

## Article

# Stakeholders' Perception of Climate Actions in Some Developing Economies

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**Abstract:** Resilience, adaptation and mitigation are unique but complimentary actions in the fight against climate change (CC), particularly in developing countries. Although evidence suggest the inclusion of stakeholder opinions as part of the frameworks for combating CC, this evidence is not well substantiated, and is not extensively described in sub-Sahara African CC literature. While language remains a big issue in CC discussions, processes comprised within climate actions are equally as important as both the language and the results. It is on the basis of the confusion surrounding the language adopted as actions geared towards combating CC that this study seeks to examine the opinions/perception of CC actors in three West African nations. It looks at perceived and/or suitable solutions to selected CC-imposed challenges in the midst of socio-economic and environmental concerns. A total of 475 individuals, representing NGOs, public and private organizations involved with CC issues, as well as private persons concerned about CC, were recruited across Nigeria, Niger, and Benin, over a two-year period (April 2017–April 2019). A questionnaire containing 15 items was administered. The results of data analysis using chi-square and Fischer's exact tests show that the mean number of CC actors differs within and across all three countries for all climate action types against CC-imposed challenges. While CC adaptive plans and projects are thought to yield immediate results, they are also observed to be cheaper in comparison to mitigation and resilience projects.

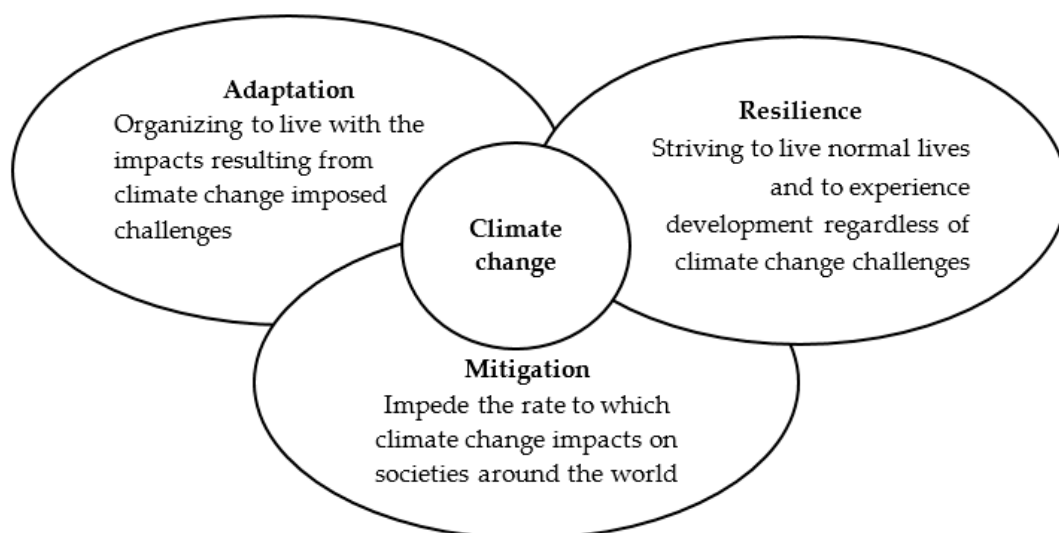
**Keywords:** developing economies; climate actions; adaptation; mitigation; resilience; climate change

## 1. Introduction

Several documented studies have suggested participation in the fight against climate change (CC) by CC actors, advocates, experts, activists, individuals from civil right groups involved in climate change (CC) activities, representatives of non-governmental organizations (NGOs) concerned with CC issues, and concerned individuals across the world [1–3]. Although this is a common practice in many regions today, there is more to be done with respect to this issue in sub-Saharan Africa. While these stakeholder groups may not present us with scientific proofs on the need to cut carbon emissions, they are sometimes closer to the places where the impacts of climate change are greatly felt [4]. This ultimately equips them with vital information on climate change actions that could have long-lasting results, and thus warrants more studies into the perception of CC actors around the world.

