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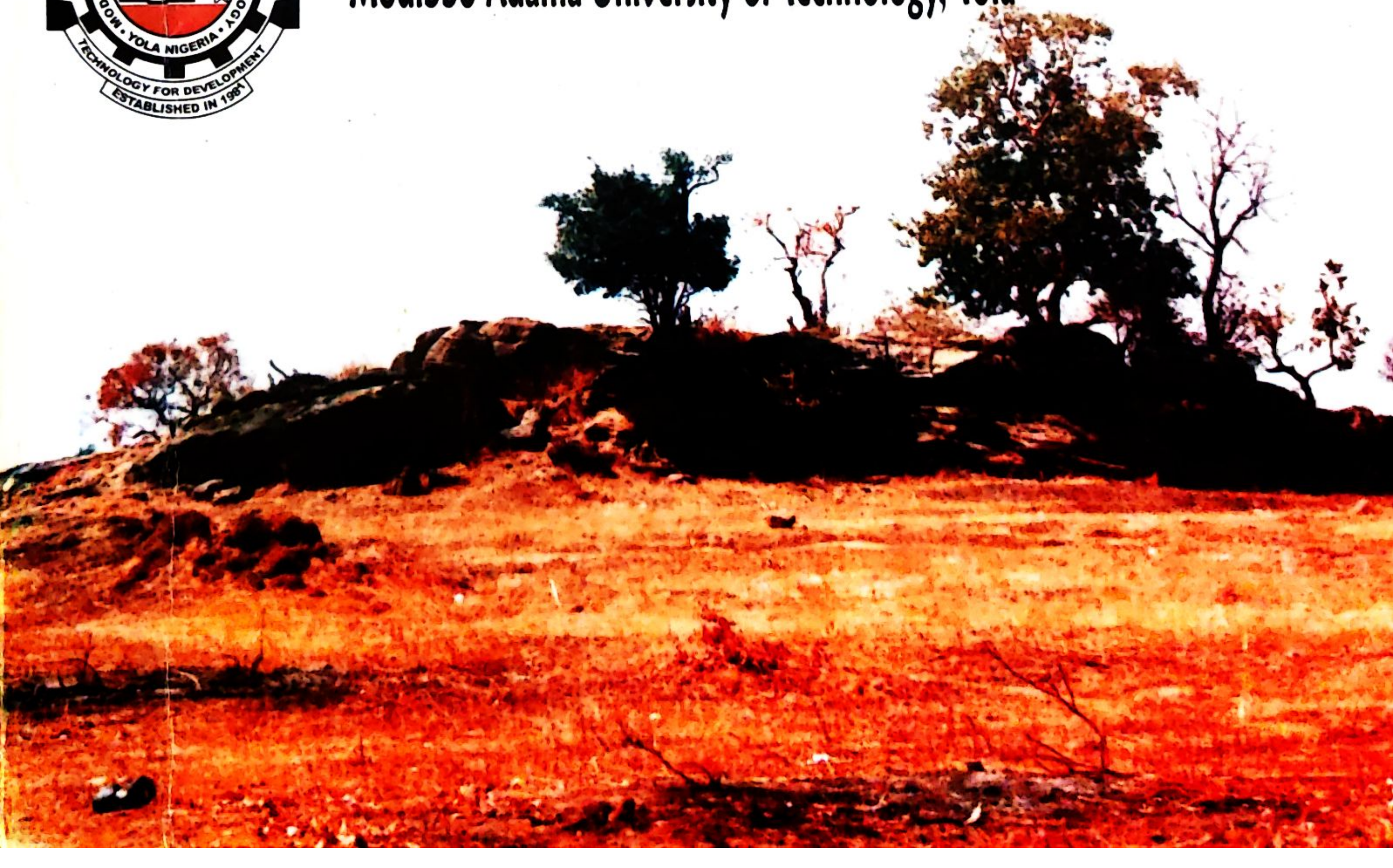

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Landuse Landcover Dynamics and Sustainability of Wetland Downstream of the Hydroelectric Dams, Niger State, Nigeria

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Abstract

The concentration of human settlement and socio-economic activities across wetland ecosystems has continued to intensify land use land cover (LULC) changes thereby, aggravating its exposure, susceptibility to flood hazard which have continued to threaten rural livelihood. Gurmana, Akare, Ketso and Nupeko in Shiroro, Wushishi, Mokwa and Lavun local government areas (LGAs) respectively were sampled for the research. These locations are the most vulnerable communities downstream of the hydroelectric dams. Landsat Enhanced Thematic Mapper (ETM) 2006, Landsat- 8 Operational Land Imager (OLI) –2016 optical imageries and Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) were analysed and imported into geospatial database for integration. Change detection affirmed vegetation degradation across the study area between 2006 and 2016. Vegetation cover and surface water declined while bare ground, built-up areas and agricultural lands increased. Similarly NDVI of 2006 and 2016 shows vegetation degradation in response to increase in built-up and agriculture earlier observed. The DEM map signals high vulnerability risk levels to the downstream communities. The suitability map showed that large proportion of the wetland agriculture is threatened. It is suggested that geospatial information can be incorporated with climatic data for developing proactive strategies that will enhance community capacity to live sustainably with risk through adaptation and management techniques.

