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IMPACT ASSESSMENT OF ENCROACHMENTS ALONG PERI-URBAN AREAS, ECOLOGICAL ZONES, AND FLOODPLAINS IN SELECTED WETLANDS AND WATERWAYS IN SOUTHWEST NIGERIA

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Abstract

Cities are characterized by high population density, modern amenities, and urban infrastructure. Considering the rate of urban growth around the suburbs, peri-urban regions are those located outside major cities, presenting a combination of urban and rural features, which means they are places with low population density that prioritize agribusiness, communal activities, and unspoiled landscapes. These lowland communities and the rapidly growing Lagos-Ogun floodplain demand strategic landscape design due to the widespread effects of floods and related risks in Southwest Nigeria. Due to their proximity to the Lagos shoreline and the urban infrastructure connecting them to the Lagos metropolis, these rising settlements need the regional and strategic physical design of the towns that are now known as "new Lagos Cities." These settlements, located in Northern Lagos and also known as Development Pressure Areas (DPAs), are facing considerable development pressure from the nearby suburbs. The present study assessed the current characteristics of a few chosen residential and agricultural communities in DPAs, as well as the flood catastrophes that occurred between April and November 2023. The purpose of this article is to provide a regional conceptual framework and appropriate landscape planning as a means of reducing flood threats. The on-site data concerning the research were analyzed both quantitatively and qualitatively. The study area is made up of five Local Government Areas (LGAs) and the three recognized ecological zones within them. They were mapped out and examined to determine the extent, impacts, and effects of the recurring flooding. Three town planners, one surveyor, one trainee surveyor, two landscape architects, and five freshmen from the Department of Urban and Regional Planning from

different universities in Southwest Nigeria conducted the on-site assessments. The analysis took into account the following urban elements: population; land use; economic, physical, and social infrastructure; urban migration indexes regarding inhabitants and farmers; and other recognized urban traits associated with growing cities. The conclusion emphasized the urgent need for prompt action from governmental bodies, agencies, and professionals in urban and ecological planning to develop robust and sustainable solutions for reducing the effects of water damage and runoffs on the local population, on waterway networks, and on physical development in a city or region.

Keywords

Regional Planning; Urban Infrastructure; Urbanization; Floodplain; Landscape Planning; Peri-urban Areas; Sustainable Design and Development.

ARTIGOS

AVALIAÇÃO DE IMPACTO DE OCUPAÇÕES AO LONGO DE ÁREAS PERIURBANAS, ZONAS ECOLÓGICAS E VÁRZEAS EM REGIÕES PANTANOSAS E CURSOS D'ÁGUA SELECIONADOS NO SUDOESTE DA NIGÉRIA

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Resumo

Cidades se caracterizam por uma alta densidade populacional, equipamentos públicos modernos e infraestrutura urbana. Considerando a taxa de crescimento urbano em torno dos subúrbios, as regiões periurbanas são aquelas localizadas fora das grandes cidades, apresentando uma combinação de características urbanas e rurais, o que significa que se trata de locais com baixa densidade populacional que priorizam o agronegócio, atividades comunitárias e paisagens preservadas. Essas comunidades localizadas em baixadas e a várzea de Lagos-Ogun, em rápido crescimento, exigem um projeto paisagístico estratégico devido aos efeitos disseminados de inundações e aos riscos relacionados a elas no sudoeste da Nigéria. Por conta de sua proximidade com o litoral de Lagos e da infraestrutura urbana que os conecta à metrópole de Lagos, esses povoamentos em ascensão necessitam do projeto físico regional e estratégico das cidades agora conhecidas como "novas cidades de Lagos". Tais comunidades, localizadas no norte de Lagos, também conhecidas como Áreas sob Pressão de Desenvolvimento (DPAs, na sigla em inglês), enfrentam uma considerável pressão de desenvolvimento dos subúrbios próximos. O presente estudo avaliou as características atuais de algumas comunidades residenciais e agrícolas em DPAs, bem como as catástrofes relacionadas a inundações que ocorreram entre abril e novembro de 2023. O objetivo deste artigo é fornecer um arcabouço conceitual regional e um planejamento paisagístico adequado como meio de reduzir as ameaças de inundações. Os dados locais referentes à pesquisa foram analisados quantitativa e qualitativamente. A área de estudo é composta de cinco Áreas de Governo Local (LGAs, na sigla em inglês) e das três zonas ecológicas reconhecidas dentro delas. Elas foram mapeadas e analisadas

visando determinar a extensão, os impactos e os efeitos das inundações recorrentes. Três planejadores urbanos, um topógrafo, um estagiário de topografia, dois arquitetos paisagistas e cinco calouros do Departamento de Planejamento Urbano e Regional de diferentes universidades no sudoeste da Nigéria conduziram as avaliações no local. A análise levou em consideração os seguintes elementos urbanos: população; uso do solo; infraestrutura econômica, física e social; índices de migração urbana referentes a habitantes e agricultores; e outras características urbanas reconhecidas associadas a cidades em crescimento. A conclusão enfatizou a urgência de ações imediatas por parte de órgãos governamentais, agências e profissionais de planejamento urbano e ecológico para desenvolver soluções robustas e sustentáveis que reduzam os efeitos dos danos causados pela água e pelo escoamento superficial sobre a população local, as redes hidroviárias e o desenvolvimento físico de uma cidade ou região.

Palavras-chave

Planejamento Regional; Infraestrutura Urbana; Urbanização; Várzea; Planejamento Paisagístico; Áreas Periurbanas; Projeto e Desenvolvimento Sustentáveis.

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Introduction

Exploring more practical flood risk reduction strategies for Nigeria should be of the utmost importance given the record of catastrophic floods that affect millions of people and result in significant economic losses (Adesina; Uduma-Olugu, 2023; Uduma-Olugu; Adesina, 2020). Flood risks in Nigeria can be classified as fluvial (caused by rivers overflowing their built-up barriers), coastal (primarily influencing coastlines and swamp zones), or pluvial (arriving unexpectedly after a strong storm) (Nnaji; Ogarekpe; Nwankwo, 2022). These floods have been an important source of worry for the urban and rural populations in Nigeria, and the efforts to address the issue have not produced satisfying outcomes, having come under fire for being unstructured, haphazard, ill-coordinated, and not well-established. The general negative impression the population has of floods, a lack of funding and better technology, an absence of political will, and insufficient high-quality data all contribute to the limited ability of the government to address flooding (Akei; Babilia, 2022; Njar et al., 2024). The increasing number of people affected by floods and the way that flooding hinders sustainable development in the country indicate that there is still much to understand about flooding in Nigeria. The fact that it is one of the most populous nations in the world, with approximately 200 million inhabitants, makes the issue even more pressing, due to the number of flood victims and the damages recorded annually.

