



Charting a Resilient Future: Climate Change as a Catalyst for Sustainable National Development
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SMART FLOATING HOUSING FOR FLOOD RESILIENT BUILDING DESIGN IN OGUTA, IMO STATE, NIGERIA

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Abstract

The practice of moving to or having settlement on elevated highland in flood-prone areas above sea level is as old as human civilisation. Floating, hydrostatic architecture and buildings in riverine areas have long been practised even in Makoko, Ijora, Ekpe lagoon communities in Lagos, Nigeria. Floating decks called pontoon services are used in riverine areas of Oguta II and places such as Oguta lake to cross cargo, people and as a means of mass transportation in these and other areas of Nigeria. This paper explores the innovative concept of incorporating smart floating foundations and decks as a promising technological solution for constructing flood-resilient buildings and facilities. By incorporating advanced smart technologies with hydraulic engineering principles, these foundations can adapt to fluctuating water levels, reduce the risk of structural damage and ensure the safety of occupants. Through literature review and relevant case studies, the paper delved into the causes of flood, increased impact of climate change, engineering design considerations for flood resilient buildings, and employable up scaling technological advancements. It found that potential benefits of smart floating foundations can reduce and solve flooding problems of ravaging climate change in perennially flooded areas of Oguta and indeed Nigeria. It thus concludes that this research not only reinforces the age-long practice of community flood problem response but provides valuable insights for the society, students, architects, engineers, and policymakers to tackle contemporary climate change flooding challenges in riverine areas.

Keywords: Community response, Flooding, Hydraulic engineering, Smart building

INTRODUCTION

Ground rainwater collects into water basins that discharge into streams, rivers, lakes, and possibly oceans. When the land surface cannot absorb water due to impervious or hard surfaces, run-off over a long distance with increasing speed occurs. But when the runoff cannot discharge, naturally most of the water due to insufficient water basin depth, poor soil filtration, blocked natural flood water ways or runoff exceeding the carrying capacity of the water basin then the function of the basin as a receptacle is compromised leading to major flooding that wreaks havoc on the affected hinterland. Furthermore, other factors that encourage flooding are; shape and depth of flood basins, soil nature, ocean tide, deforestation, indiscriminate urbanisation process, compromised land use cover due to destruction of vegetation, integrated ground flood

water flow in disjointed fragmented water bodies and hydrographic status of the river basin, (Figures 1 and 2).

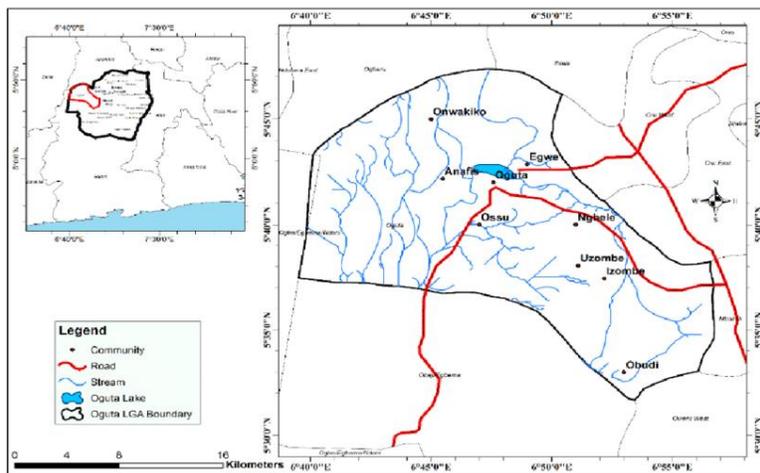


Figure 1: Map of Oguta showing fragmented water bodies in Oguta
 Source: (Osuagwu, 2023)