Keywords: Ecosystem, Economic diversification, Vulnerability, Proactive Strategies and Sustainability

INTRODUCTION

Intensification of land conversion for agriculture is accelerating land use land cover (LULC) change with its consequential impact on 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, 2004). Agricultural intensification in response to government 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 wide range of pressures affect these ecosystems and alter the quality and quantity of water. The increasing pressure on ecosystem and the consequential land degradation is intensifying runoff, siltation of river channels and flood events.

The wetland ecosystems in the country serve as direct and indirect pool of resources for the population that derive maximum benefits from exploitation of these essential resources for socio economic and sustainable livelihood. Ehsan and Farhad (2014) described wetland 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 which alter "critical" parameters of the environment (Aristeidis *et al.*, 2011). These alterations incorporate the greatest environmental concerns of human populations in recent time 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 primary focus of most developing nations.

The concentration of human settlement and socio-economic activities across the wetland ecosystem has continued to intensify land and vegetation degradation thereby, aggravating its exposure and susceptibility to flood hazard. Changes in land-use, water-use and climate can all impact wetland function and services (Josefin, *et al*, 2017). Identification of riverine wetland ecosystem LULC dynamics and sustainability challenges downstream may depict effective management strategies and measures for improved rural livelihood. Characteristics of the built environment and overall local level landuse patterns are increasingly being attributed to greater surface runoff, flooding and resulting economic losses from flood events (Samuel *et al*, 2014). Rogger *et al.* (2017) observed that land use change potentially has a very strong effect on floods as humans have heavily modified natural landscapes. Risk analysis provides a rational basis for flood management decision-making at national, regional and local scales.

Igbokwe (2010) opined that land cover and land use information should form part of the environmental data, which are kept in the form of inventories/infrastructures in many advanced and emerging economies. The rapid changes in the landuse and cover driven by population increases across the riverine wetland ecosystem and its resultant effects necessitates the analysis and integration of data. This is to identify the changes and sustainability measures of this primary agriculture community that will guide local and regional policy for sustainable livelihood and attainment of food security.

Study Area

The current study cuts across Shiroro, Mokwa, Wushishi and Lavun Local Government Areas of Niger State within the most vulnerable communities downstream of the hydroelectric dams. These villages are Gurmana (10° 0'20.28"N, 6°37'47.46"E), Shiroro and Ketso centred at (8°58'55.83"N, 5°26'36.88"E) while Mokwa and Nupeko are centred at (8°46'30.30"N, 5°48'4.61"E) Lavun Local Government Areas of the State (figure 1). Niger State has dry and wet seasons and the annual rainfall varies from about 1,600mm in the south to 1,200mm in the north. The duration of the rainy season ranges from 150 to 180 days or more from the north to the south (Ayinde *et al.*, 2013).