The rainwater cycle is a well-balanced system, and overflowing is expected to occur. Water returning to the sea balances water entering one portion of the cycle, such as the tributaries and canals (Nnaji; Ogarekpe; Nwankwo, 2022; Akei; Babilia, 2022). However, there are instances in which the amount of water entering a certain region exceeds the ability of the system to contain it within its natural boundaries. Flooding occurs when the amount of water entering the land exceeds what can be released by drainage channels or the land itself – through rainfall, surface runoff, flow in watercourses, or inundation by rivers. Every year, floods are a serious tragedy that afflicts many countries, particularly those located in floodplain zones. In addition to causing property destruction and posing a threat to human and animal life, floods can also result in diseases, such as cholera and malaria epidemics (Nwilo et al., 2021). While floods in Nigeria vary in intensity and severity, they are common throughout the country. Climate change has aggravated floods, as evidenced by its correlation with the increased frequency of intense storms and precipitation (Nnaji; Ogarekpe; Nwankwo, 2022; Akei; Babilia, 2022). The fast urban expansion and development in Nigeria, coupled with extremely inadequate planning, is another element that contributes to flooding in metropolitan areas (Nwilo et al., 2021; Njar et al., 2024).

The new towns surrounding urbanized cities like Lagos, Abeokuta, and Ibadan are called Development Pressure Areas (DPAs), also sometimes referred to as "new Lagos Cities." In Southwest Nigeria, which has seen a significant increase in flood risk in recent years, these three large cities act as the administrative capitals of the states of Lagos, Ogun, and Oyo, and due to the urban migration of settlers, this is primarily a low-income and densely populated region. The majority of religious groups operate in this area since the available acreage is primarily used for hosting their regular meetings. Also, the price and availability of land have made DPAs appealing to housing developers, real estate operators, and property investors (Olokeogun; Kumar, 2022).

Over the previous thirty years, DPAs have seen very few government-funded infrastructure and development initiatives. There is a knowledge gap that the present study aims to fill since there is little to no comprehensive flood record in different states, which seems to be hampering efforts to address the issue as well as a better understanding of the overall spatial and temporal distribution of floods in the country. Although media and humanitarian reports emphasize how serious the situation is, there is a striking lack of consistency in flood narratives in Nigeria (Oruonye; Zemba; Yusuf, 2023). The country frequently experiences a rise in non-quantitative data during flooding periods, which tends to overstate the effects of floods on the nation.

To address important questions regarding flood concerns in Nigeria, this paper aims to build on the body of knowledge already available about the topic. It also intends to determine the devastation caused by floods and how it impacts people living in floodplains, as well as to highlight the need for education and advocacy regarding floods and the decline in biodiversity in the country. Following these core concerns, the study assesses the extent of the damage and the steps being taken to stop yearly floods that are unabatedly occurring in wetlands, designated ecological zones, and DPAs. Another objective consists in evaluating population and housing indexes along waterways and green corridors impacted by flooding, therefore determining the extent of the damage in the region and for the rural/farm communities and villages most impacted, as well as investigating how to construct flood-resilient communities using modern nature-based landscape design models.

1. Theoretical framework

Extreme river flooding has happened in recent years in several African locations, and there are many interconnected variables contributing to the increased risk of flooding (Adesina; Uduma-Olugu, 2023; Kasim; Wahab; Oweniwe, 2022). Studies show that future climate change will increase rainfall frequency and intensity, which might result in more recurrent and severe natural catastrophes (Onanuga; Eludoyin; Ofoezie, 2022). Nigeria has experienced flooding since the early 1950s, when both coastal and riverine floods occurred (Onanuga; Eludoyin; Ofoezie, 2022; Oyedele et al., 2023). The inadequate terrain management and improper urban/environmental design in the country, as well as climate change, are related to flooding. The devastating effects of floods have touched every aspect of its life cycle, resulting in severe economic disruption and large-scale losses (mostly from the destruction of farmlands, agricultural landscapes, house settlements, and social and development infrastructure) (Tobore; Bamidele, 2022). In 2012 (from July to October), the nation experienced the worst floods in almost 40 years, as a consequence of strong storms that continued for several days, and 24 of the 32 states impacted were deemed badly affected by the occurrence (Onanuga; Eludoyin; Ofoezie, 2022). The vulnerability of the community to weather- and climate-related harm is growing due to demographic and socioeconomic trends, including the construction of homes in high-risk locations, such as flood zones (Takyi et al., 2022). Over 2 million individuals were considered internally displaced persons (IDPs) out of the 7.7 million people who were impacted by the floods. Besides the roughly 5,900 dwellings destroyed, nearly 5,000 people suffered bodily injuries (Oyedele et al., 2023).

The yearly obstruction of major river flows and overflowing various manmade and ecological barriers were the main causes of floods, which mostly damaged coastal habitats (Takyi et al., 2022). The biggest risk of flood in areas along the plains next to the main rivers in Nigeria – the Niger, Benue, and Hadejia rivers, for example – concerns fluvial floods. Adamawa, Kano, Niger, Jigawa, Kaduna, Cross River, and Kebbi are the states most severely impacted. In 2006, the tragedy in Kano claimed hundreds of thousands of lives and caused millions of dollars in economic losses, making it the worst-ever river flood in the country. The number of people vulnerable to these catastrophes as a result of economic and social problems in seaside areas has made the effects of such floods even more severe, hence the appeal for relief assistance from the government in the form of financial support, food, clothing and shelter. In terms of population density and projected future growth in the 2070s, Nigeria is among the top 20 nations in the world most vulnerable to coastal flooding (Adebayo; Oyesiku; Badejo, 2024). To combat floods, the Federal Ministry of Environment (FME) oversees several important organizations, departments, and agencies, such as the Federal Capital Territory (FCT) Emergency Management Agency, the National Emergency Management Agency (NEMA), the State Emergency Management Agency (SEMA), the Local Emergency Management Agency (LEMA), the National Orientation Agency (NOA), and the National Environmental Standards and Regulations Enforcement Agency (NESREA). As of 2009, Nigerian legislation has superseded the FCT Emergency Management Agency, the Nigerian Meteorological Agency (NiMet), and the Nigerian Hydrological Services Agency (NIHSA) (Adebayo; Oyesiku; Badejo, 2024; Njar et al., 2024).

Using NEMA as the managing body, the following steps can be thought of to combat water damage in Nigeria: developing policies; gathering data from pertinent agencies; educating the public about water damage; providing relief supplies to those affected by disasters; protecting and preserving the environment by obeying environmental laws, recommendations, ordinances, and norms in Africa, as well as the provisions of worldwide agreements, procedures, meetings, and treaties regarding the environment to which Nigeria is a contributor. A great deal of deaths worldwide are caused by floods, which are perhaps the most frequent weather-related danger faced by humanity due to the effects of climate change (Adesina; Uduma-Olugu; Adebamowo, 2021; Asante; Bonsu, 2023; Asante; Bonsu; Helbrecht, 2024).

