Climate Variability, Wetland Dynamics and Challenges for Sustainable Livelihood Downstream of Jebba Hydroelectricity Dam, Nigeria

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ABSTRACT

The wetland ecosystem downstream of Jebba dam across Niger State are changing rapidly, raising the concern for the wetlands' health and the sustainability of communities that rely upon its services. Land use land cover dynamic were analyzed using remote sensing satellite images (1986-2016) in order to map the land cover changes, Climate variability and trend were analyzed using Satellite grid-based Climatic data (total precipitation and temperature) record of (1979 to 2016) with Mann-Kendall trend test analysis used to determine the annual trends in the variables at 5% significance level. The land use land cover results generally revealed decreasing trends in wetland cover from 1986 to 2016 (2960.75Km^2 to 2234.39Km^2) while the resultant Mann-Kendall trend test for the temperature records indicate statistically significant increase in trend (1979-2016) of 0.029^{0}c per year except from (1979 to 2016) that shows statistically insignificant positive trend while the total precipitation indicates statistically decreasing trend (1979-2016) of 8.94mm per year except from (1979-1997) that shows statistically significant increasing trend. By implication, the identified decline in wetland ecosystem, coupled with increasing temperature and decreasing moisture content necessitates the need for the development of proactive strategies for management, restoration and sustainability of the crucial ecosystem.

Keywords: Wetland, Climate Change, Sustainability, RS and GIS

1. Introduction

Wetlands are areas where water is the primary factor controlling the environment and its associated plants and animal life (Finlayso, 2012). These are one of the crucial natural resources, which are transitional areas of land that are either temporarily or permanently covered with water. Wetlands play a vital role in the sustenance of people's livelihoods. According to Rajinkanth and Ramachadra (2006), more than three billion people, around half of the world population, obtains their basic water needs from inland freshwater wetlands. In some part of the world, such as Asia, as they are even created by humans as large number of people across this community relies on rice as staple food.

Globally, wetlands only constitutes 6.2% - 7.6% of the Earth's land surface of which 2% is lakes, 30% bogs, 26% fens, 20% swamps and 15% flood plains (Lehner & Doll, 2004), but they provide human populations with a host of goods and services, including water quality maintenance, agricultural production, fisheries, and recreation. They play an integral role in the ecosystem functioning in terms of minimizing floods, moderating change, recharging groundwater, and provision of habitat to diverse flora and fauna (Zorrilla et al., 2014) but this ecosystem is deteriorated greatly thereby threatening the sustainability of relevant socio-economic sector and human livelihood. Nigeria is blessed with abundant wetland which covers 28,000km^2 i.e. about 3% of the 923,770km^2 total surface area of the country (Uluoocha & Okeke, 2004) and 11 Ramsar designated wetlands sites covering about 10,700km^2 (Adekola et al., 2012). These wetlands contribute about 56% of Nigeria's food supply, while upland and other domestic production contribute 33.4 and 10.3% respectively (Abocho, 2014). Indeed, the River Niger floodplains wetlands are presently only marginally used, but have untapped benefits in terms of higher economic returns from agricultural production among others.

However, for a long time, wetland is considered as a land area surrounded by water with little economic importance. People thought it was only habitat for hydrophytes and insects by neglecting the importance of wetlands in the whole ecosystem (Shi et al., 2013). Wetlands are among one of the land uses on which tremendous change take place. The quality and size of wetlands of the world have been changing overtime following the outcome of agro-pastoral activities such as farming, cattle rearing, urban use, and affected by natural factors like drought (Ndezeidze *et al.,* 2008).

Therefore, this study focuses on climate variability and land-use dynamics on the inland wetland ecosystems downstream of Jebba hydrological dams, Niger State.

2. Materials and Methods

The study was carried out on the Lower Kaduna-Middle Niger Floodplain, downstream of Jebba Hydrological dam, Niger State (Fig. 1). It lies within Longitude $4^{0}40'$ to $6^{0}10'$ East of Greenwich Meridian and Latitude $8^{0}45'$ to $9^{0}45'$ North of the Equator with a total area of about 869,384.77ha. It has an annual total rainfall of about 1500mm with single rainfall maxima in September and temperature ranges from 24^{0}c -29^{0}c.

