International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

Sustainable Adaptation Strategies to Urban Flooding in Port Harcourt Metropolis, Rivers State

Burabari Akpe Nwako[1], Ajenifujah- Abubakar [2], Joseph Akinlabi Fadamiro[3]

[1]*Lecturer, Architecture Department Bamidele Olumilua University of Education, Science and Technology, Ikere-Ekiti, Nigeria.*

[2,3]*Lecturer,Architecture Department Afe Babalola University, Ado-Ekiti.*

Date of Submission: 15-08-2024 Date of Acceptance: 25-08-2024

ABSTRACT: Flooding is a natural phenomenon, but human activities such as uncontrolled urbanization and population growth have significantly intensified its impacts, resulting in substantial damage and losses. Urbanization, when poorly planned contributes to flooding by restricting runoff flow and increasing impervious surfaces, which block natural water channels and expedite the movement of floodwater into rivers. In Port Harcourt, frequent flooding incidents, especially following heavy rainfalls, are exacerbated by the city's rapid population growth and uncoordinated urban development on floodplains and drainage channels. This study evaluates and proposes sustainable adaptation strategies to mitigate the impacts of urban flooding in Port Harcourt Metropolis, Rivers State. By reviewing existing literature and identifying gaps in current research, the study recommends strategies best suited for addressing the city's flooding challenges. Key recommendations include utilizing Environmental Impact Assessments (EIAs) to identify flood hazards and guide flood-resilient designs, drawing insights from successful cases like New York City's Big U Project. Implementing these strategies can help public institutions and professional practitioners create a flood-resilient Port Harcourt.

KEYWORDS: Urban flooding, climate change, flood risk impact, Adaptation strategies, Port Harcourt.

I. INTRODUCTION

Climate change has emerged as a critical global challenge, significantly impacting various regions, particularly flood-prone areas. The phenomenon, driven by a combination of greenhouse gas emissions from anthropogenic activities and natural factors such as cyclical variations in weather conditions, threatens environmental stability and community well-being.

Port Harcourt, a bustling metropolis in Nigeria, exemplifies the challenges posed by rapid urbanization and inadequate urban planning in the face of increasing rainfall. The city's rapid growth and development have led to significant land-use changes, exacerbating its vulnerability to flooding. Flooding occurs when water volumes exceed the land's capacity to discharge it through natural or man-made channels. Contributing factors such as urbanization, deforestation, land development, impermeable soils, and low-lying topography significantly exacerbate this issue.

In Port Harcourt, rapid population growth, driven by the quest for better employment and living standards, has led to significant changes in land use. The surge in population has drastically increased the demand for housing, often without adequate infrastructural planning due to ineffective government involvement in the housing sector. Consequently, uncoordinated urbanization and development of swamps, floodplains, and natural drainage channels have exacerbated flooding issues.

The need for investing in mitigative measures is crucial, as the presence and adherence to control measures, both structural and non-structural, are key in avoiding loss and damage of properties. Effective flood management in Port Harcourt necessitates a synergy of enhanced urban planning, sustainable architectural methods, and robust infrastructure development. It is essential for government bodies, urban planners, and the local

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

community to collaborate to create a flood-resilient city. Tackling these challenges can markedly mitigate the negative impacts of flooding and foster sustainable urban development in Port Harcourt.

This study explores sustainable architectural practices as climate change adaptation measures, specifically targeting flooding issues in Port Harcourt. By examining rainfall patterns, urbanization trends, and sustainable building practices, the study aims to provide a comprehensive framework for enhancing the city's flood resilience.

II. LITERATURE REVIEW

Natural phenomena such as intense rainfall, storm surges, and rapid snowmelt, combined with environmental conditions like soil moisture retention, groundwater levels, and impervious surface coverage, significantly contribute to flooding hazards. Globally, heightened rainfall is a primary cause of flooding, occurring when soil and vegetation become oversaturated, causing water bodies to overflow. In Port Harcourt, heavy rainfall is a major factor leading to flooding (Abaye et al., 2012). Effective flood management requires infrastructural design solutions and a re-evaluation of urban planning policies.

