

Article

Adaptation to Climate Change Effects on Water Resources: Understanding Institutional Barriers in Nigeria

Sola Ojo ^{1,*}, Henry Mensah ², Eike Albrecht ¹ and Bachar Ibrahim ¹

¹ Department of Public Law with Reference to the Law of Environment and Planning, Brandenburg Technical University, Cottbus-Senftenberg, 03046 Cottbus, Germany; albrecht@b-tu.de (E.A.); bachar.ibrahim@b-tu.de (B.I.)

² Centre for Settlements Studies, Kwame Nkrumah University of Science and Technology, Kumasi 00233, Ghana; henry.mensah@knust.edu.gh

* Correspondence: Sola.Ojo@b-tu.de; Tel.: +49-15218728383

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Abstract: Climate Change (CC) and variability are global issues that the world has been facing for a long time. Given the recent catastrophic events, such as flooding, erosion, and drought in Nigeria, many have questioned institutions' capacity in managing CC impacts in Nigeria. This study explores emerging institutional barriers of adaptation to CC effects on water resources in Nigeria. The study data were obtained from in-depth interviews with institutional heads from water resources management and emergency management and a review of secondary literature from databases such as Google Scholar, Scopus, and Web of Science. The results show that inadequate hydrological data management, low awareness on how to adapt among the public and decision-makers, financial constraints, no political will to pass important bills into law, and inadequate institutional and legal framework are the main institutional barriers of adaptation to climate change in Nigeria. The study concludes that it is essential to strengthen the institutional and legal system, information management mechanism, public awareness, and participatory water resources management. The implications for further research are presented in the study.

Keywords: adaptation; climate change; Nigeria; institutional barriers; water management

1. Introduction

Climate projections have shown that water resources are vulnerable and can be strongly influenced by climate variability with wide-ranging implications on the human population and ecosystem [1,2]. For example, Climate Change (CC) has contributed to flooding, water scarcity, erosion, low water quality, droughts, salt-water intrusion and reduction in groundwater sources; therefore, making communities, living and non-living components of the environment vulnerable [3]. The Nigeria National water resources master plan highlighted the effects of CC on water demand, water resources potential, and water balance in Nigeria [4]. It was observed that the effects will include changes in air temperature, which could result in low yearly runoff of about 20%. The response of runoff against drastic changes in rainfall is more obvious in the region with less precipitation, especially in the northern region of the country. The effect could be massive during the rainy season of the year than in the dry period. CC has led to low recharge and will further reduce the underground water level from 5 m to 20 m [4]. In Nigeria, the water resources master plan shows that the average annual temperature and precipitation in Nigeria from 1960 to 2009 was estimated to be 1118 mm/year and 26.6 degrees Celsius, respectively. Data sources for the estimation were meteorological data sources from Nigeria (managed by Nigeria Meteorological Agency) and the internet (relevant websites). Figure 1 shows

the spatial pattern of average annual precipitation in Nigeria from 1960 to 2009. The average annual precipitation differs from over 3000 mm in the southern part to 400 mm in the northern part. Table 1 shows the average spatial temperature and precipitation in all the hydrological areas in Nigeria from 1960 to 2009. By calculating the average of differences recorded between 1960 to 2009, there was a reduction in precipitation with a reduction rate of -1.7% and an increase in temperature with an increment rate of $+3.0\%$ from the year 1960 to 2009 [4].

