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Assessment of Changes in Land Use and Land Cover in Hadejia Nguru Wetland of Yobe State, Nigeria

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ABSTRACT

The study assessed the change in land use and land cover changes in HNWs. Parameters evaluated include; changes in land use land cover over a 40-year window (1979-2019). Data collection for. Changes in land cover/ land use were obtained for a period of 40 years from Satellite imageries of the study area were officially downloaded from the United States Geological Survey website. Changes in land cover/ land use. Results showed that thick vegetation reduced from 14,284.25ha in 1979 to 9,560.36ha in 2019, Grassland increased from 6,339.38ha to 7,306.72ha, water bodies decreased from 4,131.70ha to 1,095.62ha and bare surface increased 1556.35ha to 8,348.98ha during the same period. Results also showed an association between respondent‘s occupational change and changes in wetland resources availability. There was also a significant Chi-square value (33.481a) between respondents' effect of change in land use and increase in farm sizes (318.431a) majority of the respondents (78.25%) were males, 68% were married, Agric/farming (15.25%) topped the occupation list, age brackets of 45-50 was highest (23.75%) and 34.5% (highest) of the respondents had primary school education. The highest household size of the respondents (51.75%) was between 7 and 9 children, the highest previous yearly income (36.5%) was between N 50,000. 00 and N 100, 000. 00 per annum while the highest (36.5%) present yearly income was from N 1,000.000, 00 to N 1,500,000.00. majority of the respondents (80.25%) had awareness of change in land cover/land use, 89.25% were aware of the impacts of Changes in land cover/ land use on livelihood and 30.5% indicated sparse distribution as a major effect of Changes in land cover/ land use.. Result of LULC. There is the need to put in place right policies to protect and preserve wetlands. . It is therefore concluded that the changes in LULC which has led to changes in livelihood patterns of the wetland communities highly significant.

INTRODUCTION

Land use and land cover (LULC) describe the economic use of land and surface features, respectively. The Land cover reflects the biophysical state of the earth‘s surface including the soil material, vegetation, forest estate natural and man-made features, cultivated and human settlements, and water. Land use, on the other hand, refers to the use of land by humans. It is the alterations done to Land cover as a result of human activities such as farming, road construction, human settlements/urbanization and industrialization (Panel, et al., 2023).

Land use and land cover are dynamic in nature and they provide a comprehensive understanding of the interaction and relationship of anthropogenic activities with the environment. Land use/cover changes also involve the modification, either direct or indirect, of natural habitats and their impact on the ecology of the area. Land use/cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes (Zaitunnah et-al, 2018) Humans play a major role as forces of change in the environment, inflicting environmental change at all levels, ranging from the local to the global scale. The various uses of land for economic purposes have greatly transformed land cover at a global scale over the last 10,000 years, almost half of the ice-free earth surface has changed and most of the result was due to the use of land by humans (Joseph, et al., 2020). Land use and land cover changes are environmental issues mostly linked to climate change in a complex manner, and changes in both can have profound effects on an ecosystem‘s ability to provide goods and services to human society Land use and land cover changes play a key role in climate changes through the exchange of greenhouse gases, sensible heat, and local evapotranspiration Approximately 35% of the CO2 emissions to the atmosphere were from land use. In addition to climate change, the growth of human population and land cover changes have an effect on the biogeochemical cycles, habitat availability, biodiversity, soil erosion, water quality, water flow, and sediment flows (Ajibola, et al. 2016).

Intensification of land conversion for agriculture is accelerating land use land cover (LULC) change with its consequential impact on the natural landscape. For practical purposes, intensification occurs when there is an increase in the total volume of agricultural production that results from a higher productivity of inputs (FAO, 2005). Agricultural intensification in response to the government's quest for economic diversification is aggravating LULC change across Nigeria particularly at the heart of wetland ecosystems. Despite the inherent dynamic system of wetlands, the ecosystem is suffering from great transformations worldwide (Arooba and Sheikh, 2017). These changes are fundamental obstacles in the country's effort towards the attainment of food security, economic diversification, growth and sustainability of the physical environment. Similarly, Sebastiá et al. (2012) affirmed that a wide range of pressures affect these ecosystems and alter the quality and quantity of water. The increasing pressure on the ecosystem and the consequential land degradation are intensifying runoff, siltation of river channels, and flood events.

The wetland ecosystems in the country serve as a direct and indirect pool of resources for the population that derives maximum benefits from the exploitation of these essential resources for socio-economic and sustainable livelihood. Ehsan and Farhad (2014) described wetlands as the kidneys of the landscape because of their functions in chemical and hydrological cycles. The vast riverine wetland ecosystem is used most importantly for agriculture (farming, grazing, and fishing) and the inhabitants primarily depend on it for livelihood. The environmental destabilization of the wetlands and of the "dynamically" developing areas as far as the geomorphological processes are concerned is mainly due to certain anthropogenic interventions that alter "critical" parameters of the environment (Grundling et al., 2013). These alterations incorporate the greatest environmental concerns of human populations in recent time's vis-a-viz loss of biodiversity, land, vegetal and water degradation, soil erosion, climate change, and its impact. Globally, the landscape and hydrological cycle have been modified by anthropogenic activity thereby, reflecting the socio-economic conditions and pattern of land resource utilization (Li et al. 2013). Monitoring and mitigating the negative consequences of LULC dynamics as well as sustaining the production of this vital riverine ecosystem should be the primary focus of most developing nations.

In spite of this there has not been any comprehensive documented information on the changes in land cover and land use viz-a-viz the interphase between the livelihood sustenance practices in the study area. Similarly, the range of change in land and land cover in the study area has not been documented. Furthermore, information on the changes in land use and land cover changes remains scanty.

The aim of this study is to assess the changes in land use/land cover in HNWs. The specific objectives are to; evaluate the changes in land use land cover over a

40-year window (1979-2019) in the study area, and assess the interphase of livelihood sustenance practices in relation to changes in land cover/ land use.

The intense infringements of land use systems into traditional forests and wetlands and also changes in land cover/ land use are contributing to the degradation of ecosystems leading to unsustainable development. Whereas such land developments could be contributing to the short-term socio-economic welfare of the people, they in the long run cause degradation and thus threaten the very livelihoods of the local people they were meant to sustain. History has it that, these lowlands were once occupied by a massive water body that has since receded, leaving behind patches. This shrinkage has been blamed on varied causes including changes in land use and anthropogenic factors. If this trend continues, the remaining wetland ecosystems may eventually be transformed into terrestrial landforms, losing a lot of their ecological and economic importance (Grundling et al., 2013).

Fishing, Nomadic pastoralism, hunting, collecting and gathering of vegetation resources constituted the main source of livelihood. Today, however, due to increased population and penetration of forces and influences of development have enormous competitive alternative and uses which includes; permanent human settlements, agriculture and forest resources commerce. Therefore, household welfare that was previously assured by a relatively smaller stable competing factors is no longer ascertain. This study will thus provide baseline information on livelihood sustenance practices, changes in climatic variables and changes in climatic variables scenario viz-viz the environmental, social, and economic responses of the communities who depend on the resources for their livelihood sustenance. The result can provide an avenue for strategic management and conservation options for the government and other stakeholders.

The study is limited to the assessment of livelihood sustenance practice in HNWs inhabitants in relation to changes in climatic factors and land use/land cover. Data collection was limited to parameters related to the stated objectives.

