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Land use planning and climate change adaptation in river-dependent communities in Nigeria

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ABSTRACT

Land use planning and climate change adaptation are critical for ensuring sustainable development and resilience in river-dependent communities in Nigeria. This study examines land use planning and climate adaptation in river-dependent communities in the Lower Niger River region of Nigeria. The research utilizes a mixed-methods approach. Data for the study were gathered from 198 households through surveys, complemented by 17 qualitative interviews and remote sensing techniques to assess land use changes and community perceptions. Findings reveal a notable trend where poor farmers face heightened vulnerability to climate change due to financial constraints, hindering their adoption of adaptive land use strategies. Specifically, more than half of the sampled households possess individual land for agricultural purposes yet lack the resources to effectively mitigate climate-related risks. Among the studied communities, Odekpe emerged as particularly vulnerable, with a prevalence of vulnerability at 32.3% and higher exposure to flood-prone zones.

The quantitative analysis delineates community engagement in land management practices, showcasing proactive resource allocation and conflict resolution efforts among over 60% of participants. However, a significant portion (57.6%) lacked awareness of hydrological changes, potentially impeding effective land use planning and adaptation measures.

Further analysis through remote sensing and mapping techniques revealed shifts in land use land cover, highlighting a transition from predominantly vegetated areas to built-up regions over the past three decades. The flood vulnerability assessment maps underscored substantial vulnerability across the Lower Niger basin, especially in downstream regions, indicating heightened risks due to proximity to the Niger River and heavy rainfall.

Qualitative insights from stakeholder interviews identified challenges impeding effective land use planning, including uncertain climate projections, insufficient data, institutional capacity constraints, and conflicting priorities. Additionally, participants emphasized the need for resilient land use decisions to address urbanization impacts, altered drainage patterns, and diminishing green spaces. The study recommends several key actions to enhance the effectiveness of land use planning and climate adaptation in the Lower Niger River region. These include the imperative to strengthen institutional capacities, improve stakeholder engagement processes, integrate traditional knowledge and practices into planning efforts, fortify legal frameworks governing land use, and prioritize the promotion of sustainable livelihoods among local communities.

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1. Introduction

Climate change is an emerging issue in our era with its impact spanning from local to global scale significantly altering environmental conditions and posing multifaceted impacts on communities worldwide. The phenomenon is particularly salient in Africa, a continent highly susceptible to the consequences of climate variability and change. The current rate of change is already causing unprecedented damage on lives, livelihoods, and properties. As elucidated in the report by (Woodward et al., 2010) the ramifications of climate change vary across different regions of the world, contingent upon diverse factors such as latitude, altitude, and specific local conditions. Broadly, regions situated at higher latitudes and altitudes are anticipated to undergo the most rapid warming due to their heightened sensitivity to shifts in global temperature. The significance of this lies in the fact that these areas, characterized by typically colder climates, can experience substantial impacts on local ecosystems and human communities even with minor temperature increases (Parr and Bishop, 2022). For example, warming at high latitudes can cause permafrost to thaw, leading to changes in vegetation patterns and soil stability. At high altitudes, warming can lead to changes in snow and ice cover, which can have cascading effects on water availability, biodiversity, and human livelihoods.

Nigeria, as a significant geographical entity within Africa, grapples with its own array of climate-related challenges that significantly affect its rural, natural resource-dependent settings (CHANGE, 1995; Darcy, 2021).

The river dependent communities in Nigeria, characterized by their reliance on natural resources for sustenance and livelihoods, face profound vulnerabilities stemming from climate change impacts (Anthony and Rob, 2014). Changes in temperature and precipitation patterns, heightened frequency of extreme weather events, and alterations in hydrological cycles have become palpable realities across the African continent, affecting agriculture, water availability, biodiversity, and local economies. These impacts are particularly pronounced in Nigeria, where communities heavily reliant on natural resources face heightened risks of food insecurity, water scarcity, and economic instability due to climate-induced changes. The absence of comprehensive adaptation strategies and inadequacies in effective land use planning exacerbate these challenges, heightening the vulnerability of rural populations to the adverse effects of climate change. This underscores the pressing need to investigate and propose context-specific adaptation measures embedded within land use planning frameworks to mitigate these vulnerabilities.

In response to the escalating challenges posed by climate change, adaptation strategies have become increasingly imperative. Adaptation entails proactive measures aimed at reducing vulnerability and enhancing resilience to the adverse effects of climate change. This is especially critical in rural, natural resource-dependent settings, where livelihoods are intricately linked to the environment.

Moreover, within the realm of climate adaptation, land use planning plays a pivotal role. It involves the strategic organization and management of land resources, including allocation, utilization, and protection, in a manner that fosters sustainable development while considering climate change impacts. Therefore, by promoting sustainable land use practices and protecting vulnerable ecosystems, land use planning can help reduce the exposure of communities to climate-related risks and promote their resilience in the face of changing conditions (Garibaldi et al., 2017). In Nigeria and many parts of Africa, land use planning becomes instrumental in navigating the intricate balance between environmental preservation, resource utilization, and societal well-being in the face of changing climatic conditions. This is the reason Cetin (2016) and Cetin et al. (2019) highlight the need for innovative, multi-actor and multi-sector approaches to address the social, economic, and environmental challenges posed by climate change.

This study aims to delve into the nexus between climate change, adaptation strategies, and land use planning within the specific context of rural, natural resource-dependent areas in Nigeria. Advocating for a comprehensive approach, the study seeks to integrates climate adaptation strategies with effective land use planning practices tailored to address the challenges of these communities. By understanding the localized impacts of climate change and identifying vulnerabilities, the study aims to underscore the urgency of implementing sustainable adaptation measures. It argues for the necessity of proactive planning and resource management strategies to enhance resilience and sustainable development within these vulnerable settings. By understanding the localized impacts of climate change, identifying vulnerabilities, and exploring adaptive land use planning approaches, this research seeks to offer insights into tailored strategies that can bolster resilience and promote sustainable development in vulnerable communities. The study aims to contribute to the broader discourse on climate adaptation and land use planning, offering practical implications for mitigating the impacts of climate change on river dependent communities in Nigeria and similar contexts across the African continent.

Table 1
Socio-economic characteristics and vulnerability.

N = 198						
Social groups	Ave. Land ownership	Poor farmers	Rich farmers	Living in flood-prone	Total	%
Umunakwo	26	12	7	9	54	27.3
Odekpe	31	18	4	11	64	32.3
Okwe	26	9	3	9	47	23.7
Oko	11	10	4	8	33	16.7
Total	94	49	18	37	198	100

2. Methodology

This study delves into the landuse planning and climate adaptation focusing specifically on the Lower Niger river region of Nigeria. This investigation employs mixed research comprising both quantitative and qualitative research methods to explore the intricate interplay between landuse planning and climate adaptation. Utilizing a case study approach, the study specifically concentrates on four communities situated along the lower Niger river, encompassing regions in both Anambra and Delta States. The selection of these communities within the Lower Niger river area is purposeful, aiming to provide a nuanced understanding of the historical, socio-cultural, and geographical factors influencing land governance. These regions have been chosen due to their significance in reflecting diverse land management practices, historical legacies, and contemporary challenges related to land reconfiguration and governance. A total of 198 households were selected and surveyed using a structured questionnaire. Additionally, key informant interviews were conducted with farmers and community leaders to gain insights into how their coping strategies influence global perspectives on loss and damage.

