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# Exploring Public Perceptions of Nature Based Solutions to Flood Risk Management In Lagos, Nigeria.

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**ABSTRACT**: Urban flood risks and vulnerability in coastal cities have been directly linked to unplanned urbanization and development solutions that isolate ecosystem peculiarity. Whereas, Sustainable Urban Drainage Systems (SUDS) as Nature-Based Solutions are capable of reducing the impact of urbanization on flooding. This study investigated public perceptions of Nature-Based Solutions to flood management in Lagos-State, Nigeria. Data for this study were obtained from primary and secondary sources. Using a multi-level approach, 339 respondents participated in the mailed survey randomly administered across the five (5) administrative divisions of Lagos-State and results were analyzed using tables and Chart. Ecosystem services connected with Nature-based Solutions (NbS) and design strategies for Sustainable Urban Drainage Systems (SUDS) were reviewed from secondary sources. Results obtained revealed a high level of awareness of the determinants of flood risks. Most of the respondents (73%) consider NbS applicable in Lagos State. Although, a larger percentage has a fair knowledge of NbS as a concept, when provided with specific examples, 68% indicated that they are familiar with the methods. The result further revealed that majority (85%) are strongly disposed to 'trees planting' as a SUD strategy. 71% will consider permeable pavements and rainwater harvesting while 61% are inclined to rain garden, 47% and 35% will consider green roof and wetlands respectively. Analysis of survey revealed that the greatest barrier to implementing SUDS is the lack of awareness of the value and multiple benefits of NBS. We conclude that there is a clear need for the design of the built environment of Lagos coastal city, particularly housing to integrate NbS and optimize its traditional function for improved urban flood resilience. Therefore, a consistent design approach and framework is required and thus calls for further studies. .

**KEYWORDS:** Community Stakeholders, Flood Risk Management, Nature-based Solutions, Sustainable Urban Drainage Systems.

## I. INTRODUCTION

Lagos State, Nigeria is one of the fastest growing urban coastal megacities in the world. Historically, human societies have been attracted to the coast and this has overtime led to coastal urbanization (Le Berre& Robert, S, 2017). Presently, industrial, residential and commercial developments have taken over the landscape of Lagos city disrupting coastal dynamics and affecting the natural ecosystems. Several activities have traditionally driven development in the coastal city of Lagos state, basically; port-based activities, rural-urban migration, attractive socio-economic prospects; and more importantly, the political and administrative status of the city as the former capital of the colony and protectorate of Nigeria since 1914 and the nation's capital following independence in 1960 until its replacement in 1991 by Abuja as the federal capital (Bigon, 2009). The growing urban population of the city has necessitated more development and building construction which usually involves extensive reclamation of wetland area and removal of trees, natural vegetation as well as the introduction of impermeable surfaces such as roofs, roads, parking lot and sidewalks. This reduces infiltration of water into the ground and accelerates run off to drainages and streams after moderate to intense precipitation; thus resulting to flash floods commonly experienced (Idowu& Home, 2015, Adelekan, 2016).

Floods are among the most expensive natural disasters (Munich Re 2014). Recurrent flood episodes in most part of Lagos city are harsh indication to the loss of wetlands and floodplain

forests (Aderogba, 2012a; Aderogba et al., 2012). Traditionally, wetlands are perceived as areas with limited development potential, hence the reclamation for beneficial human purposes. However, this view is grossly wrong and does not reflect the values and benefits associated with wetlands (Kumar &Kanaujia 2014). Despite covering only 1.5% of the Earth's surface, wetlands provide a disproportionately high 40% of global ecosystem services including, mitigating floods by controlling the rate of runoff in urban areas. In practice, they represent almost perfect nature-based solutions for flood risk mitigation and adaptation (Haase, 2017) and provide efficient spaces to naturally retain water in times of high rainfall and long periods of precipitation. This function only changes when wetlands are made object of artificial embankment and river regulation; thus, allowing water to easily migrate into surrounding spaces creating loss of life, property and assets (Scheuer et al. 2012).