MATERIALS AND METHODS

Study Area

Location of the Study area

The HNWs is located at a point where Rivers Hadejia and Jama'are flow through a fossil dune field before converging and draining into Lake Chad (Barbier and Thompson, 1998) and lie between longitude 10°15′E and 11°30′E, and latitude 12°13′N and 12°55′N. The wetlands extend for approximately 120 km from West to East within Jigawa State and a further 60–70 km downstream in adjacent Yobe State (Barbier and Thompson, 1998). In width, the wetlands range from l0km to more than 50 km from North to South, with approximately 8000 km2 of floodplain covering three Nigerian States (namely Bauchi, Jigawa, and Yobe). The extent of the floodplain varies considerably from year to year depending on the volume of rainfall and complex interactions of river flow, dam releases, flood regimes, and topography. In Nigeria, wetlands cover about 28,000 km^2 (about 3%) of the 923,768 km2 of the country's land area (Abubukar et al., 2016). One of these is the HNWs named after two major towns (Hadeja and Nguru) in the area and are surrounded by many villages.

The Hadeja-Nguru Wetlands (HNWs) is an extensive floodplain created by the Hadeja and Jama'are Rivers to form the Komadugu- Yobe River which drains into Lake Chad. The wetlands cover an area of about 350, 000 ha and have an altitude of (asl) 152 - 305m (Bird Life International, 2015). The Nguru Lake and Marma Channel Complex Wetlands (located within the HNWs) were designated as the first Nigerian wetlands of international importance under the Ramsar Convention. According to Ramsar, (1994), the wetlands are notably known for the rrecharge and replenishment of underground water in the Komadugu-Yobe Basin, economically rich habitats for the biodiversity of various fauna and flora. The area is a major tourism site for the Palearctic and Afrotropical migrant water birds (Eaton and Sarch, 1997).

Vegetation of the study area

The general vegetation is characteristic of the Sudan savanna, – Sparse shrubs and isolated tall trees mostly Acacia Species. Three broad types of vegetation occur in HNWs. There is a scrub savanna, which consists of upland farmland areas and Acacia Woodlands. The second includes the "tudu" (raised areas) which are never inundated with tree species of Acacia, Ziziphus species, Balanites aegyptiaca, Tamarindus indica and

Adansonia digitata, while common grasses include Cenchrusbiflorus, Andropogon species. and Vetiveria nigritana.

In addition, pockets of riparian forests and woodlands, known as “kurmi” comprise species of Khaya senegalensis, Mitragyna inermis, and Diospyros mespiliformis. In some parts, the kurmi has been replaced with orchards of mango Mangifera indica, and guava Psidium guajava, (Ezealor, 2001). The third vegetation type consists of the seasonally flooded marshes in which the tree Acacia nilotica, is common while Dum palms (Hyphaene thebaica) grow on small, raised islands (Ezealor, 2001). Aquatic grasses include Echinochloa and Oryza species. While in drier parts Dactylocteniu maegyptium, Setaria species and Cyperus species, occur and extensive vegetation of Typhadomin gensis along the shore of the wetlands. The favorable moisture regime due to the high ground water table supported Mitragyna ground water woodland and seasonally flooded grassland. The woodland is becoming degraded due to falling water table as reported by Hadeja-Nguru Wetlands Conservation Projects (HNWCP, 1997).

The ecosystem comprises permanent lakes and seasonally flooded pools connected by a network of channels. The ecosystem is an important site for biodiversity, especially migratory water birds from Palearctic regions (Abubakar et al. 2016). For example, at one time, the floodplain supports over 423,000 birds of 68 species, including significant numbers of Ferruginous Duck (Aythyanyroca), Spur-winged Goose (*Plectropterus gambiensis*), Black-tailed Godwit (Limosalimosa), and Ruff (*Philomachu spugnax*) (Birdlife International, 2010). Other wildlife species found include species of gazelle (Gazella spp.), duiker (*Cephalophus* spp.), jackal (Canissp) and hyena (*Crocuta crocuta*) (Ogunkoya and Dami, 2007). In total, there are about 378 bird species listed for the wetland, 103 fish species, 250 species of flowering plants and more than 136 species of aquatic flora and fauna (Oduntan et al. 2010).

Population

The HNWs is the first Nigeria wetland to be named a RAMSAR site (RAMSAR, 1994). The people in the area depend on this wetland for water supply and other daily activities. Hausa, Kanuri, Fulani and Bade are the most dominant tribes in the wetlands where Hadeja has a population of 139,400 among which 54.6% are male and 46.4% are female (National Bureau of Statistics, 2016). The population including farmers, herders and fishermen who entirely depend on the ecosystem for their livelihoods (Kaugama and Ahmed, 2014; Birdlife international, 2015). The wetlands provide essential income and nutrition benefits in the form of agriculture, grazing resources, Non-Timber Forest Products, fuel wood and fishing (RAMSAR, 2007)..

Geology, Topography and Soil

Permeable sedimentary rocks of the Chad formation underlie this natural wetland, but a film of impervious layers has been formed at the bottom of the water body through successive years of clay deposition. This has significantly impeded percolation (Emmanuel, 2019). A monotonous low-lying plain that gently slopes northeastwards towards Lake Chad characterizes the relief around the site. River flow is highly seasonal and varies considerably depending on rainfall and run-off. Peak flow occurs between August and September when banks overflow and the area is inundated. The river regime in the area has however been affected by river regulation that peak discharge in the wetland is now in September-October (Emmanuel, 2019).

Drainage

Hydrology of the Hadeja-Nguru Wetlands The hydrological genealogy of the Hadeja-Nguru Wetlands sustains water from rainfall and runoff supplements from the wet season and is later depleted by other hydrological output like infiltration to underground, soil moisture recharge and evaporation (RAMSAR, 2007).

Climate

The Hadeja-Nguru wetland is located as part of the Komadugu-Yobe River basin, it has a semi-arid climate influenced by the strong convection storm of the Inter-Tropical Convergence Zone (ITCZ). The climate of the wetland is characterized by two distinct seasons; wet season (May- September) and dry season (October-April), The rainfall period is from June to October and has an annual mean of over 1,000mm in the upstream Basement complex area and approximately 500mm in the Hadeja-Nguru Wetlands (Sanyu, 1994). The dry season normally sets in October and remains until late May. The temperature recorded in the dry season ranges between 35°C and 40°C. Significant water flows to the wetlands begin in late June or early July with peak discharges in August. Occasionally there may be a mean minimum temperature of 12°C from the month of December to January, (Ogunkoya and Dami, 2007).