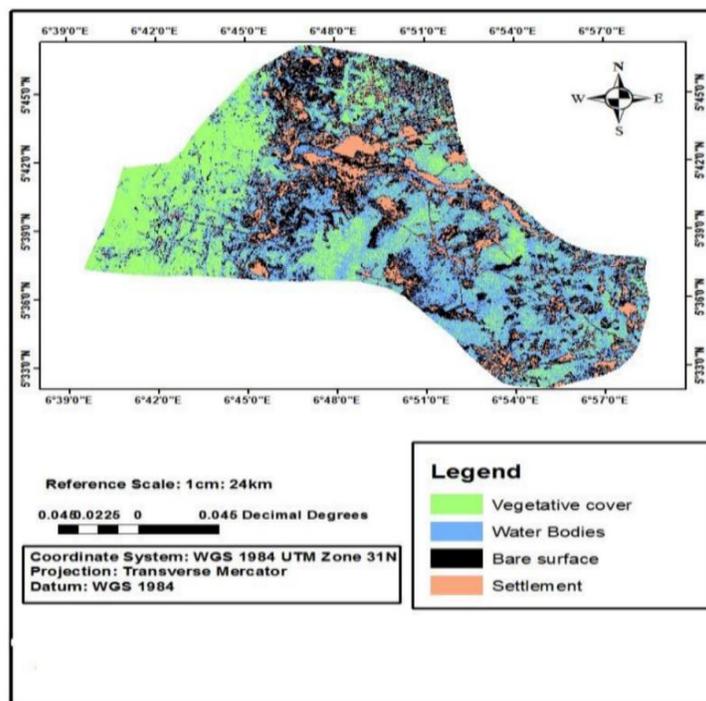


Figure 2: 1986 Land Use Land Cover (LULC) map of Oguta
 Source: (Umunakwe, Alozie, & Eneogwe, 2018)

Flooding is a growing global concern due to ravaging negative effects of climate change, urbanisation, deforestation, reduced water run-off filtration and other related environmental factors. Due to the complexity of the problem, traditional building practices which used to be effective often fall short in addressing the challenges posed by ravaging climate change-induced flooding, leading to significant economic losses and displacement of communities. Smart floating foundations solutions therefore offer a potential solution by monitoring and enabling buildings to rise and fall with water levels, minimising the negative impact of flood. Factors contributing to flooding in Oguta include; rainfall intensity, proximity to rivers with compromised wetland, drainage density, and land use, (Plate 1). Geographic information service (GIS) analysis revealed that regions near rivers with poor drainage systems were the most flood-prone, while built-up areas and water bodies with inadequate receptacles or basins showed the highest susceptibility to flooding, (Nmecha, Osumune, Adedokun, Asinobi, Esomonu and Njionye, 2024, youtube, 2025).



Plate 1: Flooding situation of communities in Oguta, 2022

Source: (theeasternupdates.com, 2022)

Problem Statement

Elevation is a key factor in flood risk management, with the Oguta study area categorised into seven (7) elevation classes as 0-1.1, 1.2-2.2, 2.3-3.4, 3.5-5, 5.7-7.1, 7.2-11 and 12-24 (Figures:1- 4) (Nmecha, 2025). The largest portion of the area falls within the lowest elevation class of 0-1.1, 1.2-2.2 and 2.3-3.4, which faces a very high flood vulnerability due to increased likelihood of inundation, whereas higher elevations have a lower flood risk, hence less destruction and losses. The land slope significantly affects flood susceptibility, as it influences the speed and volume of surface water, level and height of the flood water. The average water level in Oguta, varies between 2.7 meters during the dry season and 3.0 meters at the peak of the rainy season, (Nmecha,2025, Akadne & Adesina, 2020). This means that the minimum elevation for survival during flood should be three (3m) metres and this is significant for architecture and housing elevations. Oguta Lake, a natural freshwater lake, experiences a maximum depth of 8.0 meters and a mean depth of 5.5 meters, which seems not to cope with the increasing surface run off of flooding induced surface water leading to the observed devastation of flood in the recent past, (Plate 1). This therefore is the main concern of this paper as the problem seems to be increasing due to rapid urbanization and development.

