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FLOOD RISK ASSESSMENT, CLIMATE CHANGE ADAPTATIONS AND MITIGATION STRATEGIES OF COMMUNITIES IN EDO STATE, NIGERIA

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ABSTRACT

Despite flooding being one of the most common and destructive natural hazards, the risk it poses is systematically underestimated and still increasing due to climate change and growing concentrations of people and assets in flood-prone areas. The study carried out a flood risk assessment, climate adaptation and mitigation strategies of communities in Edo State, Nigeria. With the aid of questionnaires and GIS techniques, the flood risk level of communities within Edo states were analysed by capturing all the components of flood risk which include exposure and vulnerability. All analysis was carried out using descriptive statistics and Analytical Hierarchy Process (AHP) to determine the extent of the communities' flood. The extent of risk showed that 778 communities were captured in risk analysis, 503 (64.65%) of the communities were found within low flood risk level while 150 (19.28%) communities and 125 (16.07%) communities were found to be within medium and high flood risk level respectively. The climate variables showed some level of fluctuation while the adopted adaptation measures such as expansion of floodplain and wetlands was based on political will of administrators, and the measure was perceived less effective. There was high level of awareness about government mitigation measures in the area and the main mitigation measure by government is construction of drainage system which was perceived to be effective. It was therefore concluded that all the adopted attributes contributed to the establishment of flood risk of Edo State and was categories into high, medium and low flood risk level. Hence, there is need to intensify the planning and execution of disaster management programs with the support of the produced flood risk map.

Keywords: Flood Risk Assessment, Mitigation, Climate Change, Adaptation, Edo State.

1. INTRODUCTION

Devastating flood events in Nigeria can be dated back to 1963 in Ibadan city, when Ogunpa River was over-flown causing loss of lives and property; these hazardous events reoccurred in 1978, 1980 and 2011, with estimated damages and deaths of over 30 billion naira and 100 people respectively, thus making Ogunpa River nationally and internationally famous (Adegbola and Jolayemi, 2012; Agbola et al., 2012; Komolafe et al., 2015). The 2012 flood according to the National Emergency Management Agency (NEMA) affected 30 of the 36 States of Nigeria, 7 million peopled were affected in these States, 597, 476 houses were destroyed, 2.3 million displaced and 363 death were reported with large track of farmland and other means of livelihood destroyed, animals and other biodiversity were also gravely impacted upon (Amangabara & Obenade, 2015). In 2018, the National Emergency Management Agency

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(NEMA) announced that heavy rains across the country caused the Niger River and Benue River to overflow. According to the NEMA's report, 12 states were affected by floods, 4 states were declared under National Disaster (Niger, Kogi, Anambra and Delta), 441,251 people are affected and 108 casualties was reported (Joint Research Centre, 2018).

"Flood risk" can bear different definitions as it refers to natural disasters, depending on their adverse impacts on humans, lives, and the economy. However, flood risk can be discussed in terms of two elements: hazard and vulnerability (Safaripour et al., 2012). From the flood risk management point of view, flood risk mapping is a crucial factor. Flood mapping is limited to flood-prone hazard mapping (Safaripour, et al., 2012). Previously, some flood-related studies for determining the hazard and risk of flood have investigated a history of flood frequencies. The quantification of flood risk results either in monetary units or in loss of life units, if the losses are measurable, or in qualitative terms (e.g. allocation in classes) in the case of intangible damages (social, environment, cultural) to the affected areas (Pistrika & Tsakiris, 2007).

In Nigeria, studies have carried out various hazard and vulnerability assessment towards flood events using various model and analysis (Aderoju *et al*., 2014; Wizor & Week, 2014; Amangabara & Obenade, 2015; Komolafe *et al*., 2015; Nkwunonwo et al., 2016; Samuel *et al*., 2017; Chigbu et al., 2018; Afolabi et al., 2022); however, there are limited studies on the flood risk analysis which accommodated both the hazards, vulnerability as well exposure. Among the various components of flood risk, the aspect of exposure has received little attention which seems to have contributed to various degree of loss recorded over the years, hence, the need for flood risk assessment that capture all its components. The present study therefore, carried out a flood risk assessment climate change adaptation and mitigation strategies of communities in Edo State, Nigeria.