2.1. Study Site

The Lower Niger River region, situated in the south-eastern part of Nigeria, and typically experiences a tropical climate (ONYEISI, 2022). This study area encompasses Ogbaru in Anambra State and Asaba (Oshimili South) in Delta State, spanning approximately 36, 000 square kilometres and characterized by an intricate network of networks and channels (Effiong et al., 2024). The region experiences an annual average temperature ranging from 21.9 °C to 36.4 °C, with cooler temperatures prevalent in the mountainous areas. March to May constitutes the hottest months, reaching temperatures around 42 °C, while July to August represents the coldest period, with temperatures averaging 25 °C. The annual average rainfall stands at 672 mm, with recorded extremes of 2247 mm and as low as 8 mm. The wet season typically occurs between July and September, witnessing an average monthly rainfall exceeding 120 mm (Obarein and Lee, 2022) see Fig. 1.

2.2. Data collection

The survey questionnaire was administered in person by trained research assistants, who explained the purpose of the study and obtained informed consent from participants. The questionnaire is organized into three distinct sections. The first section captures the participant information sheet and the consent form for participation. participants were provided with essential information about the study's purpose, potential risks and benefits, and their rights as participants. They are required to read and sign the consent form, signifying their informed agreement to take part in the research.

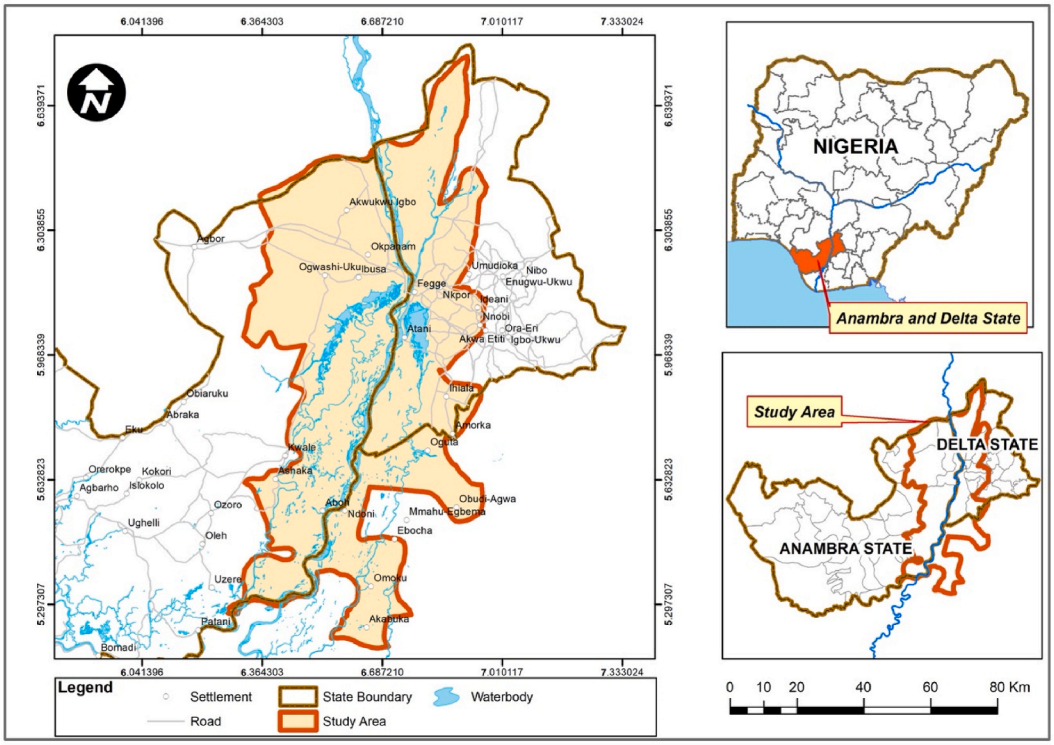

Fig. 1. Map showing the study area.
Source: Authors' design, 2023

The second section is dedicated to capturing the sociodemographic characteristics of the respondents. This segment of the questionnaire collected data on specific climate change impacts affecting rural, natural resource-dependent communities in Nigeria. These offer valuable context for understanding levels of vulnerability and compliance with landue planning.

Lastly, the third section assess the effectiveness of existing adaptation strategies and land use planning initiatives in mitigating climate-related vulnerabilities. Additionally, this section explores the strategies and actions that respondents have implemented to enhance resilience and promote sustainable development in their communities.

The key informant interviews were conducted in person, and responses were recorded and transcribed for analysis. A total of 17 stakeholders comprising farming association, community leader, NGO and government agency were asked climate related challenges that impede land use planning; and how the current land use planning decision affect community resilient, and what can be done to enhance community participation in shaping land use planning for climate resilience.

Additionally, time series data on Land Use Land Cover Change within the study area was procured from the United States Geological Survey (USGS, https://www.usgs.gov/) and analysed utilizing Landsat imagery (TM, ETM+, OLIS/TIRS). The acquired images, free from cloud cover, spanned the years 1990, 2000, 2010, and 2020. These images were geographically projected onto UTM 32N WGS84 coordinates. Employing the reflectance value algorithm outlined by (Chander et al., 2009), the imagery underwent conversion to TOA (Top of Atmosphere), followed by the application of Dark Object Subtraction for Landsat data correction, as proposed by (Zhang et al., 2010).

Subsequently, the imagery was extracted to align with the study area boundary shapefile using ArcGIS 10.4. An image enhancement process was then conducted to classify the imagery into four distinct land use categories: waterbody, floodplain, vegetation, and built-up areas. This classification was achieved through the utilization of the Random Forest image classification method initially proposed by (Breiman, 2001). The selection of this classification method stemmed from its recognized robustness and high accuracy when compared to traditional image classification methods, as highlighted in the study by (Jin et al., 2018)

For the Flood vulnerability assessment map, a combination of Digital Elevation Model (DEM) data and various indicators, including precipitation, slope, elevation, and land use land cover, were employed to demonstrate the vulnerability assessment within the area. These indicators were utilized collectively to assess and illustrate the vulnerability levels across the study area, providing a comprehensive understanding of flood susceptibility based on diverse environmental parameters.

2.3. Data analysis

Quantitative data was analysed using descriptive statistics such as frequencies and percentages, and qualitative data was analysed in NVivo, where interview data was coded and recategorized into themes to reflect land use planning and climate change adaptation. In addition, vulnerability assessment was conducted to ascertain the level of vulnerability in the study area using GIS remote sensing.