Maddox [19] categorizes flooding into three types: coastal, fluvial, and pluvial. Urban flooding refers to the inundation of land or property in densely populated areas caused by excessive rainfall, stormwater, or poor drainage systems. It often results from a combination of factors such as high population density, impervious surfaces like roads and buildings, inadequate drainage infrastructure, and changes in land use. Unlike fluvial or coastal flooding, urban flooding can occur even in the absence of significant water bodies, simply due to the inability of the urban landscape to absorb and manage water efficiently.

Urban Drainage Systems

One of the major problems in urbanised areas which greatly contributes to the risk of flooding during heavy rainfall is the design of urban drainage systems and other issues associated with drainage sanitation. Port Harcourt has an inadequate drainage infrastructure that fails to handle the excessive water, leading to widespread flooding in the event of heavy rainfall.

Inadequate urban drainage systems are a major contributor to flooding during heavy rainfall. Port Harcourt's drainage infrastructure fails to handle excessive water, leading to widespread flooding. Oliveira et al. [11] highlight the significance of preserving water spaces to address urban flooding. Poor maintenance of drainage systems exacerbates aesthetic and environmental degradation.

Flooding and Urban Development

Urbanization significantly impacts flooding events. The development of flood-prone areas is influenced by benefits such as waterfront views and commercial proximity. However, this development leads to alterations in the natural environment, increasing vulnerability to natural hazards. In Nigeria, rapid city expansion and environmental issues constrain sustainability efforts as observed by Ishaya et al., [16]. Ogundele and Jegede [23] argues that the lack of effective urban planning and poor drainage system coordination are major causes of flooding in Port Harcourt.

Research has identified several causative factors for the frequent flooding in Port Harcourt, including the lack of proper environmental planning and urban management. Effective flood management requires collaboration between local communities, non-governmental organizations (NGOs), voluntary groups, and international donor organizations. Despite the global prevalence of urban floods, management practices vary significantly among countries, influenced by existing technologies, infrastructure, and levels of urban planning.

Sustainable Adaptation Strategies

Sustainable adaptation strategies, including green infrastructure and flood-resilient designs, are essential for enhancing flood resilience in Port Harcourt. Examples from other cities, such as green roofs and permeable pavements, provide valuable insights. Strong governance frameworks and community involvement are crucial for sustainable flood management.

Flooding impacts critical infrastructure, such as housing and transportation, highlighting the importance of flood adaptation and resilience. The concept of 'living with floods' emphasizes building tolerance to prevent deaths and injuries during flood events (Chen et al., 2020). Effective urban planning and architectural solutions are necessary to mitigate flood risks and enhance resilience in rapidly urbanizing environments like Port Harcourt.

III. METHODS

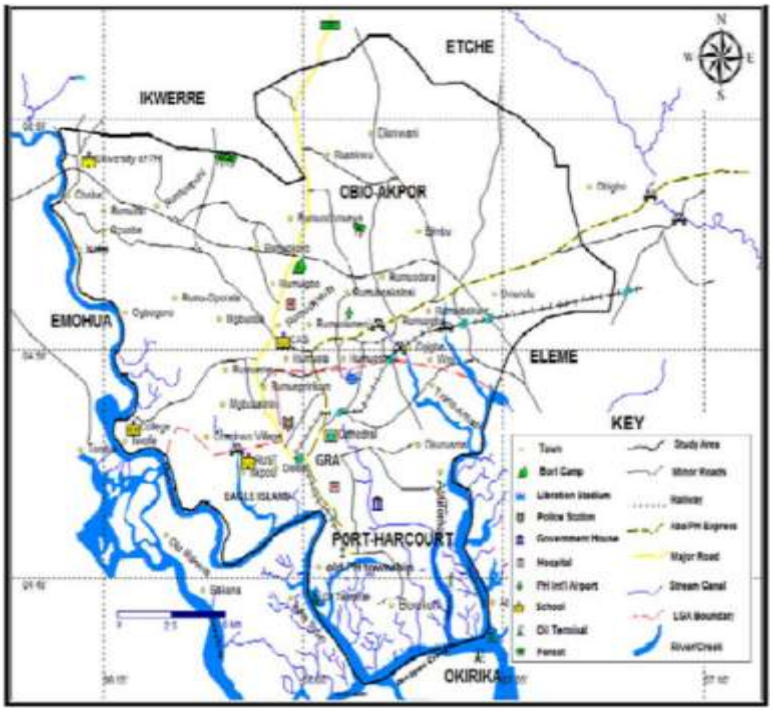
The research employed a qualitative approach by reviewing recent and existing