2.MATERIALS AND METHODS

Study Area

This study was carried out in Edo State, Nigeria which is one the 36 states that make the federation. The state is located within latitudes 5°44' 19.777'' and 7°34' 15.076''North of Equator and longitudes 4°58' 35.523'' and 6°42' 3.433''East of Greenwich. The study area is bordered by Kogi State in the North, Anambra State in the East, Delta State in the South and Ondo State in the West. There are 18 Local Government Area (LGA) councils. The state covers a land mass of about 19, 819.277km2 (see Figure 1). The temperatures across the state is relatively high with a very narrow varies in seasonal and diurnal ranges 22-36 range with an average annual rainfall of about between 2000mm-2500mm. The wet season comes between April and November and the dry season between December and March. Edo state lies at elevations between 500 feet (150 m) in the south and more than 1,800 feet (550 m) in the north. Tropical rain forest covers most of the area. The state is inhabited largely by the Edo (Bini) people, who are linked to the historic kingdom of Benin.

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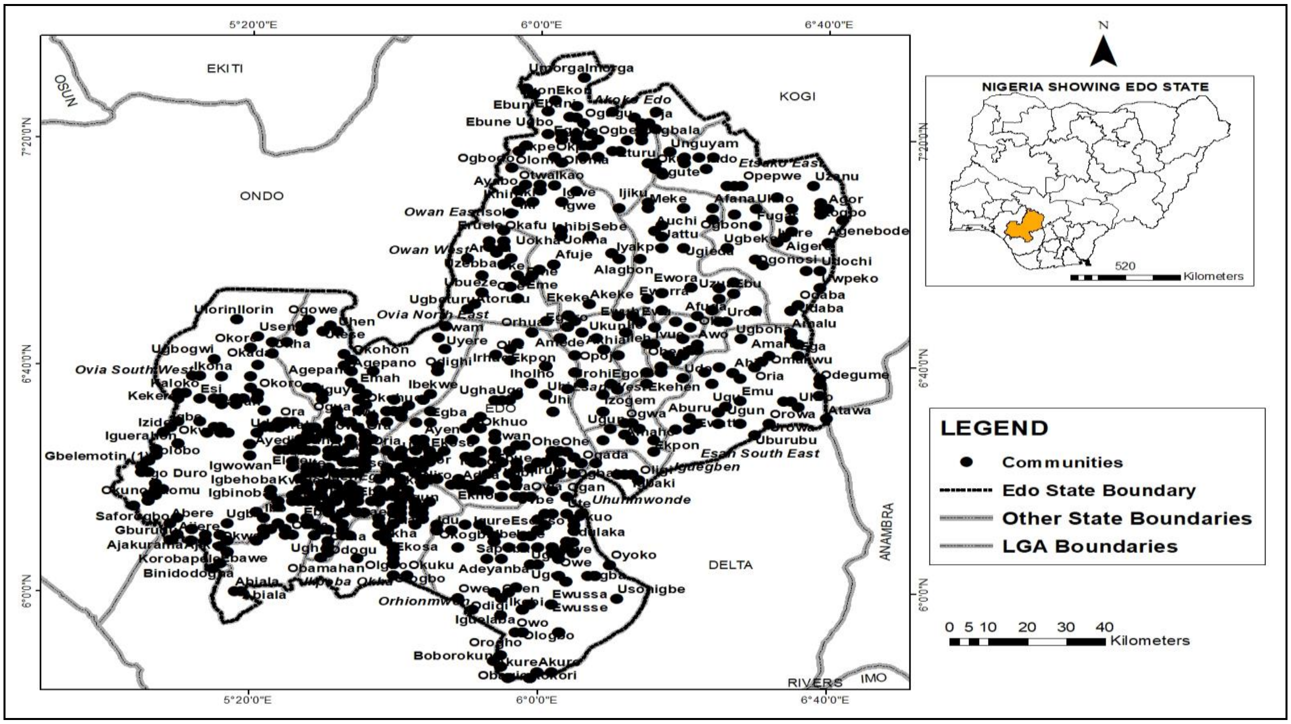

Figure 1: Overview of Edo State Showing various Communities

Source of Data

This study employed the use of both primary and secondary data.

