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Exploring loss and damage from climate change and global perspectives that influence response mechanism in vulnerable communities

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ABSTRACT

Climate change has led to unprecedented environmental and socio-economic challenges globally, especially in vulnerable communities. Loss and damage refer to the residual effects of climate change, where adaptation and mitigation measures may not be enough to prevent adverse impacts. This study examines the impact of loss and damage caused by climate change in the Lower Niger River region of Nigeria and the influence of global perspectives on the region. The research adopted a mixed-methods approach, including a survey of 198 households and 13 interviews with key stakeholders. Furthermore, an open-source terra climate data of precipitation, runoff, and temperature covering a 30-year period (1990–2020) sourced from Climate Research Unit (CRU) dataset and analysed to show distribution of trends and patterns in climate variables. Similarly, we conducted a land use land cover change (1990–2020) to ascertain the level of changes. Findings from the study have revealed that the anthropogenic factors contribute to hydrological changes in the Lower Niger River Region and these changes result in climatic disasters like flooding which cause severe loss and damage of livelihood including loss of agricultural productivity, fisheries, and accessibility. While global efforts to mitigate and adapt to climate change are important, the study uncovers that the influence of global perspectives on the Lower Niger River Region is often limited by factors such as unequal power dynamics, insufficient funding, and a lack of local ownership of initiatives. The study suggests the need for sustainable land management, resolution of farmers/headers conflict and increased awareness as measures in addressing loss and damage.

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climate change; loss; damage; global perspectives

Introduction

Climate change is one of the challenges facing human societies and the environment, and has become a global issue with potential to cause social, economic, and environmental disruption. In addition, it exacerbates existing vulnerability and poses a significant threat to sustainable development, agriculture and food security (Kasperson et al., 2022). For example, flooding causes significant loss and damage to agricultural product and increases the vulnerability of rural farmers especially in developing countries (Tolika & Skoulikaris, 2023).

The United Nations Framework Convention on Climate Change (UNFCCC) recognises loss and damage as an important aspect of climate change negotiations, with discussions focusing on financing mechanisms to support affected communities. However, different perspectives exist on loss and damage, especially on financing for addressing the issue. Developed countries tend to focus on adaptation and mitigation measures, while vulnerable communities demand urgent action and transformative change (Boyd et al., 2017).

Nigeria, like many other countries in Africa, is faced with the negative impacts of climate change in form of flooding, sea level rise, erosion, and declining agricultural productivity. Nature loss and damage in Nigeria refer to the negative impact on the natural environment and its biodiversity caused by human activities, climate change, and other natural phenomena (Olaniyi et al., 2013). Climate change is adding to the nature of loss and damage, with some countries experiencing more frequent and intense weather events such as flooding and droughts, which have led to crop failures, food insecurity, and the displacement of people from their homes (Taylor et al., 2016).

The Lower Niger River Region has experienced severe climate disasters such as flooding and has caused damage to farmland, crops, and infrastructures leading to loss of income and livelihoods. In addition, other factors like climate disasters, land use

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change, food production, insecurity, insecure tenure, and food insecurity contribute to loss and damage which makes it an important aspect in the study of climate change (Action, 2021).

In the global perspective, different arguments have emerged from stakeholders on the process of handling the issue of loss and damage. This has resulted in countries having divergent opinions on approaches to addressing damage. For example, developed countries believe that existing adaptation and mitigation efforts to reduce greenhouse gas emissions do not support climate adaptation and are insufficient to effectively address the loss and damage arising from climate change (Change, 2012). In contrast, vulnerable developing countries take an existential perspective, arguing that loss and damage represent an urgent threat to their survival and that additional dedicated finance is needed to address them (Boyd et al., 2017; Kasperson et al., 2022). This therefore increases doubt whether neo-liberal policies on climate change can fully address loss and damage especially for vulnerable communities.

This research aims to explores the impact of climate change on farming households in the Lower Niger River Region of Nigeria, with a particular focus on loss and damage. The study seeks to examine the different perspectives held by stakeholders and the extent to which loss and damage from flooding has influence the coping strategies of farmers in the region. This research among other things will contribute to the ongoing debate on loss and damage from climate hazards and provide insights into effective ways to address loss and damage especially for vulnerable communities.

Methodology

This study employs a mixed-methods approach, combining quantitative and qualitative data to explore the impacts of loss and damage from climate change and how it influences global perspectives in the lower Niger River area of Nigeria. The study area was stratified based on proximity to the river, and a random sampling technique was used to select farming households in each stratum. 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.

Study site

The study area spans two states in Nigeria: Ogbaru in Anambra State and Asaba (Oshimili South) in Delta State, Nigeria, all in South-eastern part of Nigeria. The field work was done in selected communities of these local government areas. The study area is located on longitude 7 ^{0}30''N and latitude 7°30''E in Asaba, and 6 ^{0}2'52'N and latitude 6°44'18'E in Anambra State; and is bounded by Anambra west Local government area in the North, Ihiala Local Government Area in the South; Anioch LGA in Delta in the West and Onitsha South in the East. The Niger river cut across the two states and extends into the Atlantic Ocean in the South. See Figure 1.

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 serves as the gateway, encompassing the participant information sheet and the consent form for participation. In this initial part, participants are 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.

Moving on to the second section, it is dedicated to capturing the sociodemographic characteristics of the respondents. This segment of the questionnaire collects data on key demographic factors, including age, gender, marital status, educational background, the agricultural products cultivated, farm size, work experience, farm ownership, and monthly income. These details offer valuable context for analysing how climate change perceptions and adaptation strategies may vary among different groups of participants.

Lastly, the third section delves into the perceptions of farmers regarding the extent of damage caused by flooding and their response measures to climate change and adaptation. Here, participants are asked to provide insights into the impact of flooding on their agricultural and Fishing endeavours, encompassing factors such as property damage, crop loss, and livelihood disruption. Additionally, this section explores the strategies and actions that respondents have implemented or plan to implement to adapt to the challenges posed by climate change.

Drawing from the methodology of (Katirtzidou et al., 2023) who analysed stakeholder perceptions of various

