LAND USE CHANGE DETECTION AND EVALUATION INA WATERSHED: THE IMPLICATIONS FOR OFU RIVER WATER QUALITY IN ANYIGBA, KOGI STATE

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, 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 c*hange, change detection, Ofu watershed, and River water quality*.

1.0 Introduction

The global 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 agricultural activities has adverse effects 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 (Richard, 2021). Land use and land cover change types (LULCCT) has been considered an important research area for global environmental change and sustainable development (Yunfeng, Balunacus and Dafang, 2019).

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 (Zakariya et. al., 2021).Effects of Land use change has been manifested on the ecosystem including the aquatic environment such as rivers, streams and lakes, (Matias and Lucio, 2021). 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 (Zakariya et. al., 2021). 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 nearby 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 (Matias and Lucio, 2021). The ecological integrity (the quality or condition of been pure and complete) of rivers and streams have been shown to be fundamentally connected with the surrounding land applications (Staponitos et al., 2019).

In recent times, 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 (Carreiras et al., 2014). 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 (Fekete et al, 2002). River water quality is related to the catchment land use and land cover type (Laszewski et al, 2021). 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 (Malhi, 2012). Abiotic factors, such as higher precipitation, intense and frequent flooding and warmer temperatures (Stallard and Murphy, 2012) has great ecological consequences. Land use land cover changes in the tropics are driven by logging, pasture/ranching, urbanization, agriculture, and burning of vegetation (Tanaka, et al, 2021). 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+}) (Tanaka et al, 2021).

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 (Du Plessis., Harmse and Ahmed, 2014; Tahiru., Doke. and Baatuuwie, 2020). Land uses such as agriculture and built up areas have been shown to influence soil moisture and climatic processes such as temperature and precipitation (Masroor., Avtar., Sajjad., Choudhari., Kulimushi., Khedher., Komolafe., Yunus. and Sahu,2022).Water resources are often at the Centre of urban development but, as the city expands, the environmental pressure on its water resources increases (Thandile, Brook and Binyam (2023). Clean water and safe water are critical and crucial resource for the improvement and maintenance of human -health and wellbeing (Erianger., Neal and Merz. 2005).

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 (Gondewe., Cho., Chiwa. and Geldenhuys, 2019; Obubu., Megistu., Odong., Fetahi, and Alamirew, 2021 and Nkwanda., Feyisa., Zewge and Makwinja, 2021).

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 (Howarth., Sharpley and Walker, (2002); Coultler., Kolka. and Thomson, 2004; Ongley., Xiaolan and Tao, 2010).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 (Kasey, Vivian, Sarah, Kristen, Geno, Mark, Anne, Carolina and Rachel, 2022).

2.0 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, describe the types of fertilizers used within the watershed, detect annual growth rate among land uses, project land use change extent 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 (forms and functions) 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 usedfor 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. Part of 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 Dagnalie methodology (1988).

This study tested the hypothesis that say "land use changes types has no statistically significant effects on water quality of Ofu River." Ofu River Basin has not been extensively studied to evaluate the overall land use types, its growth rate spatiotemporally, projected growth of land use changes for 2030 and the ecological effects of change on environmental resource like water, hence the need for this study.

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.

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 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).