The primary data included:

i. Landuse map of Edo State acquired from the Landsat imagery of 30 m × 30 m.
ii. Drainage Network, Road Network, Communities location, and Soil map extracted from the topographic map of 1:100,000 of the study area.
iii. Questionnaire

The secondary data included:

i. Population data for 2016 of the communities from Edo State (NPC, 2016).
ii. Topographic guide of the investigation zone from Surveyor General's Office, Ministry of Lands and Survey, Edo State.
iii. Landsat symbolism of 30 m × 30 m of 2015 got from the US Geological Survey.
iv. Rainfall and Temperature data (1991-2020) from the Nigerian Meteorological Agency (NIMET).

Data Analysis

i. *Desktop Analysis with ArcGIS:* The imagery of Edo State and topographical map was geo-referenced to world coordinate system (WGS 84) in ArcGIS 9.3. From the imagery, landuse map of the study area was acquired while drainage network, road network and communities imitative from topographical map. Soil texture map of states was also geo-referenced to WGS 84.

a. *Vulnerability Criteria:* The study adopted the use of ranking methods of the vulnerability factors which is embedded in Analytical Hierarchy Process (AHP) proposed by Saaty (1980). AHP is a multi-criteria basic leadership method, which gives a methodical way to deal with evaluating and incorporating the effects of different variables, including a few dimensions of reliant or autonomous, subjective just as quantitative data (Bapalu and Sinha, 2006; Berezi, 2019). Ranking method was adopted because the criterion weights are usually determined in the consultation process with choice or decision makers which resulted in ratio value assigned to every criterion map (Lawal *et al*., 2011). In positioning strategy, each measure under thought is positioned in the request of the leader's inclination. To create rule esteems for every assessment unit, each factor was weighted by the evaluated essentialness for causing flood.

b. *Risk Analysis:* Risk analysis involves the determination of extent of flood risk among the Edo State communities based on various components that makes up disaster risk. Therefore, the study adopted population density and rainfall volume as exposure attributes while proximity to river channel, landuse/landcover, relief and soil texture was adopted for vulnerability attributes. The methodology for risk analysis was based on various GIS operations on graphic and non-graphic data and reclassification of various map layers of the attributes.

   The results of the classifications and reclassifications was carried out in each of the landuse/land cover, drainage network buffer, soil texture, elevations, population density and rainfall which was explained using descriptive statistics such as percentage and rating.

ii. *Questionnaire:* Questionnaire administration involved two local government area (Etsako-East and Etsako-Central) and six communities (Dapapa, Agenebode, Anumeji, Udaba, Osomegbe and Anegbette) in Edo State. The retrieved questionnaire was coded and subjected to Statistical Package for the Social Sciences (SPSS) for proper analysis. The retrieved questionnaire coding was done with MS Excel before being transferred to the Data entry of SPSS window (Version 22). The data of the study was analyzed through descriptive statistics. Descriptive statistics tool such as frequency counts, percentages of response and chats was adopted for the analysis. The use of such statistics allows the researcher to present the evidence of the study in a way that can be understandable and makes conclusion concerning the variables of study.

iii. *Climate Variables (Rainfall and Temperature)*: Descriptive statistics such as mean, standard deviation, range and variance was used in analysing the climate data of Edo State from 1991-2020.

3.RESULT AND DISCUSSION

Flood Risk Level of Edo State

The flood risk analysis of the states within the western Niger Delta region was carried out by combined attributes of analysed vulnerability and exposure and the outcome was presented in Table 1-4 and Figure 2-3 for Edo state. The risk analysis indicated that a low risk level with spatial coverage of 13033.13 km^2 and it represent 64.16% of the total area of 20312.56 km^2, medium risk level with spatial coverage of 4310.57 km^2 and its represent 21.22% of the total

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area and high risk level with spatial coverage of 2968.86 km^2 and its represent 14.62% of the total area. From the analysis, a total of 778 towns/communities were captured and among them, 503 towns/communities indicated low risk level representing 64.65% of the total towns/communities, 150 towns/communities indicated moderate risk level representing 19.28% of the total towns/communities while 125 towns/communities indicated high risk level representing 16.07% of the total towns/communities.