From studies, about 60 percent of Lagos metropolis was originally natural wetlands (Asangwe, 2006). Between 1990 and 2000, forested and non- forested wetlands reduced by over 70% and 12% respectively with an exponential growth in built-up area from 3.12 to 62.62 (Sq.km) (Idiege, et. al. 2018). Survey from a recent study on exploring the processes leading to flooding in wetlands of Lagos state revealed that floods as an end state may occur from different initial states and in different ways, based upon dynamic interaction in the environment; more specifically, through natural and anthropogenic influences (Ajijola, et. al, 2020). The same study showed a low level of awareness of the impact of physical geography (topography, vegetation and soil nature) as important determinants of flood risks in coastal cities. In reality, the physical geography and characteristics of Lagos State coupled with the unique tropical climate makes Lagos susceptible to various types of floods (Oteri&Ayeni, 2016); whereas the design of the built environment of the city was done with little or no consideration for ecosystem peculiarity. The traditional approach to managing surface runoffs and flood risk within most part of the city has been with open channels and drains which are designed to discharge rainwater into rivers. Yet, most of these channels are blocked, poorly maintained or inadequate and no longer able to keep pace with on-going urbanization (Nkwunonwo et al., 2016). A clue from urban flood risk management in developed countries suggests that the world has moved mostly towards nature-based solutions (Rushton, 2001; Bliss et al., 2009; Stovm, 2010, Mbajiorgu, 2019) aimed at reducing storm water runoff as close as possible to the source (Sieker, 1998; Van der Sterren et al., 2009).

As Lagos City continues to experience rapid population growth and corresponding increase in the built up area coupled with the possibility of more precipitation associated with future climate change variability, there will be river saturation, rise in sea level and more floods; water may become part of our urban living. These thought presents an exciting opportunity for urban designers and architects to begin to reminisce on strategies and solutions inspired by nature and ecosystem peculiarity to manage flood risks. The study builds on evidences from empirical studies and existing literature on the multiple environmental and social co-benefits of Nature-Based Solutions (NbS) in addressing complex societal challenges from climate change and urbanization in a sustainable way. However, implementing NbS comes with numerous obstacles, particularly due to insufficient awareness of the benefits of such measures. Therefore, this study is aimed at investigating public perception on the application of nature-based solutions to flood risks mitigation and adaptation in Lagos State to improve community awareness on nature-based solutions and ensure environmental justice.

To achieve the goal set out in this research, the specific objectives are;

1. To appraise public understandings of flood risk determinants and the applicability of NbS to Lagos State urban flood risk management.
2. To explore ecosystem services connected with Nature-based Solutions (NbS) and design strategies for Sustainable Urban Drainage Systems (SUDS).

### 1.1 Description Of The Lagos Metropolis Of Nigeria

Lagos metropolis is a densely populated coastal city located in the south-western part of Nigeria between longitudes 2° 42/ E and 4° 21/E and latitudes 6° 22/N and 6° 41/N (Odunuga et al. 2012) and occupies a total land area of 3577.28 km2, the population density is approximately 5926 persons per Km2 (Oshodi 2013). The city lies in the tropical rainforest zone and it is characterized by a low-lying terrain of about 4 % slope, elevation of 0–2 m above sea level (BRNCC 2012) and several inland waterways including mangrove swamps, freshwater swamps, lagoons and creeks. The city serves as a major hub for transportation, tourism, and economic activities in Nigeria; and accounts for about 32 % of the national Gross Domestic Product of Nigeria (GDP) with an average internally generated revenue (IGR) of 398 billion naira (Premium times, 2019). With a current metro area

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population of over 14 million and a growth rate of 3.34 % from 2019 (MacroTrends, 2020), 70 % of her population live in unplanned settlements such as slums (Adelekan 2010), it ranks 15th in the world in terms of population exposed to coastal flooding (Sojobi et al., 2015). This is not surprising as only 45.2 % of its built-up areas are connected with drains and less than 30 % of existing drains are maintained (Aderogba 2012a).

## II. LITERATURE REVIEW

### 2.1 Application Of Nature-Based Solutions To Urban Flood Management

Diverse concepts have evolved over the years as a way to show the significance and benefits of nature and its functions in urban areas; amongst them are ecosystem services (ES), biophilic urbanism (BU), urban forests (UF), urban green spaces (UGS), green infrastructure (GI) and, more recently, nature-based solutions (NbS) (Ferreira et al., 2020; Xue, et al., 2019; Pauleit et.al., 2018; Lafortezza et al., 2018; Escobedo et al., 2019). While ES are often valued in terms of immediate benefits to human well-being and economy, BU, UF, UGS, and GI focus on the provision of these ES through biodiversity protection, NbS simultaneously addresses diverse societal challenges in the long-term, allowing benefits to people and the environment itself (Ferreira et al., 2020).