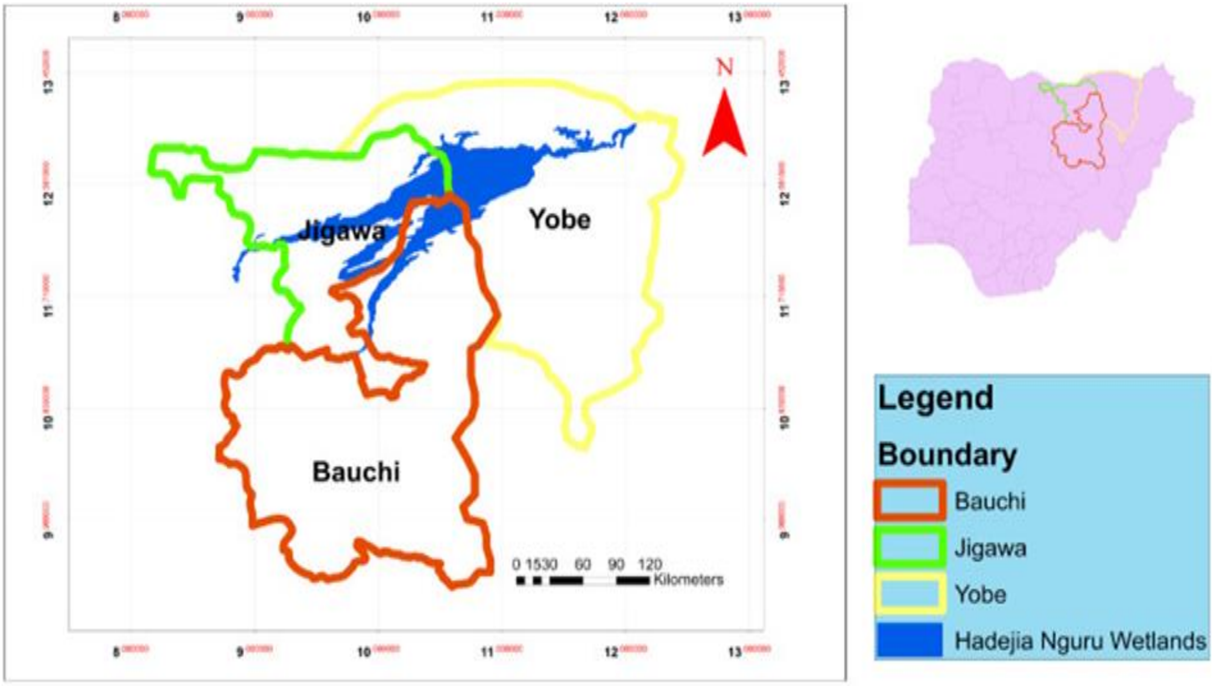

Figure: 1 Map showing boundary demarcations of HNWs between States Sources: GIS University of Maiduguri (2019)

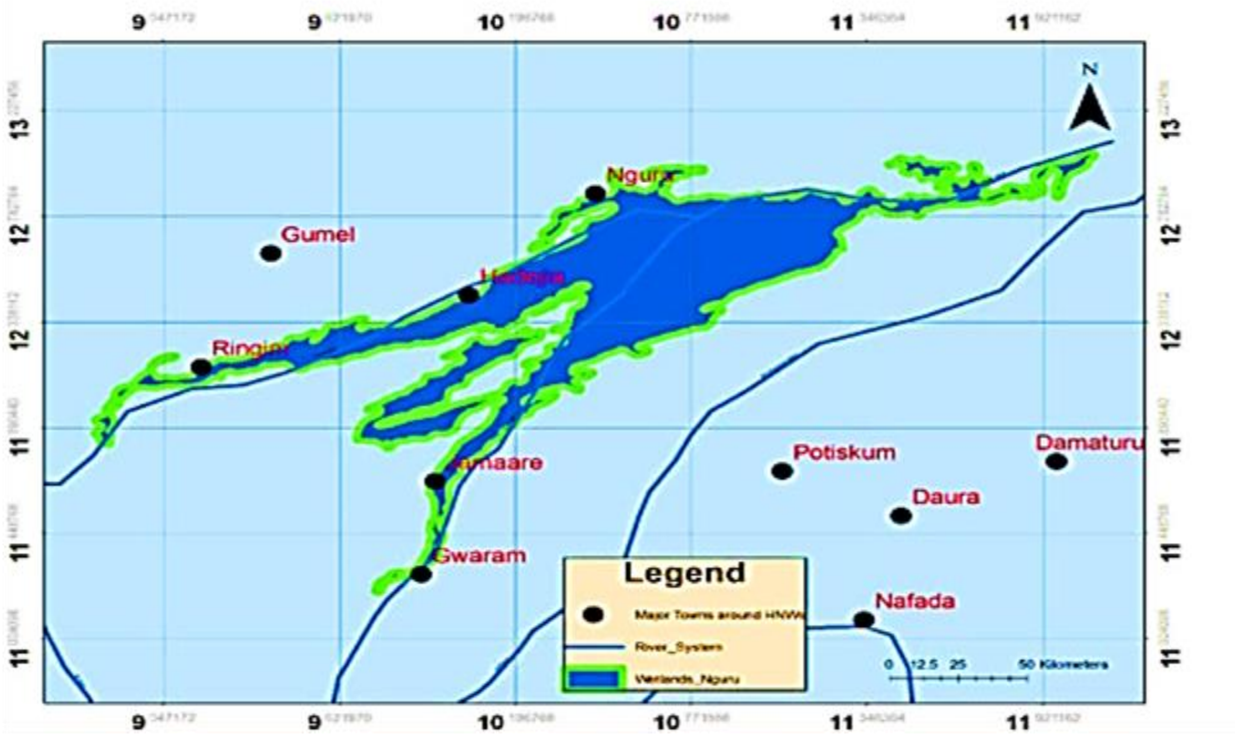

Figure: 2 legend map of HNWs

Source: GIS University of Maiduguri. (2022)

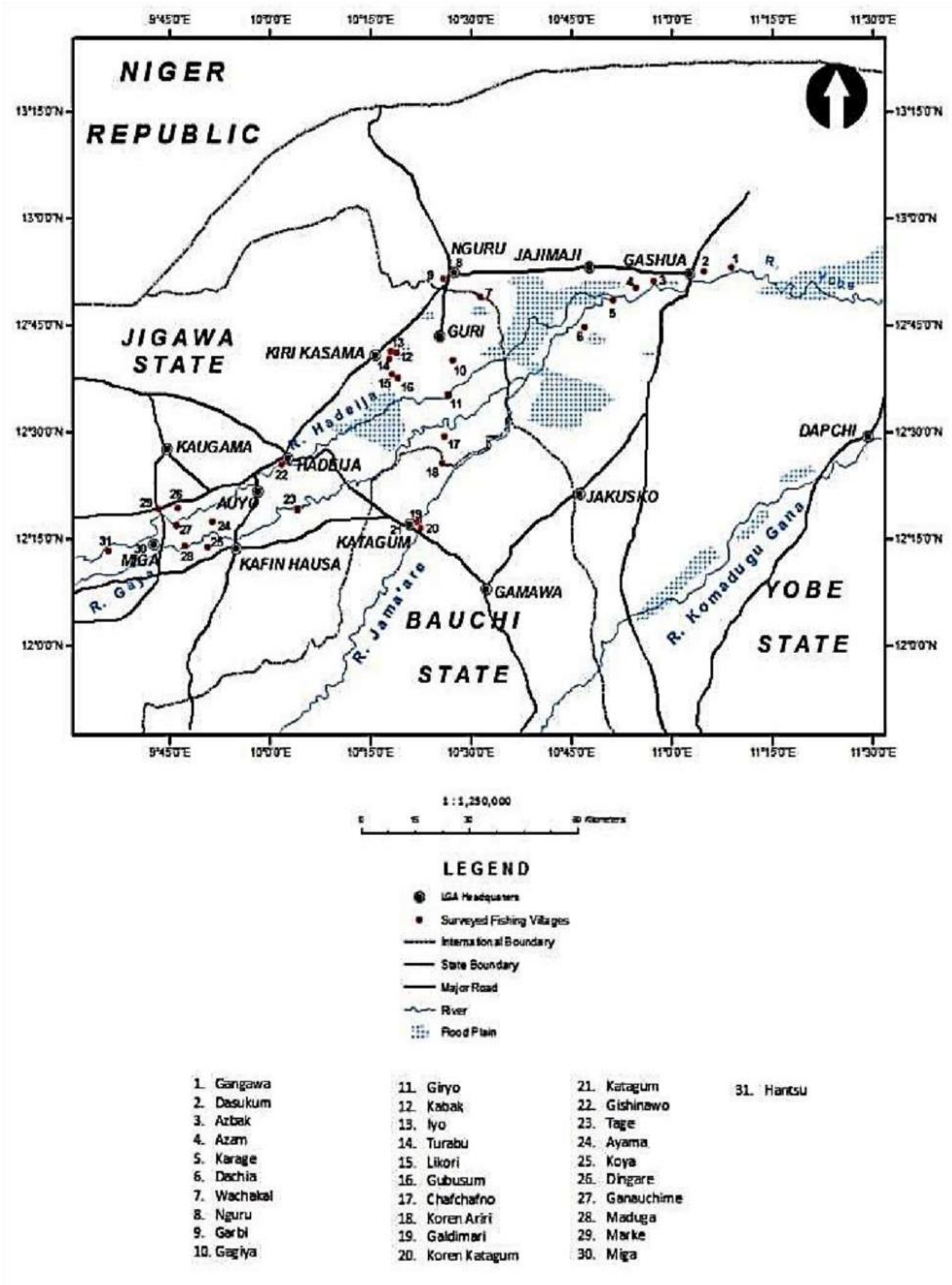

Figure 3: Map showing the extracted coordinate location of the study sites

Sources: GIS University of Maiduguri (2019)