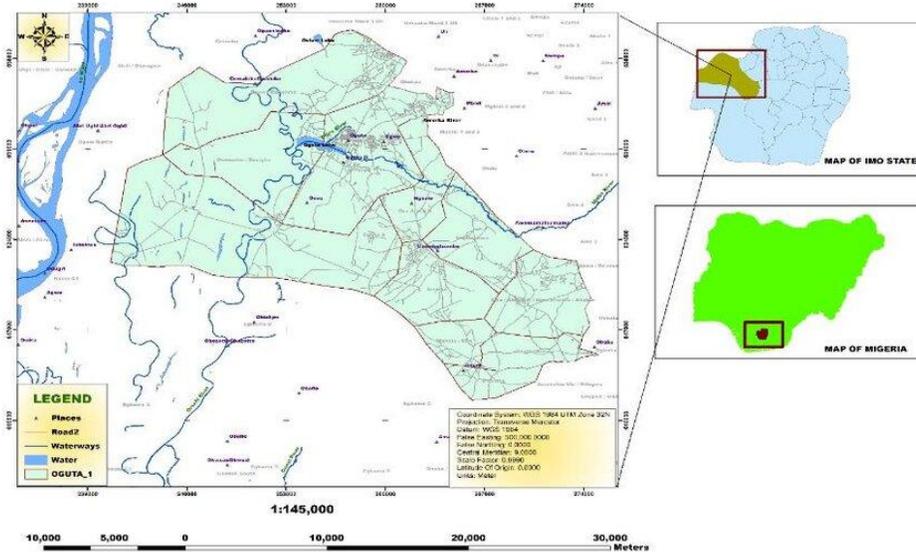


Figure 3: Topographic map of Oguta
 Source: (Nmecha et al, 2024)

Uncontrolled water and land area surface use in Oguta is therefore a problem. Oguta LGA, the study area, is within the vast Niger Delta Basin. The areas normally flooded include Oguta town, Osemoto, Nkwesi, Calabari Beach, and Eziorsu. Its geographical heart lies at approximately 6°40'N 7°04'E, placing it slightly north of the equator and a touch east of Greenwich. The land form tapestry is slightly woven with rolling hills, shimmering Oguta Lake, and a network of meandering rivers through most of Oguta Local Government Area, (LGA). The area spans roughly 506 square kilometres, offering a diverse landscape with increasing potential for mineral exploration, (Baywood, Alabi, Akande and Adesina, 2019). The intense mineral exploration is likely to increase the environmental burden of the problem of the area as it grapples with rapid urbanization, land cover degradation and deforestation.

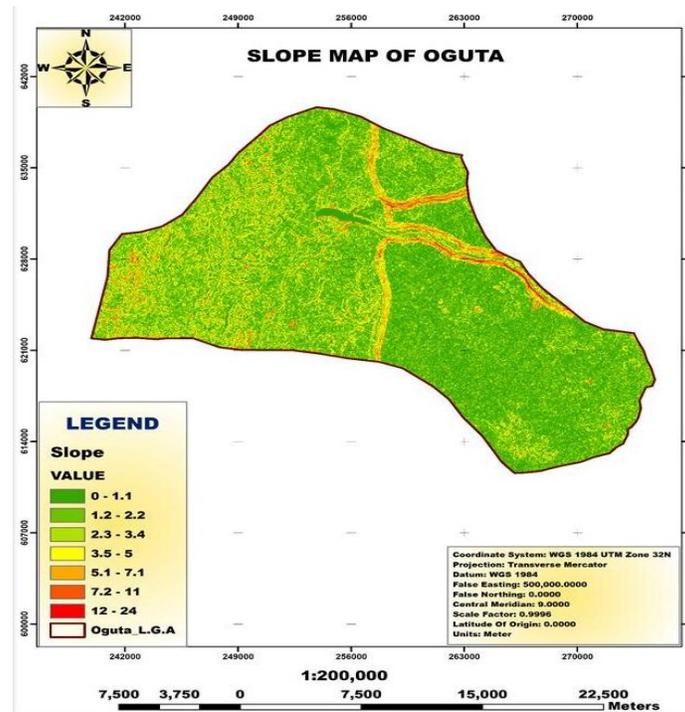


Figure 4: Slope map of Oguta area
 Source: (Nmecha et al, 2024)

Aim

To reinvent technologically through smart design the age-long practice of using higher or elevated grounds in riverine areas to reduce the negative effect of flooding.

Objectives

To identify some of the communities that suffer flooding in the study area

To identify the local community practices that helped them to survive flooding in the past

To identify and integrate relevant technology through smart design to reinforce existing the flood survival practices

Scope

The scope of the paper identified some of the communities that suffer perennial flooding in the study area and the age-long practices employed by them to reduce and survive the flooding experience. It identified the need for improved smart technology to be integrated into the local community practices to enhance the effectiveness of the community resilience in the face of increased flooding caused by climate change. The paper sought the introduction of sustainable practices for energy, small holder dams, irrigation in agriculture, drainage, waste materials with internet of things (IoT) in connected water sensor-sensitive engineering devices and facilities by harnessing the flood water in developing platform for housing estates and facilities, (Figure 5).