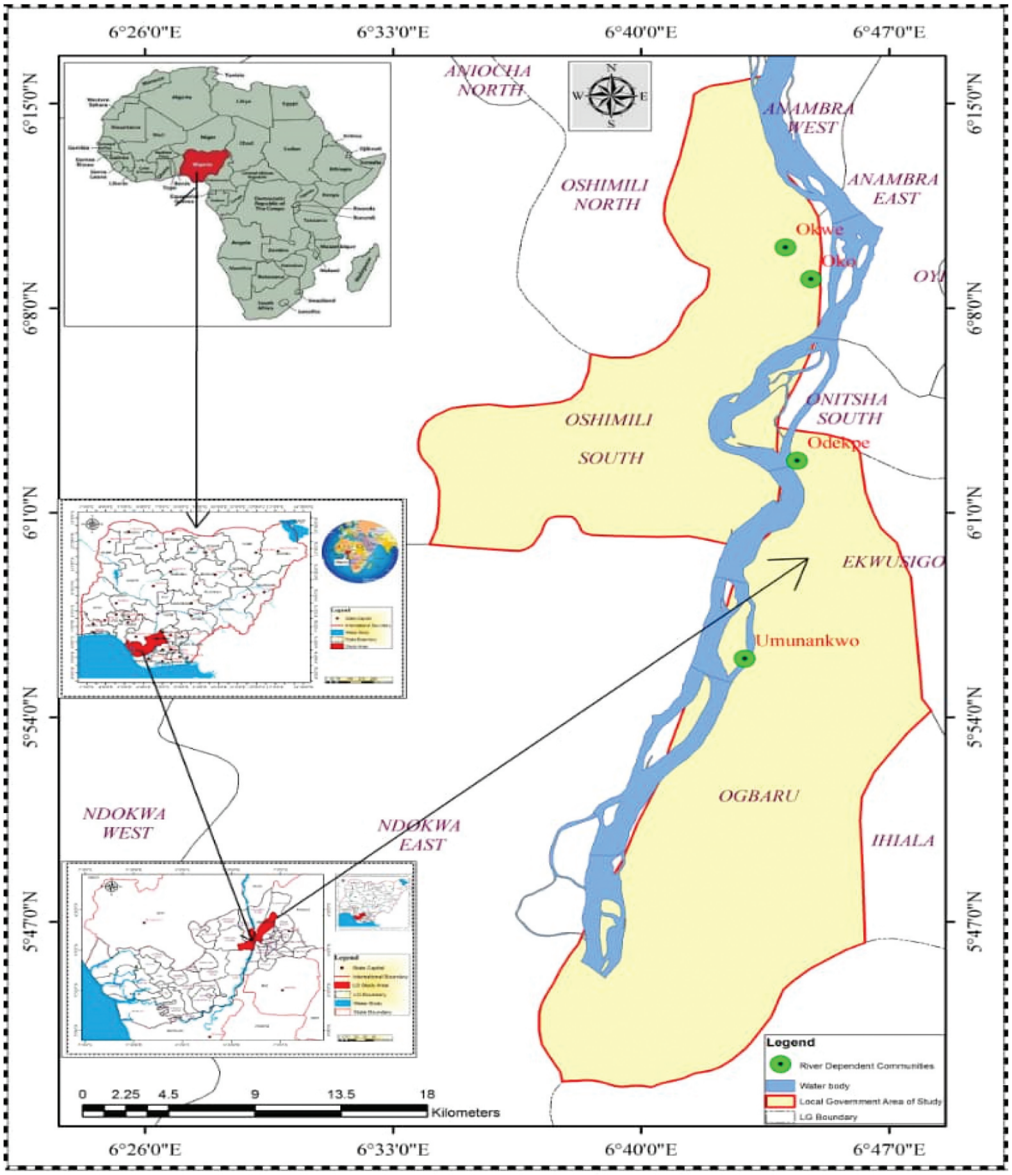

Figure 1. Map showing the study area. Source: Authors' design, 2023

climate-related phenomena, we inquired whether respondents had observed or anticipated occurrences of episodic coastal inundation, water scarcity, or changing temperature. The key informant interviews were conducted in person or via phone, and responses were recorded and transcribed for analysis. Stakeholders were asked to assess specific hazards and decision-making process covering flood risk and changing temperature and other observed challenges. In discussing these challenges, we leverage on the influence of global perspectives on loss and damage on the Lower Niger River Region. Additionally, an open-source terra climate data of precipitation, runoff, and temperature covering a 30-year period (1990–2020) was sourced from Climate Research Unit (CRU) dataset (https://climate.northwestknowledge.net/TERRACLIMATE/index_directDownloads.php) and analysed using R programming to show trends and patterns. The reason for the choice of CRU is its long-term coverage which aligns with my 30-year study. Secondly was the quality and consistency of data and being that their data undergoes rigorous quality control procedures, making it reliable for research and analysis.

Time series data of Land Use Land Cover Change of the study area was obtained from United States Geological Survey (USGS, https://www.usgs.gov/) and analysed using Landsat imagery (TM, ETM+, OLIS/TIRS). The imageries were cloud free obtained to cover 1990, 2000, 2010 and 2020. The imageries were geographically projected on UTM 32N WGS84. Using (Chander et al., 2009) reflectance value on algorithm, the imageries were converted to TOA-Top of Atmosphere and thereafter Dark Object Subtraction was applied to the Landsat data for correction (Zhang et al., 2010). The image was extracted to fit into the study area boundary shapefile in ArcGIS 10.4 and image enhancement was performed to classify the image into four land use (waterbody, floodplain, vegetation and built up) following the Random Forest image classification proposed by (Breiman, 2001). The classification was adopted because of its robustness and high classification accuracy when compared with traditional image classification (Jin et al., 2018).

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 global perspectives on loss and damage. In addition, R programming was used in analysing open-source climate data from Climate Research Unit dataset to show distribution of precipitation, runoff, and temperature. A Spearman ranked corelation was conducted to determine the level of relationship among these variables.

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.

Conceptualising loss and damage

Loss and damage, a topic garnering increasing attention in international climate change discussions, denotes the repercussions faced by certain countries, primarily developing countries, that lack the capacity to manage climate change impacts effectively, resulting in adverse consequences for people, ecosystems, and economies (Pörtner et al., 2022). This issue has gained prominence as mounting evidence suggests that countries are already experiencing loss and damage, even with adaptation and mitigation efforts in place (Roberts & Huq, 2015). The United Nations Framework Convention on Climate Change (UNFCCC) recognizes the need for a wide range of tools to address both preventable and inevitable loss and damage (Verheyen & Roderick, 2008). Preventable loss and damage can be mitigated through disaster risk reduction and climate change adaptation, while inevitable impacts persist due to socio-economic constraints.

Defining loss and damage involves recognizing climate risks from extreme events like flooding, cyclones, sea level rise, and desertification, encompassing their impacts on human and natural systems, such as loss of life, property, displacement, food and water insecurity, and ecosystem damage (James et al., 2014). The absence of a precise definition has led to ambiguity and disagreement among stakeholders, hindering policy development and delaying progress in global negotiations (Calliari, 2018). The lack of clarity also affects the implementation of risk transfer mechanisms like insurance and financial instruments, crucial for addressing loss and damage (Linnerooth-Bayer et al., 2011).

Liability and compensation issues pose further challenges, especially for developing countries that argue addressing these is essential for advancing loss and damage discussions (Tol & Verheyen, 2004). The political context surrounding loss and damage has evolved, initially focusing on adaptation but later acknowledging the limits of adaptation and exploring new approaches, including risk transfer mechanisms (Khan & Roberts, 2013). These approaches face criticism for their inadequacy, particularly in catastrophic events like hurricanes and floods. It is imperative that the international community continues working towards equitable solutions to support vulnerable populations in adapting to climate change (Smith, 2013).

Incorporating various perspectives and interdisciplinary collaboration is crucial in addressing loss and damage effectively, as emphasized by (van der Geest & Warner, 2015). Futhermore, (Boyd et al., 2021) underscores the need for a climate justice agenda and compensation mechanisms to rectify the inequality in climate impacts. Vulnerable communities, despite minimal contributions to greenhouse gas emissions, bear the brunt of climate impacts due to the absence of clear compensation mechanisms. While the literature on loss and damage has grown, a more comprehensive, multidisciplinary approach is required, integrating insights from climate science, social sciences, and economics to understand the complexities involved (Boyd et al., 2021).

Perspectives on loss and damage

In this section we examine four different perspectives on loss and damage and how they fit into the overall goal of climate risk reduction.

Existential perspective

The existential perspective on loss and damage is held by vulnerable developing countries. It emphasises the urgent need for transformative action to address the root causes of climate change (Boyd et al., 2017). In addition, it recognises the threat posed by climate change to human societies and ecosystems and argues for urgent and transformative action to address the root causes of climate change. This perspective challenges the current economic and political systems that prioritise short-term economic gains over long-term sustainability and social justice and calls for radical changes in how we live and work.

Adaptation and mitigation perspective

This perspective emphasises the importance of adaptation and mitigation with countries reducing greenhouse gas emissions and adapting to the impacts of climate change to prevent or minimise the occurrence of loss and damage (Boyd et al., 2017). This perspective acknowledges the limitations of relying solely on technical solutions for managing climate change impact particularly in vulnerable developing countries. This is the reason (Neufeldt et al., 2021) suggests that the challenges faced by these countries in effectively mitigating and adapting to the impact of climate change, result in ongoing loss and damage.

For example (Warner & Van der Geest, 2013) focuses on the residual impacts of climate change, which occur when existing coping and adaptation measures are insufficient, the costs of implementing measures cannot be recovered, measures have negative long-term effects despite short-term benefits, or no measures are adopted or feasible at all. Moreso, it includes examining the specific contexts and conditions under which different types of residual impacts occur, as well as exploring potential strategies for minimizing and addressing them.

Scholars have recognized that adaptation and mitigation strategies have their limitations, especially in regions where socioeconomic constraints, inadequate resources, and other vulnerabilities hinder their implementation (Klein et al., 2015; Kuruppu & Willie, 2015; Shackleton et al., 2015). Despite efforts to reduce greenhouse gas emissions and implement adaptation measures, vulnerable countries may still experience increasing loss and damage due to the complex and interconnected nature of climate change impacts.

Technical perspective

The technical perspective on addressing loss and damage fits into the overall goal of climate risk by contributing to the reduction of vulnerability and the enhancement of adaptive capacity (Homberg & McQuistan, 2019). By focusing on technological and engineering solutions, this perspective aims to minimize the impacts of climate-related stressors on individuals, communities, infrastructure, and ecosystems.

The application of technical measures, such as engineering solutions, early warning systems, and resilient infrastructure, is crucial for protecting people, properties, and ecosystems from the adverse effects of climate change. For example, in the case of the Lower Niger Basin, where flooding is a significant hazard, the implementation of flood-resistant buildings or flood protection systems like levees and flood barriers can help mitigate the impacts of floods and reduce potential loss and damage.

The technical perspective emphasizes the use of scientific knowledge and technological innovations to design and construct physical systems that are more resistant and resilient to climate-related hazards. By incorporating advancements in engineering and technology, this perspective aims to minimize vulnerabilities and enhance the ability of communities and infrastructure to withstand and recover from climate-related events.