Assessment of land use changes in HNW

The imageries of HNWs were officially sourced and downloaded from the official website of the United State Geological Survey (https://earthexplorer.usgs.gov/). The study area was classified into four classes or categories based on field study and personal experience of the study sites. Four land use/land cover (LULC) themes were decided for this research. These land use/cover categories or classes are: Water body, Thick vegetation, Grasses and bare land. The description and composition of these classes are presented in Table 2. This presents the remote sensing aspect of the study as it provides the land use/land cover change information for the selected study region. The detailed characteristics of the imageries used to produce the LULC maps are provided in (Table 2).

As can be observed in Table 3, the multispectral Landsat imageries covering the period from 1979 to 2019 were specifically selected from those available based on image quality. In all, three different epochs (1979, 1999, and 2019) were selected.

Data Analysis

Analysis of land use changes in HNW

To get the extent of the observed changes, post classification change detection approach was used to assess the five classified land cover maps using simple descriptive statistics. The Areal Statistics for the five land cover types were generated using the calculate area tool of ERDAS Imagine version 15 software, and this was generated in Hectares (H). Overall, from the statistics of the land cover maps, the change magnitude, change trend and Annual rate of change of the observed changes were then computed using the following formula (Abbas, 2012).

Magnitude =

$$Magnitude\ of\ the\ new\ year\ -\ Magnitude\ of\ the\ previous\ year$$

Percentage change (trend) for each LULC type was computed by dividing magnitude change by sum of observed changes between the years concerned and multiplied by 100 as shown in the equation:

$$Trend = \frac{Magnitude\ of\ change}{Sum\ of\ change} \times 100$$

To generate the annual rate of change for each LC type, the trend (percentage change) was divided by 100 and multiplied by the number of study years in between the two periods, for example 1972 – 1986, 1999-2009, 2009-2020 as shown below in the equation:

$$Annual\ rate\ of\ change = \frac{Trend \times Number\ of\ study\ years\ in\ between}{100}$$

(Abbas, 2012)

Assess the interphase of livelihood sustenance practices, and changes in land cover land use

Paired sample T-test of differences was used to test the differences in livelihood before and present while chi-square test of association was used to test the influence of the changes in LULC and climate on the livelihood as observed by the respondents in the area.

i. Students t-test

$$t = \frac{|X - Y|}{\sqrt{\frac{\left(\left(EX2/_{nx}\right) - X2\right)}{nx - 1} + \frac{\left(\left(EY2/_{ny}\right) - Y2\right)}{ny - 1}}} \quad \text{-------------------- Equation 1}$$

Where t = t-test

x = Livelihood before

y = Livelihood After

n = number of observations

ii. Chi – square

$$X^2 = \sum \frac{(O-E)^2}{E} \quad - \quad - \quad - \quad - \quad - \quad - \quad \text{Equation 2}$$

Where X2 = chi – square

O = Observed frequency

E = Expected frequen

Assessment of land use changes in HNW

The imageries of HNWs were officially sourced and downloaded from the official website of the United State Geological Survey (https://earthexplorer.usgs.gov/). The study area was classified into four classes or categories based on field study and personal experience of the study sites. Four land use/land cover (LULC) themes were decided for this research. These land use/cover categories or classes are: Water body, Thick vegetation, Grasses and

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As can be observed in Table 3, the multispectral Landsat imageries covering the period from 1979 to 2019 were specifically selected from those available based on image quality. In all, three different epochs (1979, 1999, and 2019) were selected.

Image Classification

Landsat 5 ETM, 7 ETM+ and 8 (OLI) images of 30m resolution with worldwide reference system (WRS) address of; path 187 row 051/052 (20/11/1979-20/11/1980), (08/12/1999-08/12/2000) and (05/01/2019-05/01/2019) for 1979, 1999 and 2019 respectively were downloaded from glovis.usgs.gov. The Landsat images were processed and mosaic to give a comprehensive coverage of the wetland area with help of image analysis and spatial analysis tool in Arc GIS 10.3. Unsupervised classification was adopted for the study.

Areas of the classes were calculated in km2 one after the other by highlighting the layer (class) in the attribute table, reclassified the map to produce the area of the selected class. The area of the reclassified layer (class) was then converted into a polygon and was letter calculated using calculates area tool in spatial statistics toolbox (Figures 4 and 5). All these procedures were applied in producing the LULC of each year and calculation of the areas.