2.4. Ethical considerations

This study obtained ethical approval from the Institutional Review Board of University of Birmingham. Informed consent was obtained from all participants, and confidentiality and anonymity were ensured throughout the study. Participants were informed that they could withdraw from the study at any time without penalty.

3. Scale of environmental change from global to local perspectives in the lower Niger river

Climate change is defined as the state of mean or variability of its properties which can persist over an extended period say decades or longer (Gillo et al., 2014; Parry et al., 2007). The change in climate may be as a result of weather due to natural change or man activities over a period (Change et al., 2006). Understanding climate and the distribution of species, foraging vegetation has become the focus of many ecological researchers (Thomas, 2010). However, as we continue to face changes due to impact of climate change, the interest has remained undiminished with extinction of species (Thuiller, 2007). Since climate remains an important determinant of foraging vegetation, it is pertinent that anthropogenic changes and human activities can alter its composition and threaten the existence of natural resources (Rahn et al., 2014). Already, the extent of human-induced changes to atmospheric and biosphere processes over the decades has become evident with extreme temperature, reduction in river runoff, changes in precipitation with an effect on livelihood of coastal communities. For example, the flood incidence of 2012 in Nigeria affected people, infrastructures, and farmlands. In Kogi State, an estimate of 152,575 ha of farmland was destroyed and 1.35 million people were affected (Ajaero et al., 2016). Also, the impact of climate change increases the prices of commodities in the market leading to entrenchment of poverty in the community. Furthermore, the causes of environmental change are embedded in local patterns of extraction and usage of resources that have increased the overall impact of climate change. Aside from flooding being a natural phenomenon, most human activities have increased its destructive tendency, thereby making people and livelihoods vulnerable to climate stress. Furthermore, the high dependence on natural resources for livelihoods has further increased the risk of this environmental stress (Ziervogel et al., 2008) which is linked through changes in land use, burning of fossil fuels; deforestation and increase in population which are responsible for the accumulation of greenhouse gases in the atmosphere that results in global warming (Change et al., 2006; Ziervogel et al., 2008). It is estimated that the cumulative impact of human induced stress has altered more than 75% of the hydrological changes in river dependent communities thereby making them more vulnerable to climate change (Ellis and Ramankutty, 2008). This affirms the assertion that low-income countries are the most affected and river dependent communities are most vulnerable to the impact of climate change (Sharma and Ravindranath, 2019). In the work of (Ahmad and Ma, 2020) it is opined that the continuous

over-harvesting of forest will result in dual impact-causing environmental harm which may reduce ecosystem resistance to climate change and secondly, will released of stored carbon into the atmosphere and increase the severity of climate change. To solve this problem, there is the need to understand the dynamics of human induced changes and the changes in hydrology and their interaction with landform and landscape processes.

i. Urbanization

Rapid urbanization, particularly in rural communities already grappling with the burdens of climate change, exacerbates existing challenges to livelihoods (While and Whitehead, 2013). The escalating rate of urbanization, coupled with shifts in local land use patterns, significantly influences micro-climatic conditions and ecological systems. These changes profoundly heighten the community's vulnerability to the escalating impacts of climate change. Urbanization, characterized by the proliferation of impermeable surfaces, alterations in vegetation cover, and modifications in drainage patterns, directly impacts local micro-climates by elevating temperatures, altering precipitation patterns, and intensifying heat island effects. Similarly, alterations in land use, including deforestation, expanded agricultural areas, and infrastructural development, disrupt ecological systems, thereby affecting biodiversity, soil quality, and water availability.

The projected global population surge to 9.2 billion by 2050, predominantly in less developed countries, foretells an intensified trend in urbanization (Zhongming et al., 2020). Notably, African countries constitute the most rapidly urbanizing region globally, witnessing the highest growth rate in slum populations. Presently, approximately one billion people worldwide reside in slums, with over 70% of this population, accounting for 100 million individuals, concentrated in African cities (Lau et al., 2010; While and Whitehead, 2013). This surge in urbanization, often plagued by environmental risks and inadequate city planning, contributes significantly to migration and the proliferation of refugees.

The concerning aspect of this trend stems from the environmental risks and inadequate urban planning in developing countries, precipitating migration and exacerbating the slum crisis. Moreover, urbanization amplifies environmental risks by fostering impermeable land surfaces that escalate runoff, creating distinct microclimates capable of intensifying rainfall patterns. (Lau et al., 2010). The repercussions of urbanization extend to water scarcity and challenges to aquatic ecosystems, significantly compromising health and livelihoods (Wu et al., 2014). Studies have shown that urbanization is threatening livelihood sources especially for those that depend on wetland agriculture for livelihood. For example, in 1975, the Nigerian urban population was approximately 16.3 million, constituting 21% of the total population. By 1993, this urban population had surged to 36.2%, showcasing a significant demographic shift (Effiong et al., 2024; Lwali, 2008). Despite the overall urbanization rate for the entire country being around 7%, certain cities experienced more accelerated growth.

This urban transformation has brought about notable consequences, particularly in the alteration of natural landscapes to accommodate impermeable surfaces like concrete and asphalt. The implications of this shift are substantial, especially in the disruption of the region's inherent drainage patterns. When faced with intense rainfall events, the substitution of natural landscapes with impermeable surfaces has led to increased surface runoff. Consequently, this disruption has significantly heightened the area's vulnerability to the risk of flooding.

ii. Land use Land Cover Change

Land use/land cover change (LU/LCC) is associated with the relationship of human and natural environment (Faulkner, 2004; Lambin et al., 2003). It is driven by a wide range of socioeconomic activities which can be linked with livelihood and ecological processes. Understanding the changes in land use can influence decision making for efficient management of the physical environment and natural resources (Lambin et al., 2001). Furthermore, tracing the historical pattern reveals activities responsible for modification in river system and land use land cover basin (Drummond and Loveland, 2010). Land use land cover change are two important characteristics that control hydrological process of any region. Changes in land use affects energy fluxes and influence temperature and precipitation of the region (Garg et al., 2019). Studies have shown that land use land cover change is the main forces behind changes in river flow regime, accumulation of snowbelt process in the world. For example, in Indian river basins, drastic land use land cover adjustments have taken place in the last century and have experienced adverse recurring hydro-meteorological extremes (Garg et al., 2019). Climate change is most visible in communities of developing countries where land use planning practice lacks the capacity to improve/reduce future losses arising from climatic variability, as well as not providing for river dependent communities the economic opportunities associated with climate actions plans (Kløve et al., 2011; Lin, 2011).

In Nigeria, land use have changed significantly over the last 30 years with impact on forest resources resulting in deforestation, overgrazing and reclamation (Li et al., 2007; Mati et al., 2008). Land use and climate may have direct or indirect impact on the hydrology system thereby affecting rainfall pattern, evapotranspiration, changes in temperature. It can increase or decrease the rate of river flow under certain circumstances which can be triggered by reductions in evapotranspiration and water recycling (Lambin et al., 2003). Moreso, changes in land use land cover change is responsible for climate change, changes in behaviour, income loss and development policies (Li et al., 2007).