However, it is important to recognize that technical perspectives alone are not sufficient to address all aspects of loss and damage. They should be complemented by other perspectives such as legal frameworks to establish norms and facilitate dispute resolution, humanitarian considerations for timely emergency relief and crisis management, development strategies for long-term resilience building, and recognition of non-economic values associated with loss and damage.

Risk management perspective

The risk management perspective on loss and damage recognizes the opportunity to integrate comprehensive risk management approaches into discussions and initiatives on this critical issue (Boyd et al., 2017). It aligns Loss and Damage (L&D) efforts with disaster risk reduction (DRR), climate change adaptation, and humanitarian work, aiming for a holistic approach that links these initiatives with sustainable development, DRR, and climate change resilience building.

This perspective aligns with the overarching goal of climate risk management by offering a comprehensive approach to addressing and managing climate-related risks. It acknowledges the interconnectedness between loss and damage, disaster risk reduction, climate change adaptation, and sustainable development, aiming to integrate these efforts into a unified risk management framework.

To reduce the likelihood and severity of loss and damage, risk reduction strategies are employed, such as implementing mitigation measures and promoting sustainable practices. This includes building resilient infrastructure capable of withstanding climate-related hazards and adopting land use practices that minimize vulnerability.

The risk management perspective takes a techno-pragmatic problem-solving approach, emphasizing the need to understand the interconnected nature of risks. It discourages treating loss and damage and adaptation as separate policy processes, advocating instead for an integrated approach within a broader risk management framework.

By integrating discussions and initiatives on loss and damage with existing frameworks, stakeholders can leverage synergies, build on existing knowledge and experiences, and enhance overall risk management efforts. This integrated approach enables a more coordinated and effective response to managing the risks associated with loss and damage from climate change, ultimately contributing to the overarching goal of reducing climate risk and promoting resilience.

In summary, these perspectives are interconnected and complementary. The Existential Perspective motivates action, Adaptation and Mitigation Perspectives offer strategies, the Technical Perspective provides tools, and the Management Perspective ensures effective implementation and coordination. Together, they form a comprehensive framework for understanding, addressing, and managing loss and damage from climate change.

Result and discussion

Analysis of climate data (temperature, precipitation and runoff - 1990–2020)

The primary outcome derived from the analysis conducted using R programming pertains to the distribution of temperature, precipitation, and runoff. These key climatic variables have been rigorously examined and subsequently discussed within the context of the study. The results obtained shed light on the distribution patterns observed over a 30-year timeframe. This extended period of analysis has been crucial in enhancing our comprehension of climate change dynamics and their profound implications on the well-being of the farming community.

Specifically, these findings offer valuable insights into how shifts in temperature, precipitation, and runoff have unfolded over the three decades under consideration. Such insights are paramount in comprehending the evolving climate patterns and the ways in which they impact the livelihoods of farmers. The repercussions of these climatic shifts are notable, particularly in terms of the associated loss and damage experienced by agricultural communities.

Distribution of temperature (1990–2020)

The lower Niger River region experiences a tropical climate, characterized by distinct wet and dry seasons. In Nigeria, there are two seasons (dry and raining seasons); with dry seasons starting in October—March and the rainy reason starts late March to October.

During the wet season, temperatures are generally warmer due to the higher humidity levels and increased cloud cover. Average temperatures during this time can range from 25°C to 35°C (77°F to 95°F) or even higher. In contrast, during the dry season, temperatures can be slightly cooler, ranging from 20°C to 30°C (68°F to 86°F) on average.

Figure 2 shows a regular distribution of temperature in the years under review which is reflected based on the seasons of the year. The higher the temperature, the hottest the weather which is represented with temperature above 30°C°. Similarly, the mean plot of temperature in the study area representing the two seasons (rainy and dry seasons) in the years under study. During the dry season the temperature is high and

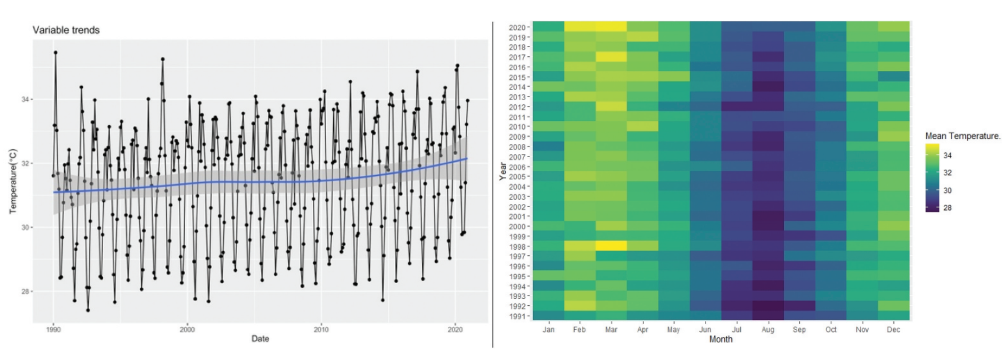

Figure 2. Distribution of temperature in the Lower Niger River (1990–2020).

during the rainy season the temperature is low. Invariably, it means the higher the temperature, the hotter the weather and the lower the temperature, the cooler the temperature. The downward trend shows the cooler temperature, and the upward trend shows the hotter temperature. The warmest temperatures, averaging 0.6°C above the long-term means, were recorded during the reference period spanning from 1990 to 2020. Notably, several high-temperature years were pinpointed, including 1990, 1999, 2001, 2002, 2003, 2004, 2005, and 2020. The data also highlighted the presence of four of the warmest years within the second study period (2000–2010), with only one of such occurrences in the third study period (2010–2020).

Distribution of precipitation and runoff (1990–2020)

The Lower Niger River region undergoes a distinctive rainfall pattern that spans from March to October, with its zenith occurring between June and September. The distribution of rainfall across space, depicted in Figure 3, signifies the recurring nature of flooding on an annual basis, with the severity of such events contingent upon the intensity of rainfall. The inception of rainfall typically takes place in March, coinciding with thunderstorms and the progression of both the Intertropical Convergence Zone (ITCZ) and the West African Monsoon system, as highlighted by (Vasquez, 2009).

Furthermore, the precipitation in the Lower Niger River area is a result of wind systems originating from the southwest and sweeping across West Africa, carrying moisture-laden air from the Atlantic Ocean, as observed by (Lélé et al., 2015). The quantity and timing of rainfall in this region vary based on the potency and trajectory of these influencing factors, including the ITCZ and the West African Monsoon system, as well as other atmospheric conditions. This variability is reflected in Figure 3, which portrays the fluctuating occurrence of extreme weather events in the area. The average annual rainfall in the region typically ranges between 1500 mm and 2500 mm. However, the Niger Delta zone experiences a more abundant annual precipitation, ranging from 2500 mm to 4000 mm. This region, characterized by a complex network of waterways, swamps, and wetlands, provides the essential foundations for the livelihoods of its inhabitants.

Statistics analysis

Utilizing the available time-series data, a Spearman rank correlation analysis was undertaken to investigate the interrelationships among precipitation, runoff, and temperature. To establish a robust foundation for our investigations, we relied on hydrological data sourced from the dataset outlined by (Amanambu et al., 2019). This dataset served as a foundation for our simulations, seeking to ensure precision and reliability. We anchored our simulation on validated parameters derived from the prior study conducted by (Efon et al., 2023), a methodology widely recognized and successfully implemented in similar contexts. Furthermore, in a bid to strengthen our validation process, we integrated observed monthly runoff,

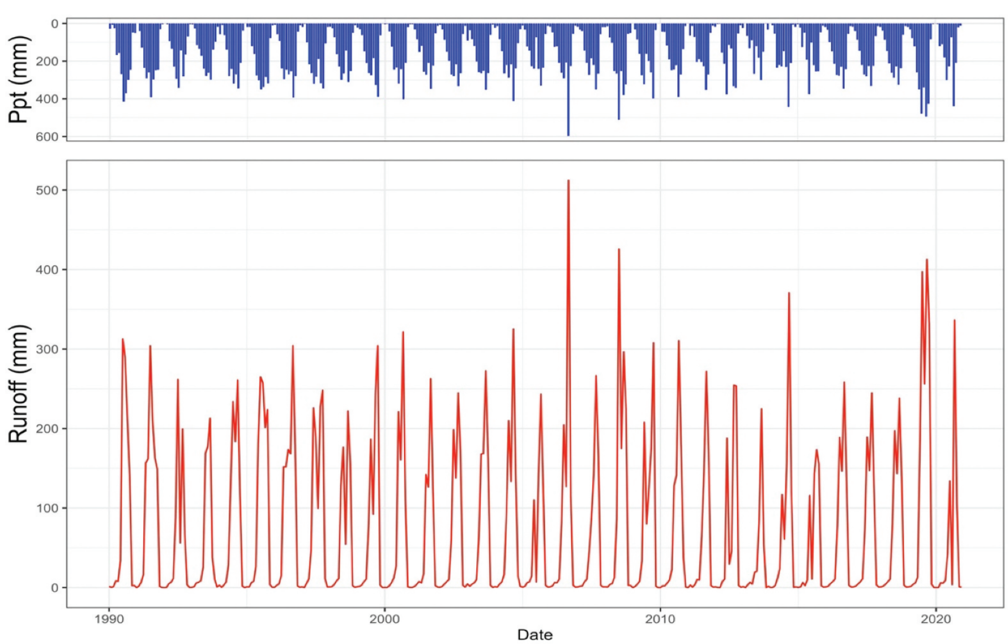

Figure 3. Hydrography showing distribution of precipitation and runoff in the Lower Niger River (1990–2020).