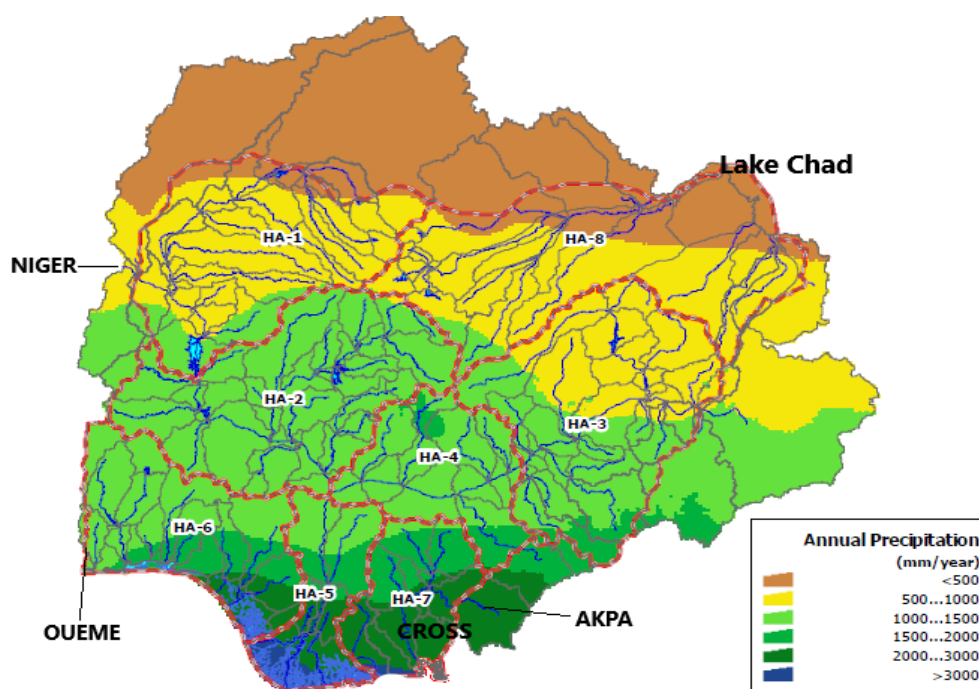


Figure 1. Map of Nigeria showing Hydrological Areas (HAs) and transboundary basins (Niger, Lake Chad, Cross, Akpa, and Oueme). Source: JICA-FMWR, 2014; Mc Cracken and Wolf, 2019 [4,5].

Table 1. Average spatial temperature and precipitation in hydrological areas in Nigeria (1960–2009).

	Entire Country	HA-1	HA-2	HA-3	HA-4	HA-5	HA-6	HA-7	HA-8
Average Precipitation (mm/year)	1148	767	1170	1055	1341	2132	1541	2106	610
Annual Mean Temperature (°C)	26.6	27.4	26.5	26.0	26.8	26.7	26.5	26.9	26.5

Source: JICA-FMWR, 2014 [4].

Vulnerabilities of Nigeria to CC effects on water resources are widely reported. Nigeria has five transboundary rivers, namely Niger, Chad, Oueme, Cross, and Ankpa [5] (Figure 1). These transboundary rivers account for 88 BCM/year (billion cubic meters per year) out of the sum of 375 BCM/year (billion cubic meters per year), which is Nigeria's water resources potential [4]. Water from these transboundary rivers is essential for dams, boosting livestock, efficient irrigation activities, robust fish farming, and numerous economic activities. However, there has been a significant reduction in water flow, particularly in the River Niger since 1970 due to severe rainfall deficit, which has occurred all over the basin in Nigeria [6]. This significant reduction in water in Nigeria would be further intensified by CC effects, thus increasing Nigeria's vulnerability to CC.

Additionally, the increase in Nigeria's population, particularly in urbanized areas [4] is another potential contributing factor. According to the United Nations, Nigeria's population will increase to 258 million people by the year 2030, which is a projection of its 2.33% growth rate [7]. In view of this population increase, municipal water demand in Nigeria would also increase to 8852 MCM/year

(million cubic meters per year), accounting for 53% out of the total water demand of Nigeria by the year 2030, which is 16,585 MCM/year (million cubic meters per year) [4]. This is already exerting so much pressure on Nigeria's water resources and climate effects will further increase the problem. Furthermore, wetlands are critical factors of Nigeria's watershed systems because of their role in connecting land and water resources [8]. The oil exploration in the Niger Delta part of Nigeria could also degrade wetlands if not well-managed. The oil explorations have the capability to pollute the environment; major effects on wetlands vegetation are reduction in photosynthesis and, ultimately, mortality [9]. This makes Nigeria more vulnerable to the impacts of CC.

Irrigation activities will take far more water demand by 2030. It is reported that Nigeria's national water consumption for irrigation has stood at 1926 MCM/day (million cubic meters per year) as of the year 2010, and this will further increase to 6245 MCM/day (million cubic meters per year) in the year 2030 [4]. CC effects on water resources would further exacerbate the increase in pressure of water resources for irrigation activities. Besides, the rising population will increase the demand for food and, in turn, increase the demand for agricultural water. This has implications for improved water resources management (e.g., better cooperation with neighboring countries that share the same transboundary water, regular monitoring of rivers, efficient management of hydrological data, and application of environmental assessment tools).

In addition, urban floods in Nigeria have resulted in the loss of lives, properties, insecurity, and affected key vulnerable sectors such as agriculture, power, water transportation, health, and tourism. A good example is the issue of perennial flooding that has always devastated properties and disrupted economic activities in Lagos State, Nigeria [10].

Research shows that adaptation is vital to tackle and minimize the negative impact of CC in vulnerable countries [3]. The United Nations reports that it will be critical for people to cope with the changing environment [11]. Adaptation means the ability to adjust to unavoidable alterations, which may arise by formulating robust governance systems, laws, and policies to minimize the future effects of climate alterations in Nigeria [12]. Adaptation is needed, either proactively or reactively [13]. The process of adaptation could be carried out before or after an extreme weather event. In Nigeria, the adverse effects of CC, such as floods, erosion, health risk, food insecurity, warrant robust adaptation planning [3,4,14].