4. Implication of urbanization and land use land cover change on climate of local communities

Urbanization has serious implication for change on the ecological landscape of land and water of local community (Kalnay and Cai, 2003). It is imperative to understand the dynamics of urbanization induced changes in the environmental landscape in order to

facilitate the planning and management of the sustainable environment (Dadashpoor et al., 2019; Patra et al., 2018). The most important influence of urbanization on climate is the increase in consumption resources including use of natural resources especially in communities whose livelihoods are dependent on the natural environment. The need for more land for farming and constructions of infrastructure to meet the needs of communities results to intrusion and conversion of forest and wetlands for human needs at the expense of other species (Tran et al., 2017). In addition, the growth in consumption especially of energy results in greenhouse gas emission which contributes to the global store of these gases and the consequent impacts on the macro and microclimate.

During Urbanization process, the changes in land use land cover along with replacement of green vegetation by impermeable surface will increase changes in the surface temperature and precipitation. As posit by (Patz et al., 2008; Tran et al., 2017), increased in impermeable surfaces and decreased green space will weaken latent heat flux and evapotranspiration in urban areas and turn more energy into sensible heat flux. Furthermore, seasonal variation in temperature, precipitation, and river discharge drives climate seasonality which could have a rippling effect on agricultural production and food insecurity (Rasul, 2021; Verdin et al., 2005).

Through studies using GIS and remote sensing technologies, it has been observed that anthropogenic activities shape local, peri-urban and urban environments in diverse ways, and therefore require adequate monitoring for planning and decision making (Dadashpoor et al., 2019; Patra et al., 2018). For example, conversion and intrusion of vegetation and agriculture land into urban settlement has change the hydrology structure of local community and increase their vulnerability to climate change (Kalnay and Cai, 2003). Furthermore, changes in hydrology pattern impact on the quality and quantity of ground water can cause water scarcity impacting on the living condition of local community.

4.1. Land tenure system in Nigeria

Land is an essential asset that encompasses various aspects of livelihoods, including food, shelter, raw materials, trade, culture, and clothing. Access and control of land rights play a crucial role in ensuring the well-being and development of individuals and society (Blewitt, 2014). Land serves as a significant indicator of wealth and is instrumental in achieving food security, poverty reduction, and sustainable development (Fabusoro et al., 2008; Visbeck et al., 2014).

In Nigeria, the control and administration of land are influenced by the land tenure system and land use practices. The ownership, usage, transfer, ownership security, and overall management of land in a particular domain are influenced by the land tenure system, which represents the relationship between individuals and society regarding land use and administration (Alao and Shuaibu, 2013). The land tenure system represents the relationship between individuals and society regarding the use and administration of land. It governs how land rights are allocated, recognized, and enforced. There are various forms of land tenure systems which include customary, statutory, and hybrid systems and they vary across regions and communities in Nigeria (Cotula et al., 2004; Onyebueke et al., 2020).

The interplay between land tenure systems in Nigeria and land use planning initiatives is pivotal in shaping communities' abilities to adapt to the impacts of climate change. Land tenure systems, delineating ownership, access, and control of land resources, profoundly influence land use decisions within these communities (Effiong & Nissi; Fabusoro et al., 2008; Maduekwe, 2014). Secure tenure typically fosters sustainable land management practices and resilience-building strategies, whereas insecure or contested tenure often leads to land disputes, degradation, and hampers the adoption of effective adaptation measures. For instance, Under the pre-colonial rule, land ownership resided with families and communities, who allocated it based on individual needs. However, during the colonial era, land control was regulated by the colonial authorities through the promulgation of ordinances aimed at centralizing control and taking land away from communities (Effiong and Nissi, 2019; Fabusoro et al., 2008; Maduekwe, 2014). Native laws were introduced during this period, which vested all land in the commissioner, leading to restricted access to land.

In the postcolonial era, the Land Tenure Law of 1962 vested control and allocation of native land in the minister for allocation to Nigerian natives (Fabusoro et al., 2008). This law was subsequently amended, and the Land Use Act was enacted in 1978, which came into effect as a "Decree" and continues to be implemented across the country (Fabusoro et al., 2008). However, since its implementation, the Land Use Act has faced criticism and encountered obstacles that hinder smooth access and land rights for both individuals and the government, thereby affecting production, investment, and livelihood activities. One of the factors contributing to the ineffectiveness of land management in Nigeria, as articulated by (Garba, 1997), is the lack of alignment of public land ownership with specific requirements and contextual issues in the localities where the policies are implemented.

Secure land tenure systems provide a foundation for effective land use planning initiatives. They promote long-term investments in land, enabling communities to implement sustainable agricultural practices, conservation efforts, and infrastructure development conducive to climate resilience. Communities with secure tenure are better positioned to allocate resources for land use in ways that align with adaptation strategies, such as watershed management or soil conservation projects.

Conversely, insecure land tenure can impede land use planning and adaptation efforts. Land disputes arising from unclear or contested tenure limit communities' abilities to implement cohesive land use strategies. This uncertainty discourages long-term investments and sustainable land management practices, leading to soil degradation, inefficient resource utilization, and reduced resilience to climate change impacts. This is in line with the work of (Omole and Akinbamijo, 2012) highlighting the challenges associated with uncoordinated land tenure. Similarly, the work of (Ghebru and Okumo, 2017) provides insights into land administration and service delivery in Nigeria and contested the challenges of land tenure can be traced to colonial administration and that political will is needed to address the challenges.

Moreover, the effectiveness of adaptation strategies is intricately linked to how land tenure systems influence decision-making regarding resource allocation and utilization. Communities with secure tenure are more likely to collaborate effectively, implement sustainable practices, and mobilize resources to adapt to changing climatic conditions. In contrast, insecure tenure systems may result in fragmented decision-making, hindering coordinated efforts and limiting the implementation of adaptive measures. See Fig. 2.

4.2. Land use planning

Land use planning refers to the systematic process of organizing and regulating the use of land in a defined area to achieve sustainable development goals (Kalfas et al., 2023). It involves assessing current land conditions, identifying future land requirements, and devising strategies to manage and allocate land resources efficiently (Metternicht, 2018). The primary objectives of land use planning include promoting orderly development, minimizing environmental degradation, enhancing community well-being, and ensuring economic growth while preserving natural resources. The core aspect of land use planning, is to strategically identifies and manage vulnerable areas to climate-related hazards like floods, storms, or wildfires (Hirokawa and Rosenbloom, 2013). For instance, by delineating areas susceptible to such risks, it enables the implementation of measures to reduce exposure and minimize vulnerability in these high-risk zones. Moreover, effective land use planning encourages and integrates sustainable land management practices such as afforestation, soil conservation, and sustainable agriculture, which contribute significantly to ecosystem resilience and aid in mitigating greenhouse gas emissions. Effective landuse planning, such as zoning ordinances, master plans, land development regulations, and growth management strategies discourages activities that exacerbate climate risks. In essence, land use planning acts as a linchpin in integrating climate adaptation into development strategies, cultivating more resilient and sustainable landscapes that fortify communities against the challenges posed by climate change.