Nature-based Solution (NbS), as used in environmental sciences and nature conservation contexts is an effective framework to adapt to and mitigate ongoing degradation of natural resources and climate change effects, while improving sustainable livelihoods and protecting natural ecosystems and biodiversity. They are solutions inspired by, supported by, or copied from nature to address complex societal challenges and combines technical, business, finance, governance, regulatory, and social innovation (Kabisch et al., 2017; Raymond et al., 2017). These solutions bring benefits to people and nature itself, and are sustainable and responsive to environmental change and hazards in the long-term. NbS present more efficient and cost-effective solutions than more traditional technical approaches (Kabisch et al., 2017).

Currently, there are several empirical evidences to the effectiveness of NbS in stormwater and flood risk management (MacKinnon. et.al, 2019). They have proved to be beneficial in improving human health and social wellbeing (Venkataramanan et al., 2019) and climate adaptation (Barton and Grant 2006; Hartig et al. 2014). The multifunctional capacity and supplementary benefits of NbS is perceived as a way to solve the ongoing debate between the interests (and continuing growth) of the economy and the environment.

Embedded in the NbS concept are Ecosystem-Based Adaptation (EBA) and Sustainable Urban Drainage Systems (SUDS) (Kabisch et al. 2017). Ecosystem-Based Adaptation (EbA) is defined as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change" (CBD 2009:41). EbA approaches include community-based adaptation; eco-system based disaster risk reduction; climate-smart agriculture; and green infrastructures, and often place emphasis on using participatory and inclusive processes and community/stakeholder engagement (Wikipedia, 2020). EbA is promoted by the United Nation Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) (Seddon et al 2016).

On the other hand, SUDS is often used interchangeably with approaches such as Low Impact Development (LID) or green infrastructure (GI); they represent a collection of water management practices that aim to align modern drainage systems with natural water processes (CIRIA SuDS Manual, 2015) and sustainably drain surface water, while minimizing pollution and managing the impact on water quality of local water bodies. SUDS as a promising NbS mimics nature and typically manage rainfall close to where it falls by utilizing a mix of natural processes and green/grey components to harvest, infiltrate, slow, store, convey and treat runoff onsite (Srishantha&Rathnayake, 2017). These solutions range from hydraulic models for the planning phase to solutions for local retention of rainwater such as subsurface infiltration beds, green roofs and permeable paving, to drainage solutions such as separate sewers for rainwater and sewage water as well as local rainwater treatment (see table 1 below). It is promoted by the US Environmental Protection Agency as a concept for sustainable stormwater management (Fletcher et al. 2014).

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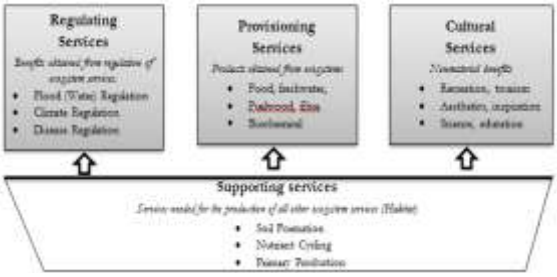


**Figure 1: Source: Ecosystem services connected with NBS**

Source: Millennium Ecosystem Assessment, 2005

**Table 1**

**DESIGN STRATEGIES FOR SUSTAINABLE URBAN DRAINAGE SYSTEMS (SUDS)**

| STRATEGIES | METHOD | BENEFIT category |
|---|---|---|
| **1. BUILDING SYSTEMS** | | |
| **Rainwater harvesting systems**  Source: www.istockphoto.com (2020) | Collect and store rainwater from roofs and other paved surfaces (such as car parks) for re-use | • Carbon reduction and Sequestration<br>• Climate change adaptation<br>• Flood risk reduction<br>• Water security/ Resource Conservation |
| **Permeable pavements**  **Source:** archiproducts.com (2020) | Act as a hard surface for walking or driving, while enabling rainwater to infiltrate to the soil or underground storage | |
| **2. VEGETATION** | | |
| **Green roofs**  | Involve constructing a soil layer on a roof to create a living surface that reduces surface runoff | • Air quality and pollution control<br>• Air and building Temperature<br>• Carbon reduction and Sequestration<br>• Flood risk reduction<br>• Groundwater and soil |