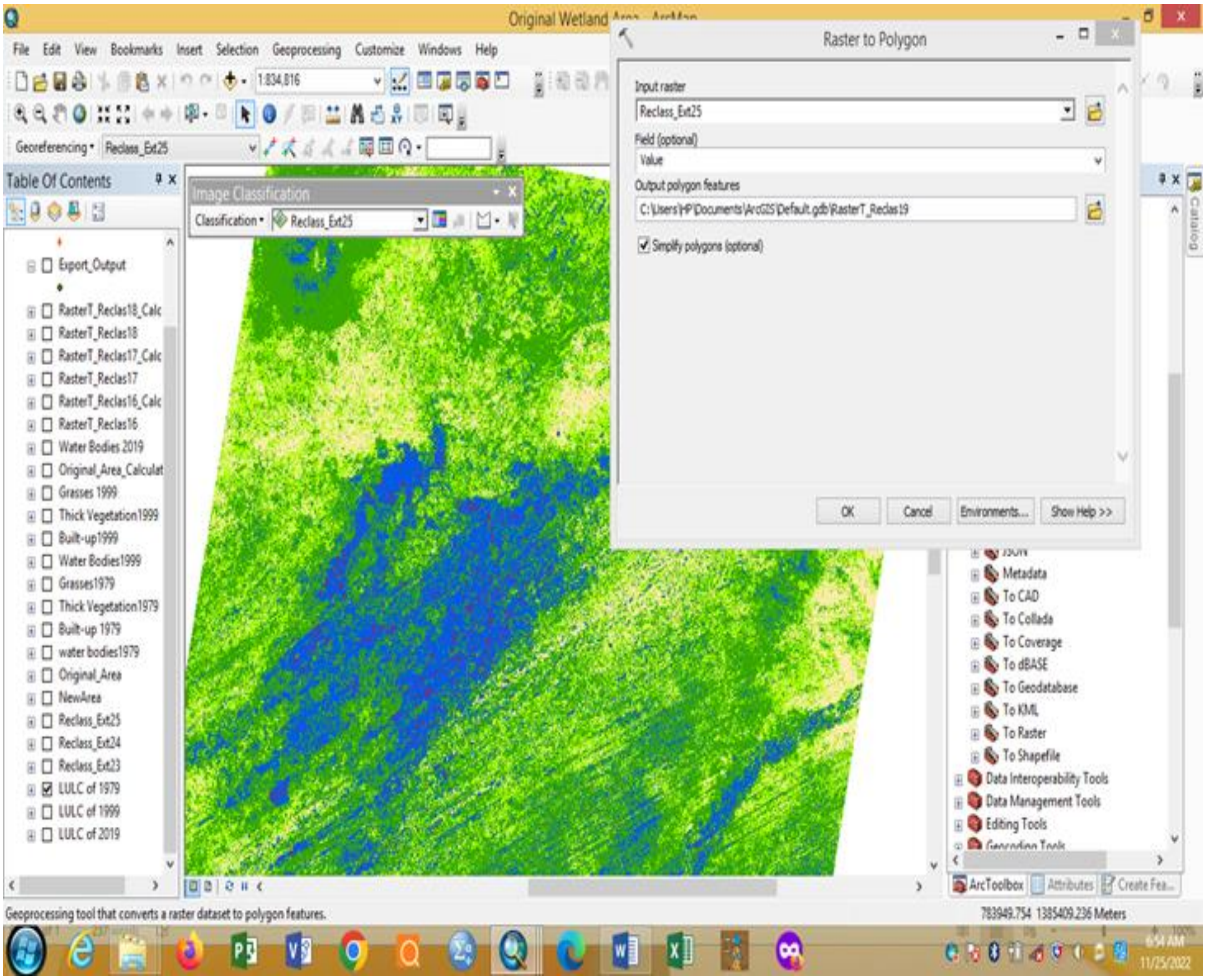

Figure: 4 Conversion of Images from Raster to Polygon

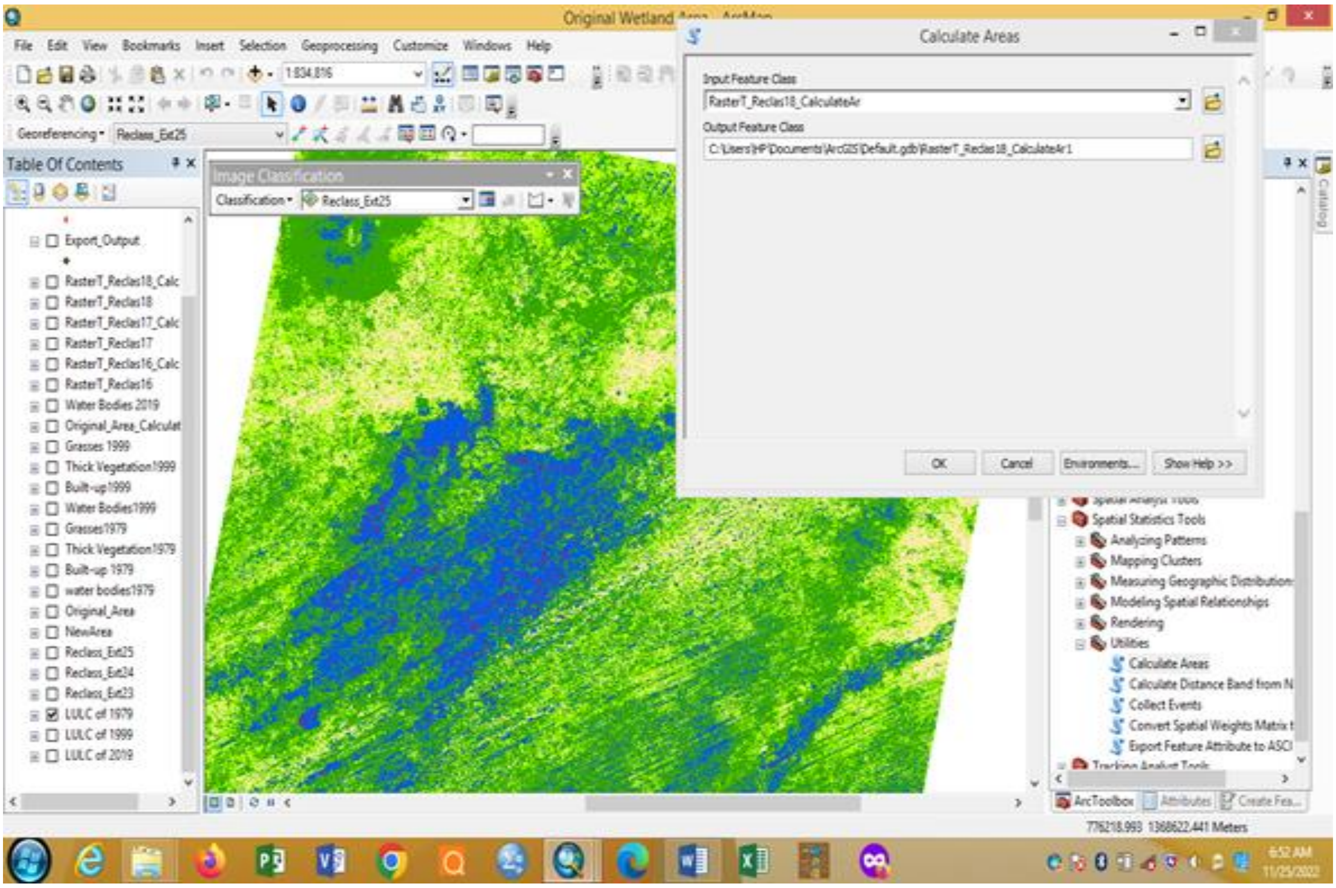

Figure: 5 calculation of total area of each class.

Table: 1 The description and characteristics of the LULC types used in the study

LULC Types	Description/composition
Water bodies -	This land cover type represents all areas of open water bodies, generally with less than 10% vegetal cover. This also represents all open water bodies irrespective of depth (both shallow and depth waters).
Thick Vegetation -	These are plants of an area that grow in disturbed or undisturbed conditions in wooded plant communities in any combination of trees, saplings, shrubs, vines, and herbaceous plants, including mature and successional forests and cutover stands.
Bare-land -	These are areas characterized by open land with little or no NTFPs. It also includes fallow agricultural fields and lands that are being subjected to continuous cultivation. Areas where soil exposure is apparent.
Grassland	These represent degraded and dried-off areas of the wetland or areas that before were occupied by NTFPs and water. It also represents inundated and dried floodplain areas. These areas largely lack vegetal cover or NTFPs and it appears dark and whitish in the raw satellite imagery.

Source: Field Work, (2021).

Analysis of land use changes in HNW

To get the extent of the observed changes, post classification change detection approach was used to assess the five classified land cover maps using simple descriptive statistics. The Areal Statistics for the five land cover types were generated using the calculate area tool of ERDAS Imagine version 15 software, and this was generated in Hectares (H). Overall, from the statistics of the land cover maps, the change magnitude, change trend and Annual rate of change of the observed changes were then computed using the following formula (Abbas, 2012).

$$\textbf{Magnitude} = \textit{Magnitude of the new year} - \textit{Magnitude of the previous year}$$

Percentage change (trend) for each LULC type was computed by dividing magnitude change by sum of observed changes between the years concerned and multiplied by 100 as shown in the equation:

$$Trend = \frac{Magnitude\ of\ change}{Sum\ of\ change} \times 100$$

To generate the annual rate of change for each LC type, the trend (percentage change) was divided by 100 and multiplied by the number of study years in between the two periods, for example 1972 – 1986, 1999-2009, 2009-2020 as shown below in the equation:

$$Annual\ rate\ of\ change = \frac{Trend \times Number\ of\ study\ years\ in\ between}{100}\ \text{(Abbas, 2012)}$$

RESULTS

The Trajectories of the LULC Change from 1979-2019

Table 1 presents the change trajectories of the four LULC classes identified in the area under study. The classified maps are also presented in Plates I and III which portrays the change trajectories of the entire landscape of HNW between 1979 and 2019. The result indicated that water body in HNW in 1979 was 4131.70 Km2 and in 1999 it occupied an area of about 1,255.99 Km2 which decreased by -69.60%. Bare surface which occupied a total area of 1,556.35 Km2 in 1979 increased to 9,466.04 Km2 in 1999 indicating an increase of 508.22%. Grassland had an area of 6,339.38 Km2 in 1979 and decreased to 2,709.38 Km2 in 1999 indicating a decrease by -57.26%, while thick vegetation which occupied a total area of 14,284.25 Km2 in 1979 decreased to 12,880.27 Km2 in 1999 indicating a decrease by -9.83%.

