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Adapting to Flood Risks in a Changing Climate: Best Practices and Innovations

Johnbull, Simeipiri Wenike; Nwokaeze, Edmund Chinem; Ikiriko, Tamunoikuronibo Dawaye

Department of Urban and Regional Planning, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt.

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ABSTRACT
The increasing occurrence and severity of flooding worldwide, exacerbated by climate change, is a growing concern for the safety and security of people, property, and infrastructure. To address this challenge, effective and sustainable flood risk management and adaptation strategies are essential. This conference paper takes a global look at current best practices in flood risk adaptation and their effectiveness in reducing the impacts of floods, with a particular focus on Nigeria. The paper also explores innovations in flood modeling, risk assessment, and insurance, and highlights successful approaches to flood risk management, such as green infrastructure, early warning systems, and community-based adaptation programs, taking into consideration the peculiarities of the Nigerian context. Furthermore, the paper emphasizes the importance of collaboration among stakeholders and continued innovation and learning to adapt to changing flood risks. The recommendations provided in this paper can inform future policy and practice in flood risk management and adaptation to a changing climate, and ultimately lead to more effective, sustainable, and resilient flood risk management strategies.

KEYWORDS: Adaptation, Flooding, Flood Risk, Climate Change, Best Practices, Innovations

I. INTRODUCTION

Floods are among the most devastating natural disasters, affecting millions of people globally every year. Unfortunately, with climate change, the risks of floods are increasing, driven by more frequent and intense precipitation events, rising sea levels, and changes in land use patterns. Flood risks are a major global concern, and experts predict that they will continue to increase as climate change worsens. According to the United Nations Office for Disaster Risk Reduction (2019), floods are the most common natural disaster, affecting over 250 million people annually, with damages exceeding $40 billion per year. The Intergovernmental Panel on Climate Change (IPCC) (2018) has also highlighted the urgent need to implement effective adaptation strategies to reduce the impacts of floods in a changing climate.

This conference paper takes a global look at flood risk adaptation and management, with a particular focus on Nigeria. Nigeria has experienced several devastating floods in recent years due to the impacts of climate change, and this has led to devastating consequences for communities across the country such as the loss of lives, property damage, and economic losses. The country is particularly vulnerable to flooding due to its topography, poor drainage systems, and climate change impacts (Mafimisebi & Ogbonna, 2020). Nigeria has adopted various flood risk management and adaptation strategies, including structural measures such as constructing dams, levees, and flood walls, and non-structural measures such as flood forecasting and early warning systems, flood insurance, and community-based approaches (Aina, Oluwande & Akinnubi, 2019; Awosika, Omojola, Ogunwale, Ologunorisa & Adeyeri, 2019).

However, there are also opportunities for innovation and improvement in flood risk management and adaptation in Nigeria. For instance, remote sensing and geospatial technologies could be leveraged to improve flood mapping and modeling. Additionally, nature-based solutions such as green infrastructure and ecosystem-based approaches offer potential for effective flood risk management (Olanrewaju, Agunloye & Adeyemo, 2020; Salami, Ogunyemi & Adetunji, 2021). These innovative strategies could help to reduce the impacts of floods, improve resilience, and support sustainable development in Nigeria and beyond.

As climate change continues to worsen, it is essential to explore and implement best practices and these innovative adaptation strategies to reduce the risks and enhance resilience to flooding.

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1.2 Problem Statement

Floods are becoming increasingly frequent and severe due to climate change, and this is leading to devastating impacts on communities around the world. The lack of effective adaptation strategies to reduce the impacts of floods is a significant problem, as traditional flood management approaches are no longer sufficient to address the challenges posed by a changing climate (IPCC, 2018).

Despite efforts to address flood risks through traditional flood management approaches, the number of people affected by floods and the associated economic losses continue to rise. Again, flood risk management and adaptation in Nigeria still face several challenges, including inadequate funding, lack of political will, weak institutional capacity, and poor public awareness (Owojori & Adekola, 2021). There is also a need to strengthen coordination and collaboration among different stakeholders involved in flood risk management and adaptation (Oyekale, Ayansina, Oloyede & Ajiboye, 2021).Moreover, many of the communities that are most vulnerable to flood risks, such as those in low-lying areas and those with limited resources, are often the least equipped to adapt to the changing flood risks. The problem, therefore, is how to adapt to changing flood risks in a way that reduces the impacts of floods on communities and enhances their resilience. This problem requires the identification and implementation of effective best practices and adaptation strategies that can address the challenges posed by a changing climate. This paper's relevance lies in its aim and objectives which are highlighted subsequently.

1.3 Aim and Objectives of the Paper

The aim of this paper is to provide a comprehensive review of current best practices and innovations in flood risk adaptation, as well as their effectiveness in reducing the impacts of floods in a changing climate domesticating it in Nigeria.

The following are the specific objectives of this paper which are:

i. To identify current best practices in flood risk adaptation and their effectiveness in reducing the impacts of floods.
ii. To explore innovations in flood modeling, risk assessment, and insurance.
iii. To examine the importance of collaboration among all stakeholders in flood risk management.
iv. To emphasize the need for continued innovation and learning to adapt to changing flood risks.
v. To provide insights that can inform future policy and practice in flood risk management and adaptation to a changing climate.

By achieving these objectives, we aim to contribute to the ongoing efforts to enhance community resilience and reduce the impacts of floods in a changing climate.

II. LITERATURE REVIEW

2.1 Theoretical and Conceptual Framework

Flood risk adaptation is an increasingly critical issue in the context of climate change, as changing weather patterns and sea level rise are expected to increase the frequency and severity of floods in many parts of the world. To effectively manage flood risk, it is necessary to identify and apply the most effective and innovative approaches to flood risk adaptation, including the use of best practices, new technologies, and community-based approaches. In this literature review, we explore a theoretical framework and key concepts related to flood risk adaptation and the flood risks and climate change nexus.

The theoretical framework for this paper is based on the concept of resilience, which refers to the ability of communities and systems to withstand and recover from the impacts of stressors, such as floods. Resilience is a multidimensional concept that involves social, economic, and environmental factors and requires a collaborative and adaptive approach to address the challenges posed by a changing climate. The concept of resilience is a key theme in the literature on flood risk adaptation and is discussed by many authors. For example, Adger, Hughes, Folke, Carpenter and Rockström (2005) define resilience as 'the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.' Similarly, Folke (2006) highlights the importance of resilience in the face of environmental change, stating that 'resilience thinking recognizes that change is inevitable and that systems need to be able to cope with and adapt to changing conditions.' Other authors who have discussed the concept of resilience in the context of flood risk adaptation include Carpenter, Walker, Anderies and Abel (2001), Walker, Holling, Carpenter and Kinzig (2004), and; Berkes and Folke (1998).

2.1.1 Key Concepts Related to Flood Risk Adaptation

The key concepts to be discussed in this section will include climate change, flooding, flood

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risk, adaptation, flood risks and climate change nexus.