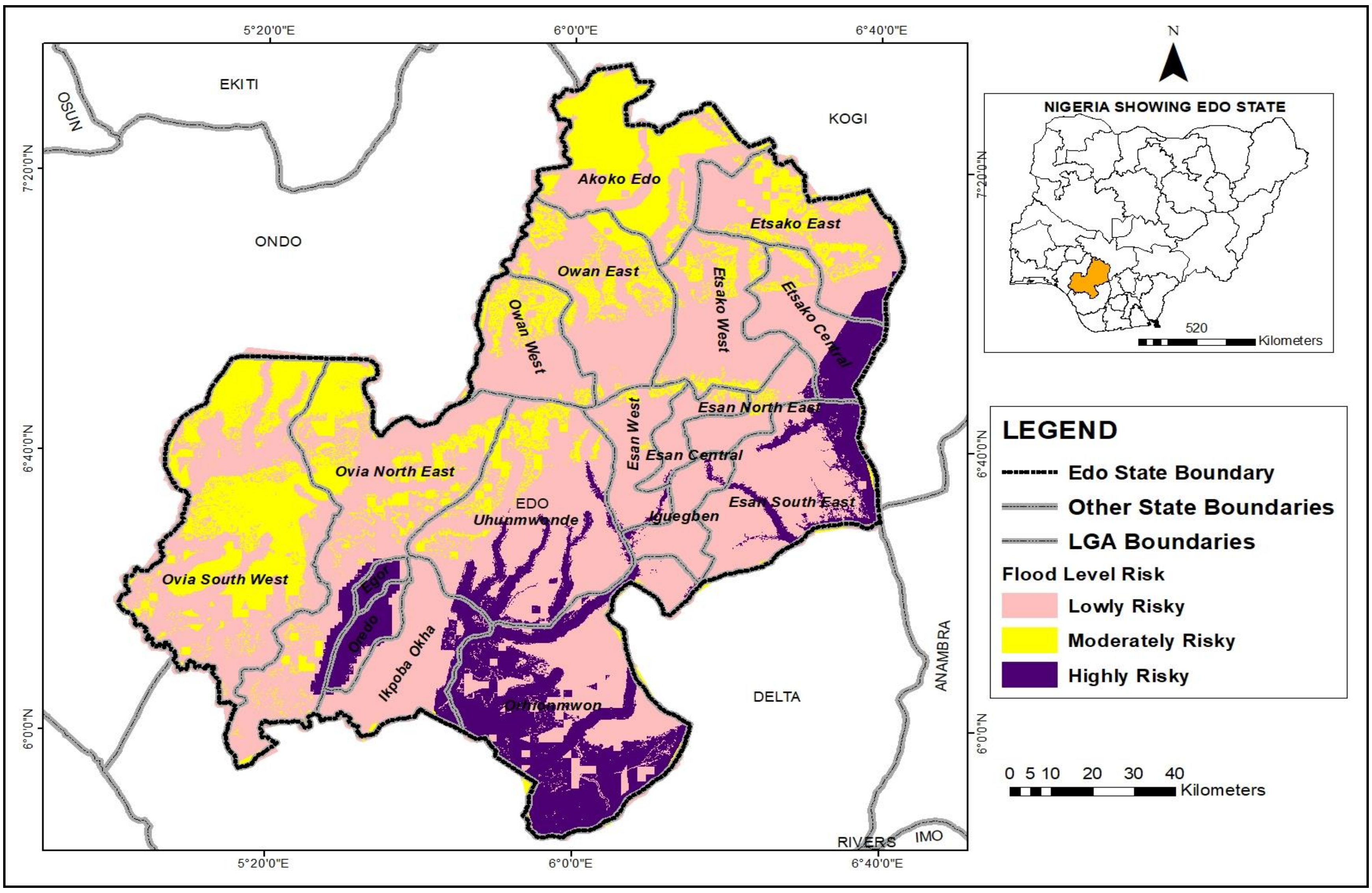
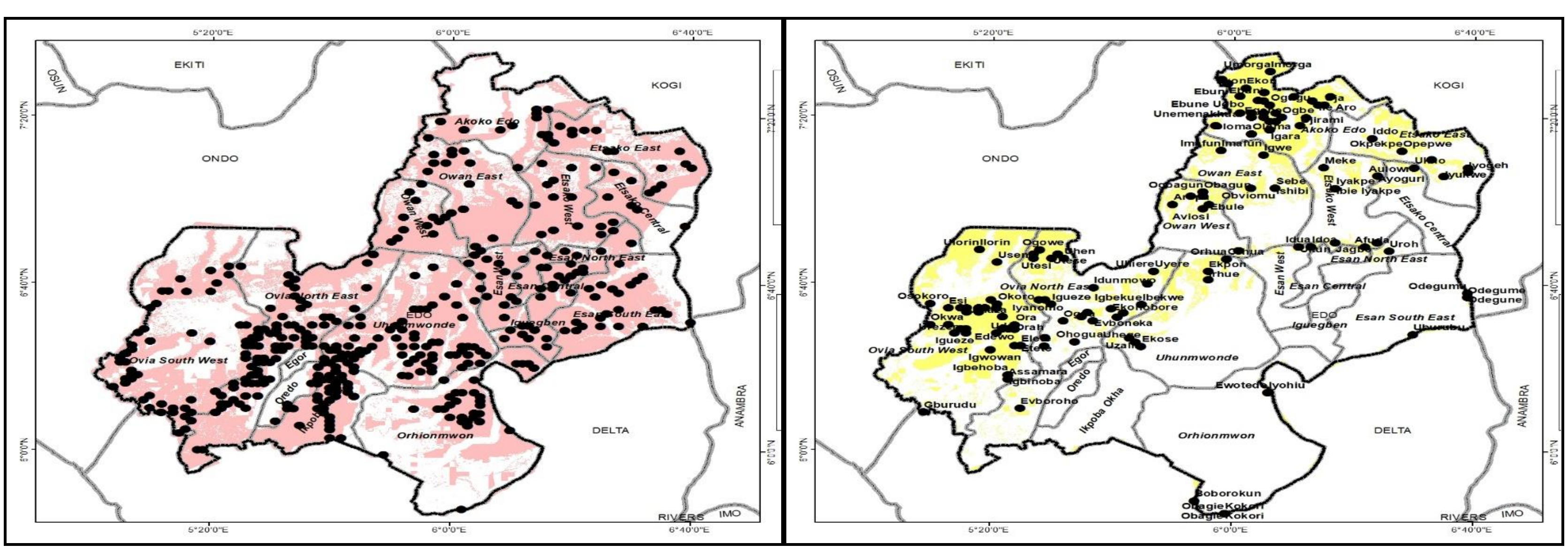