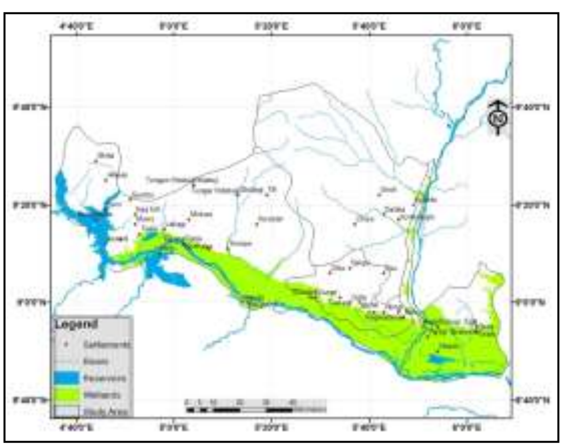

Fig. 1: Location of the Study Area

LandSat 4-5 Thematic Mapper (TM) – 1986 & 1997, LandSat-7 Enhanced Thematic Mapper (ETM^{+}) -2006 and LandSat- 8 Operational Land Imager (OLI) – 2016 were used in this study. The imageries served as the main data used in generating land use/ landcover maps using supervised maximum likelihood classification algorithm with six land covers (Wetland, forest, water body, built-ups, agriculture and bare ground) classes in the Arc GIS Software. Satellite grid-based climatic data (daily air temperature and total precipitation) from 1979 to 2016 were downloaded from ERA (European Reanalysis) Interim website and analysed using non-parametric Mann-Kendall trend test to determine the nature of the trend (Mamtimin, *et al.,* 2011). Finally, the spatial distribution maps of temperature and rainfall was produced using the Kriging spatial interpolation tools in the Arc GIS software environment (Yitea, 2012).

3. Results and Discussions

From the various spatial temporal analyses of the categorical land use and landcover maps of the ecosystem, it is obvious that the land use has been changing in size noticeably over the years (Fig. 2). The greatest change occurred in 1997 and 2016 with year 2016 showing the most drastic change. Using the 1986 map as the bench mark for comparison, Built-up was observed to have increased indiscriminately in all the years. The increase in built-up area was observed more between 1986 and 2016. Agriculture land in the area has also increased drastically from 21.30% in 1986 to 36.14% in 2016 which signifies significant agriculture expansion. The forest cover was also observed to have decreased from 34.61% in 2006 to 28.43% of the total area in 2016. The increase of farmland and the apparent decrease in forest and wetland cover area is similar to the findings of Braimoh and Vlek (2005) affirmed that land-cover change leads to loss of forests as a result of agricultural expansion. It is rightly observed from the maps, most places identified as wetland in1986 were observed to be taking over by other land use especially agriculture which is traceable to poorly implemented LULC management in the study scale.