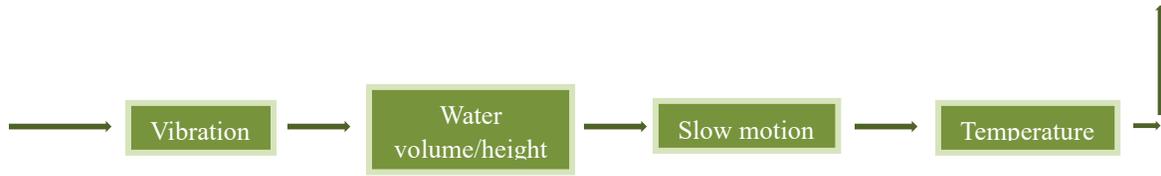


Figure 5: Flow chart of sensor deck
 Source: (Adapted from Researchgate.net, 2025)

There is also the need to have connected water basin of the scattered water bodies in the area to establish a coordinated water basin and receptacle flood water management, (Figure 6).



Figure 6: Major drainage basins (sub-watersheds) of the Oguta area
 Source: (Udoka, et al., 2016)

Theoretical Framework

Floating or hydraulic architecture, is based on the Archimedes scientific principle also known as the principle of buoyancy together with the law of floatation are all applicable in this paper. Archimedes principle states that an ‘object submerged in a fluid in this case water experiences an upward buoyant force equal to the weight of the fluid displaced by the object’. This as the result of upward force or thrust on the object (in this study houses or the housing decks), due to the pressure difference in the bottom and the top of the object. When the buoyant force is greater than the weight, the object floats and vice versa. The same principle applies, if the object density is more than the density of the fluid, (byjus.com, 2025). With this therefore, appropriate hydraulic platform with electrical engineering sensors can be developed for

individual building and or a cluster of houses on suitable engineering deck based on calibrated measures, weight and density to be used. The system is therefore could be calibrated and designed with appropriate sensors to automatically, digitally and electronically respond to critically designed warning soil vibrations and rising water levels as the result of flood water movements and levels, (Figure 7).