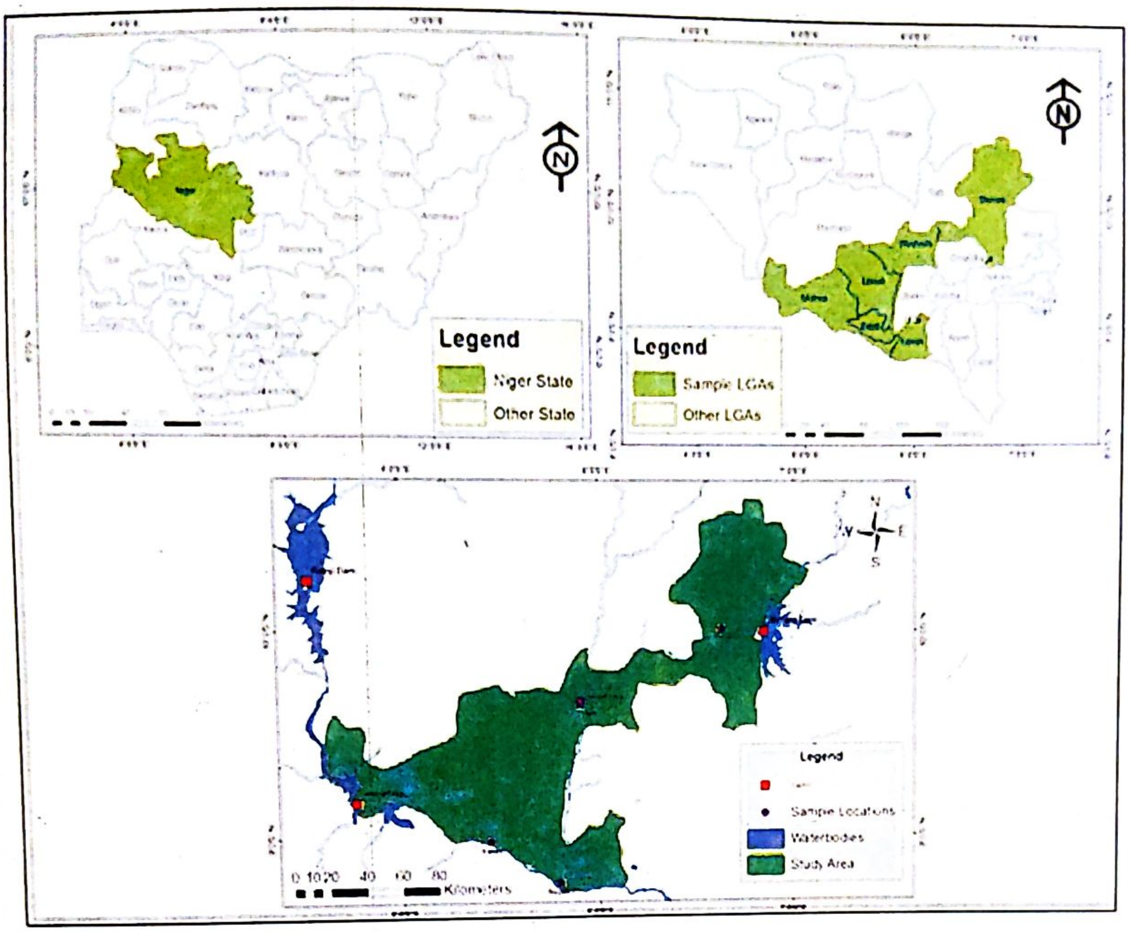

Figure 1: Location of the Study Areas in Niger State.

METHODOLOGY

Remotely sensed satellite imagery used includes; Landsat Enhanced Thematic Mapper (ETM+) 2006, Landsat- 8 Operational Land Imager (OLI) –2016, Shuttle Radar Topography Mission (SRTM) and Google Earth image covering the study area. GPS observations were used to collect coordinates of the study area. Satellite images and SRTM were subjected to radiometric, geometric correction and image enhancement for visual and digital analysis. The images were transformed to Normalized Difference Vegetation Index (NDVI) and image composite were used for land use land cover classification and were analyzed to determine varying levels of risk and vulnerability across the study area. Similarly, SRTM was transformed to Digital Elevation Model (DEM) and was filled using elevation data derived during field work in addition; the derived slope was classified into varying levels of risk. Hierarchical classification scheme was used with six (6) major land cover classes adopted for development of training sites for the supervised classification. It's necessary to synchronize the LULC legends with global standards (Bajracharya *et al.* 2010).

Several methods are used for testing the overall accuracy (i.e. producer's and user's accuracy) and Weiqi *et al.* (2009) used the Kappa coefficient. Thus, coefficient of agreement between classified image data and ground reference data was calculated using Kappa statistics. NDVI was used to determined biomass dynamic between 2006 and 2016. A geospatial database was developed for the integration of the classified variables; land use, land cover, and slope to produce the wetland risk and suitability map.

RESULTS AND DISCUSSION

The LULC map of the study area reveals increase human activities and land use change as evident in 2006 and 2016 image (Figure 2 and 3). There was more vegetative cover in 2006 particularly across the central areas that constitute lower and moderate terrain. In addition, the sampled locations show dominance of agricultural activities across the wetland ecosystem. This is obvious across Nupeko, Akare and Gurmana communities. The study reveals increment of agricultural land and decline of vegetative areas. The old Akare settlement is now taken over by agriculture while the built area of new Akare is apparent very close to Chiji village. There is also increase in bare grounds across the study area, an indication of land degradation that has the potential of generally aggravating runoff and consequently flooding across the downstream communities.