Precipitation Temperature data spanning from 1990 to 2020 obtained from the CRU dataset. Our analysis yielded noteworthy coefficients for runoff, temperature and precipitation demonstrating a robust agreement between the simulated and anticipated value. This reinforced the reliability of our findings and the accuracy of our simulated data for the Lower Niger River Basin.

This analytical approach was adopted with the objective of assessing the reliability of the data and its alignment with the observed events within the study area. The formula for calculating the Spearman rank correlation coefficient (rs) is as follows:

$$rs = 1 - [(6\Sigma d^2)/(n\ (n^2 - 1))]$$

Where:

- Σd^2 represents the sum of the squared differences between the ranks of corresponding pairs of data points.
- n is the number of data points.

The result revealed that a positive correlation coefficient (P) of 0.87 between precipitation and runoff suggests a strong positive association. As precipitation levels increase, runoff levels tend to increase as well. This means that when there is more rainfall in the study area, it leads to a higher volume of water runoff.

Furthermore, an inverse (negative) correlation coefficient of −0.70 between runoff and temperature indicates a negative relationship. When runoff increases, temperature tends to decrease. In other words, when there is more water runoff, it tends to be associated with lower temperatures in the study area. For a visual representation of these correlations, please refer to Figure 4, which presents the correlation matrix, and Figure 5, displaying the scatter plot of these correlations.

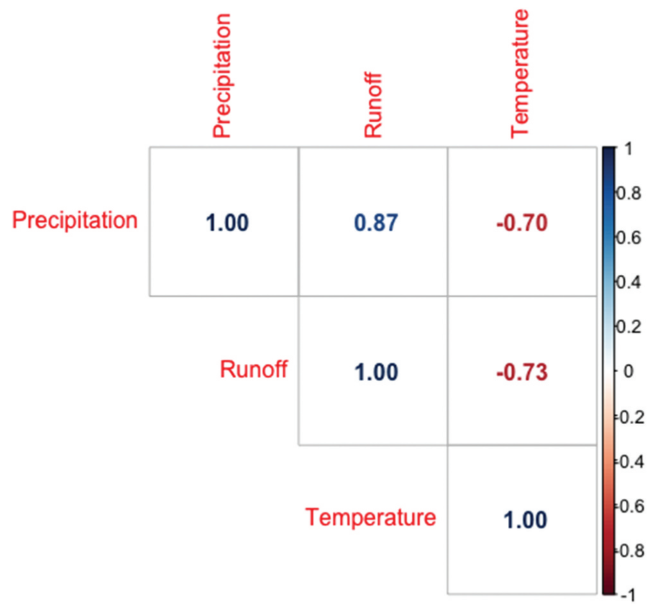

Figure 4. Correlation matrix.

Analysis of land use land cover change (1990–2020)

To ascertain changes in land use, we carry out land use land cover change within the 30-year period. The result as shown in Figures 6 and 7 revealed that the significance of anthropogenic factors, notably the increase of physical development, intensive farming, and land clearance practises, as contributing factors to the changes in the hydrological regime of the Niger River. These findings corroborate the conclusions drawn in the research conducted by (Nkiruka et al., 2023). These human-induced activities possess the potential to modify fundamental land surface attributes, including alterations in vegetation cover and changes in soil moisture content. Consequently, such alterations can significantly impact the intricate hydrological processes within the region. The cumulative effect manifests in a series of consequences directly affecting local farmers, their agricultural practices, and ultimately, their livelihoods. These outcomes align closely with the conclusions drawn in the study conducted by (Nand et al., 2023), further substantiating the observed loss and damage experienced by the local farming communities.

Significant changes in land use and land cover have been observed over a three-year study period in the Lower Niger River region, as illustrated in Table 1. Between 1990 and 2000, there was a notable 51.93% increase in built-up areas, a 39.56% expansion of floodplain regions, and an 8.09% growth in water bodies. However, this period also witnessed a substantial decrease of 50.92% in vegetation cover.

Upon comparing the results across the three study periods, distinct trends in land use changes emerge. The built-up area demonstrated an increase of 51% during the first study period (1990–2000), a more pronounced rise of 66.84% during the second phase (2000–2010), and a more modest growth of 3.04% during the third study period. Particularly noteworthy is the sharp rise of 66.8% in the built-up area during the second study period, closely followed by the 51.93% increase observed in the first period. Conversely, the third study period displayed only a 3.0% increase.

While there was a slight uptick of 3.3% in vegetation during the second study period, the trend was divergent during the first and third study periods, which saw substantial declines of 50.9% and 15.8%,

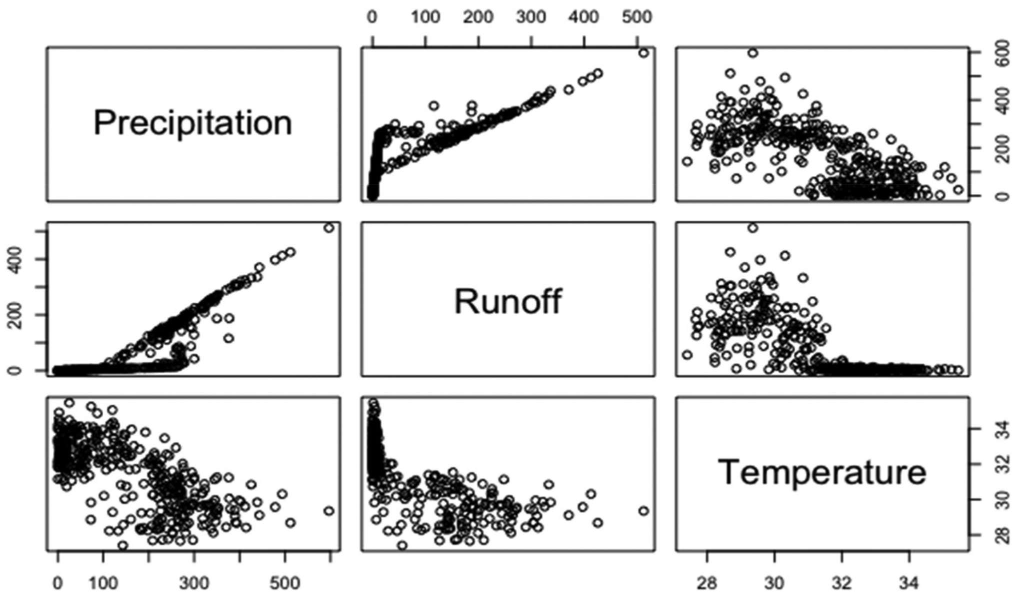

Figure 5. Correlation scatter plot for precipitation, runoff and temperature.

respectively. This decline can be attributed to the increasing expansion of built-up areas across all three study periods.

In terms of floodplain areas, a 39.5% increase was recorded during the first study period, followed by an 11.58% rise in the third period. However, the second study period experienced a decrease of 2.9%. Despite this reduction, these areas remain crucial for floodplain farming, a vital livelihood activity for the local community.

Water bodies exhibited a declining trend of 165% during the second study period and 3.5% during the third study period. This decline is a consequence of human activities linked to the overall expansion of built-up areas across all study periods. Based on the available data, a clear and compelling picture emerges, indicating that human activities exert a substantial influence on the climatic changes witnessed in the study area. The data underscores a direct correlation between human actions and the notable shifts in the local climate. These shifts, in turn, have consequential effects on the region's livelihoods, leading to evident loss and damage.