Asante, Bonsu, and Helbrecht (2024) asserted that excess water rushing through previously dry terrain causes floods, which in turn lead to over half of the deaths caused by natural disasters. Floods are the most common natural disaster, having killed over 300,000 people in the last 30 years and affected over 2.8 billion

people worldwide, accounting for 47% of all weather-related disasters around the globe. Floods are caused by a complex web of interconnected factors. In nature, they are brought on by temperature increases that trigger intense rainfall, glacier melt, and ocean thermal expansion, all of which raise sea levels and submerge coastal areas (Onyango, 2024; Asante; Bonsu; Helbrecht, 2024). The primary cause of these circumstances worldwide is climate change, which has been made worse by human actions such as building homes in areas with a higher risk of floods and deforestation. Climate change threatens to obstruct physical developments, community projects, and ecological initiatives, particularly in sub-Saharan Africa (Emmanuel et al., 2023). Development gains will be hindered by an increase in all types of catastrophes, notably floods, with different degrees of severity. In the next ten years, studies predict the likelihood of disasters resulting from climate change will grow, due to an increase in the frequency and intensity of hazard events, as well as in the susceptibility of populations that are already vulnerable to them. There is currently a greater emphasis on the United Nations sustainable development goals, one of which consists in reducing the effects of environmental degradation by decreasing the vulnerability of the settlements to floods and their impacts (Effiong; Ngang; Ekott, 2024; Faye et al., 2024).

Emmanuel et al. (2023) stated that out of the numerous catastrophic events that affect people globally, floods have the greatest potential for harm. There is proof that the number of individuals impacted by floods and the resultant economic losses are rising alarmingly on a worldwide scale (Emmanuel et al., 2023). Strategies and efforts that disrupt the present disaster cycle are necessary for mankind to shift away from the current post-disaster response paradigm, and decision makers must embrace comprehensive strategies for managing flood disasters (Effiong; Ngang; Ekott, 2024). Even though such classification is rarely accurate, depending mostly on processes that measure devastation, substantial impacts are typically understood to be the kinds that can be assessed in an economic sense, such as mold damage to the workplace. According to experts, the following factors are the most crucial in determining the effect of floods: river water depth; rainfall; pace of flow; percentage and extent of silt; wave or wind action; pollution load in flood water; and rate of water level rise when flooding begins (Guo; Li, 2024). Many people in Lagos, Oyo, and Ogun experienced floods in 2010 as a result of torrential rains worsened by the overflowing of Oyan River Dam, which caused the Ogun River to inundate its floodplain and Nigerians living in these areas to frequently fear downpours. Following the tragedy, characterized by medical professionals as a risk of an epidemic to the impacted floodplain towns, over 1,000 people were displaced (Effiong; Ngang; Ekott, 2024; Marine; Bisong, 2024).

1.1. Flood impacts and causes along the Lagos-Ogun floodplains

1.1.1. Quick population increase and inadequate environmental administration

Effiong, Ngang, and Ekott (2024) stated that since the establishment of these new Lagos cities surrounding DPAs, there has been a steady rise in the number of inhabitants in the flood-prone settlements. Consequently, housing, businesses, and institutional complexes have grown, increasing the built-up area and the need for inadequate local water systems to manage rainwater runoff (Asumadu et al., 2023). The flood prevention policy created by the federal government has not proven very effective, and appropriate environmental planning and management strategies are still lacking. Asumadu et al. (2023) warned that wetlands have been granted to facilitate development, buffer zones have been violated, and homes have been constructed next to streams. Rainwater runoff is increased in volume and pace due to construction in watersheds, along flooded areas with high risks of flooding and other unexpected alterations in land use (Asumadu et al., 2023; Mbonaga; Hamad; Mkoma, 2024). Waterways and wetland areas are meant to reduce the consequences of floods, but sadly a significant part of them is currently being occupied by constructions.

1.1.2. Poor sewage infrastructure and deteriorating canal networks

Based on visual inspection, certain drainages and canals along major flooding corridors have already suffered damage, are obstructed by floating debris, or are not large enough. The resulting risks include obstructed holes, the displacement of manhole covers, and the collapse of buildings or houses (Mbonaga; Hamad; Mkoma, 2024). One possible reason for the issue might be a lack of thorough research concerning where to place drainage infrastructure and the rerouting of rivers from their natural paths, both of which are meant to minimize flooding in these corridors.

Canal and drainage blockages are another result of improper waste disposal practices. When attempting to prevent deadly floods, it is important to establish a reliable drainage network and to work toward ensuring that water can freely flow during and after rain. Floods are a major global threat that spread waterborne diseases and many other negative impacts numerous villages have experienced, with roads being washed away and gullies being formed (Nwaogu et al., 2017).

1.1.3. Human impacts of activities on the rural and urban landscapes

Nwaogu et al. (2017) highlight deforestation; unsuitable river canalization lacking regular upkeep; inadequate metropolitan urban planning systems for organizing and overseeing human activity and infrastructure development;

and warming temperatures. In recent times, drainage in DPAs has been greatly impacted by contemporary infrastructure improvements, especially the renovation of the Lagos-Ibadan Expressway. Another worldwide concern resulting from global warming is the degradation of ecosystems and biodiversity since the rivers located in DPAs are full of chemical particles and dirt that have accumulated over time in the local greenery, such as water weeds in wetlands, and in floating plastic bottles. This has disrupted streamflow, creating floods in nearby regions when it rains heavily (Aduloju et al., 2024). Susceptibility to storms has increased as a result of the current environmental circumstances, anthropogenic activities, and construction of facilities in flood-prone DPAs, which has weakened the natural resilience of the ecosystem. As a result of continuous urbanization and landscape alteration and degradation, trees that normally absorb rainwater and lessen water flow over the terrain are no longer available. Barely considering agricultural objectives, vegetation is being destroyed, giving way to the construction of homes and businesses (Aduloju et al., 2024). Flood protection networks and mechanisms, which include drainage cavities, waterways, and retaining walls surrounded by flood storage areas, normally accelerate water drainage, especially in situations when obstruction occurs (Njar et al., 2024).

2. Research methodology

Both quantitative and qualitative methods were used in the present study. The chosen peri-urban area was split into three ecological zones, mostly based on floodplain orientation, geographical location, and stream channel/waterways). The five Local Government Areas (LGAs) – Ado-Odo/Ota, Ewekoro, Ifo, Obafemi Owode, and Sagamu – analyzed in this study were chosen due to the intense rainfall that occurred between April and November 2023. This resulted in excessive flooding in the area close to the Ogun River basin, encompassing DPAs that have not received enough attention. Additionally, these areas were chosen based on their proximity to Lagos, to the wetlands and floodplains of the Owuru and Ogun rivers, and to the largest farm settlements and villages closest to the flood-prone areas, which suffered the most from the rain. However, because of the catastrophic impact of these floods, this study dwells more on the data obtained during on-site visits and investigations in and around the wetlands and communities that were affected.