2.1.2 Climate change

Climate change is a long-term shift in the average weather conditions that have come to define Earth's climate over time. It is a global phenomenon that refers to the changes in temperature, precipitation, and other climatic variables that have been occurring over the past several decades, and which are projected to continue in the future.

According to the Intergovernmental Panel on Climate Change (IPCC) (2014), 'Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).' The IPCC further explains that this variation may be caused by natural factors, such as changes in solar radiation or volcanic activity, or by human activities, such as the emission of greenhouse gases from burning fossil fuels. Flannery (2005) defines climate change as 'the biggest threat that humanity has ever faced.' He explains that climate change is caused by the release of greenhouse gases, primarily carbon dioxide, into the atmosphere, which traps heat and causes the Earth's temperature to rise. Flannery argues that this rise in temperature is leading to more frequent and severe weather events, rising sea levels, and the destruction of ecosystems and species around the world.

Climate change is often described in terms of its effects on the physical environment, including rising temperatures, sea level rise, and changes in precipitation patterns. These changes have significant impacts on ecosystems, human health, and the global economy.

2.1.3 Flooding and Flood Risk

The United States Geological Survey (USGS) (2018) defined flooding as 'a temporary inundation of normally dry land areas due to an overflow of inland or tidal waters, or the unusual accumulation of runoff of surface waters from any source.' In other words, flooding occurs when water overflows onto land that is typically dry, whether due to heavy rainfall, melting snow, or other factors. Flooding is therefore a natural phenomenon that occurs when water overflows onto land that is normally dry whereas flood risk is the potential for flooding to occur and cause harm or damage to people, infrastructure, and the environment.

The International Federation of Red Cross and Red Crescent Societies (IFRC) (2019) define flood risk as 'the potential for physical, social, and economic consequences that may occur due to flooding.' Flood risk is determined by a variety of factors, including the likelihood and severity of flooding, as well as the vulnerability of the people and infrastructure in the affected area. The IFRC (2019) notes that flood risk can be reduced through a combination of measures, such as land-use planning, early warning systems, and preparedness and response plans.

In the context of climate change, flooding has become an increasingly urgent issue, as rising temperatures and changing weather patterns are causing more frequent and severe floods in many parts of the world. Climate change can contribute to flooding and its risk in a number of ways. Warmer temperatures can cause more intense precipitation, leading to increased runoff and more frequent flash floods. Climate change can also contribute to sea level rise, which increases the risk of coastal flooding and erosion. In addition to the direct impacts of flooding, climate change can also exacerbate the social and economic impacts of floods. For example, floods can damage homes and businesses, disrupt transportation and communication systems, and cause food and water shortages. In the context of a changing climate, these impacts can be more severe, as they can contribute to displacement, migration, and other forms of social and economic disruption.

Flood risk is a complex and multifaceted concept that encompasses a wide range of physical, economic, social, and environmental factors. A thorough understanding of these factors is necessary to effectively manage flood risk and develop effective adaptation strategies. According to recent research by Aerts, De Moel, Koomen and Botzen (2020), flood risk can be characterized by three key components: hazard, exposure, and vulnerability. Hazard refers to the likelihood of a flood occurring, while exposure and vulnerability refer to the potential impacts and consequences of the flood on people, infrastructure, and the environment. Effective adaptation strategies must address all three components of flood risk in a comprehensive and integrated manner.

2.1.4 Adaptation

Adaptation simply refers to the process of adjusting to new or changing circumstances in order to minimize the negative impacts and take advantage of any opportunities presented. In the context of flood risk, adaptation involves taking proactive steps to reduce the risks and impacts of floods, particularly in the face of a changing climate. The Intergovernmental Panel on Climate

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Change (IPCC) (2014) defined adaptation refers to 'the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.' In other words, adaptation involves making changes to our behavior, infrastructure, and other systems in response to the impacts of climate change, in order to reduce the negative consequences and take advantage of any potential benefits.

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty signed by 197 countries with the aim of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human-induced climate change. The treaty was opened for signature at the Earth Summit in Rio de Janeiro in 1992 and entered into force in 1994. The UNFCCC sets out a framework for international cooperation to mitigate and adapt to climate change, with the ultimate goal of limiting global warming to well below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degrees Celsius. The UNFCCC organizes annual Conference of Parties (COP) meetings to assess progress and negotiate further action on climate change.

The United Nations Framework Convention on Climate Change (UNFCCC) (2015) defines adaptation as "adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This refers to changes in processes, practices, and structures to moderate or offset potential damages or to take advantage of opportunities associated with climate change."

The World Health Organization (WHO) (2020) defines adaptation as 'the process of anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise.' This definition emphasizes the proactive nature of adaptation, and the need to anticipate and prepare for the impacts of climate change rather than simply reacting to them after the fact.

Adaptation to flood risk involves implementing a range of strategies, including both structural and non-structural measures. Adaptation to flood risk is particularly important in the context of a changing climate, as climate change is expected to increase the frequency and severity of floods in many regions. This means that adaptation efforts must be dynamic and adaptive to changing circumstances.

Fig. 1: The Adaptation Policy Cycle and Support offered under the UN Climate Change Regime
Source: UNFCCC (2015)

The figure above shows the adaptation policy cycle and support offered under the UN Climate Change regime.

The UNFCCC has established various bodies and initiatives aimed at advancing adaptation responses and bolstering societal and environmental resilience. The Global Goal on

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Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

Adaptation work programme, which was launched in 2021 during COP 26, outlines a roadmap for improving adaptive capacity, building resilience, and reducing climate change-associated vulnerabilities on a global scale.

The UNFCCC's focus on adaptation is longstanding, with the establishment of the Least Developed Countries Expert Group (LEG) in 2001. The LEG's current mandate is to provide technical guidance and support to the Least Developed Countries (LDCs) in formulating and implementing national adaptation plans (NAPs). Additionally, the Adaptation Committee (AC), established in 2010, serves as a global advocate for adaptation and works to promote cohesive UNFCCC action on adaptation worldwide through expert guidance, outreach, and support for the implementation of the Paris Agreement.

Furthermore, since 2018, the Facilitative Working Group (FWG) has been driving the operationalization of the Local Communities and Indigenous Peoples Platform (LCIPP), which supports the implementation of climate change policies and actions related to knowledge, capacity for engagement, and local communities and indigenous peoples.

2.1.5 Flood Risks and Climate Change Nexus

Climate change is a significant contributing factor to the increase in flood risks. According to the Intergovernmental Panel on Climate Change (IPCC), flood risks and climate change are closely interconnected. The IPCC states that the impacts of climate change are leading to an increased frequency and severity of floods in many regions of the world, as climate change is causing changes in precipitation patterns, more extreme weather events, and sea level rise, all of which can contribute to flooding (IPCC, 2014). As noted by the United Nations Framework Convention on Climate Change (UNFCCC), global temperatures are projected to continue to rise, leading to more frequent and intense extreme weather events such as heavy rainfalls, tropical storms, and hurricanes. Climate change can also affect soil moisture, evaporation rates, and snowmelt patterns, leading to changes in water runoff and contributing to flooding (UNFCCC, 2015).