The percentage change in land use land cover classes between 1999 and 2019 as presented in Table 2 and 3 and Plates I and III. The result indicated that water body which occupied a total area of 1,255.99 Km2 in 1999 decreased to 1,095.62 Km2 in 2019 indicating a decrease by -12.77%. Bare surface which occupied a total area of 9,466.04 Km2 in 1999 decreased to 8,348.98 Km2 in 2019 indicating a decrease by -11.80%. Grassland had an area of 2,709.38 Km2 in 1999 and increased to 7,306.72 Km2 in 2019 indicating an increase of 169.68 %, while thick vegetation which occupied a total area of 12,880.27 in 1999 had reduced to 9,560.36 Km2 in 2019 indicating a decrease by -25.78%.

The percentage change in land cover classes between 1979 and 2019 is presented in Table 8 and 9, Plates I and III. The result indicated that water body which occupied an area of 4,131.70 Km2 in 1979 decreased to 1,095.62 Km2 in 2019 indicating a decrease by -277.11%. Bare surface which occupied a total area of 1,556.35 Km2 in 1979 increased to 8,348.98 Km2 in 2019 indicating an increase of 81.36%. Grassland had an area of 6,339.38 Km2 in 1979 but increased to 7,306.72 Km2 in 2019 indicating an increase by 13.24 %, while thick vegetation which was 14,284.25 Km2 in 1979 decreased to 9,560.36 Km2 in 2019, indicating a decrease by -49.41%. All land cover classes indicated losses of varying degrees and rates between 1979 and 2019. The rates at which selected surfaces changed were; Thick vegetation (118.10); water bodies (75.90), Bare surfaces (169.82) and grassland (24.18) respectively. The projected years of exhaustion of thick vegetation showed that in approximately 80.95 years there will not be vegetation while water body indicated that in approximately 14 years the HNWs will disappear.

Table: 2 Area and Percentages of Land cover classes in Hectare (H) during the Study Period 1979-2019

LULC Themes	1979	(%)	1999	(%)	2019	(%)
Thick Vegetation	14,284.25	54.29	12,880.27	48.95	9,560.36	36.34
Grass land	6,339.38	24.09	2,709.38	10.30	7,306.72	27.77
Water Bodies	4,131.70	15.70	1,255.99	4.77	1,095.62	4.16
Bare Surfaces	1,556.35	5.92	9,466.04	35.98	8,348.98	31.73
Total	26,311.67	100.00	26,311.67	100.00	26,311.67	100.00

Source: GIS Analysis, (2019)

Table: 3 Magnitudes of Change in the four identified LULC themes from 1979-2019 in HNWs

LULC Themes	1979-1989	%Δ	1999-2009	%Δ	1979-2019	%Δ	Rate	Projection
Thick Vegetation	-1,403.99	-9.83	-3,319.91	-25.78	-4,723.90	-49.41	-118.10	-80.95
Grass land	-3,630.00	-57.26	4,597.34	169.68	967.34	13.24	24.18	302.14
Water Bodies	-2,875.70	-69.60	-160.38	-12.77	-3,036.08	-277.11	-75.90	-14.43
Bare Surfaces	7,909.69	508.22	-1,117.05	-11.80	6,792.64	81.36	169.82	49.16

Source: GIS Analysis, (2019)

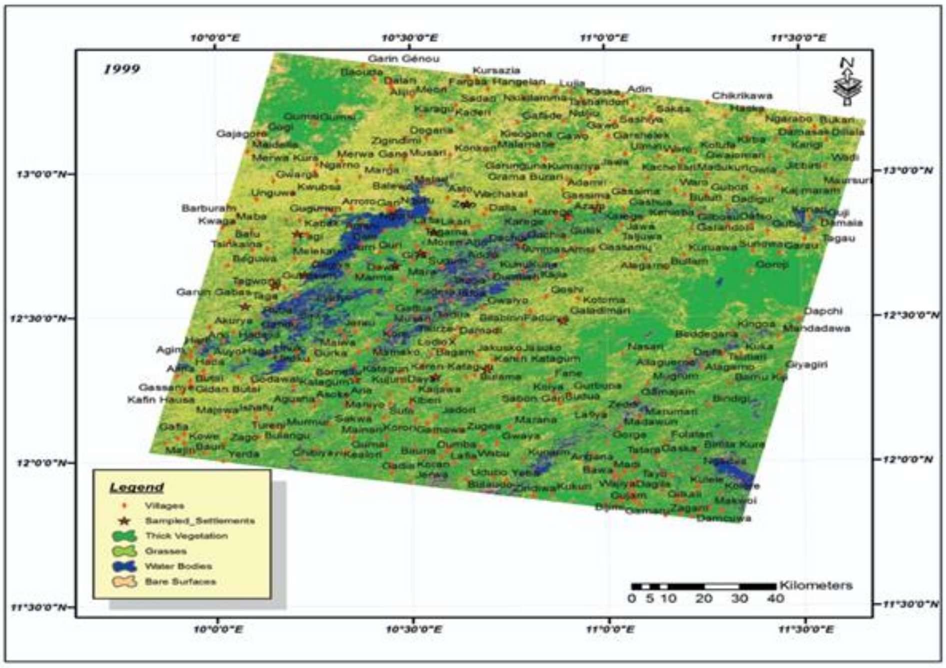

Plate: I The classified Land cover map of HNWs as at 1999
Source: GIS Analysis, (2019)

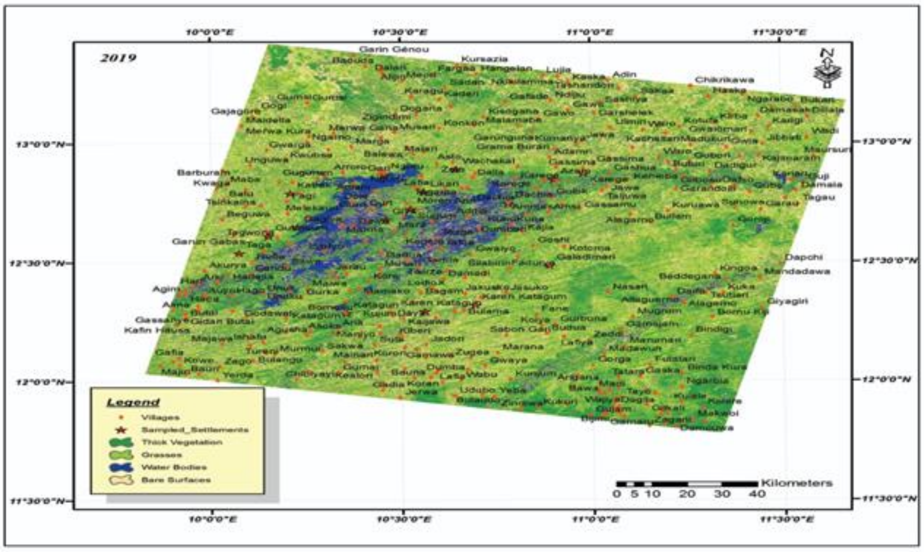

Plate: II The classified Land cover map of HNWs as at 2019
Source: GIS Analysis, (2019)

DISCUSSION

Findings from the classification of the imageries indicated continuous decrease in the water bodies from 1979 to 2019, which could be due to agricultural land use conversion. This could impact negatively on hydrological processes and ecosystem health. These observations agree with the findings of a similar study by Chen et al. (2009) on Impacts of land use change scenarios on storm-runoff generation in Xitiaoxi basin, China; Tadesse et al. (2015) who also reported on Assessing the impact of land-use land-cover change on stream water and sediment yields at an assessment of watershed level using SWAT; Woldesenbet et al. (2017) on Hydrological responses to land use/cover changes in the source region of the Upper Blue Nile basin, Ethiopia; Uluocha and Okeke (2004) on impacts of climate variability and land use change on streamflow in the Hailiutu river basin and Adepoju et al. (2019) on Vegetation Response to Recent Trends in Climate and Land use Dynamics in a Typical Humid and Dry Tropical Region under Global Change.