Institutions play a crucial role in climate change adaptation. For example, they perform the coordinating role to allow society to apply knowledge, information, technology, funding, and resources for adaptation [15,16]. Many have, therefore questioned the capacity of the institutions in managing the impact of CC in Nigeria. This implies the need to empower communities, agencies, and associations with relevant knowledge, technical capacity, infrastructure, strategies to undertake adaptation measures [17]. Additionally, limited attention has been directed to the institutional barriers affecting water management in sub-Saharan countries [18,19]. Despite the progress made in Nigeria on CC institutional strategies, gaps remain, resulting in the continuous adverse impact on the available water resources. The institutional barriers may increase vulnerability or increase adaptation costs at a later stage if not adequately addressed. However, the measures are undertaken, and the obstacles they face in implementing those measures by authorities have still not been researched adequately. In order to achieve the Sustainable Development Goals (SDGs) through CC adaptation, food security, and promoting sustainable water management, the institutional capacity to protect water resources needs to be considered. Although there is an expanding body of literature that examines climate change and adaptation, this literature generally focuses on vulnerable sectors such as agriculture [20] and infrastructure adaptation [21]. This study aims to identify institutional barriers of adaptation to CC effects on water resources in Nigeria and how these barriers affect institutions and suggest how these barriers can be surmounted.

2. Methodology

2.1. Study Setting and Participants

Nigeria is located in the tropical region, and the Atlantic Coast of West Africa between latitude 4° N and 14° N and longitude 2° 21' and 14° 30' E. Nigeria has an area spanning a surface area of 923,800 square kilometers (km²). Nigeria's population, as contained in the Nigeria Water Resources Master plan, stands at 183,523,432 people, and its estimated to rise to 380,394,709 by 2030. Nigeria is endowed with huge water resources. Water is central and useful to other sectors of the economy, such as industries, agriculture, livestock farming, water transportation, and hydropower generation. Nigeria is vulnerable to climate change; an example of the factors that could exacerbate the effects of climate change on water resources includes a reduction in the flow of transboundary rivers, increased population and urbanization, and land and wetland degradation.

The study purposively focused on national institutions and regional branches that play a key role in water resources management, CC, and emergency management in Nigeria (Table 2). Purposive sampling was used in the qualitative research study to select individuals who are particularly knowledgeable, have information, and are experienced to respond to the research questions [22,23], as well as being employed in related studies [24,25]. The institutions were purposively selected based on the constitutional mandate to manage water resources, environment, and emerging issues in Nigeria.

Table 2. List of interviewees and their affiliation.

Government Institutions		Locations	Number of Key Informants Interviewed
Institutions	Branches		
Federal Ministry of Water Resources	Headquarter	Abuja	4
	Upper Niger RBDA	Minna	1
	Lower Benue RBDA	Markudi	1
	Anambra-Imo RBDA	Owerri	1
	Ogun-Osun RBDA	Abeokuta	1
	Chad RBDA	Maiduguri	1
	Hadejia Jama'are RBDA	Kano	1
Federal Ministry of Environment	Headquarter	Abuja	2
	Lagos zonal office	Lagos	1
	Kano zonal office	Kano	1
	Port-Harcourt zonal office	Port-Harcourt	1
Nigeria Hydrological Services Agency	Headquarter	Abuja	3
	Lagos zonal office	Lagos	1
	Minna zonal office	Minna	1
Nigeria Meteorological Agency	Headquarter	Abuja	2
	Ibadan zonal office	Ibadan	1
	Lagos zonal office	Lagos	1
	Kano zonal office	Kano	1
National Emergency Management Agency	Headquarter	Abuja	2
	Lagos zonal office	Lagos	1
	Ibadan zonal office	Ibadan	1
	Kano zonal office	Kano	1

Note: RBDA = River Basin Development Authority.

2.2. Data Collection

The study relied on both primary and secondary sources of data. The primary data collection was based on interview guides. The method allowed clarity of questions and gave respondents enough

room to share their views on the topic. Some of the questions were open, therefore respondents were able to share their views on institutional barriers and challenges to the adaptation to CC. The interviews were conducted from October 1, 2019, to October 28, 2019. Interviews and data from the semi-structured interview were recorded digitally through a digital voice recorder and written in text to serve as a backup. Each session lasted between 45 min to 1 h. Interview appointments were made with the key informants through a telephone call to confirm the date and time of the interview. The secondary data sources include review and synthesis of internet-based databases such as Google Scholar, Scopus, Web of Science and reports from institutions, for example, the Nigeria National water resources master plan 2014.