Furthermore, sea level rise, which is a consequence of climate change, is contributing to coastal flooding and erosion, particularly in low-lying areas. The IPCC notes that sea level rise can be caused by the melting of glaciers and ice sheets, thermal expansion of ocean waters, and changes in ocean currents (IPCC, 2019).

The impacts of flooding in a changing climate are severe and far-reaching. According to the World Health Organization (WHO), flooding can affect infrastructure, agriculture, natural ecosystems, and human health and safety, causing damage to homes and businesses, disrupting transportation and communication systems, and resulting in food and water shortages. Additionally, flooding can increase the risk of waterborne diseases and result in displacement and migration (WHO, 2018).

III. METHODOLOGY

This conference paper utilized a desk-based approach, specifically a literature review methodology, to explore best practices and innovations in flood risk adaptation in the context of a changing climate. The literature review process involved a systematic search for relevant publications in academic journals, government reports, and industry publications, using keyword searches and inclusion criteria based on the research questions.

After an initial screening of abstracts, full-text articles were reviewed and selected based on their relevance to the research questions. Key data, such as the author, year, study design, and results, were extracted from the selected studies and organized into a database. The studies were then critically analyzed and synthesized to identify patterns, trends, and best practices in flood risk adaptation, as well as to evaluate the effectiveness of these practices in reducing the impacts of floods.

The desk-based approach was chosen because it allowed for a comprehensive synthesis of existing knowledge on the topic of flood risk adaptation, without the need for primary data collection. The literature review was used to inform policy and practice in flood risk management and adaptation to a changing climate by providing insights into successful approaches to flood risk management, the importance of collaboration among all stakeholders, and the need for continued innovation and learning in the field of flood risk adaptation.

IV. RESULTS AND DISCUSSION

Research Objective 1: To identify current best practices in flood risk adaptation and their effectiveness in reducing the impacts of floods.

4.1 Current Best Practices in Flood Risk Adaptation and Their Effectiveness in Reducing the Impacts of Floods

4.1.1 Green Infrastructure

Green infrastructure refers to the network of natural and semi-natural areas, features, and

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Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

green spaces designed to deliver a range of ecosystem services to people (European Commission, 2013). Green infrastructure includes forests, wetlands, parks, gardens, green roofs, and other green spaces that can provide multiple benefits, including flood control, improved air and water quality, and enhanced biodiversity.

According to Folke et al. (2016), green infrastructure can reduce flood damage by up to 30% compared to traditional gray infrastructure. Pahl-Wostl et al. (2013) also found that green infrastructure can provide cost-effective flood protection, as it requires less maintenance and has lower life-cycle costs than gray infrastructure. A study by Wang et al. (2019) examined the effectiveness of green infrastructure in reducing flood risks in urban areas. The study found that green infrastructure can store and absorb excess water, reduce runoff, and improve water quality, which in turn can reduce the frequency and severity of floods. The study also highlighted the importance of integrating green infrastructure with gray infrastructure, such as stormwater management systems, to enhance flood resilience.

Similarly, Pivoňková et al. (2019) investigated the role of green infrastructure in reducing the impacts of floods on urban communities. The study found that green infrastructure can reduce flood damages by providing natural flood protection, enhancing ecosystem services, and improving social and economic resilience. The study also emphasized the need for multi-stakeholder collaboration and adaptive management approaches to ensure the long-term sustainability and effectiveness of green infrastructure practices.

In Nigeria, green infrastructure has been recognized as an important approach to addressing environmental challenges, including flood risk management. The country has several green infrastructure initiatives, such as the National Forestry Trust Fund and the Green Wall Sahara Project, which aim to promote reforestation, afforestation, and sustainable land management practices.

However, the level of use and effectiveness of green infrastructure in flood risk management in Nigeria is still limited. The lack of awareness and understanding of the benefits of green infrastructure, inadequate funding, weak institutional capacity, and poor coordination among stakeholders are some of the challenges that hinder the effective implementation of green infrastructure initiatives in the country (Owojori & Adekola, 2021).

Nevertheless, there is growing recognition of the potential of green infrastructure in addressing flood risks in Nigeria, and efforts are being made to promote its adoption. For example, the Nigerian government, in collaboration with international partners, has launched initiatives such as the Nigeria Erosion and Watershed Management Project and the Nigeria Climate Change Response Program, which aim to promote sustainable land management practices and green infrastructure approaches in flood risk management (Owojori & Adekola, 2021).

4.1.2 Early Warning Systems

Early warning systems are systems that provide advance notice of impending natural hazards such as floods, earthquakes, and hurricanes, allowing emergency responders and residents to take appropriate actions to protect themselves and their property. These systems can include various components such as sensors, monitoring systems, communication networks, and warning dissemination mechanisms.

Several authors have studied early warning systems and their effectiveness in reducing the impacts of natural hazards. For example, Kron, Vajjhala, Huang, Alkire and Szeptycki (2016) found that effective early warning systems can reduce flood fatalities by up to 80%. Mechler et al. (2018) also emphasized the importance of early warning systems in reducing the impacts of natural disasters and improving community resilience. Li and Li (2017) highlighted that early warning systems can provide timely information to emergency responders and residents, allowing them to take appropriate actions to protect themselves and their property, thus reducing the risk of fatalities and damage to infrastructure. Similarly, a study by Jonkman et al. (2018) emphasized the importance of early warning systems in reducing the impact of floods in urban areas.

Early Warning Systems (EWS) are increasingly being used in Nigeria to enhance flood risk management and adaptation. The Nigerian Hydrological Services Agency (NIHSA) has established a flood forecasting and early warning system for the country's major river basins, which provides regular updates on water levels and flood risks (NIHSA, 2021). This EWS is designed to improve flood risk management and reduce the impacts of floods on communities.

There are also other EWS initiatives being implemented in Nigeria, including the Flood Forecasting and Warning System for Lagos State (FFWS) and the Early Warning System for Malaria in Kano State. The FFWS was established in 2013

to provide early warning of potential flooding in the state and to support flood risk management and response planning (Lagos State Government, 2021). The system involves the use of remote sensing and hydrological models to predict flood risks and provide alerts to communities and emergency responders.

In terms of effectiveness, the use of EWS has been shown to improve flood risk management and reduce the impacts of floods in Nigeria. For example, the FFWS has been credited with reducing the number of flood-related deaths in Lagos State, from over 50 in 2012 to just 7 in 2017 (Lagos State Government, 2017). Similarly, the NIHSA's flood forecasting and early warning system has been credited with reducing the impacts of floods on communities in Nigeria, by providing timely alerts and improving flood risk management and response planning (NIHSA, 2021).

However, challenges remain in the effective implementation of EWS in Nigeria, including inadequate funding, technical capacity, and public awareness. There is also a need to strengthen coordination and collaboration among different stakeholders involved in EWS implementation and flood risk management more broadly.

4.1.3 Community-Based Adaptation

Community-based adaptation is an approach to adaptation that engages with local communities to identify their specific risks and develop tailored solutions to address those risks. It has been shown to be effective in building community resilience and ensuring that adaptation measures are tailored to the specific needs and risks of local communities.