Following a quantitative approach, 90 houses were visited, encompassing 132 families (some of these houses had two to three families living together under the same roof), and a total population of 686 people was surveyed, covering an estimated 122.3 km^2 of land. In turn, qualitative data illustrating the perspectives of neighborhood dwellers affected by the floods was gathered through conversations

and interviews with a range of survivors, including landowners, property owners (landowners/house owners), farmers, fishermen, district officials, and market women (traders) who were unable to travel to the marketplace because of submerged access routes. The study engaged professionals in onsite surveys: town planners, landscape architects, environmental enthusiasts, and college students who volunteered to visit the field to examine the extent of the damages in the research area throughout this period and conducted on-the-spot evaluations of the districts. Due to the current land use and the chaotic physical layout of the streets affected by the floods, most of the impacted residences failed to adhere to the required 100-meter buffer from river corridors, a regulation that is not strictly observed in most of the existing buildings in the study area. The methodological approach consists of an analysis of the regions and their potential for landscape planning, taking into account the current state of affairs. This encompasses aspects that shape the growth-oriented profile of the area: tangible and rural-urban social structures, land use, facilities, and psychological growth indexes. To fully understand the intrinsic environmental goods and services of the area, the last step involves identifying the biodiversity of the wetlands. This study is in line with the opinions of Ziaul and Shuwei (2023), who stated that ecological adaptive actions include conducting field surveys in the chosen floodplains, wetlands, towns, agricultural landscapes, and farm settlements, which have been progressively encroached upon, as well as observing the rapid degradation of the terrain as a result of human factors, impacting the environment and the life of both humans and animals (Ziaul; Shuwei, 2023; Dong; Huang, 2023).

2.1. The study area: the Lagos-Ogun DPAs

The areas investigated are located within the districts just north of Lagos, in the Lagos Metropolitan Area, 60 km away from the point where the Lagos-Ibadan Expressway meets the Ogun River in Isheri. This territory crosses five LGAs: Ado-Odo/Ota, Ewekoro, Ifo, Obafemi Owode, and Sagamu (Figures 1 and 2 and Tables 3 and 4), in an area of approximately 950 km^2. People from the Lagos Metropolitan Area are moving into this neighborhood at an increasing rate, particularly low- and middle-class individuals who are forced to relocate to more inexpensive areas because they are unable to pay rent in the city. This influx of people has further increased the strain on the limited land resources and on the available land, leading to further encroachment upon the wetlands and the Lagos Lagoon.

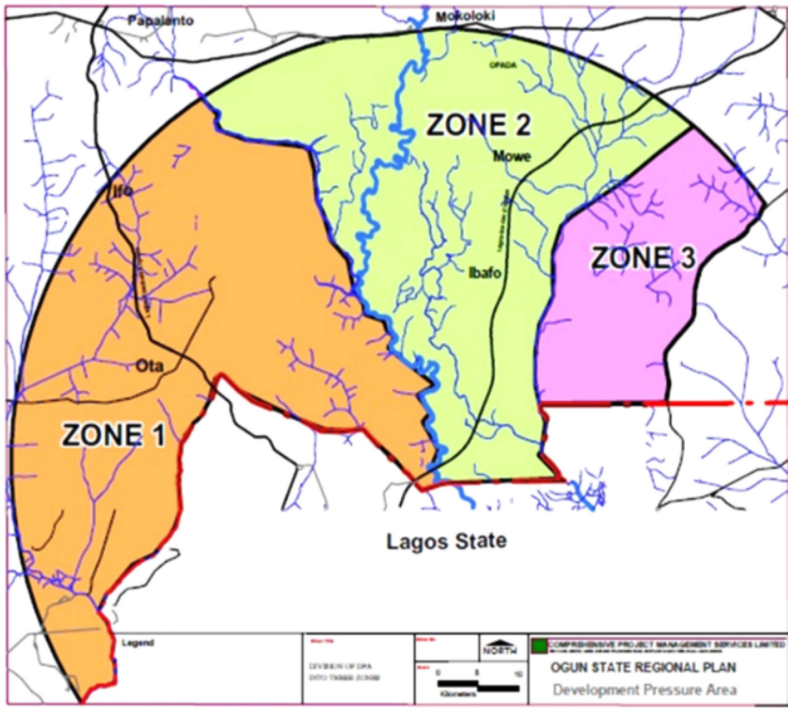


Figure 1. DPAs showing the three ecological zones in the five Local Government Areas

Source: regional plan by the Ogun State, Ministry of Physical Planning and Urban Development/ Planning Authority (2012).

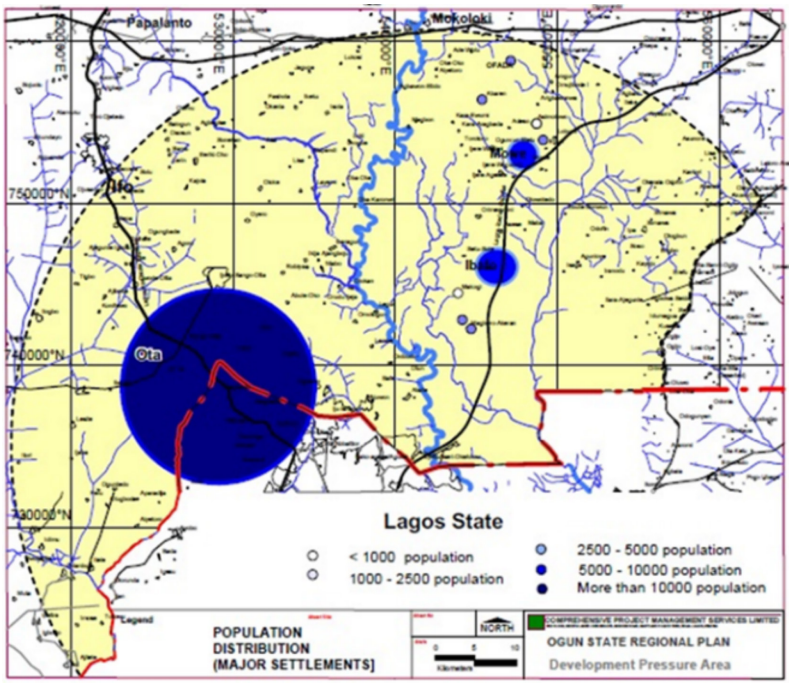


Figure 2. Biodiversity highlights and hotspots (in blue) in Lagos-Ogun, Southwest Nigeria

Source: regional plan by the Ogun State, Ministry of Physical Planning and Urban Development/ Planning Authority (2012).