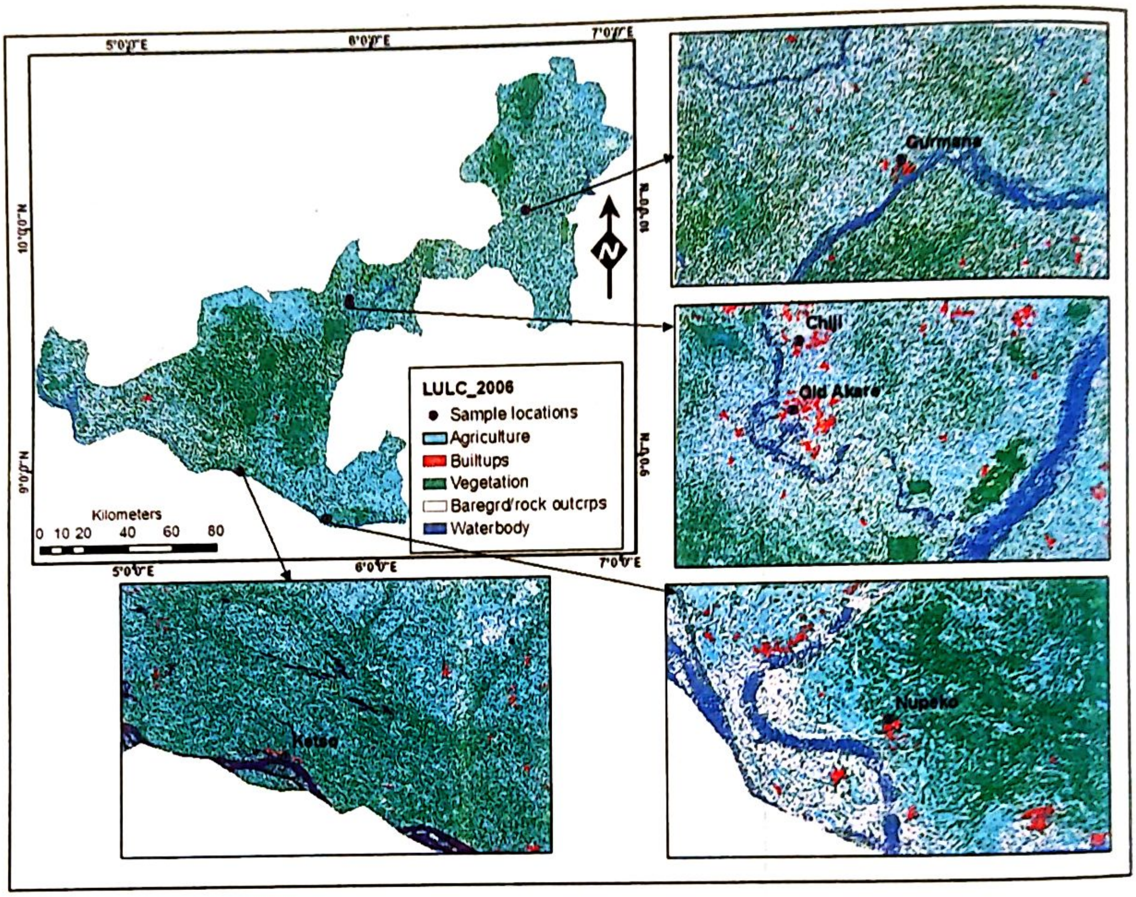

Figure 2: 2006 Land use classification.

The change analysis shows that vegetative land cover type covers about 6993.88km^2 in 2006 while in 2016 it covers only 4539.27 km^2 indicating percentage change of -15.49% (Table 1).

This was followed by agricultural land which covers 6889.47 km^2 in 2006 and extends to 8904.67 km^2 in 2016 revealing intensification of agricultural activities with about 12.71% across the study area. Bare ground and Built-up areas exhibited similar pattern while the water body declined. This is in agreement with (10) that identified increase competition for land, water, energy, and other inputs for food production. Generally vegetative cover declined from 44.14% to 28.65%, bare ground increased from 9.85%

to 12.65% with percentage increase of 2.84%, built-up from 0.10% to 0.17% and agricultural land increased from 43% to 56% while the water body declined from 2.43 to 2.31% (Table 9). All these affirmed degradations of wetland ecosystem which is potentially escalating flood.

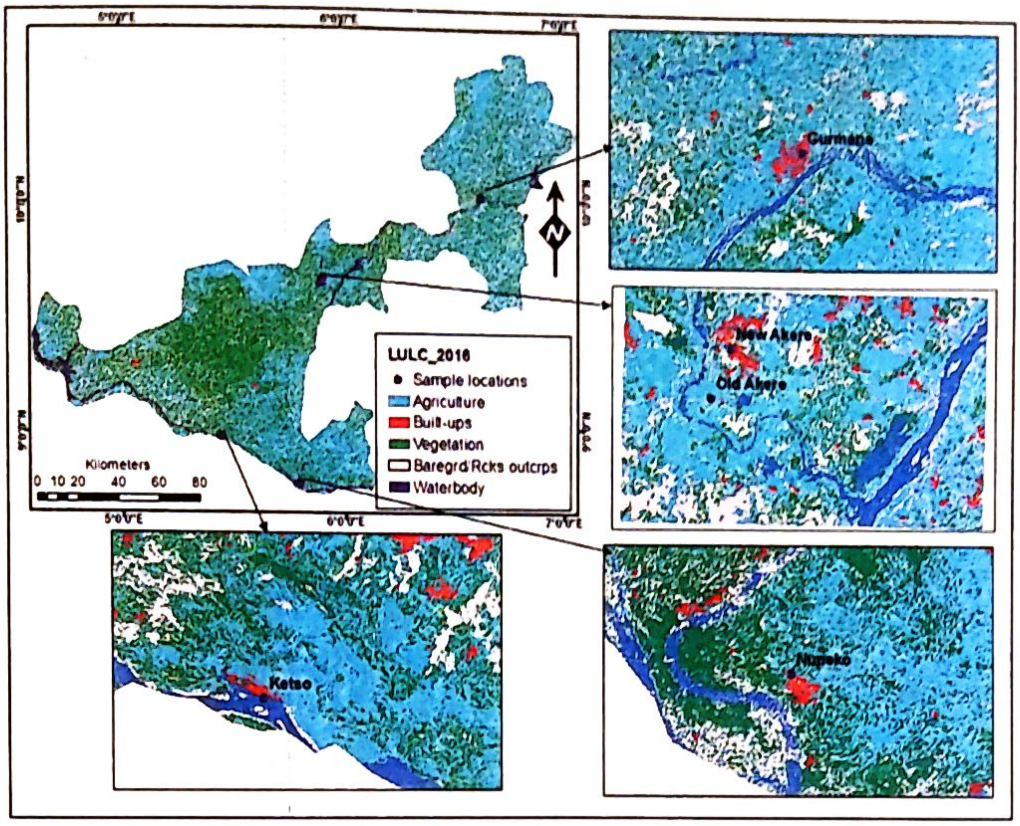

Figure 3: 2016 Land use classification

Table 1: Comparison of 2006 and 2016 Land use/ Land Cover (2006 -2016)

