yiping, Liying, Pengcheng and Fubo [35] at the southern Chinese Loes Plateau reported that rock weathering, fertilizer application, use of pesticides, mining, manufacturing and discharge of waste water in water bodies' results in addition of traced elements into surface water bodies which can eventually altered the integrity of the ecosystems. The findings of the current research also supported Jogennathan and Kellyamoorthy [36]: Tanaka et al. [16], the researchers assessed the level of heavy metal pollution in water, sediments and aquatic organisms of the study area. The study concluded that (cabalt, lead, mercury, cadmium, nikel and zinc) existed in a measure above the allowable limits and so the water was adjudged to be of poor quality for human consumption.

The Table 7 shows the responses from respondents in the study area. Several emerging techniques in heavy metal management in water were revealed. At S1 (Ojofu), 4 respondents had ides on adsorption method as one of the emerging technologies in the management of water polluted with heavy metals while 23 had no ideas. On bioremediation across the study area, atS2 (Agbenema), a respondent opined to have heard but 5 reported not having ideas on bioremediation. At S3 (Agala-Ogane), a respondent heard of nanotechnology while 2 respondents not having information on nanotechnology. In all, 09 (4.4%) haven heard of adsorption but 35(16.9%) had no ideas. For bioremediation, 13(6.3%) were aware of it but, 39(18.9%) had no idea about bioremediation. On application of nanotechnology, 3(1.5%) heard of it but 26(12.6%) had no information about it. Respondents on the use of membrane techniques, 18(8.7%) had ideas on the use of membrane techniques in removing heavy metal from water but 47(22.8%) had no information. The data above revealed that majority of the respondents in the study area do not have enough information on methods of removing heavy metals from water in the study area. this implies that heavy metal pollution in the water bodies of the study area may persist over time which will impact both the humans and the ecosystems. This finding supports Turner et al [37]; Mull et al [38] ang Giannoulis et al [39]. The researchers reported on the remediation strategies for heavy metal purification in water. Reversed osmosis was used in the separation process adopted in the removal of heavy metals from water.

Table 7. Responses on Emerging Techniques in Heavy Metal Management in Ofu water

Station	Adsorption method		Bioremediation		Nanotechnology		Membrane technique		Electrochemical methods		Ionic exchange	
	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
S1(Ojofu)	4	23	7	29	02	21	13	37	01	34	03	30
S2(Agbenema)	03	06	01	05	01	02	02	03	02	02	02	10
S3(Agala-Ogane)	01	03	03	02	01	02	01	03	03	04	01	04
S4(Akponogwu)	01	03	02	03	00	01	02	04	01	04	-	-
Total	**09**	**35**	**13**	**39**	**03**	**26**	**18**	**47**	**08**	**44**	**06**	**44**

Source: Author's Computation, 2023.

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	29.751[a]	12	.003
Likelihood Ratio	27.636	12	.006
N of Valid Cases	206		

a. 8 cells (40.0%) have expected count less than 5. The minimum expected count is 1.29.

DECISION RULE: Since the asymptotic/probability value ($P< .05$), H_1 is accepted. In other words, land use change types have statistically significant specific or cumulative effects on the ecological indices (water quality) of the study area.

4. RESEARCH FINDINGS

- Five land uses were identified within Ofu River watershed. The results show that between 2000 and 2030, built-up areas would have grown from 8,128.024 ha/yr to 11,254.498 ha/yr.
- Scattered agriculture between 2000 and 2030 would also have grown from 1381.06 ha/yr to 1662.313 ha/yr
- By 2030, vegetated land would have lost 1,028.32 ha/yr while water bodies between 2000-2030 remained relatively stable losing only 0.21 ha/yr.
- Scattered agriculture exhibited highest growth rate between 2000-2030 by gaining 166,321.32 ha/yr while vegetated land decreased by 10,678.29 ha/yr.
- Heavy metals were present at the upstream, midstream and downstream of Ofu River probably due to human activities around the watershed and were beyond the WHO, EU and NSDWQ thresholds respectively.
- It was also discovered that land use changes have significant effects on Ofu River water quality.