The study delves into the complex issue of loss and damage resulting from climate change in the Lower Niger River region of Nigeria. Climate change is a global phenomenon with far-reaching consequences, and the Lower Niger River region serves as a microcosm where the local impacts intersect with broader global perspectives. Central to this examination is the role of land-use change as a critical driver of loss and damage in the region.

Qualitative analysis

Exploring stakeholders perception

To ascertain stakeholders' perception, we conducted 13 in-person interviews with a diverse group of participants, including local farmers, fishermen, 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 gain valuable insights into the challenges posed by floods, water scarcity, and changing the result on the perspectives and decision-making processes of key stakeholders in the Lower Niger River region concerning climate-related hazards.

Perceptions of flood risks

During the interviews, participants engaged in candid discussions regarding the growing frequency and severity of floods in the Lower Niger River region, underlining the substantial toll inflicted on homes, farmlands, and vital infrastructure. Their narratives were marked by a sense of urgency and concern stemming from the escalating impact of flooding events. These floods, often triggered by heavy rainfall, have led to severe losses and damage, exacting a profound toll on the affected communities. Participants recounted distressing stories of inundated homes, damaged property, and the displacement of families, testifying to the devastating consequences of these recurring floods.

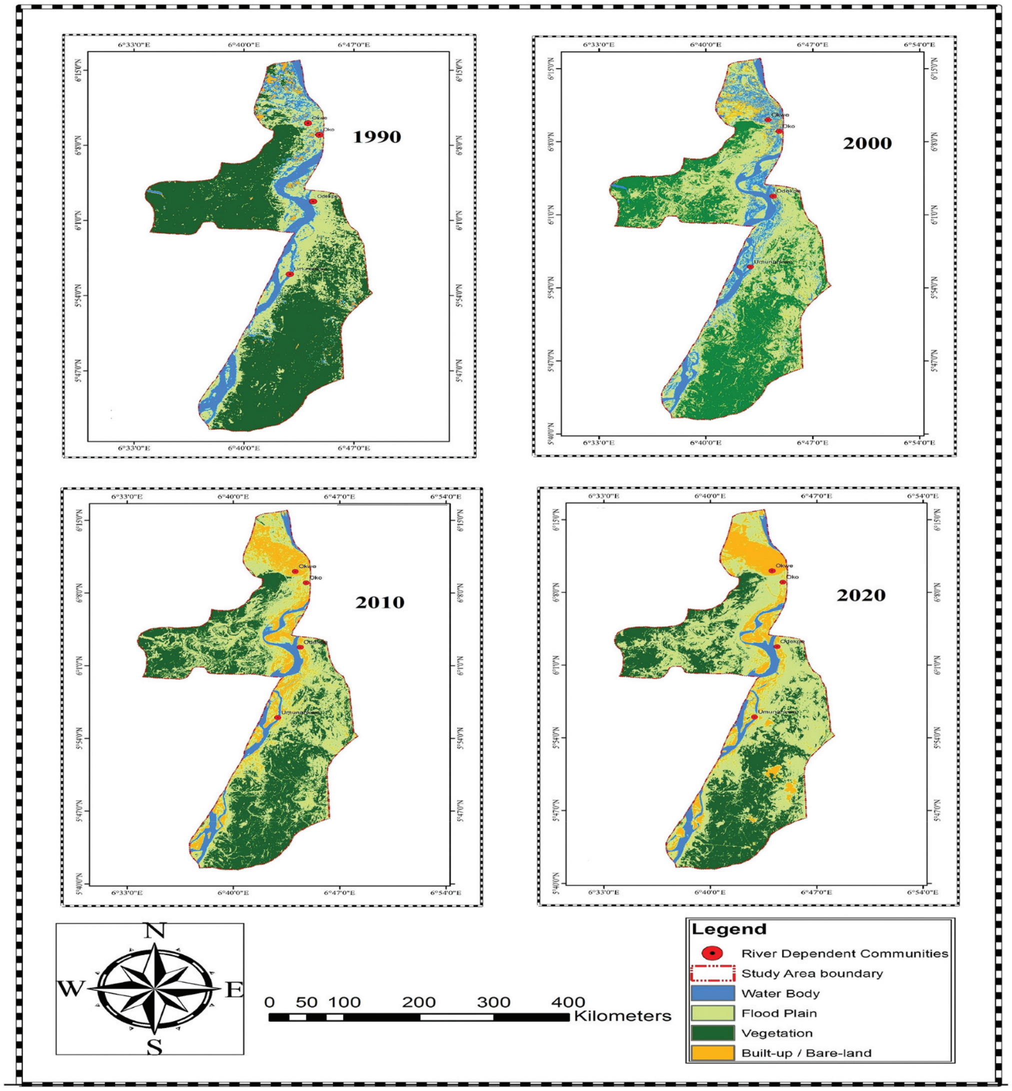

Figure 6. Map of land use land cover changes (1990–2020).

Amid these challenges, a noteworthy theme emerged—local knowledge and traditional coping mechanisms. Participants highlighted the value of indigenous wisdom passed down through generations, offering insights into flood forecasting based on natural indicators, such as wildlife behaviour and river flow patterns. They described how communities united during flood events, extending support and shelter to those affected. Additionally, participants touched upon another pressing issue related to flood impacts—the migration of Fulani cattle from the northern part of Nigeria. This phenomenon, as reported, has been causing severe damage to farmlands, as the cattle invade cultivated areas, resulting in the destruction of crops. This recurrent conflict between farmers and herders has compounded the hardships faced by communities, further underscoring the complex web of challenges associated with floods and their aftermath.

Changing temperature patterns

During the interviews, participants candidly shared their observations regarding shifting temperature patterns in the Lower Niger River Region. They emphasized the discernible changes in temperature, characterized by more frequent and prolonged heatwaves. These altered temperature patterns have emerged as a prominent climate-related concern within the region, prompting discussions that spanned various aspects of life.

Participants highlighted the multifaceted impact of these temperature shifts, particularly the intensification of heatwaves with consequences extending across health, agriculture, and overall well-being. furthermore, participants expressed concerns about the increased risk of heat-related illnesses and discomfort, particularly among vulnerable populations such as the elderly and children having malaria. This problem tends to strain

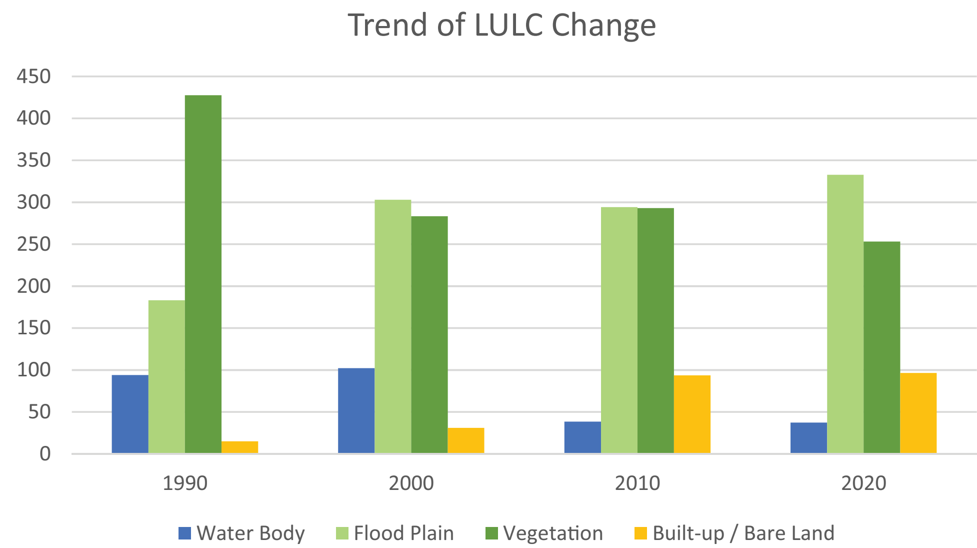

Figure 7. Trend in land use land cover changes.

Table 1. Land use land cover changes (gain, loss, and rate of change) in the Lower Niger River grouped between 1990–2000, 2000–2010, and 2010–2020, where G=gain, L=loss

	1990–2000		2000–2010		2010–2020	
LULC	G/L	% Rate of change	G/L	% Rate of change	G/L	% Rate of change
Water Body	8.275	8.09	−63.714	−165.46	−1.312	−3.53
Floodplain	119.858	39.56	−8.743	−2.97	38.548	11.59
Vegetation	−144.262	−50.92	9.866	3.37	−40.176	−15.88
Built up	16.129	51.93	62.591	66.84	2.94	3.04

healthcare systems and places additional burdens on communities already grappling with other climate-related challenges.