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

literature on sustainable adaptation strategies to urban flooding. This method involved gathering data from multiple sources, including journal articles, research papers, government reports, and case studies related to urban flooding and sustainable adaptation strategies. The focus was on identifying and analysing strategies that have been successfully implemented in different urban settings and could be adapted to Port Harcourt Metropolis, Rivers State.

The Study Area

This study focuses on Port Harcourt, the capital and largest city of Rivers State in Nigeria. Located at approximately 4°49'27" N latitude and 7°2'1" E longitude, Port Harcourt lies in the Niger Delta region, near the coast of the Atlantic Ocean. The city is strategically situated and serves as a major economic hub, particularly for the oil and gas industry. Port Harcourt is located in southern Nigeria, along the Bonny River.



Map of Rivers showing Port Harcourt

Port Harcourt is divided into two local government areas: Port Harcourt City and Obio-Akpor. These LGAs share boundaries with other neighbouring local government areas, such as Eleme, Oyigbo, Ikwerre, and Okrika. The city itself is an urban sprawl, with numerous residential, commercial, and industrial zones. According to the 2006 national population census, Port Harcourt had a population of 1,382,592. Given its rapid urbanization and economic opportunities, the city's population has grown significantly over the years, with current estimates suggesting a population of over 2 million. The city covers an area of approximately 369 square kilometres.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

Flood-prone areas in Port Harcourt

River and pluvial flooding are the main identified climatic hazards in the city of Port Harcourt with new areas being increasingly affected by devastating floods. Significantly, these new areas did not experience flooding in the past, but in recent years flooding has become an annual occurrence. The city has seen a significant rise in population and as a consequence, the number of urban dwellings.

Flooding of Peter Odili Road

Flooding of Port Harcourt Mall at Sars Road

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

Key Steps in Data Collection

- **Literature Search:** Conducting comprehensive searches in academic databases such as Google Scholar, JSTOR, and ScienceDirect using keywords like "urban flooding,""sustainable adaptation,""Port Harcourt,""flood management," and "climate change resilience."
- **Selection Criteria:** Selecting literature published within the last ten years to ensure the strategies are recent and relevant.
- **Data Extraction:** Extracting key information related to adaptation strategies, their implementation processes, outcomes, and challenges from the selected literature.

Data Analysis

The analysis involved thematic coding of the data extracted from the literature. This process included:

- **Thematic Analysis:** Identifying recurring themes and patterns related to adaptation strategies in urban flooding management.
- **Categorization:** Grouping the identified strategies into categories such as structural measures, non-structural measures, and community-based approaches.
- **Comparison:** Comparing the strategies used in different urban areas to understand their applicability to Port Harcourt Metropolis.
- **Synthesis:** Synthesizing the findings to provide a comprehensive overview of sustainable adaptation strategies and their potential effectiveness in the context of Port Harcourt.

IV. ANALYSIS AND DISCUSSION

Port Harcourt's flooding issues stem from inadequate drainage, poor urban planning, and unchecked development on floodplains. Addressing these challenges requires both structural measures, like physical flood defences, and non-structural measures, such as improved policies and community engagement, to enhance the city's flood resilience effectively.

Structural Measures

Structural measures involve physical constructions and modifications designed to reduce flood risks. This analysis examines the role of Environmental Impact Assessments (EIAs) in managing and regulating planned developments to mitigate flooding. An EIA is a systematic process used to identify, predict, evaluate, and mitigate the biophysical, social, and other relevant effects of proposed projects before major decisions and commitments are made. Several studies, including those by Nimi and Marc [20], emphasize the crucial role of EIAs in addressing urban development's impact on flood risks. EIAs can identify potential flood hazards and suggest alternative locations for urban projects to reduce flood impacts.