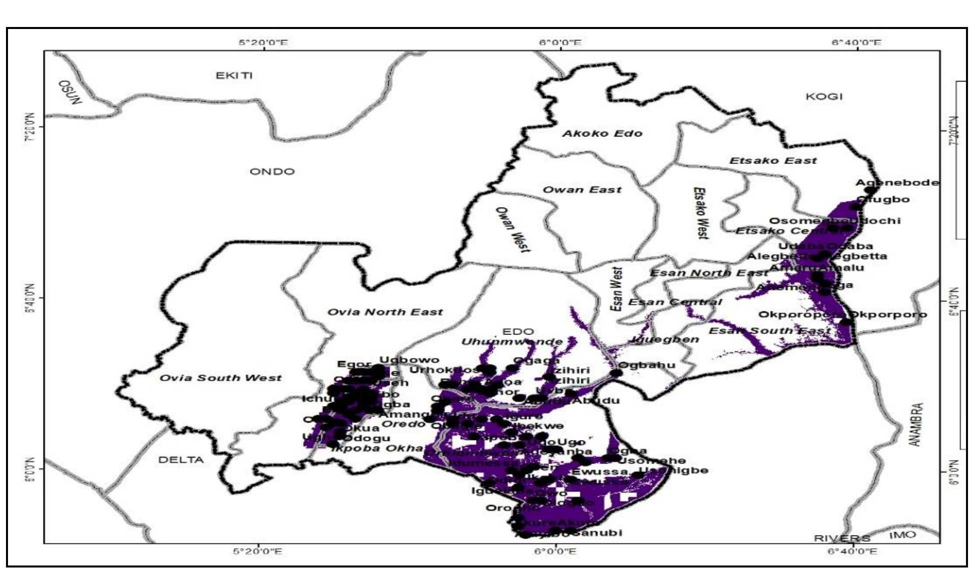