Biswas, Choudhury and Islam (2018) found that community-based adaptation can reduce flood damage and increase community resilience. Naess, Bang, Eriksen and Vevatne (2015) also found that community-based adaptation programs can increase community resilience and reduce the vulnerability of local communities to floods. Similarly, Zaidi, Pathak and Kumar (2018) found that community-based adaptation programs can involve local stakeholders in the development of flood risk management plans and improve the effectiveness and sustainability of adaptation measures.

Community-Based Adaptation (CBA) is a relatively new approach to adaptation that focuses on empowering local communities to manage their own adaptation to climate change. In Nigeria, CBA is gaining popularity, particularly in rural areas where communities are most vulnerable to the impacts of climate change. The effectiveness of CBA in Nigeria has been reported to be moderate, with some success stories in terms of increasing community resilience and reducing vulnerability to climate risks (Oyekale, Adekola & Fagbohun, 2021).

However, there are also challenges associated with the implementation of CBA in Nigeria, including limited resources, inadequate technical capacity, and a lack of political will. The success of CBA in Nigeria also depends on the level of community participation and engagement, as well as the availability of financial and technical support from the government and other stakeholders (Owojori and Adekola, 2021).

While CBA shows promise as a community-driven approach to climate adaptation in Nigeria, further research and investment are needed to fully realize its potential. This includes building the capacity of communities to identify and implement effective adaptation strategies, and strengthening the coordination and collaboration among different stakeholders involved in CBA initiatives.

4.1.4 Risk Assessment and Mapping

Risk assessment and mapping is a process of identifying and evaluating potential risks and vulnerabilities in an area, as well as creating visual representations of those risks. According to Lamond, Wilkinson and Johnson (2018) and Renaud, Kienberger, Sudmeier-Rieux and Sebesvari (2013), accurate risk assessment and mapping can help in identifying areas that are most vulnerable to floods and develop effective adaptation strategies. The use of new technologies such as remote sensing and geographic information systems (GIS) has improved the accuracy and precision of risk assessment and mapping. Remote sensing allows for the collection of data on land cover, elevation, and other factors that can influence flood risk, while GIS enables the integration and analysis of this data to create risk maps and models (Lamond et al., 2018). These tools are essential in developing effective flood risk reduction measures.

In Nigeria, there have been efforts to develop flood risk maps and conduct risk assessments to inform decision-making processes and improve flood risk management. For example, the Nigeria Hydrological Services Agency (NIHSA) has developed flood vulnerability maps for different states in the country, based on a combination of satellite imagery, ground observations, and hydrological modeling (NIHSA, 2021). The maps are intended to provide

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

information on flood-prone areas and the potential impacts of floods, as well as to support the development of flood early warning systems and contingency plans.

In addition, there have been some initiatives to conduct comprehensive flood risk assessments in Nigeria. For instance, a study by Adedeji and Oyeleke (2019) assessed the flood risk in Ibadan, Nigeria's third-largest city, using a combination of remote sensing and field surveys. The study identified the main flood-prone areas in the city and recommended a range of flood risk reduction measures, including improved drainage systems, floodplain management, and community-based flood management strategies.

However, despite these efforts, there are still significant gaps in the use and effectiveness of risk assessment and mapping in flood risk management in Nigeria. These include inadequate data availability and quality, insufficient funding and technical capacity, and limited stakeholder participation and engagement (Owojori and Adekola, 2021). There is a need for more investment in data collection, analysis, and dissemination, as well as for greater collaboration and coordination among different stakeholders involved in flood risk management and adaptation.

4.1.5 Integrated Water Resources Management

Integrated Water Resources Management (IWRM) is an approach to managing water resources that involves coordinating the management of water across different sectors and stakeholders, taking into account the social, economic, and environmental dimensions of water use (Global Water Partnership, 2000). This approach aims to balance the competing demands for water resources and promote sustainable water use. IWRM has been identified as a best practice in flood risk adaptation, as it can help to reduce flood risks and increase the sustainability of water resources (Alcamo, Henrichs & Rösch, 2007; UN-Water, 2018). Studies have shown that IWRM can also improve the resilience of communities and ecosystems by coordinating the development and management of water resources, including flood management (Zeleňáková, Čunderlík & Pavlík, 2018).

In Nigeria, the use of IWRM is still in its early stages, and implementation has been slow due to several challenges, including weak institutional frameworks, inadequate funding, and limited public awareness (Adeoti & Ogbonna, 2017; Udom, Adeoti, & Umo, 2017). However, there have been some notable efforts to promote IWRM in the country, including the establishment of a National Water Resources Bill that seeks to provide a legal framework for the management and development of water resources in an integrated and sustainable manner (Federal Ministry of Water Resources, 2020).

Despite these efforts, the effectiveness of IWRM implementation in Nigeria is still limited, and there is a need for increased institutional capacity, stakeholder engagement, and funding to ensure that IWRM principles are fully integrated into water resources management practices at all levels (Osuagwu, Chukwu, Ossai & Ebelechukwu, 2017). Additionally, there is a need for better monitoring and evaluation mechanisms to assess the impact of IWRM approaches on water resources management in the country.

While IWRM has the potential to improve water resources management in Nigeria, its effectiveness is currently limited by various challenges, and more work needs to be done to ensure its successful implementation.

4.1.6 Parametric Insurance

Parametric insurance is an innovative form of insurance that pays out based on a predefined trigger, such as the occurrence of a flood or a certain amount of rainfall. This type of insurance can help to reduce the financial impacts of floods on individuals and communities, particularly those in low-income and vulnerable areas. Studies have shown that parametric insurance can reduce the economic impact of floods and improve the resilience of communities (Harvey et al., 2017; Michel-Kerjan, Raschky & Kunreuther, 2011; Reeder and Ranger, 2018).

The effectiveness of parametric insurance in Nigeria has been evaluated in several studies, with mixed results. On the one hand, some studies have found that parametric insurance can be effective in reducing the financial losses associated with climate-related risks. For example, Adesina, Agboola and Adeyeye (2018) found that parametric insurance was effective in reducing the financial losses of smallholder farmers in Nigeria who experienced drought-induced crop losses.

On the other hand, other studies have highlighted the limitations of parametric insurance in Nigeria, particularly in terms of its availability and affordability. For example, Oyinlola, Adekanye & Fakayode (2020) found that while parametric insurance had the potential to improve the resilience of smallholder farmers to climate-related risks, it was not widely available or affordable for many farmers. Similarly, Omoniyi, Chowa & Boateng (2020) found that while parametric insurance had the potential to reduce the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

vulnerability of pastoralists to droughts, its effectiveness was limited by factors such as inadequate data and high premiums.

While parametric insurance has the potential to be an effective tool for managing climate-related risks in Nigeria, its use and effectiveness are currently limited by various factors. These include the availability and affordability of insurance products, the quality and availability of data, and the capacity of insurance companies to effectively manage and respond to climate-related risks.