Greater Port Harcourt (GPH) City Development

` The Greater Port Harcourt (GPH) city development project in Rivers State, designed to accommodate the growing population and urbanization needs, is an example of an EIA-accompanied project. Port Harcourt was selected over two other potential sites, Bori and Omoku, based primarily on planning and economic considerations such as land availability, existing land uses, continuity with the old city, and financial costs. Unfortunately, this selection process did not adequately consider flood risk implications, a significant oversight given Port Harcourt's natural flood-prone environment.

Recommendations for Improved EIA Effectiveness

To enhance the effectiveness of EIAs in flood-prone areas like Port Harcourt, it is essential to incorporate both alternative project locations and structural designs focused on flood mitigation and resilience. Recommended strategies include:

- Flood Defences: Constructing levees, floodwalls, and embankments to protect urban areas from riverine and coastal flooding.
- Stormwater Management Systems: Developing advanced stormwater drainage systems, such as underground tunnels, retention basins, and green infrastructure (e.g., permeable pavements and green roofs) to improve water absorption and reduce surface runoff.
- Urban Design Modifications: Integrating flood-resilient designs in urban planning, including raised buildings, flood-proof basements, and the creation of flood plains and green belts.

Case Study: The Big U Project, New York City

The project aims to create a comprehensive flood protection system for Lower Manhattan, incorporating flood defences, stormwater management infrastructure, and flood-resilient urban design. An Environmental Impact Assessment (EIA) was conducted to evaluate the project's environmental implications.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

The Big U Project, New York

The initiative includes multiple, interconnected design elements across different scales of size, time, and investment. The area is divided into three autonomous sectors, each equipped with tailored systems such as walls, embankments, and natural drainage zones in parklands. Mobile screens beneath the FDR Drive serve as both canopies and barriers to control water flow. The project's key objective is to blend technical infrastructure with amenities such as parks, sports facilities, natural swimming pools, and cultural pavilions to enhance Lower Manhattan's connectivity and transform it into a vibrant and iconic urban hub.

Site Layout illustrating infrastructural management of flood water

By adopting these strategies, the effectiveness of EIAs can be significantly improved, leading to better flood risk management and more sustainable urban development. In Port Harcourt, flood defense infrastructure can also serve dual purposes. Creating green belts and public spaces that double as flood barriers will not only protect against flooding but also enhance urban living and community engagement.

Non-Structural Measures

As observed by Echendu [12], lax enforcement of planning laws in Port Harcourt has led to construction projects being built on natural floodplains and within stormwater paths. This

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

obstructs the natural flow of water, exacerbates flooding, and increases stormwater problems by preventing water from finding an escape route. Such practices also compromise building integrity, leading to risks of collapse, as evidenced by the building collapse in November 2018 that resulted in seven fatalities. These issues raise significant questions about the procedures followed in granting planning approvals for these developments.

To address these challenges, non-structural measures focusing on policies, regulations, and community engagement are essential. Key strategies include:

- **Land Use Planning:** Implementing zoning laws and land-use policies that prevent construction in high-risk flood zones. Promoting the development of open spaces and green areas to allow natural water flow and reduce flood risks is also necessary.
- **Early Warning Systems**: Establishing comprehensive flood forecasting and early warning systems to alert residents and authorities about impending floods.

Land Use Planning Case Study: Room for River Programme, Netherlands

The Netherlands has implemented extensive land-use planning policies to manage flood risks, with a focus on preventing development in flood-prone areas. A key element of their approach is the "Room for the River" program, which aims to accommodate excess water and mitigate flood risks by creating floodplains and open spaces. This approach includes:

- **Creating:** Constructing infrastructure like flood defences and water channels to manage and direct water flow.
- **Growing:** Planning for future landscape development to ensure compatibility with flood risk management.
- **Water Movement:** Monitoring seasonal water level fluctuations to adjust flood management strategies.