The huge, reasonably priced areas in these regions have also drawn the attention of religious organizations searching for sites in which to host their events and some of the major real estate investors and housing developers looking for land. An on-site assessment revealed that planning authorities must act quickly to reduce the frequency of floods in this area, which are mostly brought on by continuous migration to the study area, averaging 10 km x 5 km (Figure 3), thereby leading to more physical developments and constant erosion of the land after downpours. This area is the most affected among the five LGAs analyzed, with the highest level of displacement being identified in the Obafemi Owode LGA and the other four LGAs not being as critically impacted.

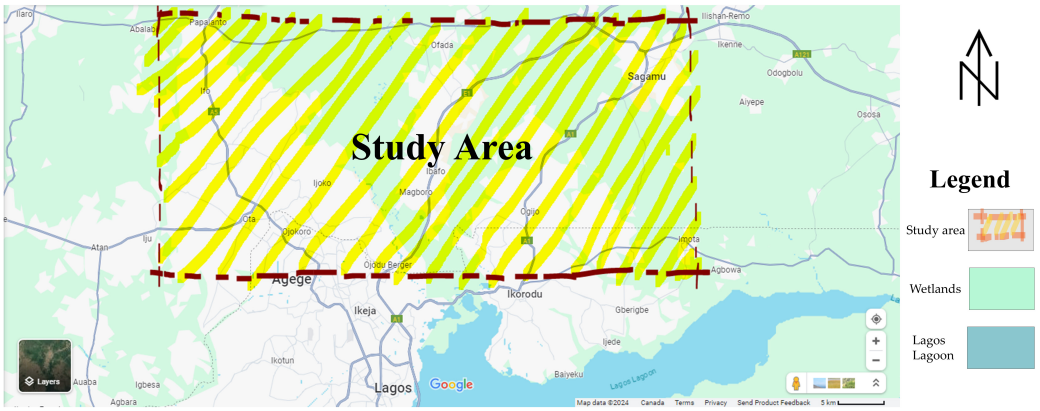


Figure 3. The study area of approximately 10 km x 5 km in the DPAs of the Lagos and Ogun States

Source: edited from Google Maps (2024).

Concerning the waterways and river tributaries in the area and their susceptibility to flooding the dark-blue lines in Figures 4 and 5 show the main waterways, while the light-blue ones show the floodplains directly linked with the affected communities, especially in the suburbs of the Lagos State. These areas are known for fast development and urbanization, which has worsened the already worrisome situation caused by human activity and further degradation of the waterways and wetlands.

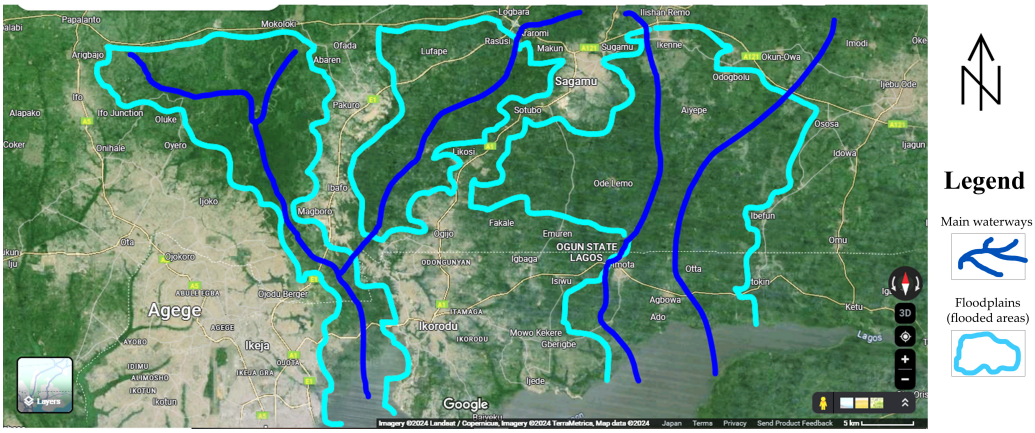


Figure 4. Areas susceptible to flooding (DPAs), main waterways (dark-blue lines), and floodplains and flooded areas (light-blue lines)
Source: edited from Google Maps (2024).

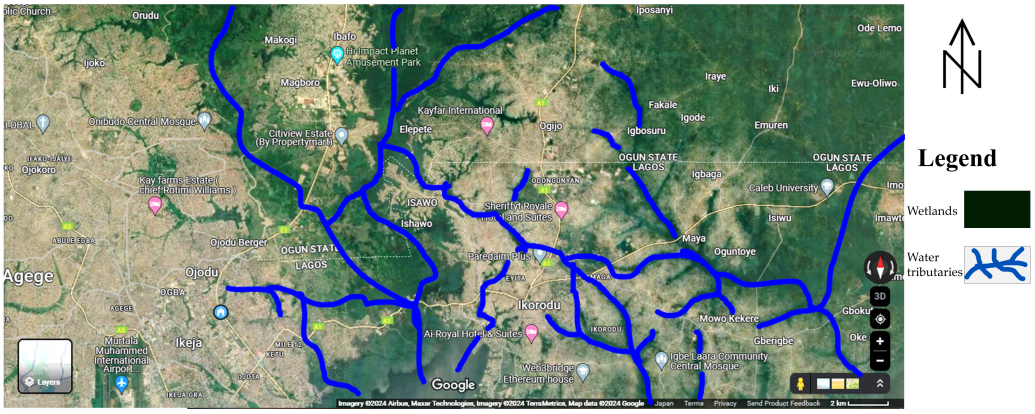


Figure 5. The Lagos-Ogun DPAs show the main wetland corridors and water tributaries (blue lines) within the communities and flooded areas
Source: edited from Google Maps (2024).

The mapping and analysis of the areas concerned result in an environmental governance structure for the creation of environmentally-conscious restored landscapes and connections with the currently flooded wetlands to establish the degree of risk and ecosystem degradation at the three designated ecological zones (Figure 1), drawing on the most recent base map of the region, high-resolution images, and a thorough site investigation encompassing the communities impacted (Figures 3, 4, and 5). This data was taken into consideration at various points in time to define the current drainage network and analyze the natural vegetation, biodiversity, impacts on livelihood, loss of lives, and wetland exploitation of the impacted regions in all the settlements located in floodplains. Following the 2023 and 2024 field trips (only the data from 2023 was used in this study because of the magnitude of the devastation), on-site surveys, information on soil and vegetation

type, water table, and river tide, and hydrological investigations were used to record forests and drainage channels in the settlements, with the aid of using high-quality pictures taken using an unmanned aerial vehicle (UAV) (Figures 6 and 7). To estimate details regarding the level of damage, data was captured in the area shown in Figure 3.