5. Analysis of findings

5.1. Quantitative analysis

In the study encompassing 198 households within the surveyed area, an analysis categorized these households into distinct social groups. The findings indicated that more than half of these households possess individual land for agricultural purposes. However, a notable trend emerged, revealing that a significant percentage of impoverished farmers face heightened vulnerability to the repercussions of climate change. These vulnerable households lack the necessary resources and capacity to effectively withstand the impact of climatic shifts. Their financial constraints prevent them from employing conventional strategies, compelling some to settle in flood-prone areas. Consequently, their inability to implement or adapt land use planning techniques leaves them exposed to severe ramifications of climate hazards.

A comparative analysis across the four communities investigated reveals distinct variations in vulnerability levels. Particularly, residents of Odekpe appear to confront a higher prevalence of climate-related hazards, constituting 33.2% of the observed cases, surpassing the vulnerability rates in other localities such as Owe and Oko. Additionally, the incidence of individuals residing in flood-prone zones notably increases in Odekpe compared to the other communities. This trend can be elucidated by the developmental differences among the communities. Owe and Oko exhibit characteristics of semi-urban areas undergoing rapid development, prompting inhabitants to adopt and integrate land use planning techniques in response to the changing landscape and climate dynamics. Conversely, Odekpe faces higher vulnerability due to limited or negligible adoption of such adaptive strategies, intensifying the community's exposure to climate hazards. See Table 1 and Fig. 3.

6. Land use planning and management strategy

In the preliminary phase of our study, participants were surveyed about their land use planning and management strategy at community level as shown in Table 2.The first question was how they secure land for development and a significant majority, surpassing 41.4% of respondents, affirmed that they secure land for development from individual; 21.2% affirmed that the predominant source of land acquisition in the community is through inheritance and 16.2% affirmed that they secure land through family allocation. A significant majority (74.2%) indicated that they did not receive building approvals, which may have implications for adherence to regulations or standards. This implies that the absence of building approvals points towards potential non-compliance with existing land use regulations or planning ordinances which non-compliance might disrupt the intended land use plans set forth by authorities. Furthermore, Buildings or structures erected without proper approvals might be more susceptible to environmental hazards like flooding, erosion, or other climate-related risks due to inadequate planning for these challenges. This aligned with the work of (Dickson et al., 2012) which affirmed that unplanned expansion of cities is exposing more people and economic assets to the risk of disasters and the effects of climate change.

The community has engaged in various initiatives such as community sanitation (43.9%), neighbourhood watch (24.2%), watershed protection (7.6%), and rotational cropping (16.2%), indicating a proactive stance towards land use planning. This approach focusses on sustainable land use practices, which could lead to better resource management and conservation efforts. Similarly, active participation in neighbourhood watch programs indicates a community effort to mitigate risks associated with crime or emergencies, potentially contributing to overall resilience against climate-related hazards.

In terms of community response to land management, over 60% of the community is actively involved in resource allocation and conflict resolution concerning land management. This suggest that a more proactive steps in community-led initiatives in fostering a collaborative approach towards land management practices which can enhance the effectiveness of land use planning by integrating diverse perspectives and local knowledge, leading to more inclusive and context-specific strategies. Moreover, this engagement fosters a stronger sense of ownership, potentially bolstering the successful implementation of climate adaptation measures tailored to community needs and concerns.

When considering the level of awareness about the hydrological changes, around 42.4% of respondents were aware of hydrological changes affecting the area, while a larger portion (57.6%) lacked awareness. This means that the limited awareness might impede

effective planning, potentially leading to inadequately prepared land use policies and strategies. This aligns with the work of (Effiong et al., 2024) which averred that lack of awareness could heighten the community's vulnerability to hydrological changes, and hindering adaptive measures. See Table 2.

6.1. Trend of land use land cover changes (1991–2021)

The estimated land size covered by each land use in the Lower Niger River between 1991 and 2021 is shown in Table 3 which was produced for the year 1991, 2001, 2011 and 2021 as shown in Fig. 4. The land uses were classified into four categories including waterbody, floodplains, vegetation, and built-up area. The major land use land cover type was dominated by vegetation in 1991 with 47.7% followed by floodplain with 42.7%, then built-up with 5.9% and water body with 4.7%. However, there was drastic change in the land use land cover in the year 2001, with dominant land use land cover type as floodplain with 47.1% thereby gaining more land. The proportion of vegetation was 35.3%, built-up was 13.3% and water body was 4.4%. In the year 2011, floodplain and vegetation maintained the dominant land use type with 39.4% and 29.6% while built-up and water body occupied 27.1% and 3.9% respectively. In 2021, built-up was the dominant land use with 38.7% followed by vegetation with 33.0% floodplain occupied a percentage land area of 25.4%, and water body occupied a proportion of 3.0% (see Fig. 4).

6.2. Analysis environmental conditions

Through community mapping exercises, participants identified the area's most prone to flooding and marked locations where livelihood activities, infrastructure, and natural resources were impacted. The mapping exercise provided a spatial understanding of the community's vulnerability to flooding and helped identify hotspots of vulnerability of which was instrumental to production of flood vulnerability assessment map. A flood risk analysis conducted through remote sensing sheds light on the vulnerability to flooding in the Lower Niger region. The analysis reveals that areas characterized by deep green colouring are at very low risk of flooding. This lower vulnerability can be attributed to their low altitudes and their proximity to developments situated near tributaries or within flood plains, a common scenario in areas primarily located along the major tributary of the river Niger.

The deep green areas enjoy a fortified defence against flooding due to their strategic location and elevation. Notably, these regions are also the most densely developed and densely populated. On the other hand, the light green areas, while also experiencing relatively low vulnerability to flooding, are situated in the highlands, where space is at a premium. Nonetheless, parts of this zone do encounter flooding challenges, primarily stemming from the absence of adequate drainage infrastructure or blockages in the existing drainages

Table 2
Land use Planning and Development.

N = 198			
Land Management	Sub Characteristics	Frequency	Percentage
Buy land from	Inherited	42	21.2
	Individual purchase	**82**	41.4
	Family allocation	**32**	16.2
	Community allocation	**21**	10.6
	Government allocation	**12**	6.1
	Rented	**9**	4.5
		198	100
Building approval	Yes	51	25.8
	No	147	74.2
	Total	**198**	**100**
Community response to Land Management and landuse	Community involvement	3	1.5
	Resource allocation	28	14.1
	Conflict resolution	121	61.1
	Regulatory compliance	46	23.2
	Total	**198**	**100**
Adaptation measures to improve land use planning	Community monitoring	38	19.2
	Awareness	52	26.3
	Stakeholders' engagement	43	21.7
	Carryout land use planning	36	18.2
	Adoption of Nature-based solutions	20	10.1
	Total	**198**	**100**
Awareness of hydrological changes	Yes	84	42.4
	No	114	57.6
	Total	**198**	**100**
Community initiated land use plan or policies	None	16	8.1
	Community sanitation	87	43.9
	Watershed protection	15	7.6
	Neighbourhood watch	48	24.2
	Rotational cropping	32	16.2
	Total	**198**	**100**

Source: Field Survey, 2023

Table 3
Total estimate of area (Km2) of each Land use Land cover change of the lower Niger river (1991–2021).