LULC Classes	2006		2016		% Change
	Area (Km^2)	(%)	Area (Km^2)	(%)	(%)
Agriculture	6889.47	43.48	8904.67	56.19	12.71
Vegetation	6993.88	44.14	4539.27	28.65	-15.49
Bareground/ RockOutcrops	1560.99	9.85	2010.15	12.69	2.84
Built-ups	16.54	0.10	26.78	0.17	0.07
Waterbody	385.28	2.43	365.29	2.31	-0.12
TOTAL	15846.16	100.00	15846.16	100	31.23

Analysis of 2006 NDVI

The NDVI visualized the vegetation reflectance and dynamics across the study area which varies from no vegetation to very high biomass across the study area (-0.97 to 0.97) in 2006 (Figure 4). The 2016 NDVI map revealed vegetation degradation across the study area; as vegetation values now range between -0.55- 0.54 compared to -0.97 to 0.97 values in 2006 (Figure 5). The water body, wetland ecosystem and built-up areas have the least biomass and this is attributed to increase human impact on the environment. This is generally aggravating runoff and subsequently flood across the study area with it attendant impact on livelihood.

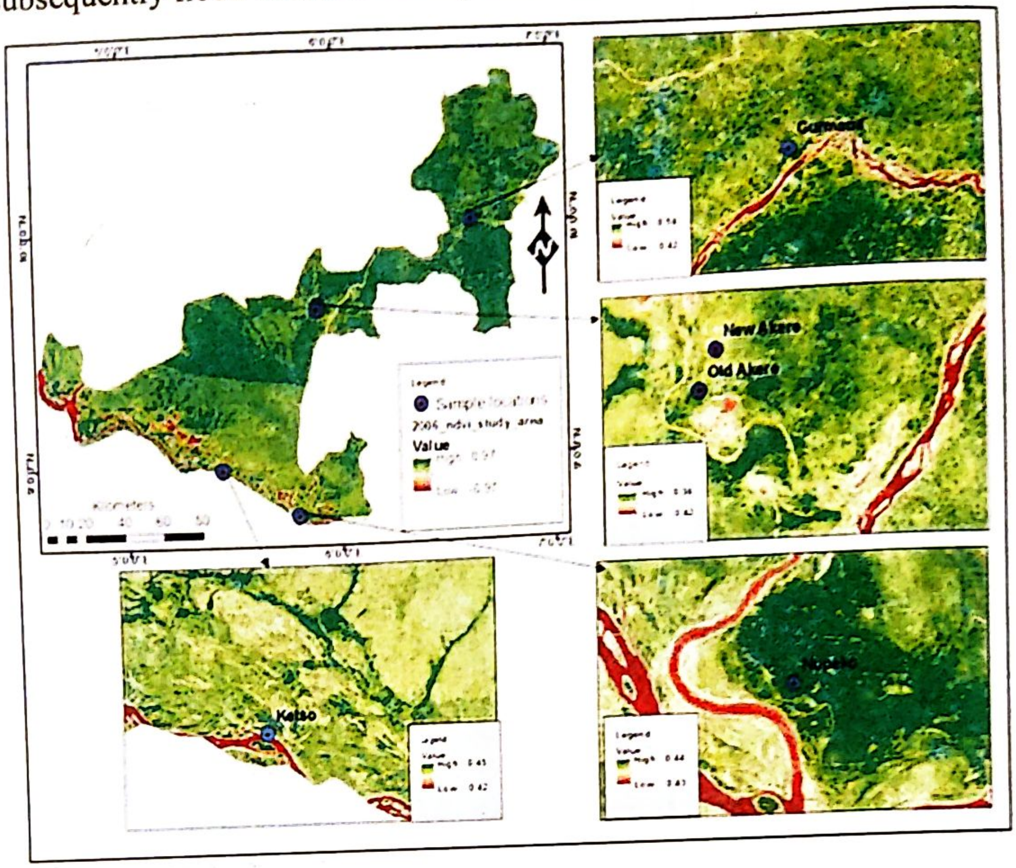

Figure 4: 2006 NDVI Maps

Digital Elevation Model (DEM) of the Study Area

The DEM of the study area ranges from very low elevation to areas of high elevation as shown on figure 6. The general DEM map indicates that the elevation ranges between 32m to 370m above mean sea level. However, the lowest sample locations are Ketso (between 60-70m) above sea level and Nupeko as Akare community reside on moderate elevation (77m and above) while Gurmana is on a fairly high location above (200m) in the study area. These reveals the locational vulnerability of the communities.

Risk Map of the study area

The vulnerability map of the sampled locations using five classes show; Very high, High, Moderate, Low and No risk areas (Figure 7). The north eastern part is generally dominated with no risk and low risk areas; thus, Gurmana should generally be a low risk zones due to its terrain but the risk is intensified by vast wetland that surround the community to the West.

The southern areas comprising of Ketso and Nupeko communities are generally high risk and very high-risk zones while the central areas (Akare community) are on moderate risk zone but the risk is escalated by the backflow of River Kaduna that generally forces River Mariga to over flow its bank. As Arooba and Sheikh (2017) conclude that the situation requires concerted efforts instead of perfunctory actions for protection, conservation and minimization of unconstructive impact on this invaluable wetland ecosystem. Hence, there is need to identify the wetland ecosystem challenges and develop proactive sustainability measures for enhance economic diversification, growth, human livelihood and socio-economic development as pathway towards disaster risk reduction.