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| | | |
|---|---|---|
| Source: www.facilitiesnet.com (2019) | | moisture recharge<br>• Health and well-being<br>• Community cohesion and education opportunities |
| **Trees**<br>  <br>Source: www.externalworkindex.co.uk (2020) | Capture rainwater while also providing evapotranspiration, biodiversity and shade | |

**3. BIO RETENTION SYSTEMS**

| | | |
|---|---|---|
| **Rain Gardens**<br>  <br>Source: www.urbangreenup.eu (2020) | Collect runoff in a temporary surface pond before it filters through vegetation and underlying soils | • Biodiversity and ecology<br>• Climate change adaptation<br>• Community cohesion and crime reduction<br>• Education opportunities<br>• Flood risk reduction<br>• Groundwater and soil moisture recharge<br>• Health and well-being<br>• Recreation<br>• Sewerage systems and sewage treatment<br>• Water quality |
| **Swales, detention basins and retention ponds**<br>  <br>Source: www.urbangreenup.eu (2020) | Slow the flow of water, store and treat runoff while draining it through the site and encouraging biodiversity.<br>Also, Promotes infiltration as an effective means of controlling runoff and supporting groundwater recharge | |

## III. METHODOLOGY

The study takes a multi-level approach in which a well-structured close-ended questionnaire was developed and administered randomly via mailed survey to community stakeholder's (building users, owners and professionals) across the five (5) administrative divisions of Lagos state (Ikeja, Badagry, Ikorodu, Lagos and Epe) in order to evaluate public perception of nature-based solutions. The questionnaire contained information on the socio-economic characteristics of respondents (Type of stakeholders and highest level of education); Flood determinants and public understanding of NbS and SUDS strategies; Acceptance, Practice and Challenges with SUDS use in Lagos State, Nigeria. 339 responses were received and results of the quantitative data are analyzed using tables and chart as descriptive statistics.

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## IV. RESULTS

### 4.1 SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

Analysis of the survey indicate that most of the respondents are built environment professionals as 55% of respondents are Urban planners and Architects while 27.5% are Constructionprofessionals. Building users, Community leaders and building owners represent 10%, 5% and 2.5% respectively. On the highset level of education attained, table 2 above indicate that 70% of the respondents attained a doctoral or master's degree (PhD/MSc), 25% had a bachelors or higher national degree education (BSc/HND), none of the respondents are with only ordinary national diploma (OND) or high school degree (SSCE) and 5% indicated that they have received other form of educational training not listed.

Data collected on the socio-economic characteristics of respondents are presented in Figure 2. andTable 2. respectively.

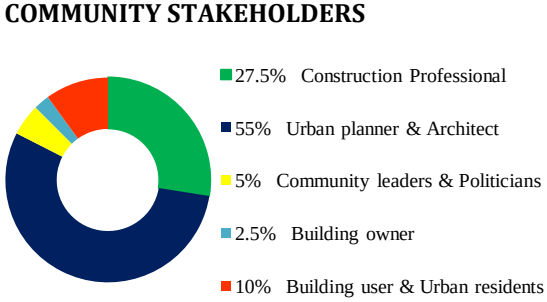


**Figure 2: Sampled stakeholder**

Source: Author's Field Survey (2020)

**Table 2:** SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

| **Administrative divisions** | **STAKEHOLDERS** | **Freq.** | **Questionnaire Administered** | **LEVEL OF EDUCATION** | **Freq.** |
|---|---|---|---|---|---|
| IKEJA | Construction professional | 48 | **176** | PhD/MSc | 123 |
| | Architect &Urban planner | 97 | | BSc/HND | 44 |
| | Community leader & Politician | 9 | | OND/SSCE | 0 |
| | Building owner | 4 | | Others | 9 |
| | Building user & Urban residents | 18 | | **TOTAL** | **176** |
| BADAGRY | Construction professional | 7 | **24** | PhD/MSc | 17 |
| | Architect &Urban planner | 13 | | BSc/HND | 6 |
| | Community leader & Politician | 1 | | OND/SSCE | 0 |
| | Building owner | 1 | | Others | 1 |
| | Building user & Urban residents | 2 | | **TOTAL** | **24** |
| IKORODU | Construction professional | 17 | **63** | PhD/MSc | 44 |
| | Architect &Urban planner | 35 | | BSc/HND | 16 |
| | Community leader & Politician | 3 | | OND/SSCE | 0 |
| | Building owner | 2 | | Others | 3 |
| | Building user & Urban residents | 6 | | **TOTAL** | **63** |