2.3. Data Analysis

Table 3 shows the key guiding questions for the interview. The study applied a content analytical procedure to reveal emerging issues and themes from the interview transcripts; offer an insight into the research problem; answer the main research questions [26]. The interviews were recorded, and respondents' responses were noted. Responses were transcribed into texts and grouped in an excel sheet. Texts from the responses were evaluated to identify trends of ideas from the transcribed interviews [27].

Table 3. List of sample guiding questions used in the interview.

1. What is the level of awareness and understanding of CC among officers and decision-makers?
2. What are the institutional barriers to adaptation to CC effects on water resources?
3. How are these barriers affecting institutions?
4. How can institutional and regulatory framework support adaptation?
5. How can Strategic Environmental Assessment support adaptation?

The study also used the lens of Oberlack and Neumärker [28] to systematically organize, identify and understand the institutional barriers to climate change adaptation (diagnostic framework). It was chosen because it helps to address real-life situation [29]. In order to arrange and organize these various examples of different adaptation scenarios and to make items that shape climate adaptation obvious, a diagnostic framework was deemed fit for this study [30,31].

The Institutional Analysis and Development (IAD) framework [29,30] was relied on as a guide to design this diagnostic framework as shown in Figure 2. Oberlack and Neumärker (2013) [28] modified the IAD framework to accommodate distinct characteristics of climate change adaptation which our study is based on. The diagnostic framework of climate change adaptation includes various variables as seen in Figure 2. Several concepts were referred to for the formulation of these variables. Examples are exposure to climate stimulus [31], interplay of governance levels [32], information [17], number of actors [33] and awareness and concern [34].

2.4. Ethical Consideration

Research ethics were paramount in this study. The aim was to ensure that the results are valid and safeguarded. The research sought the consent from interviewees before the interviews were held. Participation in the research was voluntary. The anonymity of the interviewees was safeguarded when reporting the results. There was room for respondents to ask questions and to express his or her views and observation. Because of respondents' right to full disclosure, we emphasized the aim and nature of the research before the interview started.

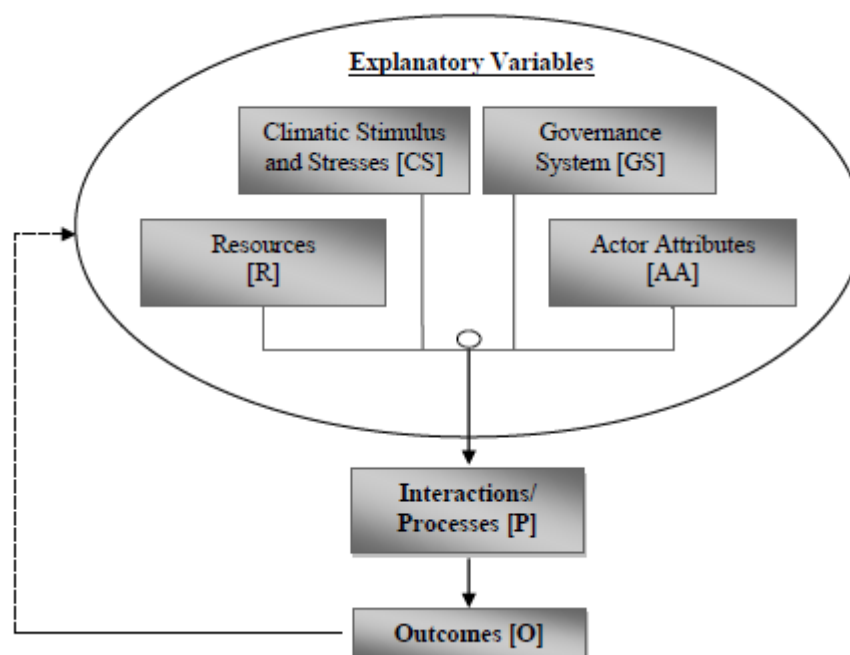


Figure 2. Components of the diagnostic framework of climate change adaptation. Source: Oberlack and Neumärker, 2013 [28].

3. Results

Institutional Barriers of Adaptation to Climate Change Effects on Water Resources in Nigeria

Despite the numerous opportunities from adaptation to CC, key barriers remain as reported by the key informants. The barriers are split into five main themes in the following section.