LULC Category	1991		2001		2011		2021	
	km^2	%	km^2	%	km^2	%	km^2	%
Water Body	346.249	4.7	321.249	4.4	289.714	3.9	220.097	3.0
Flood Plain	3152.734	42.7	3477.983	47.1	2910.999	39.4	1875.383	25.4
Vegetation	3453.697	46.7	2610.714	35.3	2185.943	29.6	2435.228	33.0
Built up	438.409	5.9	981.143	13.3	2004.434	27.1	2860.381	38.7

Source: Researcher' computation

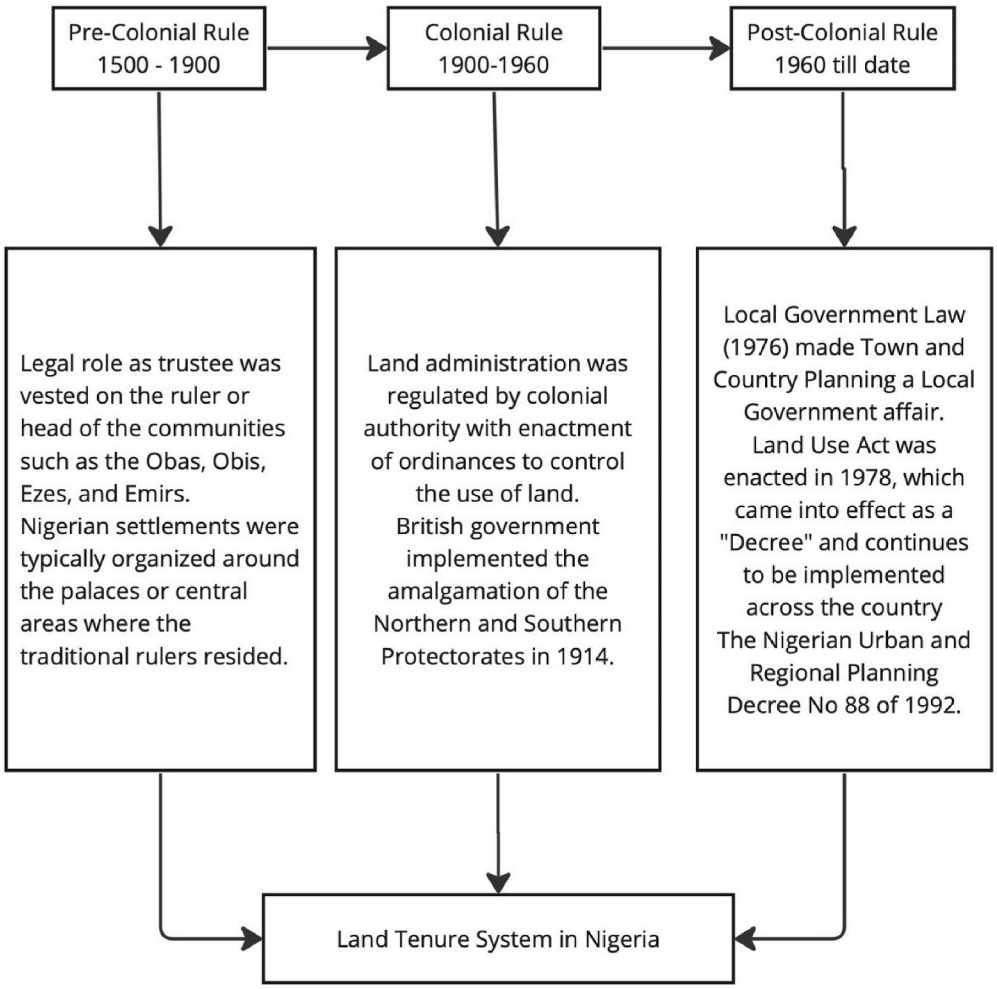

Fig. 2. Land Tenure System in Nigeria from pre-Colonial Rule till date Source:Author, (2023).

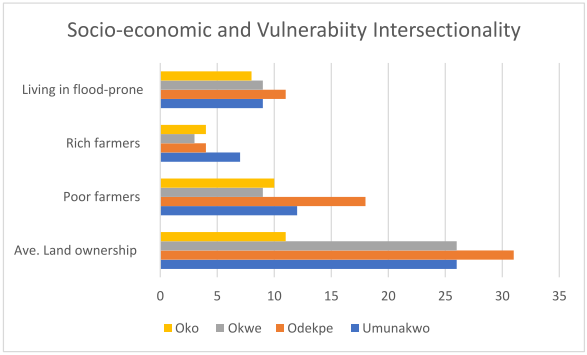

Fig. 3. socio-economic status and vulnerability.

due to silt accumulation and the indiscriminate disposal of refuse within them.

6.3. Flood vulnerability map

The creation of the flood vulnerability map in the Lower Niger basin involved the integration of various vulnerability factors such as land use/land cover, precipitation, elevation, slope, and drainage. Each factor's contribution to overall vulnerability was assessed and ranked, culminating in the generation of the flood vulnerability map illustrated in Fig. 5. This map classified areas into five categories based on vulnerability levels: very low, low, moderate, high, and very high. The findings from the analysis demonstrate that a considerable portion, specifically 3564 square kilometers or 50.5% of the land area, within the Lower Niger basin faces moderate vulnerability to flooding. This highlights a substantial vulnerability prevalent in these regions. Furthermore, the upstream, middle, and downstream sections of the Lower Niger basin exhibit high to extremely high flood risks. These areas encompass a total land area of 61 square kilometers and 676 square kilometers, respectively. Notably, the Ogbaru community experiences particular susceptibility within these high-risk zones due to its proximity to the Niger River, coupled with heavy rainfall and the potential rise in sea levels, amplifying the vulnerability in these regions (see Fig. 5).

6.4. Qualitative analysis

6.4.1. Exploring stakeholders perception

To ascertained stakeholders' perception, we conducted a 17 in-person interviews with a diverse group of participants, including women groups, youths, and community leaders, and representatives from associations, cooperatives, unions, and non-governmental organizations (NGOs). Data included in the analysis observational tools and field notes recorded during the fieldwork. The interview recordings were transcribed using NVivo and emerging theme which we used to gained valuable insights into climate related challenges that impede landuse planning, landuse decision on community resilience and community participation in shaping landuse Planning.