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| | | | | | |
|---|---|---|---|---|---|
| LAGOS | Construction professional | 15 | **56** | PhD/MSc | 39 |
| | Architect &Urban planner | 31 | | BSc/HND | 14 |
| | Community leader & Politician | 3 | | OND/SSCE | 0 |
| | Building owner | 1 | | Others | 3 |
| | Building user & Urban residents | 6 | | **TOTAL** | **56** |
| EPE | Construction professional | 5 | **20** | PhD/MSc | 14 |
| | Architect &Urban planner | 11 | | BSc/HND | 5 |
| | Community leader & Politician | 1 | | OND/SSCE | 0 |
| | Building owner | 1 | | Others | 1 |
| | Building user & Urban residents | 2 | | **TOTAL** | **20** |
| **Total Number of Questionnaire Administered** | | **339** | | | |

**Source: Author's Field Survey (2020)**

### 4.2 DETERMINANTS OF FLOOD RISKS, KNOWLEGE AND APPLICABILITY OF NATURE-BASED SOLUTIONS (NBS)

**Table 3:**FLOOD DETERMINANTS AND PUBLIC PERCEPTION OF NBS, SUDS AND ASSOCIATED ISSUES

| | **FLOOD DETERMINANTS** | | | | | | | | | | **PUBLIC PRCEPTION** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **ANTHROPOGENIC INFLUENCES** | | | | | **PHYSICAL GEOGRAPHY** | | | | | **KNOWLEDGE OF NATURE-BASED SOLUTION** | | | | | **APPLICABILITY OF NBS TO LAGOS FLOOD RISK MGT** | | **NBS STRATEGIES**Sustainable Urban Draiage System Green | |
| GRADE | Strongly agree | Agree | Maybe | Disagree | Strongly disagree | Strongly agree | Agree | Maybe | Disagree | Strongly | V. Great extent | Great extent | Fair knowledge | Low extent | V. Low | Yes | No | Yes | No |
| FREQ. | 184 | 120 | 18 | 17 | 0 | 168 | 128 | 27 | 11 | 5 | 40 | 64 | 105 | 82 | 48 | 248 | 91 | 232 | 107 |
| PER. (%) | 54 | 35 | 6 | 5 | 0 | 50 | 38 | 8 | 3 | 1 | 12 | 19 | 31 | 24 | 14 | 73 | 27 | 68 | 32 |

**Source: Author's Field Survey (2020)**

Table 3 represents an analysis of respondent's perception of the influence of human activities and physical geography on flood risks in Lagos State. It also shows public understanding of NbS and the applicability of SUDS in Lagos urban flood risk management. Results indicate a high level of awareness as over 89% and 88% of the respondents agree that anthropogenic and natural factors are strong determinants of flood risks respectively. Also, most of them (73%) consider NbS applicable in Lagos State flood risk management. However, a larger percentage of the respondents have a fair knowledge of NbS as a concept. Although, when provided with specific examples of NbS approaches (SUDS, GI or LID),

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68% indicated that they are familiar with these methods.

### 4.3 ACCEPTANCE AND CHALLENGES WITH SUDS USE IN LAGOS STATE.

**Table 4:** Acceptance and Challenges with SUDS use in Lagos State.

| | Would you consider the following Sustainable urban drainage system strategies (SUDS)? | | | | | | Challenges with the practice of **NBS / SUDS** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **GREEN ROOF** | **RAINWATER HARVESTING** | **PERMEABLE PAVEMENTS** | **TREE PLANTING** | **RAIN GARDEN / BIORETNTION** | **WETLANDS** | **LACK OF AWARENESS** | **DEVELOPERS AND BUILDERS** | **MARKET EXPECTATION** | **ECONOMIC SITUATION** | **LACK OF GOVERNMENT SUPPORT** | **LACK OF TECHNICAL KNOW HOW** | **INADEQUATE** |
| **YES** | 160 | 240 | 240 | 288 | 208 | 120 | 224 | 47 | 0 | 23 | 36 | 0 | 9 |
| **NO** | 57 | 27 | 27 | - | 20 | 67 | | | | | | | |
| **MAYBE** | 112 | 72 | 72 | 51 | 111 | 152 | | | | | | | |
| **TOTAL** | **339 respondents** | | | | | | | | | | | | |

**Source: Author's Field Survey (2020)**

We appraised respondent's willingness to consider some SUDS strategies independently and not in order of preference as indicated in Table 4 above. Figure 3 revealed that most of the respondents (85%) are strongly disposed to exploring planting of trees as a SUD strategy. 71% indicated that they will consider permeable pavements and rainwater harvesting while 61% are inclined to rain garden, 47% and 35% of the respondents will consider green roof and wetlands respectively.