Inadequate Data Management

The major institutional barrier identified was inadequate data management, which encompasses inadequate repository hydrological data across the different river basins. This was due to the poor river monitoring system and inefficient sharing of data among institutions. This has caused limited data availability when needed. Many of the respondents stated that many rivers in Nigeria are still not being monitored due to a lack of monitoring equipment. Besides, the rivers that are monitored are measured with outdated equipment. They opined that there is a need for the creation of more river monitoring stations across Nigeria. Besides, they observed that due to changing climate, many rivers in Nigeria have sediment loads, and in view of this, there is a need for consistent measurement of bed loads and suspended loads that are transported by rivers in Nigeria. Respondents narrated that this will be achieved by applying the state-of-the-art equipments, such as Manual Staff Gauge, Discharge Collection Points (DCPs), Data Loggers, Bubble Sensor, Sediment Samplers, Current Meter and Acoustic Doppler Current Profiler (ADCP), to river flow measurements together with competent and trained experts to manage these equipments. Respondents generally observed that the problem associated with poor and inadequate river monitoring has seriously led to a severe deficit of hydrological repository data across the country. A respondent expressed his view about the deficit in data:

What cannot be measured cannot be effectively managed. In order for us to plan, forecast, and develop a good adaptation strategy to CC effects, accuracy in river measurements and data generated subsequently is highly sacrosanct and very important.

On data sharing among relevant institutions and its availability for usage, respondents decried that synergies among institutions are very poor; this makes data availability often difficult. They stated

that because the central database is not updated, many institutions have carried out measurement of rivers by themselves and thus generated their data rather than sharing data from just one data point. This has led to duplication and inconsistency in hydrological data in Nigeria. A respondent expressed his view on the matter as follows:

There is a need for enhancement of data and information management mechanism on water resources in Nigeria. This could be carried out by creating an institutional mechanism to distribute hydrological data among different agencies and enhance institutional mechanisms that would aid mainstreaming assessment and evaluation.

Low Awareness and Understanding

Low awareness of CC and adaptation, which includes inadequate preparedness among technocrats and the public, was another key barrier. Generally, the respondents stated that awareness is low among decision makers and the public due to their lack of in-depth understanding of the potential risks of CC. This often results in poor judgments and decision making within institutions and the public. Moreover, low awareness among decision-makers was mainly attributed to the fact that adaptation to the climate is still at its nascent stage within the spectrum of environmental management in Nigeria. However, the respondents were hopeful that awareness of adaptation measures to CC effects would be stronger in the near future. Some respondents also stated that low awareness of the public on CC and its impacts is a barrier because people living in vulnerable communities ignore flood warnings. Lack of cooperation between the communities, government and institutions is complicated due to their cultural beliefs. For example, it was revealed that most of these local people have traditional connections with their lands and as such they have refused to relocate in the aftermath of flooding events. One of the respondents expressed his views:

There is a need to establish enough awareness at the community level, organize capacity building programs, disseminate information, conduct meetings, display graphic pictures of events, and inform people on the exposure to CC.

Inadequate Legal, Regulatory and Institutional Framework

Additionally, respondents stated that the lack of supportive regulatory and institutional framework militate against adaptation strategies. Application of environmental evaluation tools including the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA), mainstreaming CC consideration into development policies, consideration of CC in EIA and SEA, legal backing for SEA, and the passage of the water resources bill into law were listed as some of the supportive regulatory frameworks that can support adaptation. Regarding the environmental evaluation tools such as EIA and SEA, respondents reported that although the EIA has been promulgated as a legal basis for addressing environmental problems in Nigeria, there is more room for improvement in adherence to the law and strengthening stakeholders and public participation. It was also narrated that among the several benefits of EIA, it could be useful in Nigeria as a screening tool for adaptation and mitigation projects to assess the environment's negative impacts. A respondent stated the following:

The building of floodwall and coastal adaptation measures such as the construction of dikes can cause adverse effects on the environment, for example, it can lead to loss of coastal biodiversity. Given this, EIA should screen all developmental projects in Nigeria's water sector to evaluate the potential environmental impacts of such projects on the environment in the future. This will ensure sustainability.

Similar to the previous argument, another respondent narrated that:

The views and perceptions of the public on our intended adaptation projects are essential because it gives room for stakeholders to bring up areas that need improvements. This has not been the case as stakeholders have not been allowed to make comments on EIA reports.

Regarding the SEA and its legal backing, some of the respondents stated that Nigeria lacks a legal and regulatory framework for SEA as there is no SEA law. They believed that in order to meet and carry out the obligations of implementing adaptation measures by institutions, SEA should be mainstreamed in the national agenda because it is a unique tool that assesses social, climate, environmental, health impacts of proposed plans and policies. They noted that evaluation of the potential effects of adaptation policies is vital to make informed decisions pertaining to the implementation of adaptation to CC effects on water resources. One of the respondents stated the following:

Presently, there is no SEA law in Nigeria, and many of my staff are not even aware of SEA. As a policy evaluation tool, SEA will highly support our work in the quest and drive to achieve adaptation to CC.