6.5. Climate related challenges affecting land use planning

The participants highlighted several pressing climate-related challenges that significantly impede effective land use planning processes within their community. Foremost among these challenges are the escalating occurrences of extreme weather events, including floods, storms, and droughts. These events disrupt established land use plans, often necessitating immediate responses that may divert attention from long-term planning objectives. Moreover, the uncertainty inherent in climate projections poses a substantial setback, making it challenging to accurately predict and prepare for future climate impacts. A recurring concern expressed by participants revolves around the lack of comprehensive and localized climate data and information. Insufficient availability of data

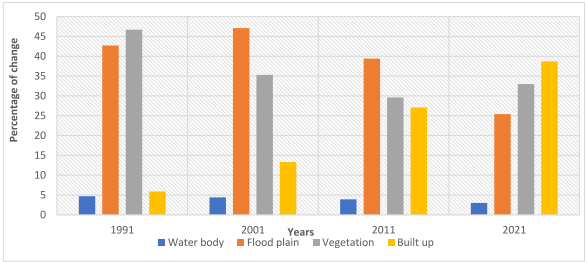

Fig. 4. Land use and Land cover Change 1991–2021.

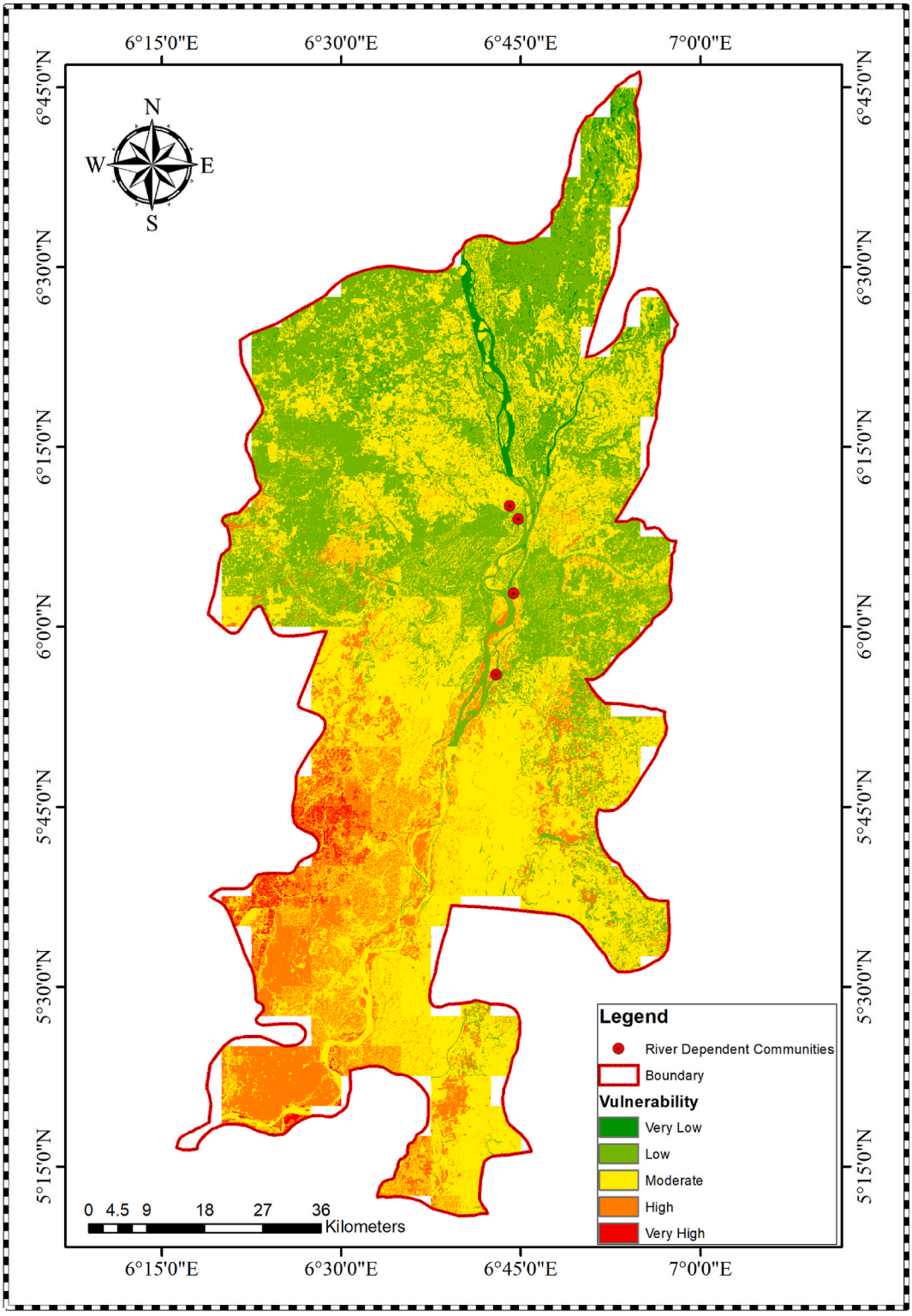

Fig. 5. Flood vulnerability Analysis Map.

hampers the precise assessment of risks and the integration of climate considerations into planning processes. Participants also emphasized the limited institutional capacity and expertise within local planning bodies, which constrains their ability to understand and address climate-related challenges effectively. Conflicting interests and priorities, inadequate policy integration, limited community awareness, and financial constraints were other notable challenges articulated by the participants.

6.6. Land use decision on community resilience

Participants provided valuable insights into the effects of current land use decisions on community resilience in the face of climate-related challenges. One prevailing concern expressed was the vulnerability stemming from urbanization and land use changes, exacerbating the community's exposure to climate risks. They highlighted that ongoing land use decisions, supporting infrastructure development often without due consideration for climate resilience, and this contribute significantly to the community's susceptibility to extreme weather events. Moreover, participants pointed out that these decisions lead to increased impervious surfaces, altered drainage patterns, and reduced green spaces, intensifying local micro-climates and amplifying the urban heat island effect. This, in turn, escalates the community's vulnerability to heat stress and flooding. Additionally, the transformation of natural landscapes for agricultural expansion or infrastructural development was highlighted as compromising ecosystem services, impacting biodiversity, soil quality, and water availability, further undermining the community's adaptive capacity. Participants emphasized the need for more resilient land use decisions that account for climate risks and ecosystem preservation to fortify community resilience in the face of a changing climate.

6.7. Community participation in shaping land use planning

During discussions on enhancing community participation in shaping land use planning for climate resilience, participants expressed several key strategies. A prevalent suggestion was the necessity for inclusive and accessible communication channels to engage a wider spectrum of community members. They emphasized the importance of conducting regular community meetings, workshops, and public forums focused on climate-related issues and land use planning. Participants highlighted the need for transparent information sharing, including the provision of clear, jargon-free materials and interactive maps to facilitate understanding among diverse groups. They stressed the significance of leveraging local knowledge and traditional practices, advocating for participatory approaches like community mapping and focus groups to gather insights and perspectives from various demographics. Additionally, participants emphasized the need for meaningful collaboration between community leaders, governmental bodies, and non-governmental organizations (NGOs) to foster a more inclusive decision-making process. They suggested that incorporating community feedback into planning processes and recognizing local contributions could motivate sustained engagement. Moreover, participants proposed the establishment of feedback mechanisms, such as suggestion boxes or digital platforms, to continuously gather inputs and ensure ongoing community involvement in shaping resilient land use planning strategies.