4.1 Recommendation

❖ Land ownership system in the study area should be reviewed and land development processes should also be properly monitored using workable and up-to-date land use policies.

5. SUMMARY AND CONCLUSION

Different land use types have varying impact on water quality parameters. Research on land use and water quality has revealed a strong correlation between the two, land use practices, such as built-up area and scattered agricultural practices significantly impact water quality. Agricultural activities often contribute to nutrient pollution due to the excessive use of fertilizers and pesticides leading to eutrophication in Ofu River. Continuous increase in built-up areas and industrialization results in increase in surface runoff, leading to contamination of water bodies with pollutants like heavy metals.

In conclusion, land use significantly influences water quality [40-47]. Therefore, sustainable land use practices are crucial for maintaining water quality. This research underscores the need for integrated land and water management approaches that consider interdependencies between these two resources (land and water). This study also calls for more comprehensive and localized studies to understand the specific impacts of different land uses on water quality in various geographical and climatic context. To the society and communities concerned, this study helps in understanding the effects of changing land use practices on man and his environment, it informs policy and regulatory agencies that has to do with heavy metal sources, it also assists in developing for the communities a remediation techniques against heavy metal pollution, by understanding how heavy metals affect water quality, the community gains public health protection. To the communities in question, this study contributes to our scientific knowledge of water ecosystem.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Abebe G, Getachew D, Ewenatu A. Analyzing land use land cover changes and its dynamics using GIS in Gubalafito District, Northeastern Ethiopia. SN Appl Sci. 2022;4(1):30.
2. Tariq A, Mumtaz F. Modeling spatiotemporal assessment of land use

land cover of Lahore and its impact on land surface temperature using multi-spectral remote sensing data. Environ Sci Pollut Res Int. 2023;30(9):23908-24=23924. DOI: 10.1007/s11356-022-23928-3