Figure 6. Flooded waterway in its natural state, not properly channelized, behind a residential estate in Redemption City (Estate 7)
Source: authors' fieldwork (2023).

Figure 7. Flooded wetlands and waterways in Redemption City, Ogun State
Source: authors' fieldwork (2023).

Figures 8 and 9 show the current situation and problems in the ecosystem and waterways of the wetland and some of the many factors taken into account in the assessment of the area, including the physical attributes of a certain location, such as vegetation, soil type, terrain, and landforms. As shown in Figures 7 and 8, other noteworthy characteristics of the impacted area have been displaced, primarily consisting of raffia palms in part of the undeveloped land that provides a clear view of the horizon; local boats, on the other hand, have restricted vision and access to the wetlands. The microclimate of the site and its relationship to the overall climate of the region we investigated using meteorological data, considering the features of this site. Rainfall records revealed that annual precipitation in the form of rainfall is high from April to November.

Figure 8. Desilting/Dredging works along a flooded waterway while heavy rain is still at its peak (photo taken in May 2023)
Source: authors' fieldwork (2023).

Figure 9. Overflowing waterway before desilting works, with water weeds visible on the surface

Source: authors' fieldwork (2023).

3. Discussion of findings

The data and results of the analysis carried out in the present study were made public to call the attention of policymakers to stop further losses of biodiversity, lives, and properties. The threats that floods, wetland encroachment, and degradation pose to ecosystems are generally overlooked, especially in rapidly growing areas where legally required buffers are ignored or hardly observed. The Lagos-Ogun DPAs are located in the rainforest zone in Southwest Nigeria, characterized by green grasslands interspersed with bushes and trees. The main rivers and streams that run through the adjacent states are primarily lined with forest flora. The unique terrain and geological structure of flooded plains discourage intensive human activity, mainly the expansion of commerce. Over the last thirty years, there has been a noticeable increase in urban activity (36%) in the DPAs, not to mention the continually growing religious colonies, which account for 25% of the land use in the area. Different kinds of farming activities are currently being carried out within this corridor. Both vegetable cultivation in tiny plots and firewood sourcing account for around 7% of land use in this area (Table 1).

Land use	Local Government Areas (LGAs)	Percentage (%)
Residential (mainly due to urban migration)	All five LGAs	26
Religious	Obafemi Owode, Ifo, Sagamu	23
Cash crop	All five LGAs	7
Firewood logging	All five LGAs	7
Fishing	All five LGAs	7
Illegal logging	Obafemi Owode, Ifo, Sagamu	5
Industrial	All five LGAs	5
Hunting	All five LGAs	5
Educational	All five LGAs	5
Commercial	All five LGAs	5
Sand mining	Obafemi Owode, Ifo, Sagamu	3
Recreational	All five LGAs	2
Total		100

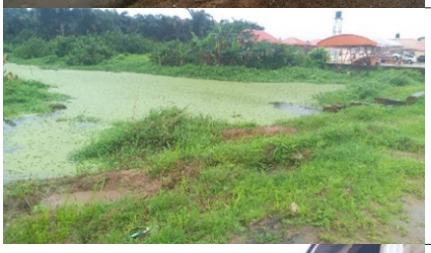
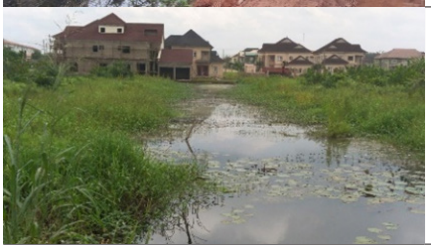
Table 1. Land use in the DPA regions and subregions (local settlements)
Source: authors' fieldwork (2023).

The primary land uses in the DPAs, as indicated by Table 1, are residential, spiritual/religious, agricultural, educational, commercial, recreational, industrial, and for activities such as firewood logging, illicit logging, fishing, sand mining (for the development of roads and structures), and hunting. The least common land is recreation (2%). Data from on-site evaluation shows that the main economic activity in the regions studied is residential real estate development (26%), which has resulted in the wetlands and streams constantly recovering ground for home construction. There were insufficient outdoor areas for sports facilities, parks, and gardens, as well as for socializing and relaxing.

3.1. Population affected by floods along the wetlands/green corridors

While still only partially built as of the writing of this article, the western portion of the region has a very high population density, and there are plans to build a large number of houses east of the Ogun River. Numerous housing complexes were built, and plots were distributed under the auspices of the Ogun State Property and Investment Corporation (Opic). In the vicinity, there are a few private housing developments, the most well-known of which is a religious organization settlement known as Redemption City, which has constructed nearly 50,000 homes for its members – and more residential estates are projected for future development. There are also several other privately owned residential real estate developers, including the Emerald, Jubilee, Haggai, and Adron, among many others in the business of acquiring land for construction. Sadly, few of these constructions

are located directly on the reclaimed wetlands. The Owuru and the Ogun river corridors are often flooded. The damaged homes and farm communities located in the five LGAs chosen for this study were determined using data obtained during a visit to the site and based on feedback from the affected residents/settlers (Table 2).

Flood impact condition	Effect	Environmental impact
	The smaller channels that accommodate water flow through the tributaries damage the public drainage infrastructure.	****
	People fish in rivers although these are unauthorized fishing zones.	*
	Water rises beyond the regular level, thereby cascading into the neighborhood and also affecting farms and small-scale vegetable gardens along water channels.	**
	Water weeds partially cover the water, preventing humans from having access to water and causing reptiles to find their way into the streets.	**
	High levels of turbidity could be detected in the waterway; moreover, in most cases, the water smells bad, making inhabitants uncomfortable.	*
	Construction activities (buildings) blocking waterways are some of the human activities affecting the free flow of water.	****

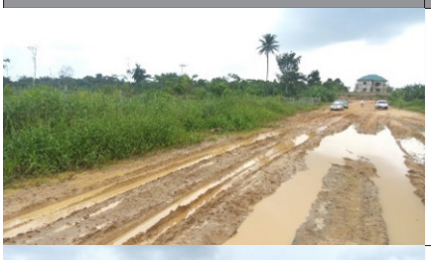
Flood impact condition	Effect	Environmental impact
	It becomes impossible to go through the new, untarred roads, which flood even with light rain, due to the lack of connecting drainage systems.	****
	Narrow channels are one of the measures to curb the impacts of floods and could be seen in some places.	**
	The rise of the water table affects major access roads, disrupting people's routines and affecting commercial activities whenever it rains.	**
	Large amounts of plastic waste could be seen blocking the waterway, demanding periodic dredging and desilting works.	***

Table 2. Problems identified at the floodplains and wetlands in the Obafemi Owode LGA

Note: **** means extreme impact; *** means critical impact; ** means moderate impact; * means low impact.