In agriculture, the effects of rising temperatures are keenly felt. Participants shared their experiences of how prolonged heatwaves and higher temperatures can lead to drought conditions, reduced soil moisture, bird mortality and stressed crops. These conditions can result in reduced yields and agricultural losses, with cascading impacts on food security and livelihoods.

During the period from January to March, my birds were subjected to high temperature due to the roofing material I have in place, which consists of corrugated zinc sheets. This roofing material does not allow the birds to sweat, and as a result, they release heat primarily through their bodies. However, during the night when the temperatures drop significantly, the birds often encounter coughing issues. This coughing problem potentially led to the unfortunate and recurring occurrence of bird mortality.

Beyond health and agriculture, participants also acknowledged the broader implications of shifting temperature patterns on their overall well-being. They described the challenges of coping with extreme heat, especially in the absence of adequate cooling and infrastructure.

Other observed challenges

The study brings to light a critical perspective on the global efforts to address climate change and their impact, or lack thereof, on the Lower Niger River Region. While international initiatives aimed at mitigating and adapting to climate change are undeniably crucial, the participants underscored that their influence in the region is frequently constrained by a range of challenging factors. These limiting factors encompass unequal power dynamics, inadequate funding, and water scarcity for agricultural production.

Firstly, participants highlighted the presence of unequal power dynamics among different actors as impediment to achieving the implementation of global climate initiatives in the Lower Niger River Region. Participants alluded that most often, decision-making processes and resource allocation favours more powerful or influential entities in communities which may not necessarily prioritize the specific needs and vulnerabilities of the region.

Secondly, participants discussed the issue of insufficient funding as a significant impediment to climate adaptation. They revealed that despite the global discourse on climate financing, the Lower Niger River Region faces challenges in securing adequate financial resources for climate mitigation and adaptation efforts. This dearth of funding hinders the region's ability to implement essential projects and strategies which could have been of immense benefit to the community. For instance, participants complained that water scarcity limits irrigation farming and the community public water has been abandoned for years without repairs and now farmers are finding it difficult to access water for irrigation farming.

Lastly, participants vividly conveyed the challenges posed by water scarcity in meeting daily household needs. They described situations where access to clean and reliable drinking water was often compromised, especially during periods of low rainfall. This scarcity has significant ramifications for sanitation, hygiene, and overall well-being, as it impedes the ability of households to maintain basic standards of cleanliness and health. In addition, participants lamented the constraints placed on their farming endeavours due to irregular water supply for irrigation. Crops wither, and yields diminish in the face of insufficient moisture, leading to food insecurity and economic hardship for farming communities.

Questionnaire analysis

Climate change impact affecting households in the last 10 years

In the initial phase of our study, respondents were queried regarding their first-hand experiences with heavy rainfall resulting in flooding over the past decade. A striking majority, exceeding 80% of the respondents, affirmed that they had indeed witnessed heavy rainfall leading to flooding within this timeframe. Furthermore, we sought to ascertain the frequency of such flood events during the rainy season. The responses revealed that 11.9% of respondents reported witnessing extreme rainfall events lasting 1–3 days, while a substantial 48.3% indicated that they had observed rainfall episodes spanning more than 7 days. Table 2 provides an overview of cumulative percentages representing respondents' awareness and concern regarding climate change impacts in the Lower Niger River region. Notably, 59.1% of respondents acknowledged that climate change had adversely affected irrigation agriculture over the past decade, while 40.9% indicated their lack of awareness regarding this issue. Additionally, the responses underscored a limited understanding of temperature fluctuations, with a significant 57.6% reporting unawareness, while only 42.4% recognized temperature increases

Table 2. Climate hazard affecting farming household in the last 10 years

Climate hazards	Sub Characteristics	Frequency	Percentage
Witness Extreme rainfall that result in flooding	Yes	197	99.4
	No	**2**	1.01
Number of days witnessed flood in rainy season due to extreme rainfall in the last 10years	None	6	3.0
	1-3days	24	11.9
	4-6days	74	36.8
	>7days	94	48.3
	Total	**198**	**100**
Number of days experience flooding in the last 10years	None	3	1.5
	1-3days	28	14.1
	4-6days	121	61.1
	>7days	46	23.2
	Total	**198**	**100**
Number of times experience water scarcity in the last 10years	1-3times	49	24.7
	4-6times	63	31.8
	>7times	86	43.4
	Total	**198**	**100**
Awareness of changing temperature which affect farming system	Yes	84	42.4
	No	114	57.6
	Total	**198**	**100**
Number of times witness flooding event cause displacement of community and livelihoods in the last 10years	1-3times	73	36.9
	4-6times	110	55.6
	>7times	15	7.6
	Total	**198**	**100**
Climate change impact have negative effect on irrigation	Yes	117	59.1
	No	81	40.9
	Total	**198**	**100**

as having already impacted the agricultural sector. Lastly, a substantial 56.6% of respondents recounted witnessing flooding events causing community displacement and livelihood disruptions within the past 10 years. This displacement occurred 4–6 times for the majority, while 36.9% reported 1–3 instances, and a minority of 7.6% stated that they had observed such events more than 7 times.

Extent of damage from flooding in the Lower Niger Basin

To ascertain the extent of loss and damage to livelihoods resulting from flooding, respondents were provided with a set of five-point indicators in the questionnaire designed to assess the magnitude of damage across various facets of livelihoods, encompassing both agriculture and fisheries. Tables 3 and 4 present a comprehensive exposition of the extent of loss and damage observed within the Lower Niger River basin, delineating these impacts across multiple dimensions of livelihood aspects.

Agriculture

The data revealed that various agricultural components including crop yield, crop production, quality of water and land availability are impacted by flood and contribute to the damage and loss of farmers in the region. Crop yield and crop produce: The data indicates that a significant proportion of households experienced moderate losses in crop yield and crop produce. For example, with 34.34% crop yield moderately affected by flood, and 21.21% of crop yield are significantly destroyed during flood. Similarly, 20.20% of crop produce are moderately affected by flood and 24.24% of crop produced are destroyed during flood. Therefore, this could lead to high price fluctuation due to scarcity of the farming product which can plunge farmers into poverty and landlessness. Secondly, depending on the duration of flood, farmers can experience extreme loss which increase their vulnerability and impact on other livelihood components of farmers. This suggests that farmers in the region have been significantly affected by flooding, leading to reduced agricultural productivity and potential scarcity of farming products. Consequently, this can result in high price fluctuations and negatively impact farmers' income and livelihoods.

Fisheries

Fisheries livelihood aspect was assessed covering Fish stock, access to fishing gear, and access to fishing equipment as shown in Table 4. The assessment reveals the extent of loss and damage to fisheries livelihoods. 30.30% of fish stocks were moderately affected by flood, while 21.21% of fish stock were destroyed by flood. Similarly, 27.78% access to fishing gear and technology were moderately affected while 21.21% access to fishing gear and technology were destroyed. The overall percentage of fisheries and accessibility moderately and extremely affected was more than 50% which suggests that flooding has adversely affected the fishing industry

Table 3. Extent of damage from flooding agriculture

			N= 198		
Livelihood aspect	Not affected at all (%)	Slightly affected loss (%)	Neutral (%)	Moderately affected (%)	Destroyed or extreme loss (%)
Crop yield	15(7.58%)	45(22.73%)	28(14.14%)	68(34.34%)	42(21.21%)
Crop produce	38(19.19%)	50(25.25%)	22(11.11%)	40(20.20%)	48(24.25%)
Quality of water	36(18.18%)	20(10.10%)	42(21.21%)	55(27.78%)	45(22.73%)
Land availability	39(19.70%)	15(7.58%)	50(25.25%)	46(23.23%)	48(24.24%)
Quality of river water	30(15.15%)	31(15.66%)	40(20.20%)	55(27.78%)	42(21.21%)

Table 4. Extent of damage from flooding (fishing and accessibility)

			N = 198		
Livelihood aspect	Not affected at all (%)	Slightly affected loss (%)	Neutral (%)	Moderately affected (%)	Destroyed or extreme loss (%)
Fish stock	24(12.12%)	36(18.18%)	36(18.18%)	60(30.30%)	42(21.22%)
Access to fishing gear and technology	35(17.68%)	40(20.20%)	26(13.13%)	55(27.78%)	42(21.21%)
Access to fishing equipment	28(14.14%)	38(19.19%)	35(17.68%)	52(26.26%)	45(22.73%)
Water flow pattern	20(10.10%)	42(21.21%)	38(19.19%)	58(29.29%)	40(20.21%)
Access to fishing ground	30(15.15)	40(20.20%)	33(16.67%)	50(25.25%)	45(22.73%)
Access to market	42(21.21%)	20(10.10%)	35(17.68%)	46(23.23%)	55(27.78%)
Price of product	32(16.16%)	26(13.13%)	40(20.21%)	52(26.26%)	48(24.24%)
Product availability	38(19.19%)	42(21.21%)	28(14.14%)	45(22.73%)	45(22.73%)
Income	30(15.15%)	31(15.66%)	43(21.72%)	50(25.25%)	44(22.22%)
skills	35(17.68%)	40(20.20%)	36(13.13%)	52(26.26%)	45(22.73%)

in the Lower Niger River basin, potentially leading to decreased fish populations, limited access to essential resources, and reduced fishing activities. The findings from the assessment indicate that the extent of loss from flooding has contributed to livelihood diversification and, in some cases, abandonment. This means that affected communities may be forced to explore alternative livelihood options or even abandon their traditional livelihood activities due to the significant impact of flooding. This can further exacerbate issues such as scarcity of commodities, price inflation, and increased vulnerability among affected households. The result highlights the effects of flooding on infrastructure, particularly in terms of market accessibility and price fluctuations. The findings suggest that flooding has disrupted access to markets, making it challenging for farmers to transport their agricultural commodities. This can lead to forced sales at lower prices, reduced profit margins, and potential financial hardships for farmers. It may also result in the need for borrowing capital for future planting seasons.

