Leveraging Innovation for Environmental Sustainability and Flood Risk Management in Nigeria

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Abstract— Flooding, pollution, deforestation, and land degradation constitute some of Nigeria's greatest environmental problems. In most cases, the extent of the displacements, fatalities, and losses caused by these problems cannot be truly ascertained. Meanwhile, as stakeholders at the local, state and federal levels are increasingly in pursuit of the right approach to address these environmental hazards, innovation is critical. However, the utilisation of innovation for flood risk management (FRM) and environmental sustainability has not gotten adequate attention in Nigeria either in terms of adoption, research, government policies, or funding. Therefore, this systematic literature review (SLR) explores the different ways that Nigeria can leverage innovation to improve its FRM strategies and achieve environmental sustainability. The SLR analyses 438 titles and abstracts, 63 full papers and makes a shortlist of 17 papers. By analysing the selected papers, this SLR identifies four broad themes of innovation that Nigeria can consider. They include big data approaches, spatial planning, design thinking, and collective environmental entrepreneurship and partnership. The paper also lays the foundation for future research to explore policies needed to stimulate innovation, find out how to scale innovation, and investigate the factors inhibiting the adoption of innovation for environmental sustainability and FRM in Nigeria.

Index Terms—Environmental Harzards, Environmental Sustainability, Flood Risk Management, Innovation, Nigeria

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1 INTRODUCTION

THE greatest environmental hazard in Nigeria is flooding, and it is majorly caused by human activities (Etuonovbe, 2011). In the last few decades, there have been severe flood incidents across the country, particularly in popular cities like Ibadan, Osogbo, Lagos, Port Harcourt, Akure, Yobe, etc. According to Amangabra and Obenade (2015), Nigeria lost over 16.9 billion US dollars in properties, agricultural goods and oil production as a result of the flood incidents across the nation in 2012. Not only that, over 2.3 million people were displaced while additional 16 million people suffered some negative impacts in different ways in the same year (Nwigwe and Emberga, 2014). These incidents threaten the nation's sustainability because they affect social life, environment, health, and economy. Meanwhile, there is no coordinated and integrated national flood risk management (FRM) strategy in the country (Oladokun and Proverbs, 2016).

Also, just like many other developing nations in the world, Nigeria faces environmental problems like deforestation, land degradation, desertification, soil erosion, pollution etc. Environmental degradation has caused the deterioration of urban and rural physical quality while desertification and drought threaten food security and Nigeria's ecology (Dyachia *et al.*, 2017). Meanwhile, these problems are primarily linked to human activities in the quest for development. Therefore, government, citizens and private organisations have the solemn obligation to work towards solving these issues and achieving environmental sustainability. Based on the Brundtland Commission Report, environmental sustainability in Nigeria and indeed the world should be recognised as a development that meets the needs of today without compromising the ability of the environment to meet the needs of the future.

According to Soumonni (2013), it is clear that continuous and accelerated innovation is essential to tackling environmental problems. In the past, innovation has been utilised to reduce air and water pollution. That is, innovation has been at work to save the environment. However, the utilisation of innovation for flood risk management and environmental sustainability has not gotten enough attention in Nigeria either in terms of research, government policies, adoption or funding. Hence, this paper conducts a systematic literature review to find out different ways that innovation can be used to improve flood risk management and achieve environmental sustainability in Nigeria. These innovations are categorised under four themes, namely: big data approaches, spatial planning, design thinking, and collective environmental entrepreneurship and partnership. The paper also lays the foundation for future research to explore policies needed to stimulate innovation, find out how to scale innovation, and investigate the factors inhibiting the adoption of innovation for environmental sustainability and FRM in Nigeria.

In section 2, the paper presents the research methods, stating the process adopted for shortlisting the papers selected for the systematic literature review. Section 3 of the paper provides the results of the SLR and a discussion of the identified innovation concepts under four themes. Section 4 presents suggestions of areas that can be explored by future researchers. Finally, section 5 concludes the paper.

2 RESEARCH METHODS

This SLR adopts the PRISMA framework, with four step-process that include searching the database, applying inclusion and exclusion criteria, quality evaluation, and data analysis.