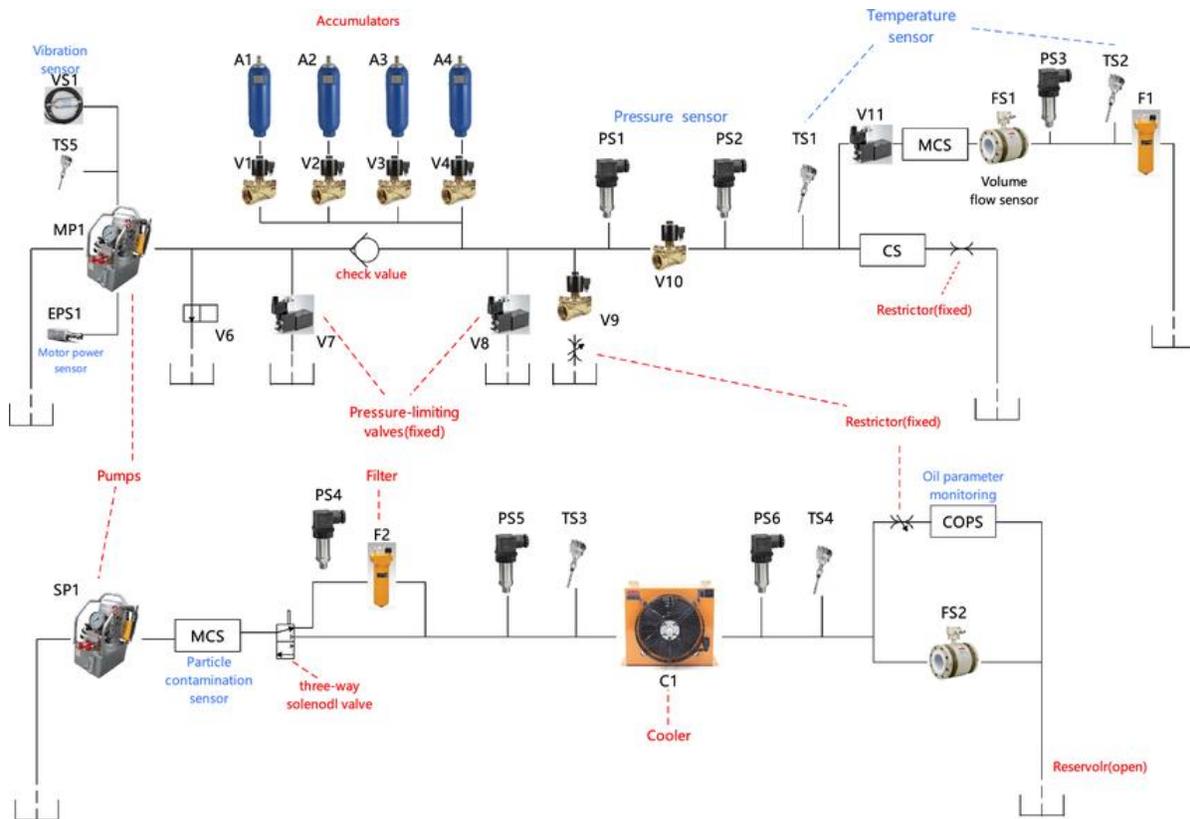


Figure 7: Hydraulic System Structure with electrical sensors under the float deck: a-working circuit b-cooling and filtration circuit.

Source: (Adapted from: researchgate, 2025)

LITERATURE REVIEW

Flood vulnerability map shows that Oguta is a highly developed low-lying part of Imo state, acutely vulnerable to flood threats. Human lives, ecosystem services, economic activities, housing, public facilities, and infrastructure are particularly at risk in this context. This could be attributed to the presence of fragmented river bodies in the study area. Other contributing factors are changing climate, urbanisation, dwindling volume and proportion of undisturbed forest cover due to deforestation and land development. Topographic features such as gentle slope and low elevation are also important issues under the foregoing situations. These characteristics have been identified elsewhere, Akinola, Suleiman and Akinluyi. (2015), who revealed that the proximity to water bodies, deforestation, and urbanisation are intimately linked to the

increase in vulnerability of Oguta to flooding. Lithology also can have a notable influence on flooding due to its impact on groundwater flow, land use cover, ground water infiltration rates, and surface runoff characteristics, (Figure 8 &9).

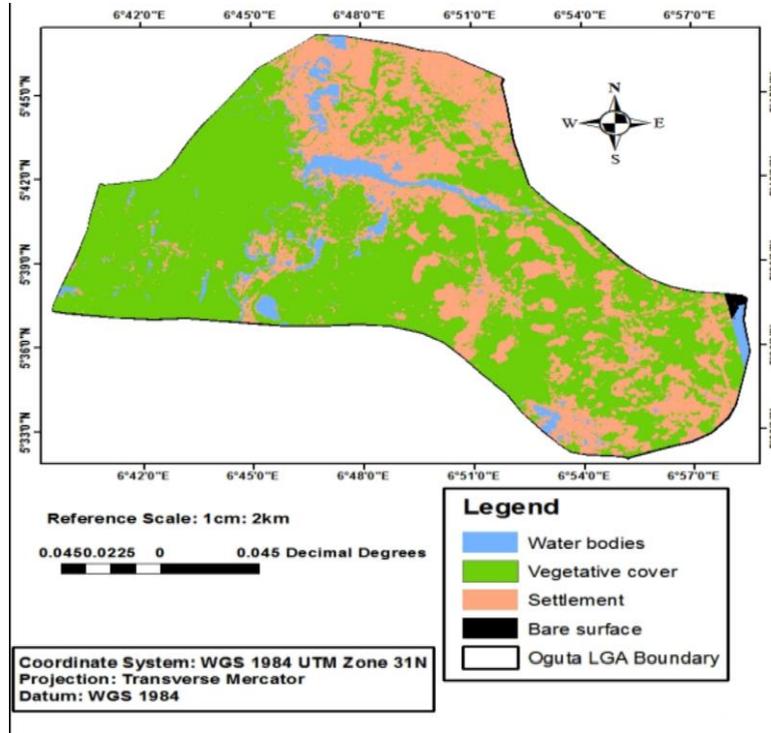


Figure 8: 2016 Land Use Land Cover (LULC) map of Oguta
 Source: (Umunakwe, Alozie, & Eneogwe, 2018)