7. Discussions of findings

The findings pertaining to land use planning and climate adaptation underscore the intricate relationship between these domains and their crucial role in enhancing community resilience. ***Social Groups and Vulnerability***: The analysis of 198 households revealed a concerning trend. While more than half of the households possess individual land for agricultural purposes, a substantial percentage of impoverished farmers, constituting 49 out of the total, are highly vulnerable to climate change impacts. This vulnerability stems from their financial constraints, limiting their capacity to adopt conventional strategies and leading some to settle in flood-prone areas. Furthermore. Communities' inability to implement or adapt land use planning techniques heightens their exposure to severe climate hazards. Among the communities studied, Odekpe stands out with a higher prevalence of vulnerability (32.3%) and residents living in flood-prone zones, shedding light on its susceptibility due to limited adaptive strategies. Furthermore, the qualitative interview supports the assertion that there is escalating occurrences of extreme weather events, uncertain climate projections, insufficient localized climate data, limited institutional capacity, conflicting priorities, and financial constraints emerged as significant impediments. These findings resonate with the research conducted by (Mavhura and Mucherera, 2020; Pathak et al., 2020), emphasizing the impact of these limitations on community resilience to climate hazards. They emphasize the need for policymakers to prioritize understanding these factors to develop tailored strategies aimed at reducing vulnerability.

Land Management Strategies and Building Approval: The predominant means of acquiring land for development, accounting for 41.4%, is through individual purchase, while 74.2% of respondents did not receive building approvals. This lack of approval indicates potential non-compliance with land use regulations or planning ordinances, highlighting a need for adherence to standards to mitigate risks associated with unplanned urban expansion and climate-related hazards. These findings align with (Dodman et al., 2022), emphasizing that urbanization processes, in conjunction with climate change hazards, amplify urban vulnerabilities and exposures, consequently heightening urban risks and impacts globally. It is observed that rapid urban growth significantly contributes to escalating vulnerability and exposure in cities and settlements.

Community Engagement and Adaptation Measures: Encouragingly, over 60% of the community actively engages in resource allocation and conflict resolution concerning land management, fostering a proactive approach to land use planning. However, a significant portion (57.6%) lacks awareness of hydrological changes, which could impede effective planning and hinder adaptive measures. The study conducted by (Effiong et al., 2024) emphasized that the elevated rate of unawareness concerning these changes significantly amplifies livelihood losses and damages for farmers and the community at large.

7.1. Trend of land use land cover changes (1991–2021)

The analysis of land use changes from 1991 to 2021 reflects a significant shift in the dominant land use types. While vegetation dominated in 1991, floodplains surged as the primary land use type in 2001 and 2011, followed by an increase in built-up areas in 2021. This transformation highlights substantial alterations in land use patterns over the years, potentially impacting susceptibility to flooding and climate-related risks.

7.2. Flood vulnerability mapping and environmental conditions analysis

The flood vulnerability map generated using GIS techniques reveals that a substantial portion of the Lower Niger basin, encompassing 50.5% of the land area, faces moderate vulnerability to flooding. Additionally, the upstream, middle, and downstream regions exhibit high to extremely high flood risks, with the Ogbaru community being particularly susceptible due to proximity to the Niger River and heavy rainfall. The study conducted by (AYTOP et al., 2023) has concluded that climate change magnifies the susceptibility of environmental conditions and the trend is supported by factors such as topography, rainfall, vegetation, and soil composition.

8. Recommendations

In view of the discussions in the study, the following recommendations are made:

Strengthen Institutional Capacity: The institutional capability of government organizations in charge of land use planning and regulation needs to be improved. In order to increase their efficiency in putting land management practises into practise and enforcing them, this entails providing them with the necessary tools, training, and support.

Enhance Coordination and Collaboration: Improve communication and cooperation between the many governmental organizations, local governments, and others involved in land use planning. To provide a comprehensive and integrated approach to land management, this can be accomplished through the creation of multi-sectoral platforms, interagency cooperation, and joint decision-making processes.

Improve Awareness and Education: Increase awareness and education about land use planning, climate change, and sustainable land management practices among community members, stakeholders, and decision-makers. This can be accomplished through focused awareness campaigns, training courses, and capacity-building projects that encourage comprehension and participation.

Incorporate Traditional Knowledge and Practices: Recognize and include traditional knowledge and expertise in planning for land use. Participate in decision-making, consultation, and execution of land management initiatives with community elders and indigenous communities. This can promote community ownership and engagement, assist conserve traditional ecological knowledge, and aid in sustainable land management.

Strengthen Land Tenure and Property Rights: By enhancing land administration methods, enacting legal changes, and implementing dispute resolution procedures, you can resolve disputes and difficulties relating to land tenure and property rights. Encourage communities to have solid land rights, especially for marginalised groups, and make sure that mechanisms for allocating and acquiring land are clear and accountable.

Foster Stakeholder Engagement and Participation: Establish methods and platforms for active stakeholder participation in land use planning procedures. This includes encouraging inclusive and participative techniques and incorporating a range of stakeholders including community members, women, youth, and marginalised groups in decision-making. This will leverage local knowledge for effective land use planning and foster resilient land use planning.

9. Conclusion

This work was to examine the nexus between land use change in adapting to climate change in river dependent communities. The study reveals interdependency between inefficient land use management strategies exemplified by the poor outlook and uncontrol development and climate risks in river dependent communities in Nigeria. Traditional knowledge and practices have historically played a crucial role in land use decision-making, with community elders serving as custodians of traditional knowledge. However, these practices face threats from urbanization, land encroachment, and globalization, which erode traditional land management practices and undermine the role of community elders. Stakeholder engagement and participation are crucial in ensuring inclusive and sustainable land management. However, challenges such as limited awareness, power imbalances, exclusionary practices, and resource constraints need to be addressed to foster meaningful participation of community members, women, youth, and marginalised groups.

Land use decisions have a significant impact on community livelihoods and economic growth. Agriculture, fishing, tourism, and other small-scale sectors are all severely impacted by changes in land use patterns, which has an influence on local livelihoods and community well-being. Sustainable land management techniques depend on achieving a balance between economic growth and environmental protection. Based on the findings, several recommendations have been made to enhance land use planning and climate change adaptation in river-dependent communities in Nigeria. These include strengthening institutional capacity, improving coordination and collaboration, incorporating traditional knowledge and practices, addressing land tenure and property rights challenges, fostering stakeholder engagement and participation, and balancing economic development with environmental conservation. Monitoring and evaluation of implementation efforts are also important to assess the effectiveness of land management practices.

Implementing these recommendations will contribute to effective land use planning and regulation which hitherto will promote climate change adaptation, sustainable land management, economic development, well-being of communities in river-dependent areas

of Nigeria. This will ensure that Nigeria moves toward a more resilient and sustainable land management practices that will protect both the environment and the livelihoods of its communities.

CRediT authorship contribution statement

Cyril Effiong: Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. **Eric Ngang:** Investigation, Resources. **Idibeke Ekott:** Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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