Most respondents believed that consideration of CC adaptation plans and projects is still low in planning and developmental processes. The respondents called for institutionalization of SEA and greater application of EIA by institutions in Nigeria, particularly in the water management sector. One of the respondents stated the following:

CC poses so much threat to water resources in Nigeria. Therefore, it is imperative to consider CC when applying the SEA on development policies in the water sector and used in a greater preference when applying EIA on developmental projects in the water sector.

On the passage of the water resources bill into law, respondents believed that the proposed water bill, when passed into law, would much support their work with regard to implementing adaptation strategies. It was agreed that the water bill contains many regulatory instruments that could yield the desired results. An example is creating catchment management offices across all the river basins in Nigeria to execute and design catchment management plans and regulate all environmental resources at different catchments. This will also help in mainstreaming CC issues. One of the respondents stated the following:

Inadequate awareness and lack of information among the legislative arm of government on the usefulness of the water bill was the main challenge that has impeded the passage of the water bill into law in Nigeria.

No Political will

Political will geared towards adaptation was reported as one of the main institutional barriers of adaptation. Pertaining to development issues and the passage of the water resources bill into law, the interest of the legislative arm of the government prevails; therefore, there is no urgency attached to the passage of the water bill into law. The water bill contains regulations on how water can be effectively managed in a changing climate. However, almost all the members in the legislative arm lack orientation about the bill and have ignored the importance of the bill. Respondents argued that bureaucracy, lack of orientation, ignorance, political interests of lawmakers were some of the barriers impeding the passage of the water bill and overall an institutional challenge of adaptation to CC in the water sector. Also, they stated that the implementation of adaptation strategies at their various institutions could only be smooth if the right regulatory framework is implemented to enable them to execute their mandate. One of the respondents stated the following:

The proposed water resources bill has been before the legislative arm of government for years, and till now, it has not been passed due to political interests, ignorance and lack of understanding of the issues at hand. There is a need to sensitize all the lawmakers in the National assembly on the bill and the issues at hand.

Financial Constraint

Financial constraint affects all the institutions and has undermined the execution of CC adaptation related projects. Respondents believed that robust funding is needed to trigger actions since adaptation

to CC projects require much money. They enumerated capacity factors and its drivers needed by people to adapt and cope with climate hazards such as technology, implementation of planning regulations, management of natural hazards, capacity building, access to health services, and infrastructures all comes at a huge cost. One of the respondents stated the following:

Due to financial constraints, there have been slow implementations in some of the projects that have been initiated in my department useful for adaptation. The projects include the construction of CC models for all eight hydrological areas in Nigeria and research for useful adaptation strategies in Nigeria water sector.

A breakdown of responses from respondents in each of the institutions visited can be found in Figure 3.