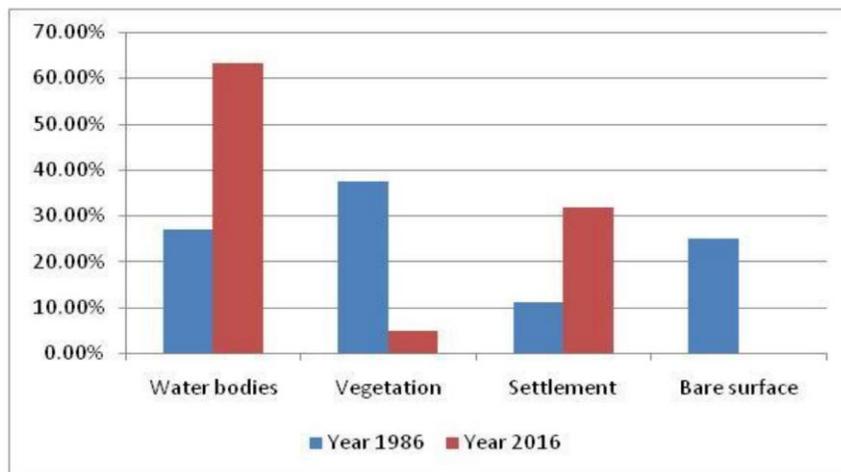


Figure 9: Graphical representation of 1986 and 2016 Land Use Land Cover (LULC) map of Oguta
 Source: (Umunakwe, Alozie, & Eneogwe, 2018)

The lithology of the area was classified into four major geological units which include: River alluvium, sands and clay, clays, sandstones, lignite and shales, and mangrove swamp. The lithology was extracted from the Nigeria Geological & Mineral Explorations survey map shows highly permeable lithologies such as sand and gravel allow water to infiltrate more easily, (Baywood, Alabi, Ejike and Iwuoha, 2024). The water surface area also changes, from 180 hectares in the dry season to 300 hectares during the rainy season, (google.com, 2025). But these have been compromised due indiscriminate land use and urbanization. Due to urbanization, change in Land use of 1.507kmsq occurred from 1985 to 2000 and 1.711kmsq from 2000 to 2015. This led to decrease in forest and vegetation cover from 2.997kmsq between 1985 and 2000 to 0.925 between 2000 to 2015,(Umunakwe,Alozie & Eneogwe,2018,Tales 1 &2). Bare land flood plain declined from about 1.494kmsq to 0.976kmsq from 1985-2000 to 2000 -2015 respectively. The effect of this in the face of climate change is therefore significant and understandable to explain the continuously ravaging flooding immediately after this period.

Table 1: Values of the 1986 Land Use Land Cover (LULC) map of Oguta

Objects	Land use	Count	Quantity in Km ²	Percentage
1	Water bodies	144129	130	26.80%
2	Vegetation	200773	181	37.32%
3	Settlement	58660	53	10.93%
4	Bare surface	134869	121	24.95%
Total		538431	485	100.00%

Source: (Umunakwe, Alozie, & Eneogwe, 2018)

Table 2: Values of the 2016 Land Use Land Cover (LULC) map of Oguta

Objects	Land use	Count	Quantity in KM ²	Percentage
1	Water bodies	339782.5	306	63.11%
2	Vegetation	26786.62	24	4.97%
3	Settlement	170835.2	154	31.73%
4	Bare surface	1026.77	1	0.19%
Total		538431	485	100.0%

Source: (Umunakwe, Alozie, & Eneogwe, 2018)

The above scenario is no doubt as the result of wetlands and surface cover destruction due to urbanisation. This exposure of soil is believed to be the reason for increasing negative flood impact on Oguta and its environs during peak rainfall season. There is also the contributing factor of inter-conversion of lake area to land and land to lake for urban development purposes including the proposed river port and the Naval base in Oguta. Accordingly, from 1985 to 2000 the 3.40% of the Lake remain unchanged, change occurred when 0.18% of the catchment area was converted to lake and 2.84% of Lake was converted to Land. 93.57% of the catchment area remained unchanged. From 2000 to 2015, 3.32% of lake remained unchanged, the change occurred when 0.35% of the catchment area was converted to lake and 0.72% of Lake was converted to Land. 95.61% of the catchment areas remained unchanged, (researchgate.net, 2024). Under these

conditions, the likely sinking of the Oguta area is also conspicuously inevitable. There is therefore the need for designed engineering dredging of the lake through Urash river into the river Niger and Atlantic Ocean to improve the entire water ecosystem and environmental management in Oguta area (researchgate.net, 2025).