Source: remarks from on-site interviews and coastline assessment.

The overwhelming environmental impact of floods along the floodplains was rated according to the indicators presented in Table 2, and most impacts were caused by lack of infrastructure or inadequate drainage systems, including small drainage channels (1.2 m and 1.5 m wide, for instance, as measured in some locations), houses built along waterways, untarred roads without proper drainage channels, and dumping of plastic waste bottles. These human activities, as well as housing developments in the LGAs (Table 3), block the waterway, which has a ripple effect on the communities, mainly the immediate neighborhoods, with extreme consequences all around the suburbs as well (Figure 10).

Local Government Area	Houses affected	Families (approx.)	Area flooded (km²) (approx.)	People displaced (approx.)	Percentage (%) of displaced people
Ado-Odo/Ota	20	34	16.5	110	16
Ewekoro	8	12	9.3	60	9
Ifo	12	17	34.0	102	15
Obafemi Owode	34	45	47.5	270	39
Sagamu	16	24	15.0	144	21
Total	90	132	122.3	686	100

Table 3. Residential settlements affected by flooding, April-November 2023
Source: authors' fieldwork (2023).

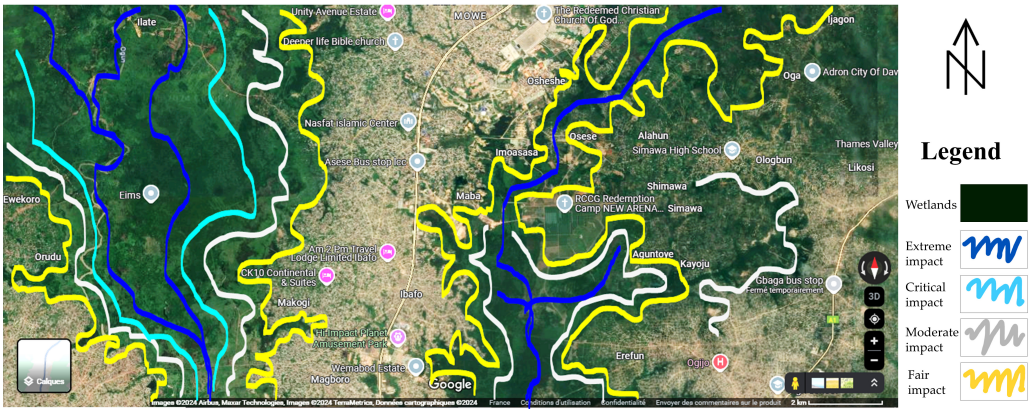


Figure 10. Area susceptible to flooding
Source: edited from Google Maps (2024).

The dark-blue lines in Figure 10 show the main waterways, which have a direct and extreme impact on communities, whereas the light-blue lines show the floodplains with critical impact, the grey lines show the areas with moderate impact, and the yellow lines show the areas with fair impact, close to human activities (farm settlements), markets, community squares, recreation areas, and residences (as well as residential streets). Table 3 demonstrates that a total of 90 houses and 132 families – comprising approximately 686 individuals aged 1-95, including pregnant women – were displaced during the flood in an area of approximately 122.3 km². Properties valued at millions of dollars were severely damaged. Building resettlement houses and camps for internally displaced people has been made possible by government agencies, nongovernmental organizations (NGOs), and citizens. The numerous agricultural settlements and fishing ponds located along the wetlands suffered significant damage, while the impact on the residential towns was much lower. Table 4 therefore highlights the 34 agricultural settlements and villages visited during the study.

Local Government Area	Farm settlements affected	Area (km²) (approx.)	Percentage (%) of the area
Ado-Odo/Ota	7	350.5	14
Ewekoro	8	580.5	25
Ifo	3	470.0	20
Obafemi Owode	12	650.0	28
Sagamu	4	320.5	13
Total	34	2,371.5	100

Table 4. Areas and farm settlements affected by floods and extreme weather conditions (April-November 2023)

Source: authors' fieldwork (2023).

Table 4 reveals that the villages in the Obafemi Owode LGA, which has an estimated area of 650 km², were the most severely affected by the flood. These villages are followed by the ones in Ewekoro (580.5 km²), Ifo (470 km²), Ado-Odo/Ota (350.5 km²), and Sagamu (320.5 km²), which was least affected. Considering all five LGAs, the total area impacted – mostly made up of farming communities, fishing zones, and villages – was approximately 2,371.5 km².

Figure 11 shows the study area of approximately 10 km x 5 km, with red dots representing the areas extremely impacted by floods and in which the highest number of people was displaced and yellow dots indicating a critical impact and not too many people displaced, although the volume of rainfall and water retention in those areas was alarming, leading the migration of wild reptiles into the streets. The dark-blue dots show floodplains with moderate impact and very few people displaced from their homes, with no visible damages having been observed during the on-site assessment, although some people might have suffered severe losses after the downpours. Finally, the light-blue dots represent the area with fair impact and no recorded damages as of the moment when visits took place, and the grey dots show the spots with the lowest level of impact, which maintain their natural scenery and lush landscapes without degradation.

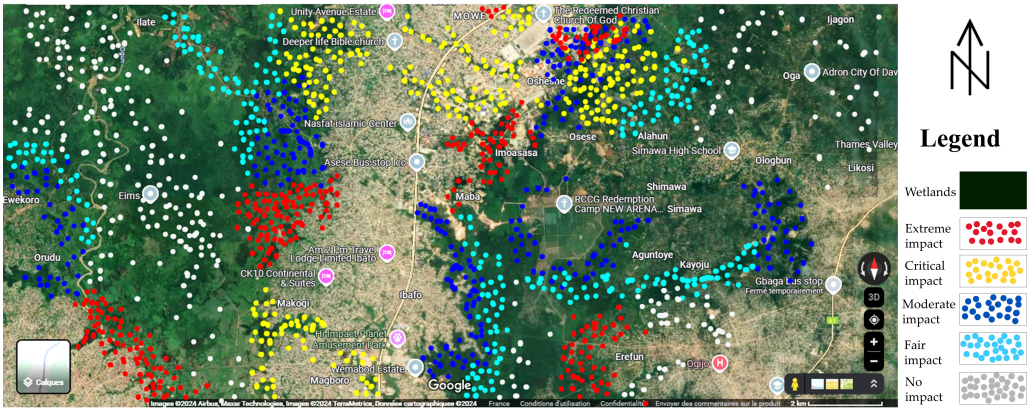


Figure 11. Level of human displacement and environmental impacts caused by devastating floods

Source: edited from Google Maps, 2024.