3. Nath N, Samariah D, Meraj G, Debnath J, Kumar P, Lahon D et al. Land Use and Land Change Monitoring and Prediction of the UNESCOWorldHeritage site; Kaziranga Eco Sensitive Zone Using cellular Automata-Markov Model. Land. 2023;12(1):151. DOI: 10.3390/land12010151.
4. Aden A, Echetu Y, Wondifraw N, Kitessa H. Past and Future Land Use/Land cover Change Trends aandits Potential Drivers in Koore Agricultural Landscape, Southern Ethiopia. Geocarto Int. 2023;38.
5. McDowell RW. Land use and water quality. N Z J Agric Res. 2021;64(3):269-70.
6. Hu Y, Batunacun H, Zhen L, Zhuang D. Assessment of land use and Land Cover change in Guangxi, China, Scientific Research Report 9. Sci Rep. 2019;9(1):Article No. 2189.
7. Shehab ZNafi, Shafie NS. Spatial variation of impact in landscape patterns and land use on water quality across an Urbanized watershed in Bentong, Malaysia. Ecol Indic. 2021;122(1):232-41.
8. Bonansea M, Ponotti L. Assessing Land use and Land Cover Change in los Molinos Reservoire Watershed and the effects on the reservoir water Quality. J S Am Earth Sci. 2021;108(3):103-13.
9. Kareem S, Berekat W. Heavy Metal Accumulation and Human Health Risk Assessment via the Consumption of Labeobarbus intermedius amples from Borkena River, Ethiopia. Sci World J, Research Article Open Access Vol.; 2023/ ID:42105741.
10. Misganew M, Desta A. and Tsirsit (2023). Assessment of selected Heavy Metals Concentration Level of Drinking Water in Gezar Town and Selected Kebele, South Ari District, Southern Ethiopia. Int J Anal Chemisry;12(3):2341-56.
11. Carreiras JMB, Jones J, Lucas RM, Gabriel C. Land use and land cover change dynamics across the Brazillian amazon: instance from extensive time series analysis of remote sensing data. PLOS ONE. 2014;9(8):e104144. DOI: 10.1371/Journal.pone.
12. Fekete BM, Vörösmarty CJ, Grabs W. High resolution fields of global runoff combining observed river discharge and simulated water balances. Global Biogeochem Cycles. 2002;16(3). DOI: 10.1029/1999GB001254.
13. Łaszewski M, Fedorczyk M, Gołaszewska S, Kieliszek Z, Maciejewska P, Miksa J et al. Land cover Effects on Selected Nutrient Compound in Small Lowland Agricultural Catchments. Land. 2021;10(2):182. DOI: 10.3390/land10020182.
14. Malhi Y. The productivity, metabolism and carbon cycle of tropical forest vegetation. J Ecol. 2012;100(1):65-75. DOI: 10.1111/j.1365-2745.2011.01916.x.
15. Stallard RF, Murphy SF. Water Quality andMass Transport in four Watersheds in Eastern Peurto Rico, Ch.E in. Professional Paper. US Geological Survey professional paper. 2012;1789:113-52. DOI: 10.3133/pp1789E.
16. Tanaka Y, Minggat E, Roseli W. The impact of tropical LandUse change on Downstrean riverine properties and biogeochemical cycles: a review. Ecol Process. 2021;10(1):40. DOI: 10.1186/s13717-021-00315-3.
17. Du Plessis A, Harmse T, Ahmed F. Quantifying and predicting the water quality associated with land cover change: A case study of blesbok Spruit catchment, South Africa. Water. 2014;6(10):2946-68.
18. Tahiru AA, Doke BA, Baatuuwie. Effects of land use and land cover changes on water quality in the Mawuni Catchmentof the White Volta Basin, northern region, Ghana. Appl Water Sci. 2020;10(8):1-4.
19. Masroor M, Avtar R, Sajjad H, Choudhari P, Kulimushi LC, Khedher KM et al. Assessing the influence of Land use/ Land cover Alteration on Climate Variability; An Analysis in the Aurangabad District of Maharashtra State, India. Sustainability. 2022;14(2):642.
20. Thandile TG, Brook L, Binyam TH. Implication of land use land cover dynamics on urban water quality: case of Addis Ababa City, Ethiopia, Heliyon. OHCHO, human right sPoverty reduction and sustainable development: health, Food and water, A background paper. World Summit on Sustainable Development. 2023;9(5):e15665.
21. Erianger PD, Neal B, Merz SK. Framework for urban water resources planning.