4.1.7 Successful Approaches to Flood Risk Management in Nigeria

There have been several successful approaches to flood risk management in Nigeria, including:

i. The use of early warning systems: According to Adeloye, Oyinloye & Oyebisi (2018), early warning systems have been implemented in some flood-prone areas in Nigeria, particularly in Lagos, to help mitigate the impacts of flooding. These systems involve the use of sensors and other technologies to detect changes in water levels and issue alerts to residents.

ii. Community-based approaches: This approach has been successful in Nigeria, particularly in rural areas, where communities have a strong connection to the land and are often best placed to identify local flood risks and develop appropriate solutions. Examples of community-based flood risk management in Nigeria include the construction of community-based early warning systems, the establishment of flood shelters, and the development of community-led flood risk reduction projects. According to Ologunorisa, Ologunorisa and Ayeni (2018), community-based approaches have been successful in managing flood risks in Nigeria.

iii. Urban planning and land use management: According to Ologunorisa et al. (2018), effective urban planning and land use management can help mitigate the impacts of flooding in Nigeria. This involves zoning flood-prone areas for non-residential uses and ensuring that building codes and regulations are enforced to minimize the risks of flood damage.

iv. Infrastructure development: The Ibadan Urban Flood Management Project (IUFMP) is an example of a successful infrastructure development project aimed at managing flood risks in Nigeria. According to Governor Seyi Makinde (2020), the IUFMP has rehabilitated flood prevention infrastructure and provided a medium to long-term flood risk management framework in Ibadan. The State governments of Lagos, Uyo and Port Harcourt cities has constructed flood control channels in the city, which diverts floodwater away from densely populated areas, reducing the risk of flooding. The Lagos State Government has also implemented a 'Greening Initiative' aimed at increasing green infrastructure, including parks, green roofs, and rain gardens, to reduce flood risks in the city. Asiyanbi and Oyedele (2017) examined the effectiveness of green infrastructure in reducing flood risk in Lagos State, Nigeria. The authors found that the Lagos State Government's 'Greening Initiative' had been successful in increasing green infrastructure, including parks, green roofs, and rain gardens, which had helped to mitigate flooding in some areas. Additionally, the authors recommended the use of permeable pavements, wetlands, and retention ponds as additional green infrastructure solutions to address flood risks in Lagos State.

Case Study

The Ibadan Urban Flood Management Project (IUFMP) was initiated in response to the devastating flooding that occurred in Ibadan City on August 26, 2011. The project was launched in February 2015 and is aimed at rehabilitating flood prevention infrastructure and providing a medium to long-term flood risk management framework for the city. The project is funded by a $200 Million loan from the World Bank, which is paid out in tranches as the project progresses.

One of the main objectives of the IUFMP is to dredge rivers and streams in Ibadan to increase their capacity to discharge flood water. To achieve this objective, the project has launched the dredging of 45 rivers and streams, as well as desilting of blocked drains, at different locations across the 11 local government areas within the Ibadan metropolis. The project is being executed by four successful bidders who won the competitive bidding process for the four lots of the project. The IUFMP has achieved some significant milestones, including the dredging of a cumulative length of 339,412 meters of rivers and streams in different locations in Ibadan since 2016. The project has also reconstructed damaged hydraulic infrastructure across the city, which has helped to enhance the capacity of the water channels to discharge flood

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

water and boost the flooding resilience index of the city.

The Ibadan Urban Flood Management Project (IUFMP) is an important initiative aimed at reducing the impact of flooding in Ibadan City. The project's focus on dredging rivers and streams, rehabilitating flood prevention infrastructure, and providing a long-term flood risk management framework is commendable. The project's achievements so far demonstrate its effectiveness in reducing the incidence of flooding in the city.

Fig 4.1-4.3 Ibadan Reference Point Flood Control Project Pictures

Source: Nigerian Tribune (Online), 2021

4.1.8 Effectiveness of Flood Risk Adaptation Strategies in Nigeria

The effectiveness of flood risk adaptation strategies in Nigeria is still a subject of debate and limited research. However, some studies have evaluated the effectiveness of specific adaptation strategies.

Table 4.1 Effectiveness of Flood Risk Adaptation Strategies Evaluated

Author(s)	Strategy Evaluated	Effectiveness	Limitations	Recommendations
Oyekale and Ogunjobi (2020)	Flood Early Warning Systems (FEWS)	Potential to reduce flood damage and loss of lives	Inadequate resources, lack of public awareness, and insufficient data	Improve resources and awareness for effective implementation
Adelekan et al. (2017)	Community-based adaptation strategies	Significant reduction in community vulnerability to floods	Lack of participation from some community members	Encourage active participation of all community members
Adefisan et al. (2021)	Green Infrastructure	Reduction in flood impacts by enhancing natural capacity of ecosystems to absorb and retain water	Limited awareness and adoption of green infrastructure	Promote widespread adoption of green infrastructure, such as wetlands and green roofs

Source: Authors, 2023

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

Table 4.1 provides a summary of three studies that evaluated the effectiveness of flood risk adaptation strategies in Nigeria. The first study by Oyekale and Ogunjobi (2020) assessed the effectiveness of Flood Early Warning Systems (FEWS) in Nigeria and found that although FEWS have the potential to reduce flood damage and loss of lives, their implementation is hindered by inadequate resources, lack of public awareness, and insufficient data. The study by Adelekan, Johnson and Adebayo (2017) evaluated the effectiveness of community-based adaptation strategies in Lagos, Nigeria and found that such strategies can significantly reduce the vulnerability of communities to floods. The authors noted that community-based adaptation strategies that involve the active participation of local communities in flood risk management can enhance social resilience and promote sustainable development. Adefisan, Adedeji and Sridhar (2021) evaluated the effectiveness of green infrastructure as a flood risk adaptation strategy in Nigeria and found that it can reduce the impacts of floods by enhancing the natural capacity of ecosystems to absorb and retain water. The authors recommended the widespread adoption of green infrastructure such as wetlands and green roofs to enhance flood resilience in Nigeria. Generally, the table highlights the potential effectiveness of different flood risk adaptation strategies in Nigeria, but also points out some of the challenges that may hinder their successful implementation.

Research Objective 2: To explore innovations in flood modeling, risk assessment, and insurance.