The increase in bare surfaces in the wetlands between 1979 and 2019 could be attributed to increased farming and grazing (including lopping of trees for livestock as well as for tradomedicinal uses) as observed during ground truthing. These findings are in consonance with those of Ikusemoran and Ezekiel (2011) in their study of Remotely Sensed Data and Geographic Information System Techniques for Monitoring the Shrinking HNWs, Nigeria where they affirmed human interventions especially agricultural practices to be the major cause of the changes in the wetlands, also grazing by herdsmen in the wetlands area for several generations. Geist and Lambin (2002) and FAO (2005) reported grouping of the land cover classes gave rise to three groups, which included the water body, the vegetation covers and the bare surfaces/farmland. This is in agreement with the fact that most areas in Africa, including Nigeria and HNWs in particular experience land tenure insecurity, particularly due to increasing land transactions for expansion of agri-business in conformity to the studies of Woldesenbet et al. (2017) and Pare, (2008).

Since, several factors contribute to a more complex land use dynamics pattern, the vegetation experienced losses as it decreased over the period in the study location. The overall change of thick vegetation in HNWs study sites between 1979 and 2019 was on the negative side (-49.41%) indicating a decrease. The marginal depletion of vegetation of the site may not be unconnected with the interruption of the natural flood regime via diverting flood water in the wet season and releasing damaging flood surges during the dry season and also as a result of several dams (including two large ones at Tiga and Challawa) and other hydro agricultural projects with intensive water demand have been commissioned at locations upstream as noted by Ikusemoran and Ezekiel (2011). The combined effects of these factors must have caused the dynamics of vegetation of the study site.

CONCLUSION AND RECOMMENDATION

Conclusion

Both natural and human activities are known to modify the natural environment, and HNWs is not an exception. The communities in the wetlands depend largely on the natural resources for their livelihood and survival. These natural resources have been significantly altered and continue to deplete due to unsustainable practices and over population. The natural resource scarcity that resulted from environmental changes have had severe impacts on wetland through loss of biodiversity, soil productivity and accelerated environmental degradation thereby increasing vulnerability and reduction in biodiversity. This hardship imposed led to a number of adjustments by individuals and communities to continue making out a living within the same environment. However, the current community level of adaptation measures may not be sufficient to meet the challenges of the current environmental change particularly in the face of change in LULC. It is therefore very important to improve the understanding of local populations and communities on the prevailing changes in their immediate environment because their behavior of removing vegetation cover , over the study period and the test of the relationship on vegetation cover as represented by the land use changes showed that there is an interwoven relationship among all the factors. The massive increased in removal of vegetation cover had the strongest impact amongst other factors that the research examined on the deterioration of the vegetation cover, wind speed increased steadily as observed during study periods. Based on the findings of this study, it is clear that the HNWs area should be protected because of the richness in biodiversity.

Recommendation

Based on the findings of the study the following are some of the recommendations

i. There is need to put in place right policies to protect and preserve wetland to enhance its sustainability and resilience to climatic changes and variability.

ii. Policy making as well as academic research on ecosystem changes should integrate people's testimonies and their stories as evidence of those changes. Such integration of local knowledge will help in foregrounding place-based sustainability models.

ii. Finally, there is the need for the government to have a plan action of mitigation and adaption measures in place and to provide a legal frame work for their adoption.

REFERENCES

Abbas, I.I. An assessment of land use/land cover changes in a section of Niger Delta, Nigeria. *Frontiers in Science*, 2012, 2(6), 137-143.

Abubakar, M.M.; Kutama, A.S.; Suleiman, I.M.; Ringim, A.S. Impact of climate change on the Hadeja-Nguru Wetlands: A review. *Dutse Journal of Pure and Applied Sciences*, 2016), 2(1): 150-158.

Adepoju, K.; Viola, F.; Adelabu, S. Fashae, O. Vegetation Response to Recent Trends in Climate and Landuse Dynamics in a Typical Humid and Dry Tropical Region under Global Change. *Advances in Meteorology*, 2019, Volume 20 |Article ID 4946127, 15 pages. https://doi.org/10.1155/2019/4946127

Ajibola, M.O.; Adeleke, A.M.; Ogungbemi, O.A. An assessment of wetland loss in Lagos Metropolis, Nigeria. *Developing Country Studies*, 2016, 6(7),1-7.

Arooba, Z.; Sheikh, S.A. Land Cover Classification of Ucchali Wetlands Complex and Assessment of its Correlation with Temporal Climatic Changes. *Science, Technology and Development*, 2017, 36 (1), 17-29.

Barbier, E.B.; Thompson, J.R. The value of water: floodplain versus large-scale irrigation benefits in Northern Nigeria. Ambio, 1998, 27(6), 434-440.

Bird Life International. Important Bird Areas factsheet: Hadeja- Nguru wetlands. 2015.

Campos, J.C.; Sillero, N.B.; José C. Normalized difference water indexes have dissimilar performances in detecting seasonal and permanent water in the Sahara-Sahel transition zone. *Journal. Hydrology*, 2012, 464, 438–446.

Chen, Y.; Xu, Y.; Yin, Y. Impacts of land use change scenarios on storm-runoff generation in Xitiaoxi basin, China. *Quat. Int*. 2009, 208, 121–128.

Eaton, D.; Sarch, T.M. The economic importance of wild resources in the Hadeja-Nguru wetlands: Collaborative Research in the Economics of Environment and Development (CREED).-London (International Institute for Environment and Development) (No. 13). Working Paper., 1997, Pp 10-19.

Ehsa, D.; Farhad, T. Analytical Study on Threats to Wetland Ecosystems and their Solutions in the Framework of the Ramsar Convention. International. *Journal of Environmental and Ecological Engineering*, 2014, 8 (7), 2108-2118.

Emmanuel, J. The shrinking of the Wetland. The depletion of Hadeja Nguru Ramsar site, causes and implication from geophysical Approach. 2019.

Eric, F.L.; Jianchu, X. The causes of land-use and land-cover change: Moving beyond the myths. *Global environmental change*. 2011, Volume 2 issues 4, 2011.

Ezealor, A.U. Important Bird areas in Africa and associated islands. Report by Nigeria Conservation Foundation (NCF), Lagos, Nigeria., 2001, Pp 675-688.

Food and Agricultural organization (FAO). State of the World's Forest. FAO Forestry Paper No. 140. 2001, 84pp.

Food and Agricultural organization (FAO). Adaptation of forest ecosystems and the forest sector to climate change. Forests and Climate Change Working Paper No. 2, Rome, FAO/Swiss Agency for Development and cooperation. 2005.

Gauthier, G.; Giroux, J.F.; Reed, A.; Bechet, A.; Belanger, L. Interactions between land use, habitat use, and population increase in greater snow geese: what are the consequences for natural wetlands? *Glob. Change Biol*., 2005, 11 (6), 856–868.