Figure 2: Flood Risk Level Map of Edo State



Low Risk | Medium Risk



High Risk

Figure 3: Classification of Flood Risk Level of Edo State

Table 1: Flood Risk Level to Flood in Edo State

Risk Levels	Spatial Coverage (sq km)	Percentage (%)
Low	13033.13	64.16
Moderate	4310.57	21.22
High	2968.86	14.62
Total	20312.56	100.00

Table 2: Classification Towns to Various Risk Levels

Risk Levels	Number of Towns	Percentage (%)
Low	503	64.65
Moderate	150	19.28
High	125	16.07
Total	778	100.00

Through the combination of various vulnerability and exposure attributes, the flood risk level indicated that risks are not evenly distributed and categorized into three levels. The outcome showed similarity with of Poussard et al. (2021) which observed that attributes related exposure to flood hazard varies across their study area. With the aid of GIS techniques, the flood risk of states in the western Niger Delta region was categories into low, medium and high flood risk. The outcome showed similar pattern with study conducted by Wondim (2016) and Gacu et al. (2022) which were delineate various flood risk level for their studies. According to Bailey et al. (2021) flood risk is still on the rise due to increasing exposure and hazard trends. Furthermore, flood risk is further compounded by the fact that population, urbanization, and economic growth are fastest in developing countries where vulnerability is higher. Aydin and Birincioglu (2022) noted that flood risks depend on many factors such as precipitation, flow, earth slope, soil structure, and population density. A holistic flood risk analysis considering all these factors will provide a more effective disaster management.

Climate Change Variability (1991-2020)

The spatial variability in rainfall and temperature of Edo state between 1991-2020 was reported and presented in Table 4.

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Table 4: ***Climate Change Variability (1991-2020) of Edo State***

Edo	Sum	Mean	SD	Min.	Max.	Range	Var.	Ske.
Rainfall (mm)	67427.60	2247.59	323.84	1748.6	3052.35	1303.75	104873.47	0.88
Temperature (˚C)	831.0	27.72	1.38	24.9	31.0	6.1	1.91	0.43

SD = Standard Deviation, Min.= Minimum, Max.= Maximum, Var.= Variance, Ske. = Skewness

The high value of the standard deviation can be directly associated with the high precipitation range. The precipitation range means the contrast between the greatest and least yearly precipitation. This submission is similar to that of Odigwe et al. (2020) which asserted that the standard deviation and the range of climate variable demonstrate the changeability of yearly precipitation. Both the rainfall and temperature of the understudied years showed some level of fluctuation which showed tendency of upward and downward pattern consistently. The outcome showed similarity with the study conducted by Suleiman et al. (2020), Oyerinde (2021) and Ofordu et al. (2022). High value of the standard deviation additionally proposes that year-to-year variations are high while a low standard deviation shows that variances are lower.