Step 1: Searching the Database

The electronic scientific databases selected to source the papers for the SLR are Elsevier ScienceDirect (www.sciencedirect.com/) and Google Scholar (www.scholar.google.com/). The search terms used to get the existing literature related to the subject matter include "innovation environmental sustainability", "innovation flood risk management", "innovation environmental problems", "flood risk management Nigeria", and "environmental sustainability Nigeria".

Step 2: Inclusion and Exclusion Criteria

The papers identified from the databases are screened based on some pre-defined inclusion criteria like titles, meta-analyses, literature reviews, study area etc. Exclusion criteria were also applied to exclude duplicate studies and informal papers.

Step 3: Quality Evaluation

The selected papers were thoroughly evaluated based on three quality evaluation questions, as follows:

QE1: Does the paper cover relevant work?

QE2: Does the paper explore the research topics comprehensively?

QE3: Does the paper provide clear findings with justifiable results and conclusions?

Any paper that records 0 or 1 'yes' answer is excluded from the SLR while papers with 2 or 3 'yes' answers are included. 17 papers passed the quality evaluation process and are, therefore, the final papers that make it to the analysis stage. Figure 1 shows the summary of the selection process for the SLR using the PRISMA framework.
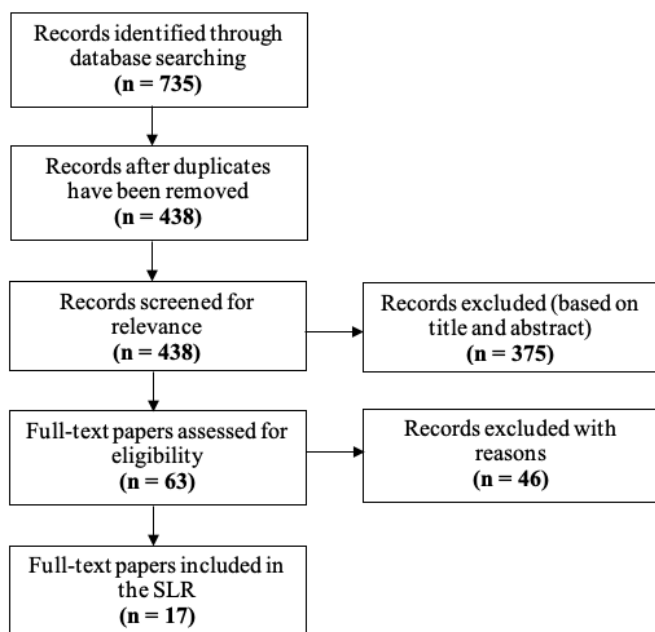
Figure 1. PRISMA Framework Adopted for the SLR.

Step 4: Analysis

Each of the 17 shortlisted papers was analysed according to its scope, topic area, and the summary of its research questions and answers. Based on the analysis, four broad themes are identified, and the papers are discussed under the themes, as shown in the next section.

3 RESULTS

As a result of the analysis of the selected papers, innovation for environmental sustainability and flood risk management in Nigeria can be categorised under four themes. These include Big Data Approaches, Design Thinking, Spatial Planning, and Collective Environmental Entrepreneurship and Partnership.

3.1 Big Data Approaches

According to Pollard *et al.* (2018), Big Data Approaches (BDAs) involve the use of historical data, live data streams and different technologies to get insights into societal complexities through storage and analytical capabilities. In Nigeria's environmental sector, BDAs have not been effectively utilised. Therefore, Nigeria can leverage the approaches to get insights into flood and environmental risk assessment, thereby aiding long-term adaptation planning and mitigation.