Geist, H.J.; Lambin, E.F. Proximate causes and underlying forces of tropical deforestation. *Bioscience*, 2002, 52, 2:143–150.

Giannecchini, M.; .Twine, W.; Vogel, C. Land cover change and human environment interaction in a rural cultural landscape in South Africa. *The Geophysical Journal*, 2007, 173(1) 26-42.

Grundling, A.T.; Van den Berg, E.; Price, J.S. Assessing the distribution of wetlands over wet and dry periods and land-use change on the Maputo land

Coastal Plain, north-eastern KwaZulu-Natal, South Africa. *South African. Journal*., 2013, Geomatics. 2 (2), 120–138.

Hadeja Nguru Wetland Conservation Project (HNWCP), Dynamic of livelihood System and the resources base in the Hadeja-Nguru Wetlands. Submission to the renewable natural Resources (RNR). Sector Coordinator of the United Kingdom, Development (DFID) Kaduna by HNWCP-Nguru, July 1997.

Ikusemoran, M., Ezekiel, Y. Remotely Sensed Data and Geographic Information System Techniques for Monitoring the Shrinking Hadejia – Nguru Wetlands, Nigeria., 2011.

Inuwa, K.B. Assessment of land use and land cover change in Nguru Part of Hadejia-Nguru Wetlands, Yobe State, Nigeria. M.Sc Thesis, Department of Geography, Unimaid, Nigeria., 2016, pp: 1-98.

Inuwa, K.B. Assessment of land use and land cover change in Nguru Part of Hadejia-Nguru Wetlands, Yobe State, Nigeria. M.Sc. Thesis, Department of Geography, Unimaid, Nigeria, 2016, pp: 1-98.

Joseph. S.; Ibrahim, N.M.; Raghavan, S.; John, B.; Venkat, L. Mapping Land Use Land Cover Change in the Lower Mekong Basin from 1997 to 2010. *Front. Environ. Sci*., 2020, 19 March 2020Sec. Land Use Dynamics Volume 8 - 2020 | https://doi.org/10.3389/fenvs.2020.00021

Lambin, E.F.; Geist, H.J.; Lepers, E. Dynamics of land-Use and Land-Cover change in tropical regions. *Annual. Review. Environmental Resources*., 2003, 28:205–41doi: 10.1146/annurev.energy.28.050302.105459Copyrightc∞ 2003 by Annual Reviews. All rights reserved first published online as a Review in Advance on July 16, 2003

Lambin, E.F.; Geist, H.J.; Lepers, E. Dynamics of land-use and land-cover change in tropical regions. Annual review of environment and resources, 2003, 28(1), 205-241.

Li, Q.; Cai, T.; Yu, M.; Lu, G.; Xie, W.; Bai, X. Investigation into the Impacts of Land-Use Change on Runoff Generation Characteristics in the Upper Huaihe River Basin, China. *J. Hydrol. Eng.*, 2013, 18, pp. 1464-1470.

Liang, S., Automatic land-cover update approach integrating interative training sample selection and a Markov Random Field model. *Remote Sens. Lett*. 2014, 5(2). 148–156.

Mundia, C.N.; Aniya, M. Dynamics of land use/cover changes and degradation of Nairobi city, Kenya. Land degradation and development, 2006, volume 17, issue 1.pp-97

Mundia, C.N.; Aniya, M. Dynamics of landuse/cover changes and degradation of Nairobi city, Kenya. 2006, Land degradation and development volume 17, issue 1.pp-97.

Obang, O.O.; Sintayu, L.G.; Dessalegn, O.G. Analyzing the rate of land use and land cover change and determining the causes of forest cover change in Gog District, Gambella Regional State, Ethiopia. *Journal of remote sensing and GIS,* 2017.

Oduntan, O.O.; Akinyemi, A.F., Adetoro, A.O.; Osunsina, I.O.O. Seasonal availability of farmland and its contribution in wildbirds-landuse conflicts in Hadejia-Nguru wetlands, Nigeria. *African Journal of Agriculture*, 2010, 6:3, 131-137.

Ogunkoya, O.O.; Dami, A. Information Sheet on Ramsar Wetlands (RIS) – 2006-2008 version: Dagona Sanctuary Lake, Hadejia-Nguru wetlands. Annual report submitted to Ramsar. Gland, Switzerland, 2007.

Panel, H.W.; Xiong, X.; Kehuan, W.; Xin, L.; Hongjuan H.; Quanliang, L.; Hengqing, Y.; Chenxi, W. The effects of land use on water quality of alpine rivers: A case study in Qilian Mountain, China. Science total environment, 2023, volume 875, 2023162696.https://doi.org/10.j.scitotenv.2023.162696.

Paré, S. Land use dynamics, tree diversity and local perception of dry forest decline in southern Burkina Faso, West Africa. Land Use Dynamics, Tree. Faculty of Forest Sciences Department of Forest Genetics and Plant Physiology Umeå Doctoral Thesis Swedish University of Agricultural Sciences, 2008.

Ramsar. The Ramsar Convection on Wetlands; Convention on wetlands of international importance‘s especially waterfowl‘s habitat, Paris. 13 July 1994. Ramsar convection secretariat, Gland, Switzerland.

Sanyu. The study of the National Water Resources Master Plan. Sanyu Consultants Inc. For Japan International Cooperation Agency., 1994., Science, Technology and Development 36 (1), pp. 17-29.

Sebastiá, M.T.; Rodilla, M.; Sanchis, J.A.; Altur, V.; Gadea, I.; Falco, S. Influence of nutrient inputs from a wetland dominated by agriculture on the phytoplankton community in a shallow harbour at the Spanish Mediterranean coast. *Agric. Ecosystem. Environment*, 2012, 152, pp. 10–20.

Tadesse, W.; Whitaker, S.; Crosson, W.; Wilson, C.. Assessing the Impact of Land-Use Land-Cover Change on Stream Water and Sediment Yields at a Watershed Level Using SWAT. *Open Journal*. *Mod. Hydrol.*, 2012, 2015, 5, 68.

Tijjani, M.N.; Adekoya, A.E.; Fashae, O.A.; Tijjani, S.A.; Aladejana, J.A. Land-Use Changes and Urbanization Impacts on Livelihood and Groundwater Sustainability of Coastal Areas of Lagos, SW-Nigeria: Integrated GIS-based, Livelihood and Hydro chemical Assessments. *Journal of Mining and Geology*, 2018, 54(2) 2018, 187– 202

Uluocha, N.O.; Okeke, I.C. Implications of wetlands degradation for water resources management: Lessons from Nigeria. *Geo Journal*, 2004, 61, 151-154.

Umar, I.A.; Yaduma, Z.B.; Dishan, E.E.; Adaeze, J.E. Land cover Change of Gashaka Gumti National Park within 21 Years Window (1991 to 2011) Using Satellite Imageries. *Open Access Library Journal*, 2019, Volume 6, e5750. ISSN Online: 2333-9721. ISSN Print: 2333-9705 DOI: 10.4236/oalib.1105750 Sep. 26, 2019 1

Woldesenbet, T.A.; Elagib, N.; Ribbe, L.; Heinrich, J. Hydrological responses to land use/cover changes in the source region of the Upper Blue Nile Basin, Ethiopia. Science of the Total Environment., 2017, 575. 724-741. 10.1016/j.scitotenv.2016.09.124.

Zaitunnah, A.; Samsuri, Ahmad, A. G.; Safitri, R.A. Normalized differences Vegetation index. Analysis for land cover type using landsat. IOP Publishing Conference series earth and environmental science, 2018, 126.