4.2 Innovations in Flood Modeling, Risk Assessment and Insurance

4.2.1 Innovations in Flood Modeling

Flooding is a complex and dynamic natural hazard that poses a significant risk to communities and ecosystems worldwide. Effective flood modeling is crucial to understanding and managing flood risks, and recent innovations in flood modeling techniques have improved the accuracy and precision of flood risk assessments. This literature review summarizes three recent innovations in flood modeling and their potential benefits for flood risk management.

i. High-Resolution Flood Modeling: High-resolution flood modeling techniques use high-quality data to simulate flooding at a more detailed level, which can improve the accuracy of flood risk assessment and inform the design of flood management strategies. This technique can provide more accurate flood predictions and can help to identify areas that are particularly vulnerable to flooding. According to Bates, Sampson, Smith, Neal, Almeida, Freer and Waller (2015), high-resolution flood models can significantly improve the accuracy of flood risk assessment and enhance the effectiveness of flood management strategies.

ii. Agent-Based Modeling: Agent-based modeling is a type of simulation that models the behavior of individuals and groups in response to flood events. This modeling approach can provide insights into the social and economic impacts of floods and inform policy decisions. For instance, an agent-based model can simulate how people react to flood warnings and how this information can impact evacuation decisions. This technique can be particularly useful for developing flood management policies that are tailored to specific communities. According to Zhou, Yu, Liu and Chen (2020), agent-based modeling can provide a valuable tool for understanding the behavior of people during floods and for designing effective flood risk management strategies.

iii. Hybrid Modeling: Hybrid modeling combines different modeling approaches to improve the accuracy of flood modeling and to capture the complexity and uncertainty of flood risk. For example, a hybrid model can combine high-resolution modeling with agent-based modeling to create a more comprehensive and accurate picture of flood risk. Hybrid models can also be used to integrate multiple sources of data, such as hydrological and meteorological data, to create a more accurate and reliable flood forecast. According to Vojinovic, Chen, Cai & Shamseldin (2019), hybrid modeling can provide a more complete understanding of flood risk and help to develop more effective flood risk management strategies.

These recent innovations in flood modeling techniques have the potential to improve flood risk assessment, enhance the accuracy of flood prediction, and inform the design of flood management strategies. The application of these models in flood risk management can lead to more effective and efficient policies, and help to build resilient communities that are better prepared for the impacts of flooding.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

Innovations in Flood Modeling in Nigeria

Flood modeling is an essential tool for understanding and predicting flood risks. In Nigeria, there have been some innovations in flood modeling to improve flood risk management and adaptation strategies. One notable innovation is the use of remote sensing and geographic information system (GIS) technology to develop flood inundation maps and identify flood-prone areas. This approach has been used in Lagos State, where a flood risk assessment and mapping project was carried out in 2010 to identify flood-prone areas and develop flood inundation maps.

Another innovation is the use of hydrological and hydraulic models to simulate flood events and predict their impacts. In 2020, the Nigerian Hydrological Services Agency (NIHSA) developed a flood forecasting model for the Niger and Benue Rivers, which are the two main rivers in Nigeria. The model uses real-time data on river levels, rainfall, and other variables to forecast flood events and issue early warnings to communities at risk.

Furthermore, there have been efforts to develop community-based flood models that involve local communities in flood risk assessment and management. In 2019, the Global Facility for Disaster Reduction and Recovery (GFDRR) launched the OpenCities Project in Nigeria, which aims to use open data and citizen engagement to develop community-based flood models in Lagos and Ibadan. The project involves working with local communities to collect data on flood risks and vulnerabilities and developing flood models that reflect local knowledge and experience.

These innovations in flood modeling in Nigeria are helping to improve flood risk management and adaptation strategies by providing more accurate and timely information on flood risks and impacts. However, there is still a need to strengthen the capacity of local institutions and communities to use these models effectively and to integrate them into broader flood risk management and adaptation plans.

4.2.2 Innovations in Risk Assessment

Risk assessment is a critical step in identifying and prioritizing mitigation and adaptation strategies for reducing the impacts of floods. In recent years, several innovations in risk assessment have emerged that aim to improve the accuracy and effectiveness of flood risk assessments. This literature review examines three key innovations in risk assessment: multi-hazard risk assessment, climate change scenarios, and participatory risk assessment.

i. Multi-Hazard Risk Assessment: Multi-hazard risk assessment is an approach that considers the potential impacts of multiple hazards, including floods, on a community or region. By examining the interactions between different hazards and their potential cascading effects, multi-hazard risk assessment can help to identify and prioritize mitigation and adaptation strategies that address multiple hazards. A study by Aerts, Botzen, Clarke, Cutter, Hall, Merz and Ward (2019) showed that multi-hazard risk assessment can improve the effectiveness of disaster risk reduction efforts and increase community resilience.
ii. Climate Change Scenarios: Climate change scenarios are used to project the potential impacts of climate change on flood risk. By modeling the potential changes in precipitation patterns, sea level rise, and other climate factors, climate change scenarios can inform the design of adaptation strategies and policy decisions. A study by Kundzewicz, Kanae, Seneviratne, Handmer, Nicholls, Peduzzi and Sherstyukov (2019) found that climate change scenarios can improve the accuracy of flood risk assessments and inform the development of effective adaptation strategies.
iii. Participatory Risk Assessment: Participatory risk assessment is an approach that involves engaging with local communities and stakeholders in the risk assessment process. By incorporating the perspectives and knowledge of local communities, participatory risk assessment can improve the relevance and effectiveness of risk assessment and increase community resilience. A study by Pelling and High (2005) showed that participatory risk assessment can improve the quality of risk information and promote community ownership and participation in risk reduction efforts.

These innovations in risk assessment offer promising approaches to improve the accuracy and effectiveness of flood risk assessments. By incorporating multi-hazard risk assessment, climate change scenarios, and participatory risk assessment, stakeholders can develop more comprehensive and effective mitigation and adaptation strategies to reduce the impacts of floods on communities and ecosystems.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

Innovations in Risk Assessment in Nigeria

One innovation in risk assessment in Nigeria is the use of remote sensing and GIS technology. This technology involves the use of satellite imagery, aerial photographs, and other geospatial data to map areas at risk of various hazards, including flooding, landslides, and erosion. By combining this data with information on population density, infrastructure, and other relevant factors, risk assessments can be conducted more accurately and efficiently, helping to identify areas that are most vulnerable and prioritize risk reduction efforts.

Another innovation in risk assessment in Nigeria is the use of crowd sourcing and citizen science. This approach involves engaging local communities in the data collection and analysis process, allowing them to provide input on areas that are most at risk and contribute to the development of risk maps. This approach not only provides more accurate data but also empowers communities to take an active role in the risk reduction process.

In whole, there is a growing interest in incorporating climate projections into risk assessments to better understand how climate change will affect the frequency and intensity of various hazards. This involves using climate models to project future changes in temperature, precipitation, and other factors, which can then be used to predict how hazards like floods, droughts, and heat waves may evolve over time. By taking into account these future changes, risk assessments can help to identify adaptation strategies that are robust over the long term.

4.2.3 Innovations in Insurance

i. Index-Based Insurance: Index-based insurance has emerged as a promising tool to manage flood risk in low-income and vulnerable areas. Index-based insurance pays out based on a predefined index, such as the amount of rainfall or the water level of a river, which reduces the burden of individual assessments and claims processing. Index-based insurance programs have been implemented in different parts of the world, including India, Africa, and Central America, and have shown promising results in terms of providing affordable and accessible insurance to people in flood-prone areas (Jude & Iroham, 2019; Skoufias & Diagne, 2012).

ii. Parametric Insurance: Parametric insurance is another innovative approach that has gained attention in recent years for managing flood risk. Parametric insurance pays out based on a predefined trigger, such as the occurrence of a flood or a certain amount of rainfall, without requiring an actual loss assessment. This reduces the cost and time associated with claims processing, making it an attractive option for low-income and vulnerable populations. Parametric insurance has been used in different contexts, including in the Caribbean and Southeast Asia, and has shown potential for providing financial protection to individuals and communities in flood-prone areas (Morton, Oppenheim & Skees, 2019; Rose, Linnerooth-Bayer, Mutter & Mechler, 2014).

iii. Microinsurance: Microinsurance is a type of insurance that provides coverage to low-income and vulnerable populations, who are often the most affected by floods and other natural disasters. Microinsurance can help to increase the resilience of these populations and reduce the financial impacts of floods on their livelihoods. Microinsurance programs have been implemented in different parts of the world, including South Asia and Latin America, and have shown potential for improving the financial security of vulnerable communities in flood-prone areas (Karuppannan, Selvaraj & Thirumaran, 2020; Menon & Datta, 2019).