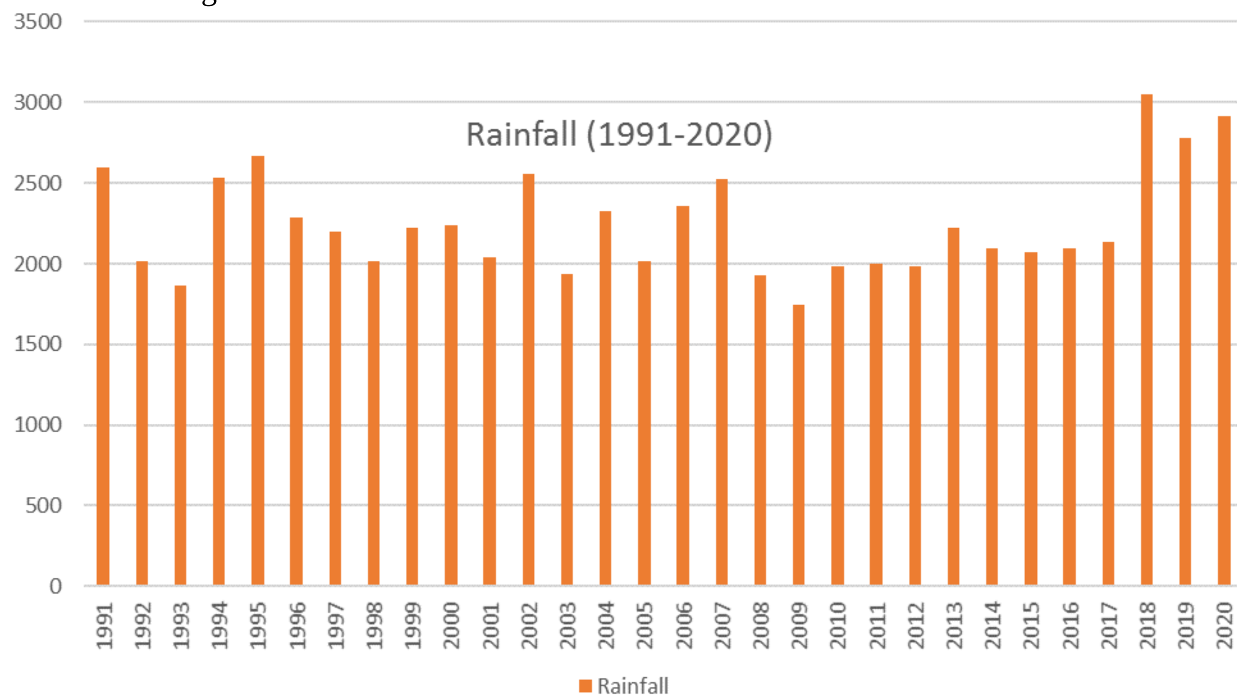

Figure 4: Rainfall distribution in Edo State between 1991-2020

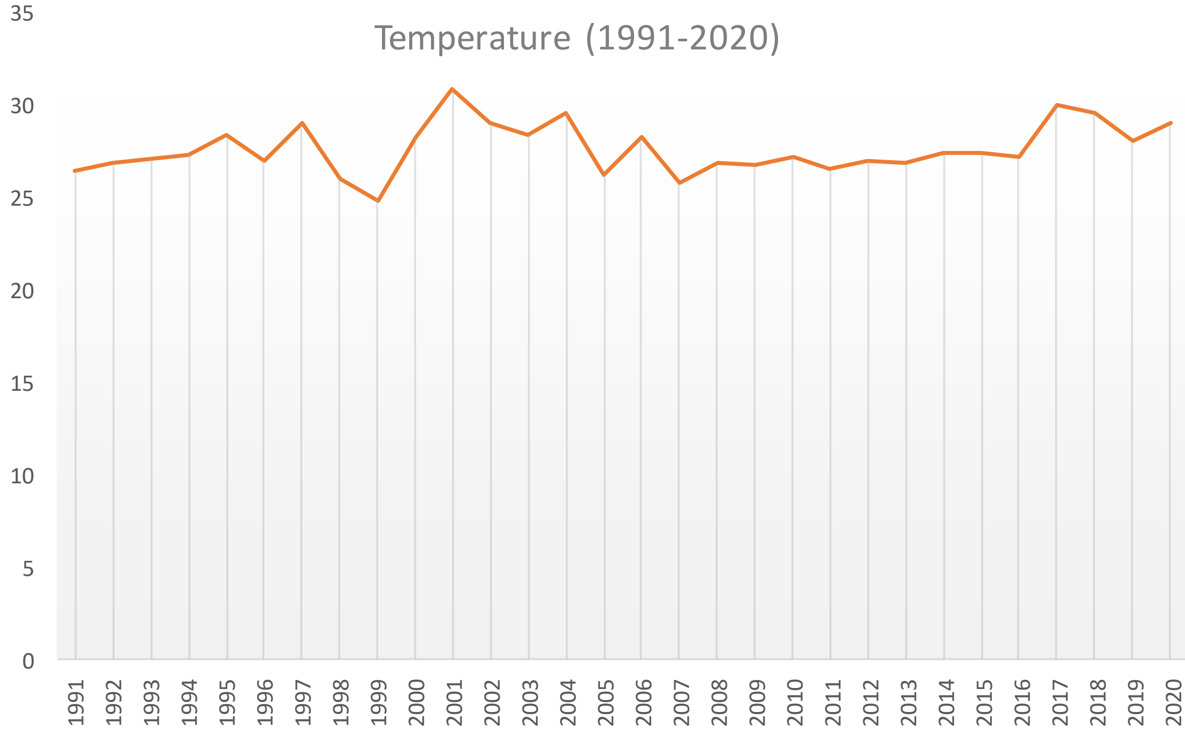

Figure 4.5: Temperature distribution in Edo State between 1991-2020

Flood and Climate Change Adaptation and Mitigation Practices

The respondents' perception towards flood and climate change adaptation and mitigation measures available in their community was presented in Table 4. The adaptation measures indicated early warning systems (20.5%), adoption of risk-informed land planning (20.5%), and expansion of floodplain and wetlands (20.5%) while the extent of risk determines (26.5%) the adopted adaptation measures while the adaptation measures were perceived less effective (51.8%). Raising of house foundation (47.0%) remain the major mitigation measures which was adopted due to the readily available materials (41.0%) for its adoption. Government mitigation measure in the studied area was construction of drainage system (45.8%) which was perceived effective (49.4%). The outcomes of the study shared similarity with the submission of Aerts et al. (2014) and Jongman (2018) which asserted that effective adaptation to rising flood risk requires a diversified approach of interventions, while the right mix of measures varies from place to place, subject to levels of risk, funding, and political will. The outcome indicated that the the adopted adaptation measure is less effective; although, Jongman (2018) opined that effective adaptation to flooding is feasible, even when faced by growing exposure and a changing climate. Baylie and Fogarassy (2022) opined that adaptation to flooding is uncertain, as the consequences of climate change are complex, since it involves the interactions of social, economic, demographic, spatial, and natural systems that vary across space and time. There are a lot of issues that explain the dynamism of flood adaptation.

Table 4: Flood and Climate Change Adaptation and Mitigation Practices

Variables	N	%	Variables	N	%
Adaptation Measures towards Flood			**Reason for Adopted Mitigation Strategy**		
Construction of Dyke and Levees	11	13.3	Cost of production and maintenance	17	20.5
Early Warning Systems	17	20.5	Readily available materials	34	41.0
Risk-informed Land Planning	17	20.5	Based on family decision	17	20.5
Expansion of Floodplains and Wetlands	17	20.5	Based on community decision	11	13.3
Protection of the Vulnerable People	10	12.0	Other	4	4.8