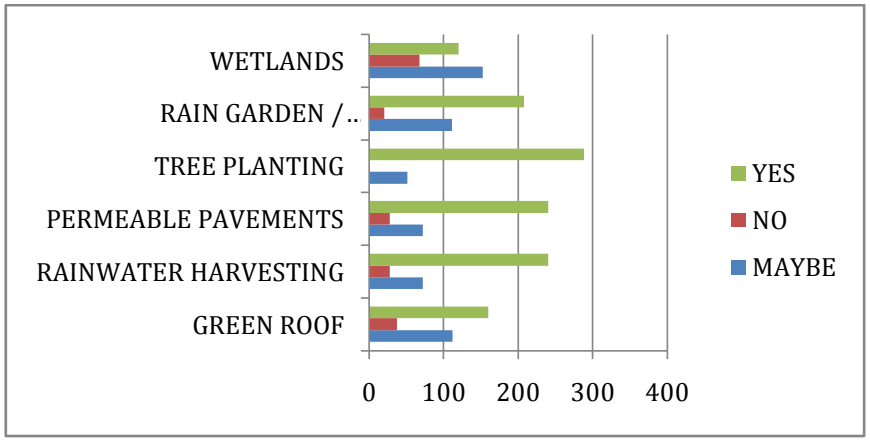


**Figure 3: Respondents willingness to consider SUDS strategies**

**Source: Author's Field Survey (2020)**

### 4.4 DISCUSSION

On evaluating the challenges with implementing Sustainable Urban Drainage System (SUDS) strategies for sustainable urban flood management; analysis of survey revealed that 66% of respondents agreed that SUDS is a relatively new concept and that the greatest barrier to practicing SUDS is the lack of awareness of the value and multiple benefits of NBS for improved urban flood resilience. 14% agreed that the role of developers and builders cannot be underestimated as they tend to keep things as simple as possible. 11% indicated the impact of lack of government support in SUDS practices while 7% and 3% agreed that current economic situation and inadequate stakeholder support are major limiting factors.

## V. CONCLUSIONS

Through literature review, we explored ecosystem services connected with Nature- Based Solutions (NbS) and design strategies for Sustainable Urban Drainage Systems (SUDS). We further conducted a quantitative survey to appraise current understandings of flood risk determinants and the applicability of NbS to Lagos State urban flood risk management. In addition, the survey also focused on evaluating public acceptance and challenges with the practice of SUDS within the study area.

Based on the review of the values of Nature-based Solutions (NbS) and benefits of Sustainable Urban Drainage System (SUDS), it appears that SUDS as a viable Nature inspired solution can be an effective option to the traditional piped or open drainage methods in managing surface water runoffs and reducing the impact of urbanization on flooding. Critical issues including population growth, urbanization, and climate change infer that traditional systems are no longer the most adequate option.

While majority of the respondents in this study who are professionals in the built environment (Architects, Planners and Construction Professionals) are very much aware of the influence of physical geography and anthropogenic factors as flood risk indicators, there is a general low level of awareness in the practice of Nature-Based Solutions (NbS) and Sustainable Urban Drainage System (SUDS) in Lagos State. Although, they are familiar with some of the SUDS design strategies. The most common practice is 'tree planting' mainly because it is an initiative promoted by the Lagos state government in response to changing ecosystem and climate conditions (Bassey, 2019). There is the need for government support in the implementation of SUDS.

To ensure public acceptance and confidence in the use of SUDS, we recommend continued research on the efficacy and associated benefits (cost, health, aesthetics and eco-social) of SUDS in Lagos urban flood risk management; wealso advocate for targeted collaboration between researchers, practitioners, policy makers and community stakeholders; and suggest adopting dissemination initiatives that integrates awareness and education of NbS in grassroots community meetings.

We conclude that there is a clear need for the design of the built environment of Lagos coastal city, particularly housing to optimize its traditional function and integrate NbS for improved urban flood resilience. Therefore, a consistent design approach and framework is required and thus calls for further studies.

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