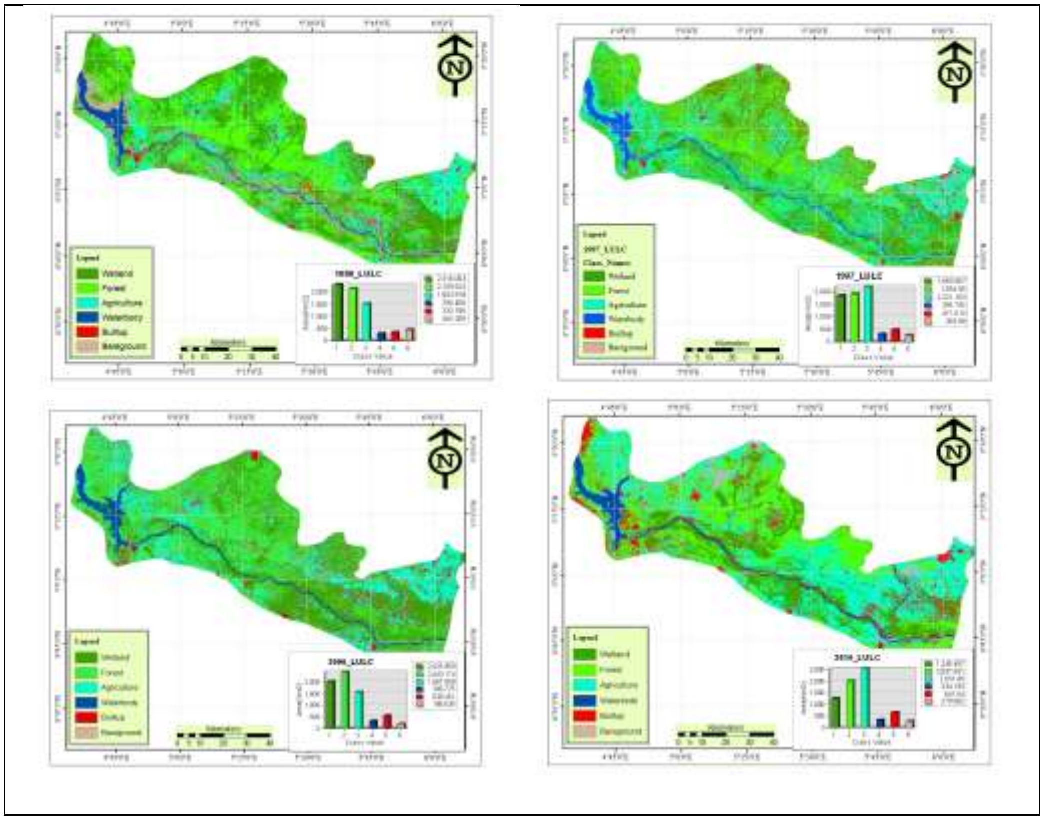

Fig 2: LULC Classification Maps (1986, 1997, 2006 and 2016).

The Mann-Kendal trend of temperature revealed that from 1979 to 2016 with the p-value of **<** 0.0001 (less than alpha=0.05) suggesting an increase in temperature trend which is statistically significant as it was evidenced from the sen's slope value of 0.032 (Table 1) while the time series of the trend has been on the increase by 0.029^{0}c and fluctuating over years, with the mid 80s and 1992 showing a sharp decrease to 26^{0}c below average (Fig. 3). The increase in temperature is capable of increasing evaporation rate and precipitation which might increase flooding potentials thereby causing destruction and washing away of agricultural land as well as affecting the natural balance of the wetland ecosystem. This conforms to the findings of Winter (2000) that wetlands are vulnerable to climate change mainly (air temperature and precipitation) is dependent on how water recharge and discharge, and how associated wetland water balance response to these changes.

Similarly, fig. 4 shows the spatio-temporal variation in temperature from 1979-2016 with the highest temperature value of 27.89^{0}C in the north central part of the study area and with lowest value of 27.18^{0}C along the river course in the southern part.

Table 1: Mann-kendall trend test of Temperature

	Mann Kendall Test						
Temperature	Mann Kendall Statistic (S)	Kendall's Tau	Variance (S)	Sen's slope	p-value (two-tailed test)	alpha	Test Interpretation
1979-1986	-18	-0.643	65	-0.087	**0.035**	0.05	Reject Ho
1986-1997	-16	-0.242	213	-0.039	**0.304**	0.05	Accept Ho

1997-2006	19	0.422	125	0.069	**0.107**	0.05	Accept Ho
2006-2016	15	0.273	165	0.025	**0.276**	0.05	Accept Ho
1979-2016	353	0.502	6327	0.032	**< 0.0001**	0.05	Reject Ho