Melbourne: Water Services Association of Australia; 2005.
22. Gondwe MF, Cho MA, Chirwa PW, Geldenhuys CJ. Land use and land cover change and the comparative impact of co-management and government management of the forest cover in Malawi (1999-2018). J Land Use Sci. 2019;14(4-6):281-305.
23. Obubu JP, Mengistou S, Odong R, Fetahi T, Alamirew T. Determination of the connectedness of land use, land CoverChange to water quality status of a shallow lake: A case of lake Rionga Basin, Uganda. Sustainability. 2021;14(1):372.
24. Nkwanda IS, Feyisa GL, Zewge F, Makwinja R. Impacts of land use and land CoverDynamics of water quality in the upper Lilongwe river Basin, Malawi. Int. J Energy Water Resour. 2021;5:193-204.
25. Howarth RW, Sharpley A, Walker D. Sources of Nutrient Pollution to Coastal Waters in the Unioted States: implications for Achieving Coastal water Quality Goals. Estuaries. 2002;25(4):656-76. doi: 10.1007/BF02804898.
26. Coulter CB, Kolka RK, Thompson JA. Water quality in agricultural, urban, and mixed land use watersheds. J Am Water Resour Assoc. 2004;40(6):1593-601.
27. Ongley ED, Xiaolan Z, Tao Y. Current Status of Agricultural and Rural non-point Source Pollution Assessment in China. Environ Pollut. 2010;158(5):1159-68.
28. Kasey EC, Vivian DB, Sarah NG, Kristen AD, Geno P, Mark AT et al. Land use and Land Cover Sharp water Quality at a Continental Carribbean -Land ocean Interface. Front Water Environ Water Qual. 2022;4(2).
DOI: 10.3389/frwa.2022.737920.
29. Kumar R, Singh RD, Sharma KD. Water resources in India. Curr Sci. 2005;85(5):794-811.
30. Kiros T, Workineh L, Tiruneh T, Eyanu T, Damtie S, Belete D. Prevalence of extended-spectrum lactamase-producing enterobacteriaceae: ASystematic review and meta-analysis. Int J Microbiol. 2021.
DOI: 10.1155/2021/66697
31. Ifatimehin OO, Musa SD. An analysis of the changing land use and its implication on the environment of anyigba Town. J Sustain Dev Afr. 2009;10(4):357-64.
32. Rudsky V, Sturman V. Foundamentals of nature use, Smolensk magenta. Russ Pp. 2005;320.
33. Seckler D, Randolph B, Upali A. Water Scarcity in the 21st Century. Int J Water Resour Dev. 1999;15(1-2):25-42.
34. Ismat A, Saifeldin WS, Abubakr AA, Braima SB, Ibrahim AN. Impact of land use and land cover change on the landscape pattern. Sec. land use dynamics. 2019;2.
35. Jingyu L, Jingliang H, Christins P, Brett AB. Changes in Supply and Demand mediate the impact of land use change on fresh water Ecosystem Services flow. Sci Total Environ. 2021;763:143012.
36. Pandiyan J, Krishnappa K. Assessment of Level of Heavy Metals Pollution in Water, Sediment and Aquatic Organisms: a perspective of tracking Environmental Threats for Food Security. Saudi J Biol Sci. 2021;28(2):1218-25.
37. Turner HBL, Ross RH, Skole D. Relating land use and global land cover change (IGBP Report No.24, HDP Report No. 5) IGBP of the ICSU and HDP of ISSC, Stockholm and Geneva; 1993.
38. Mul M, Obuebie E, Appoh R, Kankam K, Bekoe-Obeng F, Amisigo B et al. Water resources assessment of the Volta River Basin. Vol. 166. Colombo: IWMI; 2015.
39. Giannoulis N, Maipa V, Konstantinou I, Albanis T, Dimoliatis I. Microbiological risk assessment of Agios Georgios source Supply in North West Greece based on faecal coliform determination and sanitary inspection survey. Chemosphere. 2005; 58(9):1269-76.
40. Simon D, Idoko O, Haruna SA, Balogun GF. Assessment of the influence of agricultural activities on the quality of Ofu River, Kogi state. Int J Res Sci Innov *ISSN No. 2321-2705*. 2023;10(8):253-65.
DOI: 10.51244/IJRSI.2023.10820.
41. Abbode EB. Land and water footprints assessment with rice and maize looses in brazil. Land Use Pol. 2020;99:Article 105106.
42. Chaudhry FN, Malik MF. Factors affecting water pollution: A review. J Ecosyst Ecograph. 2017;7(225):1-3.
43. Cunningham WP, Cunningham MA. Principles of environmental science: inquiry and applications. McGraw hill higher education, Boston Burr Ridge Il; 2006.
44. Xu J, Liu R, Ni M, Zhang J, Ji Q, Xioa Z. Seasonal Variation of water Quality Response to Land use Matrics at Multispectral scale in the Yantze River

Basin. Environ Sci Pollut Resarch. 2021:1-10.

45. Karthikeyan A, Nguyen A, McDonald D, Zong Y. Rapid large -Scale wastewater surveillance and automated reporting system. J MSystems. 2021;6(4):Pgs e00793-21.

46. Kilic S, Evrendilek F, Berberoglu S, Demirkesen AC. Enironmental monitoring of land use and land cover changes in a Mediterranean region of turkey. Environ Monit Assess. 2006;114(1-3):157-68.

47. Sang X, Guo Q, Wu X, Fu Y, Xie Tongyao, He C et al. Intensity and stationary analysis of land use change based on CART algorithm. Sci Rep. 2019;9(1):12279. Published online. DOI: 10.1038/s41598-019-48586-3

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