These elements collectively help to accommodate excess water, prevent development in flood-prone areas, and enhance overall flood resilience.

Room for the River Programme, Netherlands

Implementing effective land use planning and zoning laws is crucial for managing flood risks in Port Harcourt. Drawing inspiration from the "Room for the River" approach, the following strategies can be summarized:

- **Floodplain Designation:** Identifying and designating specific areas as floodplains is a vital step. By restricting construction in these zones, the natural landscape can absorb excess water during floods. This not only reduces the impact on urban areas but also preserves the ecological balance.
- **Green Infrastructure Policies:** Promoting the development of green spaces, parks, and wetlands within designated floodplains through zoning laws and urban planning policies can significantly enhance flood management. These green infrastructures

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 344-353 www.ijaem.net ISSN: 2395-5252

naturally manage floodwaters while providing recreational areas for the community, contributing to the overall quality of urban life.

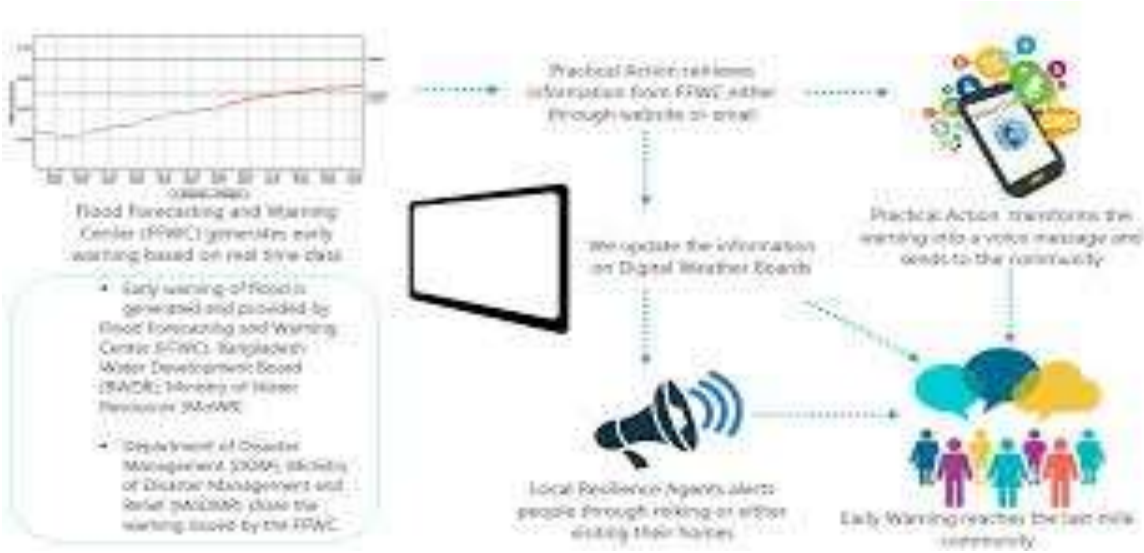
- **Policy Implementation:** Strict zoning laws must be developed and enforced to prevent construction in high-risk flood zones. To ensure compliance, policies that offer incentives, such as tax breaks for developments outside flood-prone areas, should be implemented. This approach encourages developers to adhere to regulations and supports sustainable urban growth.

Early Warning Systems: Case Study from Bangladesh

Effective flood risk management requires comprehensive early warning systems. Bangladesh's approach to flood early warning serves as a compelling model, offering strategies that can be adapted to address the flooding challenges in Port Harcourt. The key components of this system are real-time data collection, predictive modelling, robust communication networks, community engagement, and advanced technology use.

- **Real-Time Data Collection:** Collecting data on rainfall, river levels, and weather conditions.
- **Predictive Modelling:** Using hydrological models to predict flood levels and areas of inundation up to five days in advance.
- **Communication Networks:** Disseminating warnings through radio, TV, SMS, and community organizations to ensure wide reach.
- **Community Engagement:** Training communities to understand and respond to flood warnings, with local response plans in place.
- **Use of Technology:** Employing GIS and remote sensing for accurate predictions and effective warning dissemination.