The big data approaches proposed by Pollard *et al.* (2018) and which can be adopted in Nigeria include:

i. Synthesis and harmonisation of coastal datasets
ii. Process-based modelling and Bayesian networks
iii. Ensemble forecasting
iv. Handling and validating satellite imagery
v. Natural language processing of social media

For example, to apply the fifth approach in the Nigerian context, a search for flood incidents was carried out on Twitter, one of the results captured was a tweet made on June 20th, 2020. The exact words of the tweet are shown below:

> "Houses around Olodo area of Ibadan were overrun by flood today…"

Using humans to collect relevant information like this from Twitter in real-time for emergency response operations is costly and requires intensive work (Pollard *et al.*, 2018). Therefore, to extract relevant data at a faster rate and in real-time, Smith *et al.* (2015) proposed an automated technique that uses natural language processing algorithms to extract and filter tweets based on appropriate timestamp, precise locational information and semantically relevant keywords. Utilising the technique proposed by Smith *et al.* (2015), the tweet earlier identified by this paper can be broken down as follows (Fig 2):
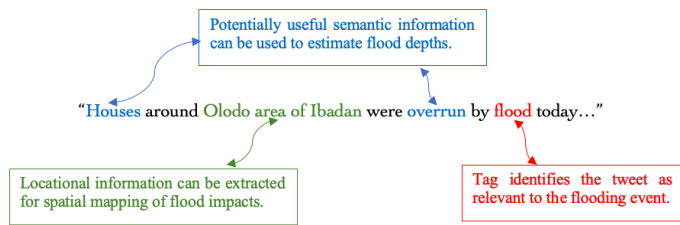
Figure 2. Shows how the natural language processing algorithms can be used to extract a tweet about flooding in Ibadan, Nigeria.

Big Data Approach was also employed by Zhang *et al.* (2018) to effectively use the cyberGIS-enabled multi-criteria spatial decision support system proposed by the researchers. The system was proposed as an efficient strategy for environmental emergency response. It utilises social media data as well as combines decision analysis models (Weighted Sum Model) and high-performance computing environment. The system generally allows emergency responders to create decision goals, select appropriate evaluation criteria and carry out interactive weighting and sensitivity analyses.

Lamond *et al.* (2019) also opined that data for disaster risk reduction is essential to enable resilience. However, the utilisation of data in this respect has been limited to national scale risk assessment in many African countries. A research survey involving stakeholders in FRM in Nigerian cities showed that the provision of data and climate services should be designed collaboratively to be more inclusive and build local capacity. Indeed, this can constitute another form of innovation concept called **devolution,** according to Fenn *et al.* (2015). The same point was amplified by Guerriero and Penning-Rowsell (2020), who identified devolution as one of the avenues of innovation in FRM. The researchers cited the devolution of power away from the central government in London to local agencies and authorities in Scotland and Wales as a case in point. The devolution empowers the local authorities to develop environmental strategies (e.g. Surface Water Management Plans) and increase their capacity to deal with the risks faced at the local level effectively.

3.2 Spatial Planning

Nigeria's flood response is more focused on post-disaster approach than control and pre-disaster approach (Cirella and Iyalomhe, 2018). According to Okoye (2019), there is no proper attention to flood control and management at the national level while previous efforts made at addressing the challenge have suffered poor coordination and failed. Also, the lack of an integrated FRM practice in the country allows for the use of sub-optimal solutions, thereby creating more problems in the process.

To solve these problems, Oladokun and Proverbs (2016) proposed the use of spatial planning as an innovative Flood Risk Management strategy primarily because it can integrate existing practices. The strategy is also known as the most sustainable flood risk management approach.

Also, using spatial planning is suitable for Nigeria's local communities because the location of the country is in a relatively geological stable zone that is not prone to extreme natural disasters like cyclones, earthquakes, landslides, hurricanes, etc. In essence, this gets rid of the uncertainty of not knowing when the next geological disaster will happen (Egbenta *et al.*, 2015).

With spatial planning, Nigeria can adopt modern concepts like sustainable and flexible collaborative planning (Lagopoulo, 2018). Spatial planning also integrates sustainable drainage systems as a flood risk management strategy. In fact, one of the avenues of innovation in FRM proposed by Guerriero and Penning-Rowsell (2020) is Sustainable Urban Drainage Systems (SUDS). This innovation involves retaining a catchment's natural hydrology such that its flood risk regime is not increased. Natural Flood Risk Management measures constitute another innovation. By using natural processes, floodwaters can be channelled away from city centres by slowing down the runoff flow (Dadson *et al.*, 2017).