3.0 DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

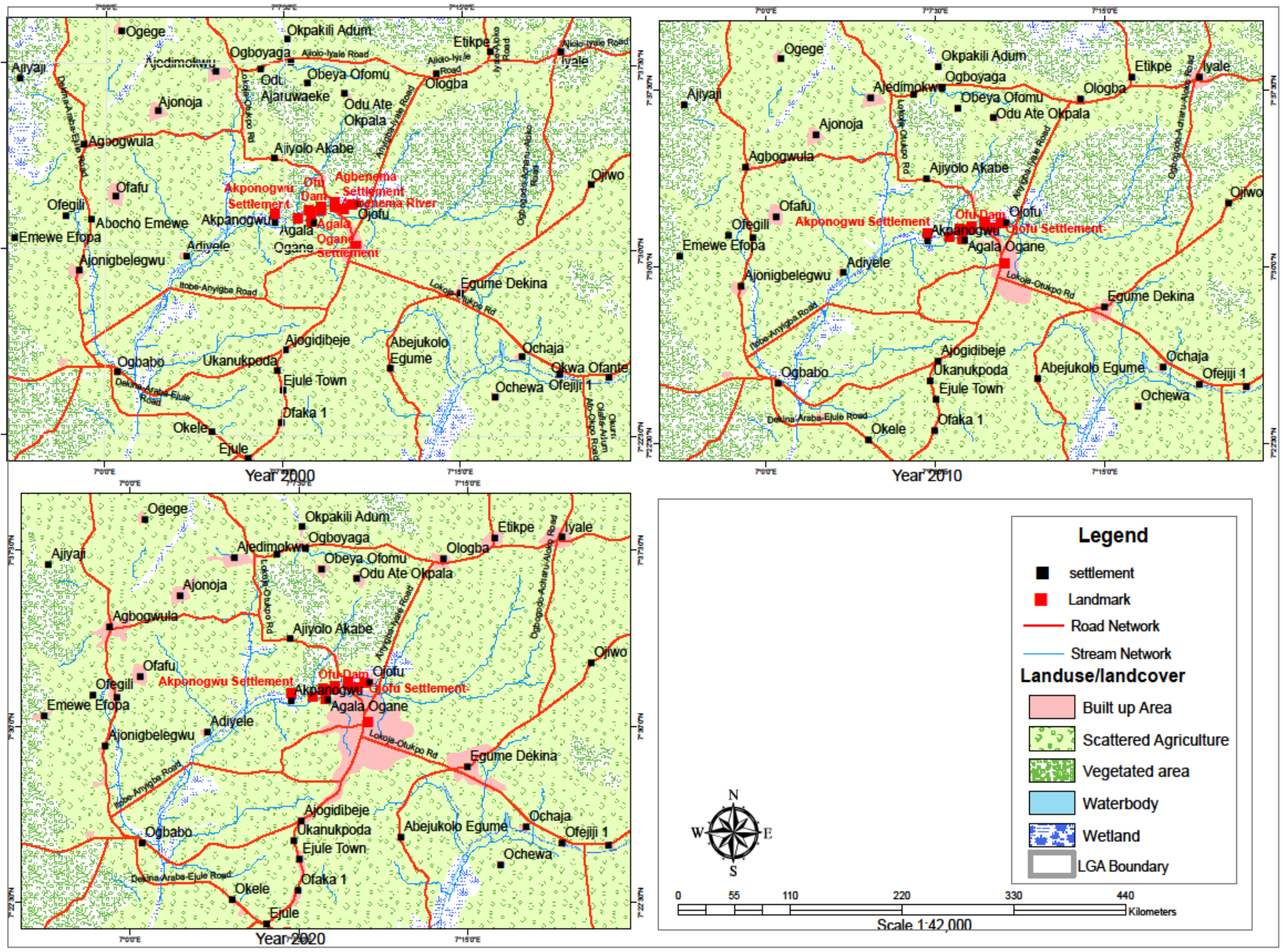

Figure 1: Detected Land Uses in the Study Area
SOURCE: Field Survey, 2023.

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.

Table 2 reveals the intensity of any land use type at any given location at a time. Juxtaposing 2000 and 2020 data, it was revealedthat 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 (2009) 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.

In contrast to the expansion of built-up land use type and scattered agriculture in study locations and as indicated by table 2vegetated area in year 2000 occupied 41.543km^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.

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.

As presented in table 3, the land use matrix for the study area indicated that from 2000 to 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 from 2000 to 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 from 2000 to 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, from 2000 to 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 from 2000 to 2010, water body and wetland were 8.21 km^2. From 2000 to 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 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 4as 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 from 2000 to 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.