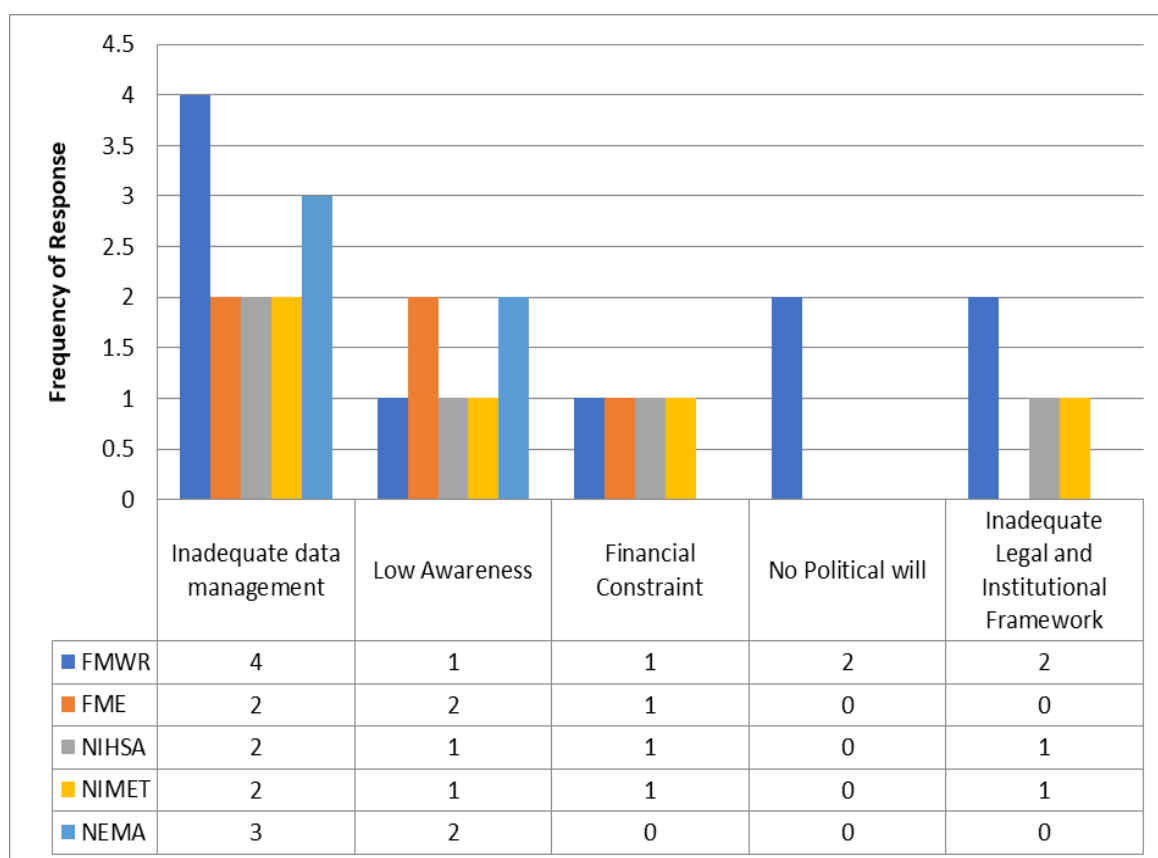


Figure 3. Respondents’ opinions on institutional challenges. Note: FMWR = Federal Ministry of Water Resources; FME = Federal Ministry of Environment; NIHSA = Nigeria Hydrological Services Agency; NIMET = Nigeria Meteorological Agency; NEMA = National Emergency Management Agency.

4. Discussion

The diagnostic framework has supported the study to organize and understand the key barriers of CC adaptation strategies or processes. The five barriers (financial constraint, inadequate data management, legal and regulatory barriers, low awareness, and political will) were grouped around low awareness and knowledge, institutional shortfalls, and limited resources.

Many relevant agencies are still faced with an inadequate institutional and regulatory framework to carry out adaptation to CC effects on water resources in Nigeria.

Respondents indicated application of environmental evaluation tools such as the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA), mainstreaming CC

consideration into development policies, consideration of CC in EIA and SEA, legal backing for SEA, and the passage of the water bill into law were some of the supportive regulatory frameworks that can support adaptation. These respondents also listed lack of legal backing for Strategic Environmental Assessment (SEA) and non-passage of the water bill. This finding is similar to the study conducted by Dover and Henzri, 2010 [15], which showed that an institutional and regulatory framework needs to be embraced for a successful CC adaptation process. SEA is a decision-building tool for the screening of robust spatial and sector policies, plans and programs, in ensuring the correct examination of the ecosystem [35]. In order to achieve carrying out adequate adaptation strategies by institutions, EIA and SEA are two important environmental evaluation tools that are deployed across the globe for broad environmental assessment, which encompasses the forecast and assessment of the three pillars of sustainability effects of a proposed plan [36]. This assessment supplies an important examination of environmental effects of regional spatial development including changes to infrastructure and health [37]. SEA was drafted alongside EIA in 1969 with the United States National Environmental Policy Act [38]. As a flexible instrument, SEA can also be applied to screen environmental issues such as CC. SEA is a more effective environmental assessment instrument used to assess CC adaptation options in contrast to EIA. Thus, the evaluation of the potential effects of adaptation plans is crucial to make useful decisions for adaptation. The United framework convention on climate change (UNFCCC) instructs all parties to ensure CC is taken into consideration and applies necessary methods such as EIA and SEA on projects and plans to combat or adapt to climate variability. In Sri Lanka, the government has made SEA compulsory for all practitioners to evaluate all plans before the execution of its projects [39]. This will reduce negative impacts on the economy, health, and standard of the environment. Given this, SEA has been selected as the most preferable tool for evaluating the climate alteration adaptation process [40].

Shortage and inaccuracy of hydrological data could be a clog in the wheel for carrying out adaptation to CC effects on water resources [41,42]. Inadequate data were the major challenge that was stated by respondents who were interviewed. The country's water resources assessment has not been adequately carried out due to poor hydrological monitoring across the country. For example, the Nigeria, hydrological services agencies, saddled with the responsibility of collecting, processing and disseminating all hydrological data across the country have not been able to achieve its mandate fully. This is due to poor planning, design, and operation, no political will, bad state of monitoring equipment, and low technical competence. Research shows that the enhancement of the data and information management mechanism on water resources is necessary for effective water resources management and CC adaptation [41,42]. This could be carried out by creating an institutional mechanism to distribute hydrological data among different agencies [42].