Contribution of climate change to the observed flooding event

Climate change plays a pivotal role in exacerbating flooding events observed in the Lower Niger River region of Nigeria, impacting the region through various mechanisms. While it's crucial to acknowledge that individual weather events result from a complex interplay of factors, including natural variability, human activities, and climate change, the contribution of climate change to the observed flooding in the Lower Niger River is notably significant, particularly concerning continuous deforestation and land use changes.

The observed increase in loss and damage in the region can be attributed significantly to climate change, although it is essential to acknowledge the interplay of anthropogenic factors that exacerbate these impacts. Notably, the intensification of physical development, extensive farming practices, and land clearance activities are focal contributors to the alteration of the hydrological regime within the Niger River basin.

Climate change indeed has multifaceted impacts on river flow regimes, with far-reaching consequences for various aspects, including agriculture and ecosystem. These impacts primarily stem from the projected changes in precipitation patterns, sea level rise, and temperature increases, each contributing to altered river flows in distinct ways which aligns with the work of (Nasr et al., 2023; Yang & Frangopol, 2019) on climate change impact on long-term risk.

The rapid expansion of physical development, including urbanization and infrastructure projects, has led to alterations in land use and land cover. Changes in land use is driven by urbanisation which has led to expansion of cities thereby increasing the intensity of climate disasters. For example, Nigerian urban population in 1975, was approximately 16.3 million, constituting 21% of the total population. Consequently, by 1993, this figure had risen to 36.2% (Arimah & Adeagbo, 2000; Lwali, 2008). While the overall urbanization rate for the entire country is estimated at around 7% (Potts, 2012) notable cities such as Lagos, Ibadan, Kano, Onitsha, and Aba were already experiencing more rapid expansion. The consequences of this transformation have been the substitution of natural landscapes with impermeable surfaces, such as concrete and asphalt. These alterations have disrupted the inherent drainage patterns of the region, giving rise to heightened surface runoff when confronted with heavy rainfall events. Consequently, this disruption has significantly escalated the vulnerability of the area to the risk of flooding.

Furthermore, alteration of rainfall patterns, the intensification of rainfall events, prolonged periods of drought and extreme rainfall are facets of climate change that have directly contributed to heightened flood risks, crop failures, and the erosion of agricultural productivity. These climate-driven changes have subjected local communities to increased vulnerability and have catalysed the surge in loss and damage incidents. As observed in research findings, these changes have contributed to a more prolonged and intense rainy season in the Lower Niger River region which in turn, exacerbates the risk of flooding, causing substantial damage and losses for local farmers.

Another pivotal factor in the context of the region is the pressing issue of deforestation, closely intertwined with the heavy reliance on unsustainable energy sources for cooking. Field study data sheds light on the alarming extent of this dependency, revealing that a staggering 78.6% of households utilize firewood as their primary cooking fuel, with 12.8% relying on charcoal and 8.4% on kerosene. This pronounced and widespread reliance on firewood has profound consequences, particularly in terms of deforestation, which is both environmentally unsustainable and a substantial contributor to greenhouse gas emissions. Furthermore, it exacts a toll on human health, with adverse effects.

Response mechanism of farming households in the lower Niger region

The field data shows that farmers in the Lower Niger region are experiencing extreme losses of agricultural produce and income due to climate-related disasters. In addition, factor such as the power relations, marginalization and insecurity have increased their vulnerability. For example, loss of income due to flooding has resulted in a livelihood shock that has affected their living standards. This recognises the urgency need for transformative action to address the impacts of climate change and to provide financial and technical support to vulnerable communities to cope with loss and damage. By emphasizing the experiences of farmers in the Lower Niger region who are facing extreme losses of agricultural produce and income due to climate-related disasters, the information underscores the urgent need for transformative action and support for vulnerable communities to cope with loss and damage. It also highlights the importance of local stakeholders taking proactive measures that fit their specific contexts.

Considering the challenges faced by farmers in the region, we assessed the response mechanisms employed by farmers to mitigate vulnerability. The results, as illustrated in Figures 8 and 9, unveiled a range of strategies adopted by farmers before and after to proactively address hazards. These strategies encompassed various approaches, including casual manual labour, borrowing resources from friends and neighbours, early planting and harvesting practices, and diversifying crop varieties.

It is noteworthy that while a substantial portion of farming households embraced these proactive measures, some were constrained by limited financial resources and a lack of capacity to access and process information, which hindered their ability to adopt preemptive strategies to prepare for potential hazards.

Additionally, many farming households reported borrowing resources from friends and neighbours to expand their farming activities and mitigate the risks associated with climate hazards. This included endeavours such as planting trees, commencing planting early in anticipation of rainfall, crafting irrigation channels in readiness for rains, and cultivating flood-resistant crop varieties.

Of particular significance were the observations from wetland farmers, who noted that the recurrent rise in sea levels posed a considerable threat to their agricultural endeavours. In response, they took the initiative to construct local embankments, aimed at minimizing water ingress into their farms during episodes of sea level rise.

Another notable strategy implemented by farmers was the practice of planting and harvesting crops ahead of the typical onset of rainfall or in anticipation of extreme rainfall events. Those farming households that adopted this approach reported comparatively minimal losses when compared to farmers who did not engage in such preparatory actions.

These findings resonate with the work of (SeinnSeinn et al., 2015) which suggests that farmers exposed to climate-related risks tend to opt for crop varieties that exhibit resilience to flooding and other adverse conditions. The adoption of such adaptive measures underscores the importance of proactive strategies in enhancing the resilience of farming communities facing climate-related challenges.

Likewise, our assessment encompassed an exploration of the post-hazard strategies employed by farmers in response to the challenges posed by climate-related events. The findings, shown in Figure 9, shed light on the multifaceted dynamics of these post-hazard strategies.

One of the predominant themes that emerged was the significant role played by financial constraints in limiting farmers' capacity to adopt post-hazard strategies effectively. Many farmers expressed their inability to implement such strategies due to a lack of financial resources. However, they exhibited resilience by resorting to alternative coping mechanisms, relying on remittances from family members, friends, and relatives to navigate the aftermath of climate shocks.

As one respondent eloquently put it, *'I have lost farmland and crops to flood. Now I'm struggling to feed because I do not have money. If not for my son who sent me money, I would literally be begging people to feed my family'*. This poignant testimony highlights the pivotal role of remittances in providing a lifeline for vulnerable farming households during times of crisis.

Furthermore, impoverished farming households, confronted with financial constraints, often sent at least one family member to seek employment as house help in larger cities. The expectation was that remittances from the family member working in urban areas would bolster the household's ability to augment their consumption needs in the face of climate shocks. This practice underscored the essential role of remittances in supporting rural families' resilience.

Additionally, farmers implemented various strategies to adjust their household expenditures and adapt to reduced income levels after climate disasters. These adjustments included reducing the frequency of meals from three square meals to two daily squares, adopting a more frugal approach to spending by prioritizing essential family needs, and avoiding unnecessary expenses. Moreover, some farmers expanded their labour supply as a substitute for lost income, particularly those with surplus labour resources at their disposal.