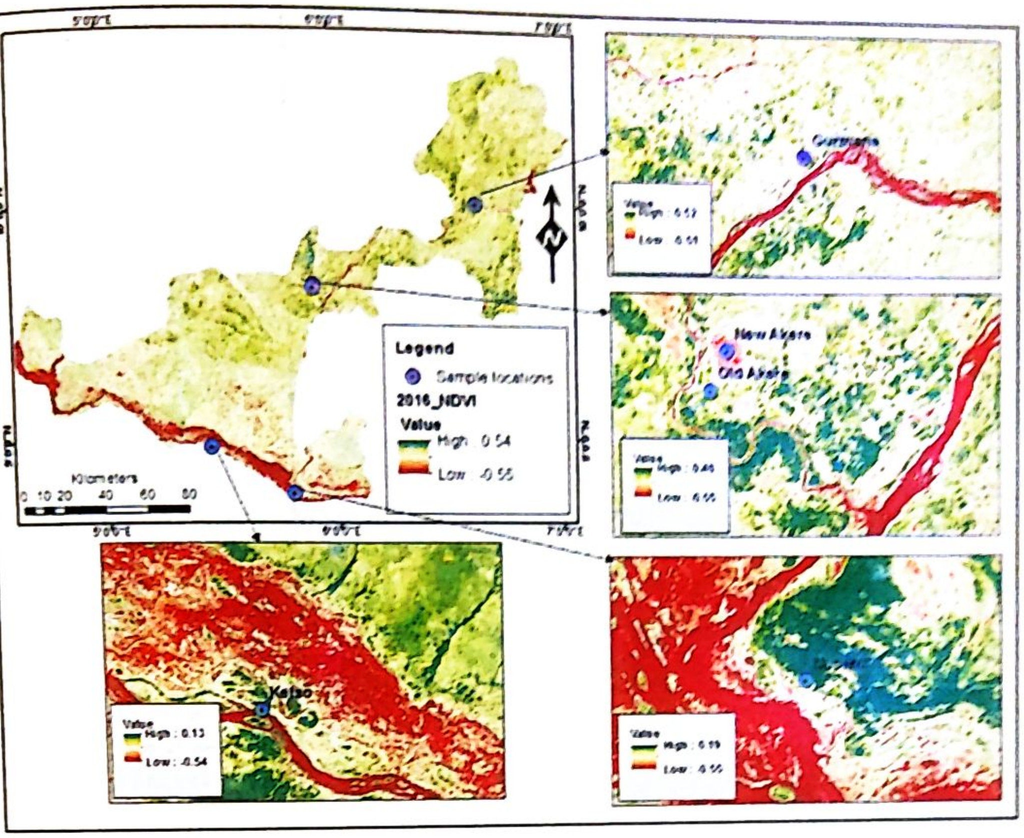

Figure 5: 2016 NDVI Maps

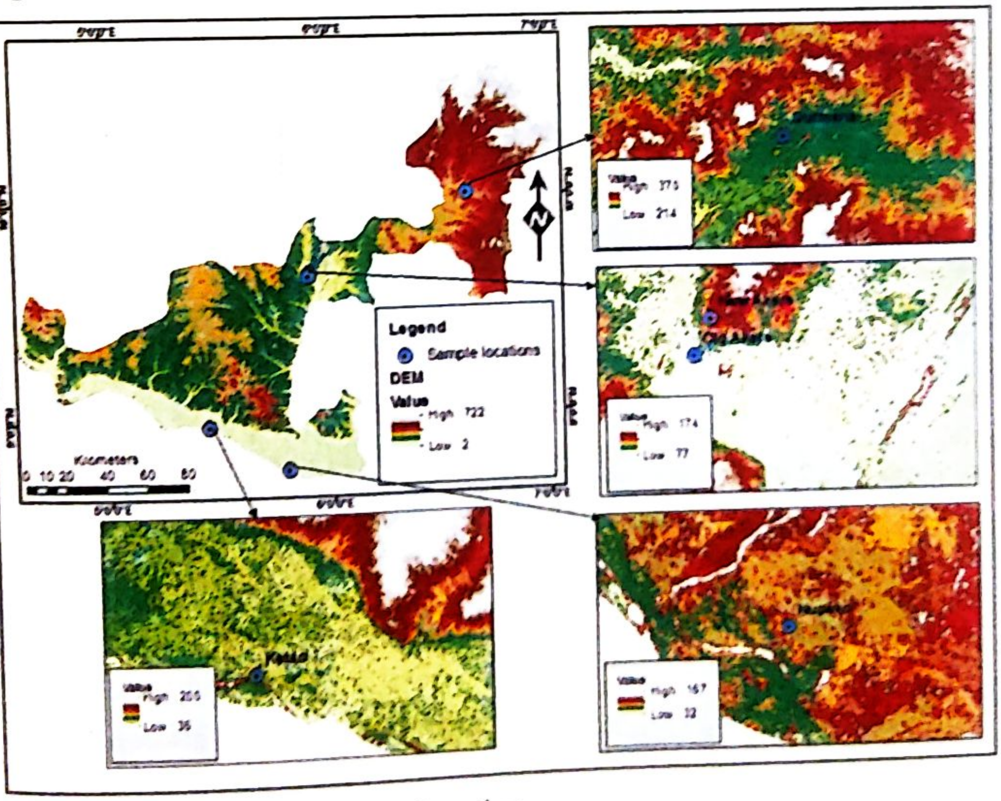

Figure 6: DEM of the sample location

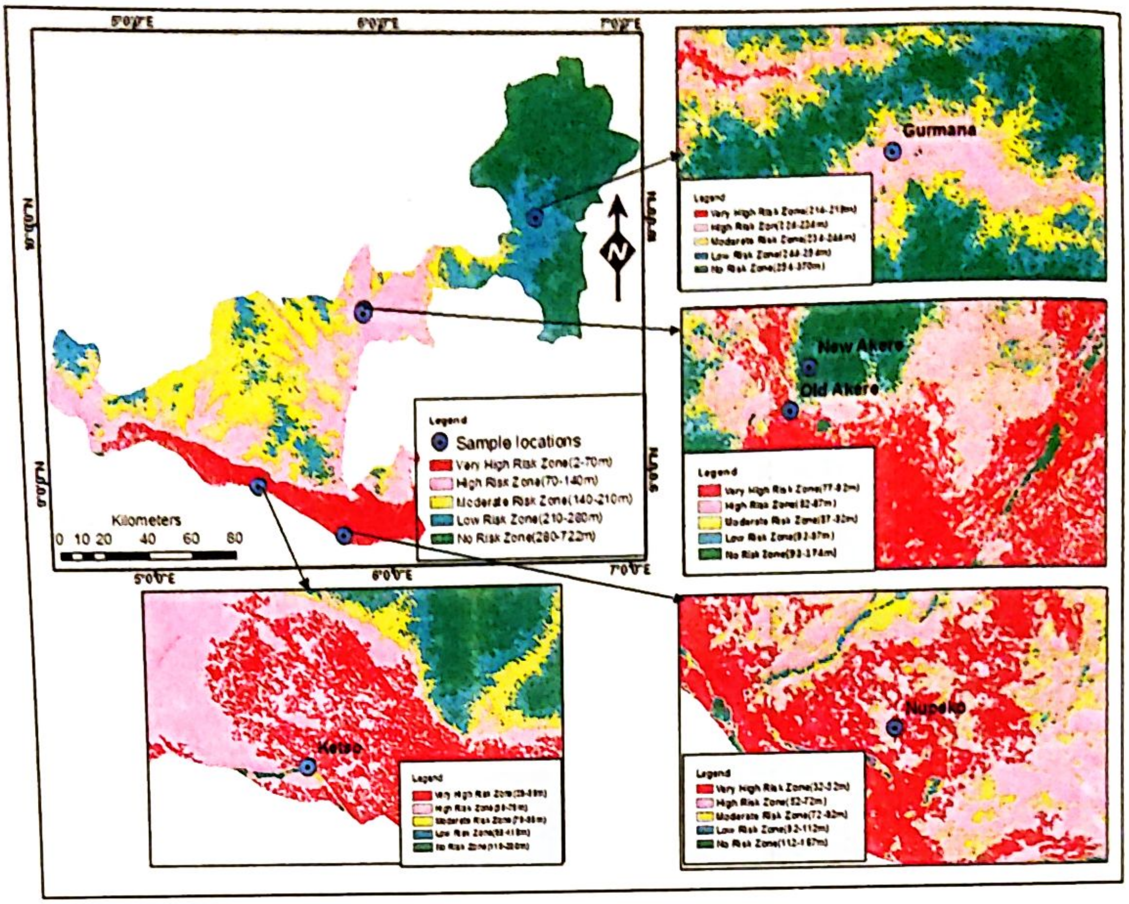

Figure 7: Flood vulnerability map

Specifically, in Gurmana community about 52.58% of the total area is on very high-risk areas, 13.89% high risk area, 11.51% moderate risk area and 15.67% are no risk areas. Similarly, 38.66% of the land in Akare is on very high-risk area, 27.5% high risk area, 9.85% moderate risk area while 4.26% low risk areas and 19.73% is no risk areas that now accommodate the new Akare. Additionally, in Ketso about 55.44% are on very high-risk, 38.39% high risk while 4.32% moderate risk areas, 1.4% low risk areas and 0.45% are no risk areas. Furthermore, in Nupeko, about 57.02% are on very high risk, 30.67% high risk areas, 8.43% moderate risk areas whereas 2.86% and 1.02% are low and no risk areas respectively.

This result unveils the high-level risk typical of the riverine communities; justifying the need for immediate proactive (environment-friendly and structural) action for enhanced resilience across the wetland communities. There is a need to identify the risk in flood-prone areas to support decisions for risk management, from high-level planning proposals to detailed design (Balica *et al.*, 2013).