Implementing similar early warning system in Port Harcourt can help ascertain, monitor and properly handle issues relating to rising water levels and flood risk.



Overview of the Bangledash Flood Early Warning System

V. CONCLUSION

The analysis of sustainable adaptation strategies for urban flooding in Port Harcourt underscores the need for a multifaceted approach to effectively manage flood risks. Rapid urbanization and population growth have intensified the city's vulnerability, exacerbated by inadequate drainage infrastructure and insufficient land use regulations. Addressing these challenges requires both structural and non-structural measures.

Structural interventions, such as advanced flood defences and improved stormwater management systems, are crucial. Environmental Impact Assessments (EIAs) can play a vital role by identifying potential flood hazards and guiding the design of flood-resilient infrastructure. The Greater Port Harcourt (GPH) City Development highlights the importance of integrating flood risk considerations into urban planning. Insights from New York City's Big U Project, which combines flood defences, stormwater management, and urban

design, can be applied to enhance resilience in Port Harcourt.

Non-structural measures are equally important. Effective land use planning, including strict zoning laws and floodplain designations, can prevent construction in high-risk areas and promote green infrastructure. The Netherlands' "Room for the River" program serves as a model for managing excess water through strategic land use. Additionally, implementing early warning systems, as demonstrated by Bangladesh, can improve flood preparedness and response through real-time data collection and predictive modelling.

In summary, tackling urban flooding in Port Harcourt requires a comprehensive approach that integrates structural improvements with non-structural strategies. Enhancing urban planning, investing in resilient infrastructure, and fostering community engagement are essential for building a flood-resilient city. Collaborative efforts among government bodies, planners, and the community are crucial to improving existing strategies and ensuring sustainable urban development.

REFERENCES

[1]. Abaye B, Ati OF, Iguisi EO. Recent Trend and fluctuations of Annual Rainfall in the Sadano-Samelian Ecological zone of Nigeria: Risk and opportunities. Journals of sustainable society. 2012;1(2):44–51.

[2]. Adeloye, A. and Rustum R. (2011): Lagos (Nigeria) flooding and influence of urban planning. Journal of Urban Design and Planning (ICE), Volume 164 (3), pp. 175 – 187.

[3]. Adekola, P. O. ed. (2016). Migration, Urbanization and Environmental Problems in Nigeria, University of Lagos Press and Bookshop Limited.

[4]. Akukwe, Thecla & Ogbodo, Chinedu. (2015). Spatial Analysis of Vulnerability to Flooding in Port Harcourt Metropolis, Nigeria. SAGE Open. January-March. 1-19. 10.1177/2158244015575558.

[5]. Bassey, A. E., Ede, P. N., & Wokekoro, E. (2020). Influence of rapid urbanisation on environmental quality in selected neighbourhoods of Port Harcourt Metropolis. Journal of Studies in Social Sciences and Humanities, 6(4), 244–257.

[6]. Big 2013-2019, AV Monografias 211-212, pages 140-143, accessed 29 July 2024, The Big U Project, New York - BIG Bjarke Ingels Group | Arquitectura Viva

[7]. C.P Konrad, "Effects of Urban Development on Floods," U.S Geological Survey Publications Warehouse - USGS, accessed July 29 2024, https://pubs.usgs.gov/fs/fs07603/.

[8]. Chen, Y., Liu, T., & Chen, R. (2020). Influence of the Built Environment on Community Flood Resilience: Evidence from Nanjing City, China.

[9]. Cookey-Gam, A. An Overview of the Greater portHarcourt City Master Plan and Opportunities in Building a World Class City over the Next 20Years; Greater Port-Harcourt City Development Authourity: Port Harcourt, Nigeria, 2010.