Urban Green Spaces	9	10.8		**83**	**100**
Others	2	2.4	**Aware of Government Mitigation Measures**		
	83	**100**	Yes	36	43.4
Reason for Adopted Adaptation Strategy			No	27	32.5
Extent of the Risk	22	26.5	Don't Know	20	24.1
Availability of Financial Support	17	20.5		**83**	**100**
Political will of Administration	19	22.9	**Government Mitigation Measures Available**		
Best Available Practices	11	13.3	Early warning system	22	26.5
Other	14	16.9	Construction of drainage	38	45.8
	83	**100**	River Channelization	9	10.8
Effectiveness of the Adaptation Measures			Building dikes around rivers edge	8	9.6
Very Effective	5	6.0	Removal of sand and debris from drainage	6	7.2
Effective	9	10.8		**83**	**100**
Less Effective	43	51.8	**Effectiveness of the Mitigation Strategy**		
Ineffective	26	31.3	Very Effective	19	22.9
	83	**100**	Effective	41	49.4
Mitigation Measures towards Flood			Less Effective	17	20.5
Relocation	20	24.1	Ineffective	6	7.2
House foundation raised	39	47.0		**83**	**100**
Use of sand bags	18	21.7			
Wooden bridge construction	5	6.0			
Drainage Regular Cleaning	1	1.2			
Others	-	-			
	83	**100**			

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4.CONCLUSION AND RECOMMENDATIONS

The approach of GIS and RS techniques have further established their usefulness in the area of flood risk management study. Through series of physical environment (proximity to active river channels, landuse/land cover, soil texture, elevation), social (population density) and climate change (rainfall volume) attributes, flood risk of Edo state region was established at the communities' level. It was therefore concluded that all the adopted attributes contributed to the establishment of flood risk of Edo State and was categories into high, medium and low flood risk level. In addition, there was a noticeable variation in climate variables while adaptation and mitigation measures are in place to lessen the impact of flood and climate change influence in the study area. There is needs to intensify the planning and execution disaster management programs (prevention, mitigation, preparedness, operations, relief and recovery) with the support of the produced flood risk map. Government should involve in various developmental projects that would also serve as a mitigative approach towards flood risk reduction as well as provision of alternative to livelihood prior, during and after flood event.

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