These innovative insurance solutions have the potential to reduce the financial impacts of floods on individuals and communities in low-income and vulnerable areas. However, the success of these solutions depends on a range of factors, including the design of insurance programs, the accuracy of risk assessments, and the availability of reliable data. Therefore, it is important to continue evaluating the effectiveness of these innovations and to develop new and innovative solutions to address the challenges of adapting to flood risks in a changing climate.

Innovations in Insurance in Nigeria

One key innovation in insurance in Nigeria is the use of mobile technology to provide micro-insurance to low-income individuals. This allows them to access affordable insurance coverage for a variety of risks, including health, crop failure, and death. This approach has been successful in reaching underserved populations and providing them with a safety net against unexpected events that could cause financial distress. Another innovation is the use of

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

parametric insurance, which pays out based on predetermined triggers such as rainfall or wind speed, rather than actual losses. This approach allows for quicker and more efficient payouts, which can be critical in the aftermath of a disaster. However, there are still challenges to the widespread adoption of these innovations, including low levels of awareness and trust in insurance products, as well as regulatory and operational hurdles.

4.2.4 Summary of Innovations in Flood Modeling, Risk Assessment, and Insurance Adopted in Nigeria

In Nigeria, there have been some innovations in flood modeling, risk assessment, and insurance in recent years. Here are a few examples:

i. Flood modeling: The use of remote sensing and geographic information systems (GIS) has improved flood modeling in Nigeria. These technologies have made it possible to collect and analyze data on the location, extent, and severity of floods, which can inform flood risk management strategies.
ii. Risk assessment: The Nigeria Hydrological Services Agency (NIHSA) has developed a flood forecasting and warning system that provides flood risk maps for various parts of the country. These maps are used to inform risk assessment and disaster preparedness planning at the national and local levels.
iii. Insurance: The Nigerian government has introduced the National Agricultural Insurance Scheme (NAIS), which provides insurance coverage for farmers against crop losses due to natural disasters, including floods. In addition, private insurance companies in Nigeria have also started offering flood insurance policies to individuals and businesses.
iv. Early warning systems: The Nigeria Meteorological Agency (NIMET) has developed an early warning system for floods, which provides information on potential flood risks to various stakeholders, including the government, emergency services, and the public. The system uses weather monitoring stations, river gauges, and rainfall data to forecast potential flood risks and provide early warnings.

While more needs to be done to address the growing threat of floods in Nigeria, there have been some innovations in flood modeling, risk assessment, and insurance in recent years. These innovations have improved our understanding of flood risks, enhanced disaster preparedness and response, and provided some financial protection against the impacts of floods. However, continued investment and innovation will be necessary to address the challenges posed by climate change and ensure effective and sustainable flood risk management in Nigeria.

Research Objective 3. To examine the importance of collaboration among all stakeholders in flood risk management.

4.3 Importance of Collaboration among All Stakeholders in Flood Risk Management

Several authors have emphasized the importance of collaboration among all stakeholders in flood risk management. According to Fekete, Grunewald and Schneiderbauer (2018), effective flood risk management requires a collaborative approach involving all relevant stakeholders, including government agencies, private sector actors, and local communities. This approach can help to ensure that all stakeholders are actively engaged in the decision-making process and that flood management strategies reflect local knowledge, needs, and priorities.

Moreover, Ahern, Kovacs and De Ruig (2017) emphasize that collaboration is essential for improving coordination among different stakeholders involved in flood risk management. The authors argue that flood risk management involves multiple sectors and levels of government, as well as different types of organizations and actors, and collaboration can help to ensure that different stakeholders are working together effectively.

In addition, collaboration among stakeholders can also lead to increased resources for flood risk management (Schröter, Kunz, Meyer, Pohl & Steinführer, 2019). By pooling resources and expertise, stakeholders can develop more effective and comprehensive strategies for managing flood risk.

Collaboration therefore has the capacity to enhance community resilience to floods (Vojinovic, Abbott & Maksimović, 2020). By involving local communities in the decision-making process, stakeholders can ensure that flood management strategies reflect local knowledge, needs, and priorities. Clear and open communication among stakeholders is critical for effective flood risk management, as it can help to ensure that all stakeholders are aware of the risks and potential impacts of floods, as well as the strategies being used to manage those risks (Ahern et al., 2017.

Collaboration among all stakeholders is essential for effective flood risk management. It

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

creates a shared sense of responsibility, improves coordination, leads to increased resources, enhances community resilience, and improves communication. By involving local communities in the decision-making process and working together, stakeholders can develop more effective and comprehensive strategies for managing flood risk, which is critical for ensuring the safety and well-being of people living in flood-prone areas.

In Nigeria's flood risk management context, it is essential that various stakeholders collaborate to achieve effective results. Some of the institutions that need to collaborate include:

i. Federal Ministry of Environment
ii. State Ministries of Environment
iii. National Emergency Management Agency (NEMA)
iv. National Water Resources Institute (NWRI)
v. National Agricultural Extension Research and Liaison Services (NAERLS)
vi. National Hydrological Services Agency (NIHSA)
vii. National Environmental Standards and Regulations Enforcement Agency (NESREA)
viii. Nigerian Institute of Town Planners (NITP)
ix. Nigerian Institute of Builders (NIOB)
x. Nigerian Society of Engineers (NSE)
xi. Nigerian Institution of Water Engineers (NIWE)
xii. Non-Governmental Organizations (NGOs)
xiii. Community-based Organizations (CBOs)
xiv. Private sector organizations and businesses.

Obj 4: To emphasize the need for continued innovation and learning to adapt to changing flood risks.

4.4 Emphasizing the Need for Continued Innovation and Learning to Adapt to Changing Flood Risks

The need for continued innovation and learning to adapt to changing flood risks cannot be overemphasized. As the climate continues to change, the risks associated with floods are likely to increase, making it essential for stakeholders to continually adapt their strategies to manage these risks. Here are some reasons why continued innovation and learning are crucial:

Flood risk is dynamic and constantly changing, with flood patterns likely to shift as a result of changes in precipitation patterns and sea levels. Additionally, there may be new and emerging risks associated with floods that were not previously anticipated. According to Hilary and Matyas (2018), continued innovation and learning can help stakeholders to stay ahead of these changes and develop more effective strategies for managing flood risk.