3.3 Design Thinking

Design thinking is another innovation that Nigeria can leverage towards achieving environmental sustainability and strengthening its FRM strategies. According to Tiang (2020), design thinking is an iterative process employed by teams to understand users, redefine problems, challenge assumptions, and build innovative solutions to prototype and test. This non-linear process involves 5 phases, namely: Empathise, Define, Ideate, Prototype and Test (Figure 3).

Figure 3. Design Thinking (Tiang, 2020).

According to Bojórquez-Tapia *et al.* (2017), using a design thinking approach for sustainability science has the potential to help nations overcome the challenges faced towards the realisation of the United Nations' Sustainable Development Goals. This is evident from the outcomes of environmental efforts driven by design thinking. For instance, Pruneau *et al.* (2018) adopted design thinking and Facebook as methods to guide Moroccan women to solve the problem of poor drinking water. On Facebook, the women shared their flood experience using videos and pictures. Then, they collaborated to solve the problem of poor drinking water using design thinking. This approach helped the women to create a prototype of different potential water purification solutions.

Indeed, the use of design thinking approach to solving environmental sustainability problems is already gaining momentum. Research by Léger *et al.* (2020) compared the conventional approach to design thinking approach towards solving the

problem of local water contamination. Two groups were created, one for each approach. The results of the study revealed that the group that adopted the design thinking approach found more creative and feasible solutions with a focus on people's needs than the group that adopted the conventional approach.

3.4 Collective Environmental Entreprepneurship and Partnership

Existing government entities that carry out environmental sustainability and flood control projects in Nigeria lack proper integration and collaboration. This makes control projects ineffective. Also, flood risk management in Nigeria is primarily done by the states with inadequate support from the federal government. Among these states, there is a lack of coordination and partnership as states with similar environmental problems adopt different practices (Oladokun and Proverbs, 2016). In the private sector, individual businesses are also pursuing entrepreneurial initiatives to solve environmental problems.

However, environmental issues have evolved into big challenges that go beyond the influence of one government agency or individual firms. To address this, Doh *et al*. (2019) explored the possibility of environmental entrepreneurship and cross-sectoral partnerships. The researchers therefore proposed *collective environmental entrepreneurship*. The strategy can help overcome the challenges facing individual government agencies or private firms in building innovative solutions to grand environmental problems. Adopting this strategy can also help in reconciling the divergent interests of different organisations. The strategy was applied to a practical case where private firms, governments and civil society organisations leveraged innovative partnerships to adapt to the physical impacts of climate change.

SMEs also have a pivotal role to play in environmental partnerships. As noted by PricewaterhouseCoopers (PwC), SMEs in Nigeria account for 96% of businesses, contribute 48% of the national GDP, and 84% of employment. Therefore, for a nation like Nigeria, achieving environmental sustainability through innovation can only be possible with the involvement of SMEs.

4 FUTURE RESEARCH

The possible areas that can be explored in future research works are provided as follows:

i.   The Need for Innovation Policy: A successful adoption of innovation for environmental sustainability will require policies that go beyond conventional approaches. Consequently, there is a need for policy instruments that target innovation directly. It has also been reported that nations that do not have a framework that supports environmental innovators may lose in rapidly changing markets. Based on this, future research works should look into the possible pol-

icies that Nigeria can make to stimulate innovation for environmental sustainability and flood risk management.

ii.   Future research should thoroughly investigate the factors inhibiting the adoption of innovation for environmental sustainability and FRM across local, state and federal levels in Nigeria.

iii.   Scaling innovation: Future research should explore the possible ways through which innovation can be scaled up across systems to make it more sustainable in the long-term.

iv.   Continuous search for new and better ways: Conscious and deliberate efforts should be made continuously by future researchers to find new innovative and disruptive ways of solving environmental issues in Nigeria.

5 CONCLUSION

This systematic literature review has unveiled the different innovation that Nigeria can utilise to strengthen its flood risk management strategies and achieve environmental sustainability. Adopting these innovative concepts will also promote the nation's effort towards realising the United Nations' Sustainable Development Goals (SDGs). The SLR identified four themes of innovation which include big data approaches, spatial planning, design thinking, and collective environmental entrepreneurship and partnership. The paper has also laid a foundation for future research by providing four different avenues that can be explored in future works.

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