Indeed, floating architecture platforms and houses are not new, not much has been done by intentionally and sustainably integrating a digital sensor-based engineering system especially in Nigeria. While Makoko, in Lagos Island presents a local example the angular floating house, in Amsterdam is a foreign example, (Plates 2-4, Zeiba, 2018, denzeen.com, 2021). Although the Lagos example is referred to as a slum, it presents an interesting and pragmatic inspiration for improvement and modernisation using appropriate digitally sensor-based technology that can exist side by side with improved traditional floating system.



Plate 2: Makoko Floating Estate buildings, Lagos Nigeria
Source: (bbc.com, 2020)



Plate 3: Makoko Floating school buildings, Lagos Nigeria
Source: (bbc.com, 2020)



Plate 4: Angular floating house, Amsterdam

Source: (Griffiths, 2021)

The modern digitised components are to use pneumatic systems, thermostatic systems, vibration and sensor systems set at critical temperature and water volume systems that are set to be activated to respond at critical levels. With appropriate buoyancy to support the building's weight, structural stability during both stationary and moving conditions, appropriate anchoring system to prevent the foundation from drifting, accessibility during flood conditions and incorporating energy-efficient systems for lighting, ventilation, and other essential functions such as landscaping, walkways, using both local light and resilient materials like bamboo, waste or recycled materials like used tyres, and waste containers as efficient cost effective housing programme for flood prone areas is possible. Another sustainable feature is solar and small dam hydroelectric energy from the rivers, dredging to get adequate water basin hydrometer smart houses that are possible.

Technological and digital systems that would include sensors to monitor water levels, structural integrity, environmental conditions, hydraulic systems to control the foundation's elevation stability, automation technologies for efficient operation, maintenance and renewable energy sources such as wind and small hydro dams to reduce reliance on public power grid system are possible.

As stated about Figure 7, under the deck the vibration, water volume and height, slow motion and temperature monitoring sensors activate the hydraulic system to lift the deck to safe level and move to a controlled safe distance as seen in the pontoon system being used in the area.

DISCUSSION

While the practice of physically moving to elevated land areas as a means of adjusting to flooding is as old as the inhabitants of flooding settlements, the construction of floating buildings and platforms have been in use in many places including Makoko in Lagos. Plates 2-3. The determination of foundation and damp-proof course level is to be at the level minimum of the water level taken over a period of time in the flood zones and areas which has been observed to be not less than three (3) metres, although this varies from place to place depending on the height above sea level. In this era of technology and artificial intelligence

what is needed is simply to tap into these practices and scale up the practice into sustainable and improved status, through sensor hydraulic technology adapted from floating deck such as the one improved from pontoon for estates and individual house types.

Traditional practices of using sand bars, small dams and drainages are other important measures used by the communities that can be up-scaled and used for small holder irrigation farms to reduce washing of the farmlands in the rainy season while for irrigation purposes in the dry season farming. These systems can be up-scaled with appropriate sensor engineering technology for better performance. The use of animal and bird migrations behaviours and of other living creatures with appropriate meteorological technologies as warning signs to alert habitants for proactive steps for activation of the flood mitigation systems to reduce the negative effects of flooding are also possible smart measures. These measures cannot be effective without adequate public education especially of youths in the flood prone areas.

Audio-visual public education and awareness are therefore important for constant warning and enlightenment of the members of the communities using local town criers, town hall rallies and meetings. Other benefits of proactive smart floating foundation technologies are; protecting buildings from flood damage, ensuring continued functionality, reducing repair costs and minimising business disruptions and losses, promoting sustainable building practices and minimise the negative impacts on the riverine ecosystems, thus enhancing the safety of occupants during flood events.

RECOMMENDATIONS AND CONCLUSION

The following measures can help upscale and harness climate change flood situations into viable developmental issues;

1. Nigeria Building Research Institute, (NIBRI) work on the integration of sensor electrical technology prototype for the development of houses and other designs on floating architecture.
2. Use of pilot scheme deck schemes in flooding areas to develop appropriate technologies to reduce the negative effects of flooding.
3. Policy development and incorporation of sensor hydraulic technology into building codes
4. Training of local technicians and engineers with stakeholders for full commercialisation and full mass production
5. Combination of both digital and physical elevation systems of building foundation and damp-proof course construction for floating architecture and landscape
6. There is the need for designed engineering dredging of Oguta lake into the Atlantic Ocean through the Urashi river for effective flood water management receptacle and basin
7. Continuous geotechnical monitoring of ground water, forest, land surface depletion, urbanization, aquifer depletion and sinking rate in and around Oguta.

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