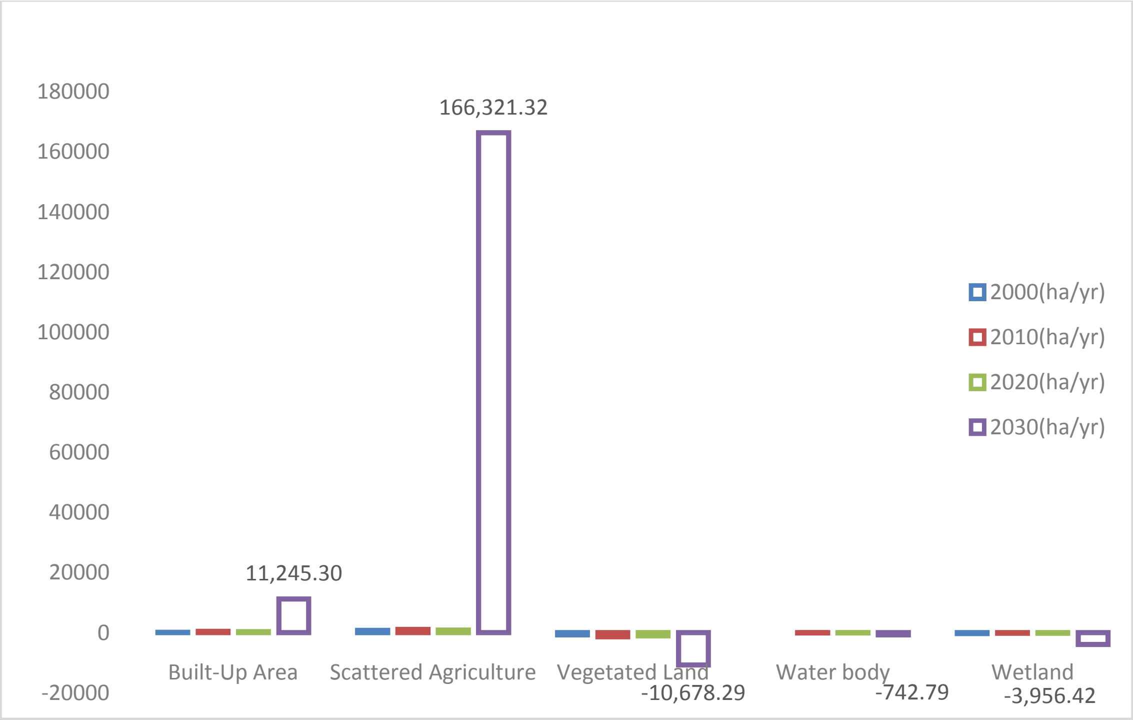

Figure 2: Showing land use gains and losses for the Study Area.

Source: Field Survey, 2023.