4. Recommendations

This study has demonstrated the necessity of implementing a new city plan, urban design, sustainable landscape design, an infrastructure master plan for the green corridor, and urban management to reduce both the risks associated with floods and the environmental effects of climate change, mainly in the Lagos-Ogun DPAs. Therefore, it is imperative that by 2030 local planning authorities introduce rigorous regulations regarding urban growth and landscape management to minimize the global threat of climate change and reduce the ongoing risk of flooding in towns located in floodplains. DPA communities can significantly minimize the consequences of flooding and land degradation brought on by climate change and other human activities by taking into account the flood prevention strategies presented in the sequence, which may be a real asset. Cultivating trees along riparian/buffer zones and habitats will help protect waterways, a regeneration effort that is really necessary, since trees absorb rainwater and can help slow down flooding when rivers overflow. It is important to highlight that urbanization cannot be stopped, especially in and around Lagos metropolises, where destruction takes place in order to make room for urbanization and sometimes farming activities, which constantly affect the richness of the wetlands and the ecological zones of peri-urban areas. Regenerating downstream regions, stopping continuous runoffs and wetland loss, and repairing ruined marshes might all significantly reduce the effects of rising temperatures and reoccurring floods.

4.1. Improving drainage and building dikes and levees

Building dikes makes it easier for greater amounts of water to flow, particularly in established waterways, during flash floods, so the drainage systems in these locations must be improved and sometimes restored. Geological features

and swamps naturally transport debris in water during periods of high precipitation and when extreme weather events take place; therefore, rehabilitating and cleaning water drainage systems, such as desilting trenches, canals, and subterranean water channels, building sailing routes (water transportation network), and substantial debris and trash removal from waterways can enhance drain efficiency. Drainage network systems that are both sustainable and effective guarantee that floodwater runoff reaches a clean stream, lake, or lagoon. Retaining walls and ridges can also prevent water surges and excess runoffs by directing water to manmade water channels that stop discharges from flooded areas, barriers and ridges limit streams during natural catastrophes.

4.2. Building canals and urban infrastructure

Manmade waterways, or canals, are essential for preventing flooding, providing linear reservoirs and water locks, which help regulate the amount of water that flows through them. The water that overflows is sent through canals to areas downstream that are not at risk or to other places where there is a strong need for water, including semiarid and desert regions. Additionally, to stop floods and store water for later use, canals can be built to confine surplus floodwater in linear reservoirs. Particularly in floodplains, houses in riverine communities should be built using conventional construction techniques and procedures to maintain a proper building height off the ground. It is recommended to plant trees in the surrounding area, three to five meters away from the foundations.

4.3. Long-term preventive and protective measures

Appropriate landscape design, urban planning and management, and biodiversity conservation of the wetlands mean limiting where construction can take place when granting development and building permits, as well as controlling the layout of areas at risk by means of environmental laws and development policies requiring a methodical and periodic assessment of possible natural hazards. These preventive and protective measures will consist of the following: strong policies regarding the preservation of wetlands and the reclaiming of lands; guidelines prohibiting the development of buildings near waterways and unauthorized access to flood risk areas; and a commitment to regenerate and maintain biological diversity as well as to manage mountainous areas and water bodies.

Final considerations

Flood risks within the study area are mostly caused by human activities on wetland encroachments and degradation brought on by the rapid development of DPAs (owing to urban migration from both island and mainland populations

in Lagos to these suburbs and peri-urban areas). To effectively mitigate climate-related risks and natural catastrophes like floods, it is critical to enhance landscape resilience and adaptability, not only in Lagos-Ogun but throughout Nigeria. Landscape professionals, engineers, urbanists, and environmental experts must act urgently to re-plan and revitalize waterways, because it may take years to alleviate the suffering of flood victims without the assistance of these experts. There must be a system in place for managing urban landscaping and the risks associated with floods, such as green infrastructure strategies, sustainable landscape planning, and urban management, which have to be implemented immediately to mitigate the effects of flooding and reduce the environmental damage it causes. Developing urban strategies and built-environment regulations to reduce climate change – a worldwide threat – by 2030 and strictly adhering to them would be a major step for authorities in their attempt to counteract the global phenomenon. Nature around areas that have faced floods has to be restored, which would benefit both humans and the physical environment. Establishing villages and agricultural settlements that are flood-resistant requires modern concepts regarding regreening, landscaping, and environmentally conscious innovations.

It is best to restrict industrialization and commercial activities near wetlands in peri-urban areas that are currently being developed by private real estate developers drawn by the low cost of property acquisition in swamps. Restoration of wetlands serves the extremely useful purpose of shielding terrestrial ecosystems from flooding in the current context of sea level rise continuously brought on by climate change. To broaden the local economy, the study suggests using the wetlands as an ecotourism destination. A local framework that would preserve our marshes and save locals from looming environmental calamities is desperately needed; and before any physical development occurs in districts in both Lagos and Ogun States, planning authorities and development control enforcement units have to guarantee an Environmental Impact Assessment (EIA) concerning the location and project, to guarantee that crucial elements such as drainage system, road height, and setbacks between buildings and bodies of water are taken into account. To stop buildings from being built in flood-prone locations, adequate planning and strong regulations should be implemented and strictly followed. Moreover, an urban green infrastructure (UGI) master plan and biodiversity conservation strategies must be proposed as means of incorporating climate change mitigation measures into national planning strategies and policies. To retain water and ensure appropriate outflow across flood-prone regions and lowland areas, UGI designs have to take into account afforestation and wetland restoration at buffer and riparian zones. With a view to maintaining a well-drained ecosystem free of runoff water following

any rain, it is important to have good sustainable drainage systems (SuDS) and waterway networks built to guarantee that trash, debris, and waste are carefully transported to deposit locations. New urban strategies for managing floods, pollution, and environmental concerns must include SuDS, mimicking drainage mechanisms by controlling the outside discharge of water sources. Through this careful environmental design, these drainage structures and the interconnectivity of rural and urban road infrastructure may help minimize the underlying causes and effects of floods. It helps to eliminate impurities from wastewater coming from cities and to integrate water (runoff) conservation with wetlands management so as to further conserve biodiversity. In addition, it contributes to the preservation of the organic flow and circulation patterns of rivers and streams, while improving both well-being in the city and the comfort of dwellers as well as connecting people to a more sustainable environment.

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Submitted: August 1, 2024.
Approved: February 20, 2025.

Editors: Maria Encarnação Beltrão Sposito and Everaldo Santos Melazzo.

How to cite: ADESINA, J. A.; UDUMA-OLUGU, N.; TANG, X. Impact assessment of encroachments along peri-urban areas, ecological zones, and floodplains in selected wetlands and waterways in Southwest Nigeria. *Revista brasileira de estudos urbanos e regionais*. V. 27, E202541, 2025. DOI: http://doi.org/10.22296/2317-1529.rbeur.202541.