Low awareness and information on CC effects on water resources are two of the challenges to adaptation as stated by respondents. Bangladesh, Egypt, Tanzania, Uruguay, Nepal and Fiji experience similar challenges [43]. People living in vulnerable communities need to be sensitized on flood risk and the importance of early flood warning. In similar studies, the lack of knowledge on CC is usually triggered by cultural beliefs among people living in vulnerable communities, creating adaptation challenging [44]. The vulnerable communities refuse to obey flood warnings and relocation due to the ancestral ties they have to their land.

Financial resources are essential to initiate and carry out projects to solve CC effects on water resources. Research shows that communities with low financial resources lack the capacities to cope and adapt to disasters caused by CC effects on water resources [45,46]. The ability of human systems to adapt to CC effects on water resources depends on planning, education, and research—which require funding [45,46]. Some respondents stated that the lack of political will also undermines adaptation practices in the study area. Therefore, the implementation of adaptation strategies at the various institutions can be enhanced if an appropriate regulatory framework exists.

5. Concluding Remarks

The overarching aim of this study was to explore key institutional challenges of adaptation to CC effects, focusing on water resources in Nigeria. The barriers to adaptation to CC effects on water resources in Nigeria include inadequate data management, low awareness, financial constraint, inadequate legal and institutional framework, and no political will. For a robust adaptation of the human-environment to be enhanced, these challenges must be addressed as a matter of urgency. Based on the diagnostic framework, we understand the barriers leading to low awareness and knowledge, institutional shortfalls, and limited resources, and supply the leverage to explain the effects of these barriers on institutions' adaptation process. Therefore, government and decision-makers could benefit from the diagnosis to improve institutional blockages in managing water resources in Nigeria. The ensuing recommendations may enhance institutions' capacity to address CC effects on water resources and adaptation in Nigeria.

Data Management: To ensure wider coverage of rivers that are monitored in Nigeria, there is an urgent need for upgrading of existing equipments and procurement of more equipment for surface water monitoring such as river flow, water quality and groundwater level in Nigeria. Due to the increasing sediments on many rivers in Nigeria, there is a need for consistent measurement of bed loads and suspended loads transported by rivers in Nigeria. This could be carried out by the application of suspended and bed load samplers. Professionals also need to be trained to apply these types of equipment. To ensure data availability and distribution, there is a need to create an institutional mechanism to distribute and share hydrological data among different agencies and also to enhance institutional mechanisms that would aid mainstreaming assessment and evaluation.

Increased Awareness and Sensitization: To increase awareness of CC and adaptation, there is a need to regularly orientate and sensitize professionals in these institutions and decision makers on new dimensions of the CC issues. There is also a need for information and sensitization on hydrological evaluation so that the public would easily understand hydrological data and water level. There is also a need to enhance public awareness and participatory management of water resources through initiation of surveys across the country to acquire suggestions on water problems and establish a database. The creation of awareness and sensitization will trigger planning and community actions.

Availability of Legal, Regulatory, and Institutional Framework: Supportive framework that can enhance adaptation such as SEA should be made compulsory in the water sector and will be important in curtailing environmental degradation. The application of SEA should be enacted and passed as a law in Nigeria, such as in the case of Sri Lanka. SEA would enhance adaptation to CC effects on water resources in Nigeria. EIA, another form of environmental assessment, should also be made compulsory in evaluating all water projects and its results strictly applied and enforced. This will ensure environmentally friendly projects in settlements and cities. Moreover, the quick passage of the water resources bill into law by the legislative arm of the government will enhance adaptation to CC effects on water resources in Nigeria.

Availability of Fund and Political Will: There is a need to strengthen public-private partnerships through privatization of various water supply infrastructures, including irrigation and dam facilities currently owned by the governments. This will minimize the huge direct capital investment expended by the government. It is worth noting that privatization should be carried out because licenses could be revoked for the non-performance of investors. Likewise, there is a need for more government cooperation with international development partners to seek financial support to implement adaptation projects. It is suggested that the government organize regular donors' conferences and stakeholders' meetings. In addition, there is a need to adequately sensitize all lawmakers in the national assembly on the water resources bill and the emerging issues and encourage them to pass the bill into law.

The focus of this study is to identify institutional barriers that impede adaptation to CC effects on water resources in Nigeria; however, there is a need for more studies and research, especially as it pertains towards exploring in-depth solutions to these barriers. Finally, future research should direct

attention towards exploring the challenges faced by the communities affected by the impact of climate risk and come up with specific remediation.

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