Wetland Suitability Map

The suitability map shows that large proportion wetland is not suitable and thus the agricultural activities across the riverine wetland ecosystem is endanger (Figure 8). Hence, the need to develop proactive strategies that will enhance communities' capacity to live sustainably with risk; as flood risk can only be minimized and not entirely eliminated. Moreover, population is attracted to this zone because of the benefits derived from floods: improved soil fertility, employment opportunities, access to food and water, sustenance of aquatic and riparian ecosystems, as well as attainment of enhanced livelihood. As

Agbonkhese *et al.* (2014) concluded that Government from all level needs to shift from being reactive to being proactive in responding to flood menace. The very unsuitable zones are mainly water bodies which cannot be cultivated at all while the unsuitable and suitable zone can be cultivated successfully by adopting an effective cropping calendar and crop species.

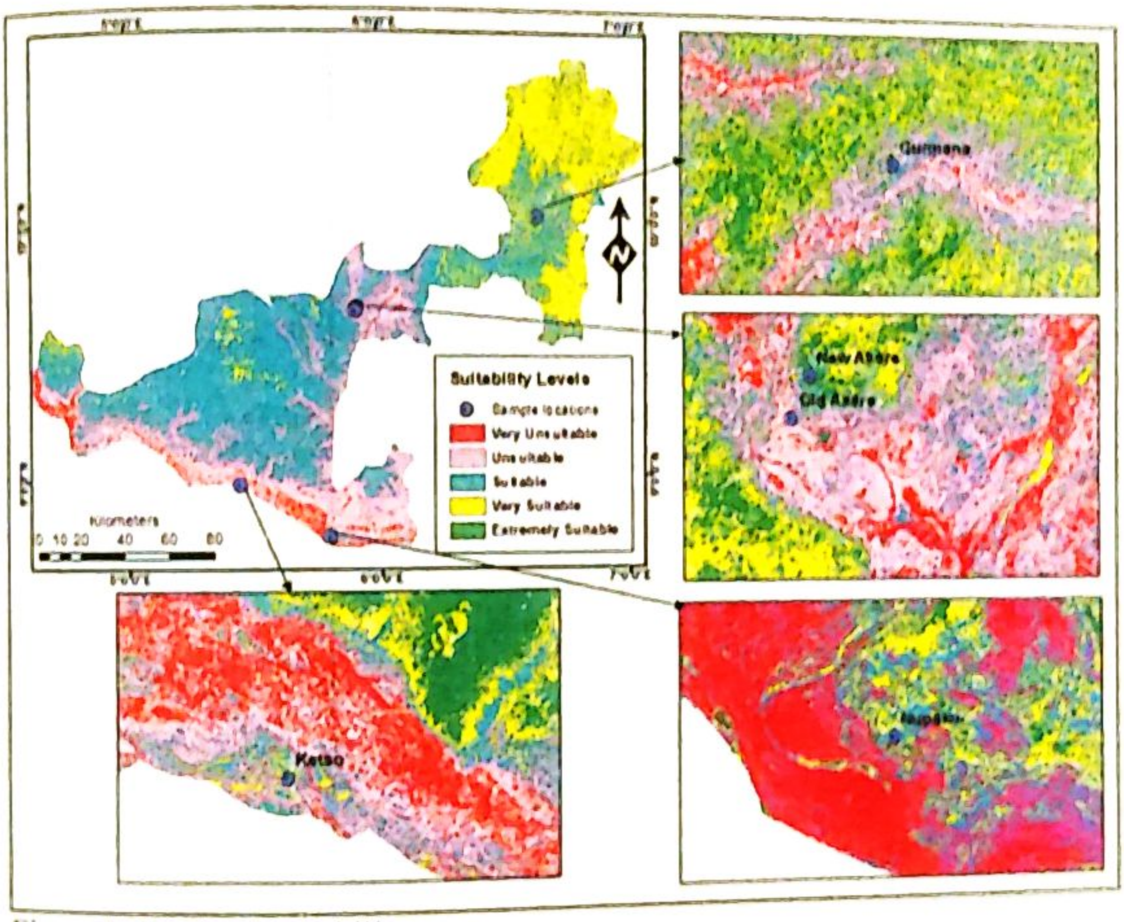

Figure 8: Wetland suitability map

Consequently, there is need to develop cropping calendar based on scientific findings for effective adaptation across the wetland ecosystem such that harvest is accomplish before the peak of rains that the farm lands will be flooded. Eco-friendly strategies that enhance flood resilience such as desilting of existing dams and river channels, sustainable landuse management practices; agroforestry, leaving crop residues on farm, development and adoption of improve early mature/flood resilient species, promotion of vegetable cultivation and dry season agriculture should be adopted for agricultural sustainability across the ecosystem.

CONCLUSION

The resultant land use land cover trend and slope of the riverine wetland ecosystem are fundamental non-climate drivers that are acting synergistically to threaten human livelihood across the wetland ecosystem. The risk levels across riverine wetland ecosystem signalled the high vulnerability of vital resources and socio-economic livelihood typical of the downstream communities. The developed suitability map showed that large proportion of the wetland ecosystem are threaten by flood and thus not suitable. This can be used by the Local Government Areas, extension workers and communities to prepare flood mitigation, adaptation and early warning schemes for enhanced resilience as path way towards disaster risk reduction and enhanced livelihood.

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