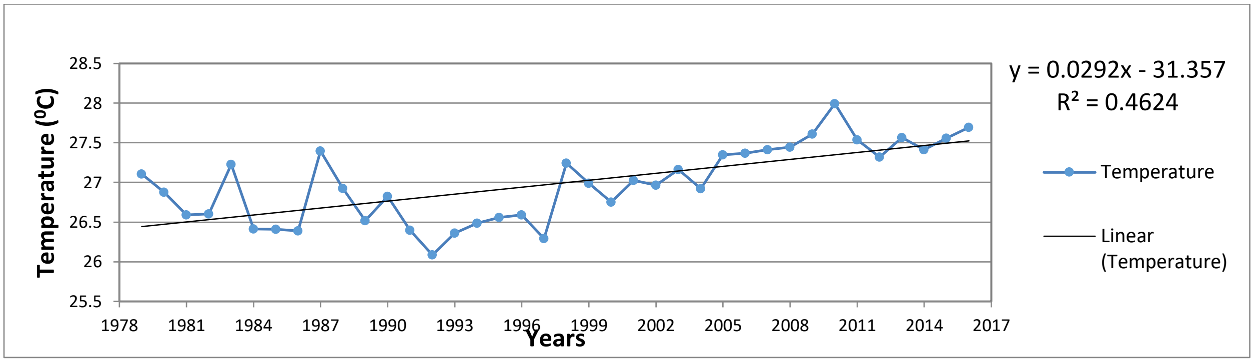

Fig. 3: Mean annual temperature trend

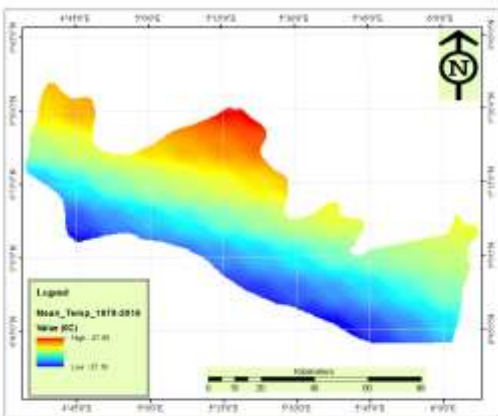

Fig. 4: Mean annual spatial temperature distribution map

While the Mann-Kendall trend test for rainfall over the study area revealed that from 1979 to 2016 with p- value of 0.37 (greater than alpha=0.05) suggesting a decrease in rainfall trend though not statistically significant as it was evidenced from the sens slope value of -9.458 while between 1979 to 1997 with p-value of 0.025 (less than alpha=0.05) suggesting an increased in rainfall trend which is statistically significant as shown in table 2 and time series of decreasing trend of 8.94mm over the years (Fig.5). Furthermore, the spatio-temporal variation in rainfall revealed areas with the highest rainfall value of 1683.11mm are in the southeastern part of the study area and with lowest value of 1270.01mm in the northwestern part (Fig. 6).

Table 2: Mann-kendall trend test of Rainfall

	Mann Kendall Test						
Rainfall	Mann Kendall Statistic (S)	Kendall's Tau	Variance (S)	Sen's slope	p-value (two-tailed test)	alpha	Test Interpretation
1979-1986	0.000	0.000	65.333	1.082	**1**	0.05	Accept Ho
1986-1997	22	0.333	212	39.966	**0.150**	0.05	Accept Ho
1997-2006	13	0.289	125	30.029	**0.283**	0.05	Accept Ho
2006-2016	-3	-0.055	165	-4.336	**0.876**	0.05	Accept Ho
1979-2016	-167	-0.238	6327	-9.458	**0.037**	0.05	Reject Ho