These observations align with the findings of (Giupponi et al., 2022), which emphasize the utilization of labour market responses as a means to substitute income and minimize vulnerability to risks in the wake of climate-related hazards. In essence, the farmers'

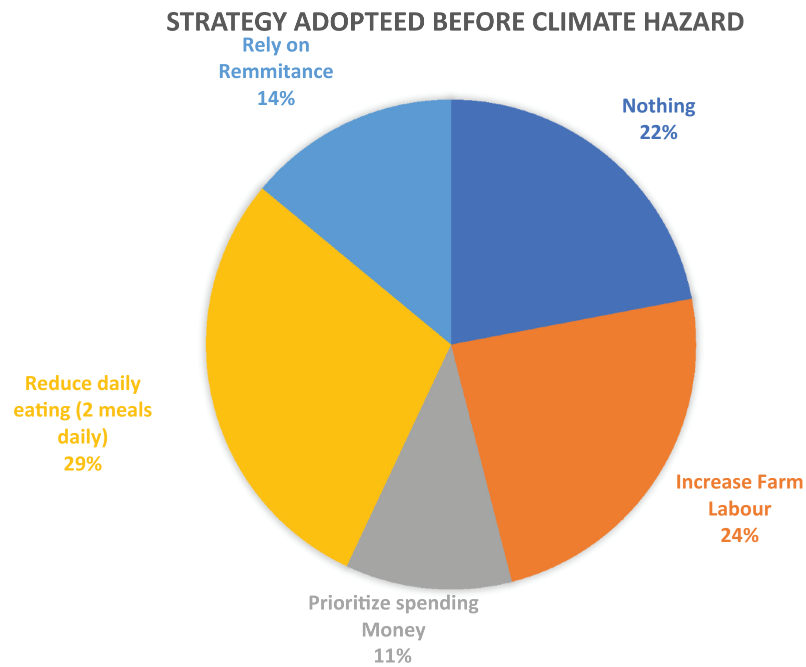

Figure 8. Strategy adopted before hazards.

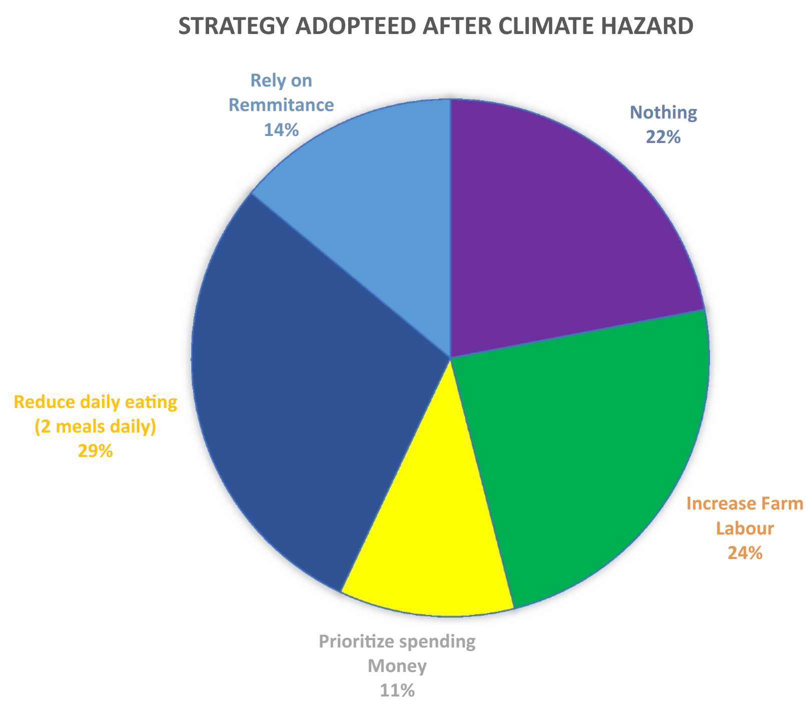

Figure 9. Strategy adopted after hazards.

ability to adapt and employ these post-hazard strategies reflects their resilience and resourcefulness in the face of adversity, demonstrating the critical importance of diversified coping mechanisms in building resilience to climate shocks.

Limitation of the study

The study presented valuable insights and findings, yet, like any research endeavour, it is important to recognize and acknowledge its limitations. Although these limitations were not explicitly detailed, it is essential to contemplate potential shortcomings that could impact the study's applicability and the interpretation of its outcomes.

One potential limitation is the data source as the research heavily relied on dataset from climate research units, questionaries, and interview. These sources might have failed to comprehensively represent the full diversity of experiences and perspectives across the entire region.

Furthermore, the size and diversity of the study's sample might not adequately capture the entire spectrum of viewpoints and encounters linked to climate change, flooding, water scarcity, and temperature fluctuations. In addition, the study may not have accounted for external factors or events that could potentially influence the perceptions and experiences of the study's participants. These external factors might encompass government policies, economic fluctuations, or other ongoing developments within the region.

Recommendations

Based on the findings of the study, several recommendations can be made to address loss and damage in the region and support vulnerable communities.

Firstly, the adoption of sustainable land management practices holds the potential to significantly mitigate the adverse impacts of flooding, if not entirely prevent them, thereby minimizing the extent of loss and damage. A fundamental approach within this realm involves the implementation of techniques such as shifting cultivation and land fallowing. These strategies can play a crucial role in maintaining soil health, enhancing water retention capacities, and fostering a more resilient ecosystem in the face of flooding events.

Furthermore, a secondary approach involves advocating for nature-based solutions as a proactive measure to prevent loss and damage. This entails initiatives such as tree planting and safeguarding greenbelts to prevent the conversion of reserved land into alternative uses. These strategies not only enhance the natural environment but also act as a protective barrier against the potential consequences of land use changes, contributing to the reduction of vulnerability and potential losses.

Resolving the conflicts between farmers and herders is paramount in establishing a sustainable environment that fosters investment and enables the continuation of farming and other business activities. By addressing these conflicts, a conducive atmosphere can be cultivated, ensuring that individuals can engage in their livelihood pursuits without disruptions or threats to their security. This proactive approach not only promotes economic growth but also contributes to social harmony and stability within the community.

Initiating an intensified awareness campaign serves as a pivotal step in educating farmers about the imperative of taking preventive measures to mitigate loss and damage in the event of flooding. By disseminating this crucial information, farmers can gain insights into effective strategies aimed at minimizing the impact of flooding on their endeavours. Additionally, providing the community with accessible and relevant climate information equips them with valuable insights into potential climate-related disasters, enabling proactive preparedness and response measures to be put in place. This comprehensive approach not only empowers individuals with knowledge but also fosters a culture of resilience in the face of climatic challenges.

Conclusion

The research was to explore damage and loss and how they influence the global perspective debate on loss and damage. The findings obtained from the study have brought to light a critical insight that anthropogenic factors play a pivotal role in driving significant alterations in the hydrological dynamics of the Lower Niger River Region. These alterations, in turn, give rise to climatic hazards, with flooding being a prominent outcome. This flooding, in its wake, inflicts substantial and far-reaching consequences, particularly in the form of severe loss and damage to various aspects of livelihoods. Among the most impacted sectors are agriculture and fisheries, both of which experience significant declines in productivity. Additionally, the accessibility of the region is compromised, exacerbating the challenges faced by the local community.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that supports the findings of this study are available upon request. Due to the sensitive nature of the data collected, which includes personal information and community-level data from vulnerable populations, restrictions apply to the public availability of the dataset. However, researchers who wish to access the data for valid research purposes may contact the corresponding author to request access.

The primary data consist of qualitative interviews conducted with farmers and community leaders to gain insights into how their coping strategies influence global perspectives on loss and damage.

These data capture valuable insights, experiences, and perspectives of the participants regarding the impacts of climate change and the response mechanisms employed in their communities. For the survey, a total of 198 households were selected and surveyed using a structured questionnaire.

Due to the sensitive nature of the data, which includes personal information and potentially identifying details, it cannot be made publicly available. However, researchers interested in accessing the primary data for legitimate research purposes can contact the corresponding author [provide contact information] to request access. Any requests will be subject to review to ensure compliance with ethical considerations, privacy protection, and data sharing agreements.

The secondary data was sourced through an open-source terra climate data of precipitation and temperature covering a 30-year period (1990 –2020) was sourced from Climate Research Unit (CRU) dataset and analysed using R programming to show trend and pattern. Additionally, we obtained relevant information from report, academic studies, government publication and other sources within the manuscript.

To facilitate transparency and reproducibility, the manuscript includes a comprehensive description of the methodologies employed for data collection, data cleaning, and data analysis. This information enables readers to understand the research process and the basis for the presented findings.

We recognize the importance of data sharing and the potential for collaboration and further research in this field. However, we also respect the privacy and confidentiality of the research participants and the communities involved. Therefore, access to the primary data will be granted in a manner that upholds ethical standards and protects the rights of the individuals and communities who contributed to this study.

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