Evidence-based approaches to flood risk management are essential to ensure that strategies are effective, efficient, and sustainable. Continued innovation and learning can help to generate new knowledge and evidence that can inform more effective flood risk management. As highlighted by Kreibich, Di Baldassarre, Vorogushyn, Aerts, Apel, Aronica and Merz (2019), this evidence-based approach is crucial to making informed decisions about which flood management strategies to implement.

Innovation and learning can also provide opportunities for collaboration among stakeholders. By sharing knowledge and expertise, stakeholders can develop more comprehensive and effective strategies for managing flood risk. As noted by De Ruig, Rijke and Nijland (2019), collaboration among stakeholders can also help to increase community engagement and support for flood risk management efforts.

Emerging technologies, such as remote sensing, machine learning, and artificial intelligence, is providing new opportunities for flood risk management. Continued innovation and learning can help stakeholders to stay up to date with these emerging technologies and identify opportunities to leverage them for flood risk management. According to Chen, Lu and Tao (2019), these emerging technologies can help to improve flood forecasting and warning, which can be critical for effective flood risk management.

Continued innovation and learning can help stakeholders to build community resilience to floods. By developing new and innovative approaches to flood risk management, stakeholders can increase the capacity of communities to withstand and recover from flood events. As highlighted by Veldkamp, Van Vliet and Aerts (2018), building community resilience is an important aspect of flood risk management, as it can help to reduce the impacts of floods on communities and ensure that they are better prepared for future flood events.

4.4.1 Innovation and Learning to Address Changing Flood Risks in Nigeria

Continued innovation and learning are crucial for improving flood risk management in Nigeria. As climate change and urbanization continue to present new challenges, stakeholders must be open to new ideas and willing to

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 01 Jan 2024, pp: 225-246 www.ijaem.net ISSN: 2395-5252

experiment with different approaches to address these challenges.

One way to promote innovation and learning is through research and development. Academic institutions, research organizations, and government agencies can collaborate to identify best practices, test new technologies and strategies, and evaluate their effectiveness.

Additionally, training and capacity building can help stakeholders develop the skills and knowledge needed to implement effective flood risk management strategies. This can include training on the use of new technologies, risk assessment and mapping, and community engagement.

Sharing of knowledge and experiences among stakeholders can facilitate learning and improve the effectiveness of flood risk management efforts. This can include regular meetings, workshops, and conferences, as well as the development of online resources and knowledge-sharing platforms. By working together and continually seeking new knowledge and innovative solutions, stakeholders can better manage flood risks and build more resilient communities in Nigeria.

Research Objectives 4: To provide insights that can inform future policy and practice in flood risk management and adaptation to a changing climate.

4.5 Insights for Future Policy and Practice in Flood Risk Management and Adaptation

The following are some insights that can inform future policy and practice in flood risk management and adaptation to a changing climate:

Integrating climate change adaptation, emphasizing collaboration, and incorporating green infrastructure are key insights that can inform future policy and practice in flood risk management and adaptation to a changing climate. These insights are supported by several authors:

The Intergovernmental Panel on Climate Change (IPCC) emphasizes the need for integrating climate change adaptation into flood risk management policies and practices, including early warning systems, emergency response planning, and land-use planning (IPCC, 2014).

The World Bank highlights the importance of collaboration among stakeholders in flood risk management, as well as the need to build partnerships and engage local communities in the decision-making process (World Bank, 2021).

The Nature Conservancy stresses the benefits of incorporating green infrastructure into flood risk management strategies, such as using natural features to absorb and slow down floodwaters, which can provide cost-effective and sustainable solutions (The Nature Conservancy, 2021).

Other key insights supported by the literature include the need to strengthen early warning systems, address equity and social justice concerns, incorporate flexibility, invest in research and development, prioritize risk reduction over risk transfer, and ensure long-term sustainability (Adger et al., 2018; Birkmann et al., 2013; UNDRR, 2019; Zscheischler et al., 2020).

The above insights highlight the importance of adopting a holistic and forward-thinking approach to flood risk management and adaptation to a changing climate. By incorporating these insights into future policy and practice, stakeholders can develop more effective and sustainable strategies for managing flood risk and building community resilience.

V. RECOMMENDATIONS FOR POLICY AND PRACTICE

Based on the implications discussed above, the following recommendations can be made for policy and practice:

1. Enhanced collaboration among stakeholders: There is a need for collaboration among different stakeholders involved in flood risk management in Nigeria, including government agencies, private organizations, civil society groups, and local communities. Collaboration can help to coordinate efforts, share resources and knowledge, and promote a more holistic approach to flood risk management.
2. Adoption of innovative and sustainable flood risk adaptation strategies: Given the growing risks of floods in Nigeria, there is a need to adopt innovative and sustainable strategies for flood risk adaptation. Such strategies can include green infrastructure, community-based adaptation, and early warning systems, as highlighted in the studies discussed above.
3. Investment in flood risk research and data collection: There is a need for investment in flood risk research and data collection in Nigeria. This will help to improve the understanding of flood risks, including their causes, impacts, and distribution. Additionally, the availability of reliable data can support evidence-based decision-making and policy formulation.
4. Strengthened institutional frameworks: There is a need for strengthened institutional frameworks for flood risk management in Nigeria, including the development of clear

policies and regulations, the establishment of dedicated agencies, and the provision of adequate resources for flood risk management activities.

5. Public awareness and education: There is a need to increase public awareness and education on flood risks in Nigeria. This can include the provision of information on flood risks, their impacts, and how individuals and communities can prepare for and respond to floods. Additionally, education can promote behavioral changes that reduce the risks of floods, such as avoiding building on flood-prone areas and maintaining clean drainage systems.

In general, the recommendations discussed above can support the development of effective policies and practices for flood risk management in Nigeria. However, their implementation will require sustained commitment and collaboration among different stakeholders.

VI. CONCLUSIONS

Flood risk management is a critical issue in Nigeria due to the increasing frequency and severity of floods caused by climate change and rapid urbanization. The country has experienced devastating floods that have led to loss of lives, displacement of people, and destruction of property, infrastructure, and the environment. While several flood risk adaptation strategies have been implemented in Nigeria, their effectiveness is still a subject of debate and limited research.

This paper has highlighted some best practices and innovations in flood risk adaptation strategies in Nigeria, including the use of green infrastructure, community-based adaptation, and flood early warning systems. It is recommended that these strategies should be widely adopted and implemented across the country to enhance flood resilience.

Moreover, collaboration among stakeholders, including government agencies, local communities, NGOs, and international organizations, is crucial in the effective implementation of flood risk adaptation strategies. This collaboration should promote participatory approaches that involve local communities in flood risk management, enhance social resilience, and promote sustainable development.

Continued innovation and learning therefore are essential in flood risk management. Stakeholders should regularly evaluate the effectiveness of flood risk adaptation strategies, identify gaps, and develop new and innovative approaches to enhance flood resilience. It is only through this continuous improvement that Nigeria can effectively adapt to flood risks in a changing climate.

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