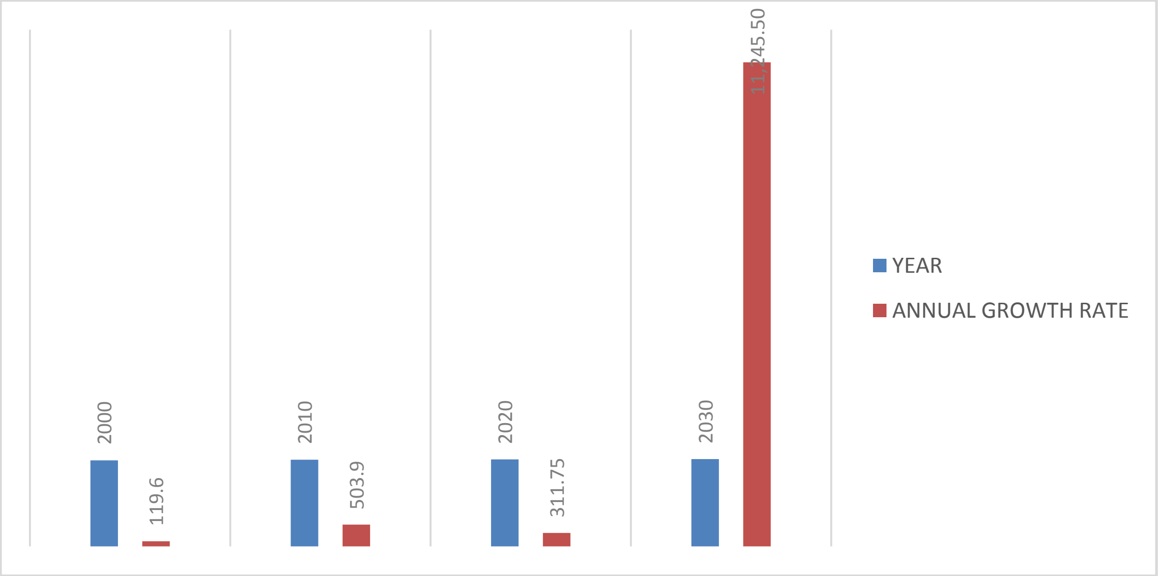

Figure 3: Projected Land use Growth Rate for 2030.

Source: field Survey, 2023.

As presented in table figures 2 and 3, revealingland 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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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.

Several types of fertilizers exist based on the peculiarity of soil. Table 5reveals 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 were been used on the farms along Ofu River watershed. This indicates that these organic and inorganic fertilizers could 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 theeffect of fertilizer application on concentration of agricultural pollutants in the United States watershed.

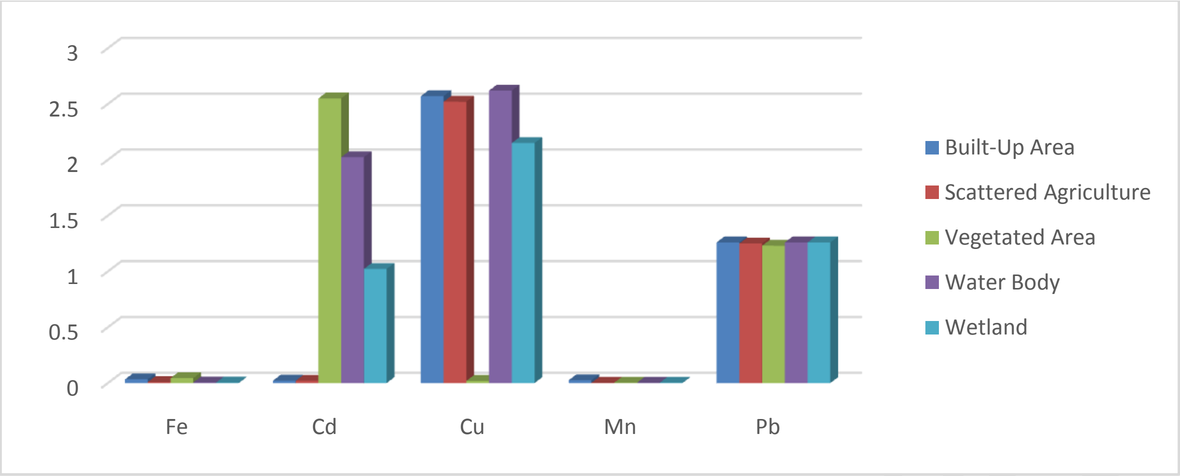

Figure 4: Heavy Metals' concentration among different land uses at (S1) Ojofu

Source: Field Survey, 2023.

Based on the result presented in figure 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 (2021), 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 6Heavy 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.

Table 7 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.

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 RiverSample 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 ratesof 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 treatmentis 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 water pipes, 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 amongthe 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 thatS2 (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(2019)**.** 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 meanconcentration 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 (2021) 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 andESA 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

(2021) 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 (2021) the researchers assessed the level of heavy metal pollution in water, sediments and aquaticorganisms 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 beof poor quality for human consumption

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.

4.0 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 waterbodies from 2000 to 2030 remained relatively stable losing only 0.21 ha/yr.
- Scattered agriculture exhibited highest growth rate from 2000 to 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.

4.2 SUMMARY AND CONCLUSION

Understanding the correlation between land use types and ecological quality is essential to improve the state of the ecology in the area of impact prediction and provide guidance for land use planning. Studying the relationship between the proportion of land use types and its ecological effects on Ofu River watershed indicated that built-up areas increased and so the agricultural land.

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