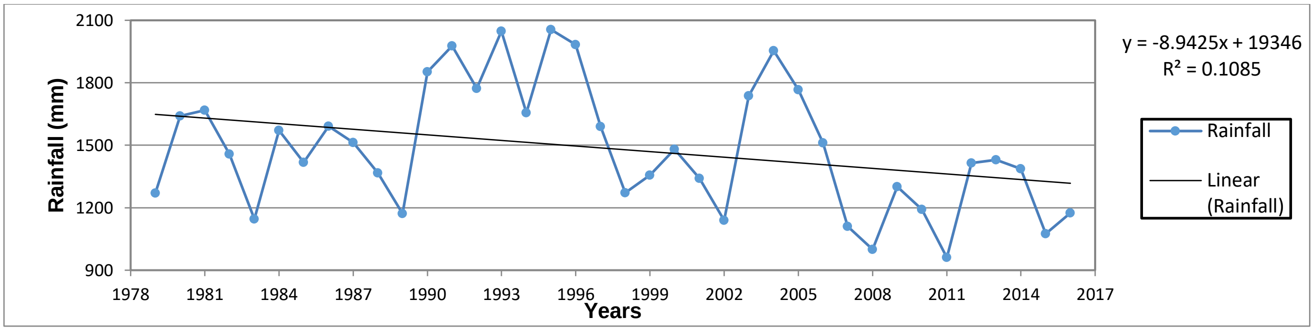

Fig. 5: Mean annual temperature trend

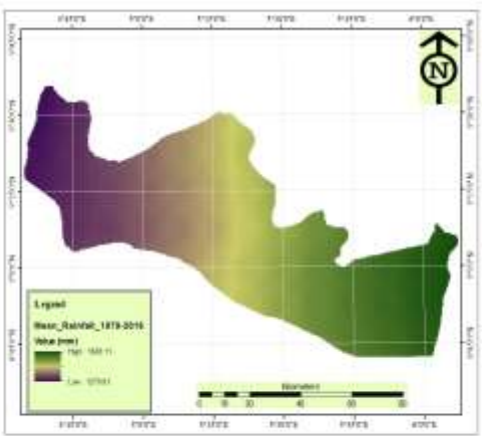

Fig. 6: Mean annual spatial temperature distribution map

4. Conclusion

The study has highlighted the LULC patterns from 1986 to 2016 with major transformation occurring within wetland category and significant increase in agricultural land use. While temperature shows an increase in trend and rainfall decreases in trend. However, the continued warming without corresponding precipitation increase may expose the wetland ecosystem to potential degradation. Therefore, there is need to put in place right policies to protect and preserve wetland to enhance its sustainability and resilience to climate change and variability.

References

Braimoh, A., & Vlek, P. (2005). Land-cover change trajectories in northern Ghana. *Environmental management*, 36(3), 356-373.

Finlayson, C.M. (2012). Forty years of wetland conservation and wise use. Aquatic Conservation: Marine and Freshwater Ecosystems 22: 139–143.

Junk, W.J., An, S., Finlayson, C.M., Gopal, B., Květ, J., Mitchell, S.A., Mitsch, W.J., & Robarts, R.D. (2012). Current state of knowledge regarding the world's wetlands and their future under global Climate Change: A synthesis. Aquat. Sci., 75, 151–167

Lehner, B., & Doll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. J Hydrol. 296:1_22.

Mamtimin, B., Et-Tantawi, A.M.M., Schaefer, D., Meixner, F.X., & Domroes, M. (2011). Recent Trends of Temperature change under hot and cold desert climates: Comparing the Sahara (Libya) and Central Asia (Xinjiang, China). Journal of arid environments, 75(11), 1105-1113.

Ndzeidze, S. (2008). Detecting changes in wetland: Using Multi-Spectral and Temporal Landsat in the Upper Noun valley Drainage Basin-Cameroon.

Shi, Y. (2013). A remote sensing and GIS based wetland analysis in Canaan valley, West Virginia. http://mds.marshall.edu/etd

Solomon, S., Qin, D., Manning, M., Marquis, M., Averyt, K., Tignor, M. M. B., Miller, H. L. J., & Chen, Z. (2007). Climate Change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the intergovenmental panel on Climate Change.

Winter, T.C. (2000). The Vulnerability of Wetlands to Climate Change: A hydrologic landscape perspective. JAWR J. Am. Water Resource. Assoc. 36, 305-311.

Yitea, S. (2012). Spatio-temporal Analyses of Climate Elements, Vegetation Characteristics and Sea Surface Temperature Anomaly. Unpublished MSc Thesis in Geospatial Techniques, University of Erasmus Mundus, Netherlands.

Zorrilla, M.P., Palomo, B.E., Gomez, L.B., Martin, P.L., Lomas & Montes, C. (2014). Effects of land use change on wetland ecosystem services: A case study in the Donana Marshes (SW Spain). Landscape Urban Plan, 122: 160-174.