[10]. Damian Holmes (2017). "Room for the River", World Landscape Architecture, accessed 29 July 2024, Room for the River | Nijmegen, The Netherlands | H+N+S Landscape Architects (worldlandscapearchitect.com)

[11]. De Oliveira, A. K. B., Battemarco, B. P., Barbaro, G., Gomes, M. V. R., Cabral, F. M., de Oliveira Pereira Bezerra, R., & Miguez, M. G. (2022). Evaluating the Role of Urban Drainage Flaws in Triggering Cascading Effects on Critical Infrastructure, Affecting Urban Resilience. Infrastructures, 7(11), 153.

[12]. Echendu, A. J. (2021). Relationship between urban planning and flooding in Port Harcourt city, Nigeria; insights from planning professionals. Journal of Flood Risk Management, 14(2), e12693.

[13]. Etuonovbe, A.K. (2011): The Devastating Effect of flooding in Nigeria. Bridging the Gap between Cultures. FIG Working week 18- 22 May, Marrakech, Morocco.

[14]. Ibama, B., & Wocha, C. (2017). Urban growth: challenges, management and planning implication in port harcourt municipality. Journal of Global Ecology and Environment, 6(4), 135-148.

[15]. Iheamnachor D (2018) Panic in Rivers communities as police mop up arms from vigilante groups. Vanguard, 20 March, accessed 30 July 2018, www.vanguardngr.com

[16]. Ishaya, D. A., Dabo, D. I., & Fadason, R. T. (2016). Challenges In the Delivery of Environmental Sustainability in Housing Development in Abuja, Nigeria. 9th cidb, 53.

[17]. Isikwie BC Ameh ME, Utah EY. Analysis of Rainfall Variability over some Cities in

Nigeria using Harmonic Analysis technique. Nigerian Jour of Physics. 2013; 24:16–24.
[18]. Lateef Olayinka (2021), Port Harcourt Floods: Govt, Victims Trade Blames, accessed 29 July 2024, https://mail.tell.ng/port-harcourt-floods-govt-victims-trade-blames/
[19]. Maddox, I. (2014). Three common types of floods explained. Retrieved from https://www.intermap.com/risks-of-hazard-blog/three-common-types-of-flood explained.
[20]. Nimi G., Dan-Jumbo, and Marc Metzger (2019). Relative Effect of Location Alternatives on Urban Hydrology. The Case of Greater Port-Harcourt Watershed, Niger Delta. Journal of Hydrology, 2019, 6, 82; doi:10.3390/hydrology6030082
[21]. Ogata, S., & Sen, A. (2003). Human security now, commission of human security. Commission on human security, New York.
[22]. Tamana Rahman (2022). Early warning systems to reduce loss and damage in riverine char communities in Bangladesh. Flood Resilience Portal, accessed 29 July 2024. floodresilience.net.bd
[23]. Ogundele, J., & Jegede, A. O. (2011). Environmental Influences of Flooding on Urban Growth and Development of Ado-Ekiti, Nigeria. Studies in Sociology of Science, 2(2), 89.
[24]. Ologunorisa, T.E. (2004): An Assessment of Flood Vulnerability Zones in the Niger Delta, Nigeria. International Journal of Environmental Studies, U. K. Vol. 61(1).
[25]. Orok, H.I. (2011): A GIS-Based Flood Risk Mapping of Kano City, Nigeria. Unpublished M.Sc. thesis, School of Environmental Sciences, University of East Anglia, Norwich.
[26]. Port Harcourt Submerged After Hours of Rain (2021), accessed 29 July 2024, https://www.tell.ng/port-harcourt-submerged-after-hours-of-rain/?amp
[27]. Scannapieco, D.; Naddeo, V.; Belgiorno, V. Sustainable power plants: A support tool for the analysis of alternatives. Land Use Policy 2014, 36, 478–484.
[28]. Surminski, S., Mehryar, S., & GolnaraghI, M. (2020). Flood Risk Management in England: Building flood resilience in a changing climate. The Geneva Association-International Association for the Study of Insurance Economics, June, 1–55.
[29]. Yerima, I., Musa, J. J., & Zegi, S. (2017). Challenges of Drainage System in Nigeria with Respect to Grey Water Use for Irrigation: Case Study of Minna.