The United Nation Framework Convention on Climate Change's (UNFCCC) 23rd Conference of the Parties (COP) organized by Fiji, and held 6–17 November 2017 in Bonn, Germany, identified resilience, adaptation, and mitigation as the three pillars to humankind's response to CC [5]. These terms have

attracted wide discourse amongst CC researchers and stakeholders alike. Although all three terms aim at combating abrupt changes in climate, approaches adopted differ significantly from one to another. In a report published by the Center for International Forestry Research (CIFOR) [6], it was explained that CC adaptive measures are often segmented (i.e., appearing to focus on many small-scale projects across several sectors of a nation's economy), and are designed to be effective on local and regional scales. On the other hand, mitigation in developing countries is mostly implemented through planned long term projects, while developed nations have emission control measures in place to manage carbon emissions in the midst of economic growth [3,4]. These differences in approach indicate how the actions impact different sectors. As noted by Tol [7], embarking on CC mitigation projects, such as building carbon sinks, can be too costly for poor countries. In comparison, small-scale adaptation projects that are easy to implement only have a minor impact on a nation's spending power [8]. The third pillar to fighting CC, resilience, differs slightly from mitigation and adaptation. Figure 1 briefly describes specific details of each of the terms. Although the comparison of the pillars of CC may be an interesting part of the fight to contain the impacts of CC, only a few authors have comprehensively compared the terms [1,2,5–7]. It is on this premise that the present study aims at examining the priorities of CC actors with respect to adaptation, mitigation and resilience, by seeking to know their preferred choices in terms of actions/plans to combat flooding, drought, massive rural-urban migration, rising sea levels, increase in aeroallergen levels, etc., among other challenges imposed by CC in some low-income and low-middle income countries of West Africa.



**Figure 1.** Three pillars of our warming climate (modified from 23rd Conference of the Parties (CoP) of the United Nation Framework Convention on Climate Change (UNFCCC) [5]).

Given the urgent need for concerted efforts toward achieving pre-industrial global temperatures, the main question raised by this study is; what are the opinions/perception of CC actors in three West African nations on perceived suitable solution to selected CC-imposed challenges, in the midst of socio-economic and environmental concerns? This study therefore tries to explore how CC actors in some developing countries are striving to combat the global challenges created by CC through perceived prioritized actions using the pillars of CC. As a contribution, this line of research is particularly useful for the design of plans and projects that could help combat CC in areas that may presumably suffer the most from the impacts of CC [9]. Furthermore, a number of existing reports have stressed the need for localized actions to boost the fight against CC. However, these actions must be championed by specific social units which are sometimes absent in developing countries. As such, research that seeks the ideas of CC actors will contribute to giving direction to grassroots contributions to the fight against CC. The influence of CC actors in combating CC in developing countries cannot be under-estimated.

This is due to that fact that while these countries battle socio-economic woes and prioritize getting out of economic hardship, some individuals still take steps to protect the environment.

The rest of this paper is organized as follows; details of some of the challenges imposed by CC in selected countries are described in Section 2, with brief discussion on what mitigation, adaptation and resilience entail. This section also stresses the CC situation in Nigeria, Benin, and Niger, which are highlighted as study cases. Section 3 describes the methodology used to depict the combined perception of some CC-imposed challenges by recruited CC actors. In Section 4, gathered data are interpreted and discussed to gain insights on the situation. Section 5 draws conclusions on mitigation, adaptation, and resilience measures in relation to the challenges posed by flooding, drought, massive rural-urban migration, rising sea levels, increase in aeroallergen levels in the selected West African nations. The section also outlines recommendations for future work.

## 2. Impacts of Climate Change in Sub-Saharan Africa

It has been largely predicted that the impact of CC will be strongly felt in many ways throughout sub-Saharan Africa [10]. This reality is catching up with the region, with CC projections for Africa linked to a continuous warm trend. This situation is even more pronounced in inland areas, with regular episodic events of extreme heat, and rainfall changes—predicted to decrease in the South and increase in the East [11]. Outbreak of diseases and vulnerability of rain-fed agricultural systems is currently being witnessed, negatively impacting availability of food and livelihood [12].

The incidence of gully erosion in sub-Saharan Africa has been largely documented in the literature, with causes varying from CC to unstable soils, land clearing and degradation among others. Rowntree and Foster [13] reported that the age-long concerns surrounding degradation of land surface in some parts of South Africa has forced farmer to relocate to areas where they can cultivate crops. According to Boardman and Foster [14], it is difficult to separate the role of climate change from the land degradation process. Therefore, rather than focusing on guiding against gully erosion, it would be more reasonable to tackle CC. The eastern part of Nigeria is also known to suffer tremendously from gully erosion. This has been mostly triggered by human activities in areas like Anambra State [15]. Akanwa [16] explained that farmers in some parts of Anambra face a hard time during the planting season, as they have to travel to neighboring towns in search of suitable farmlands.

Increased rural–urban migration is another CC-driven challenge in Africa today [11,17]. Barr This research received no external funding ios et al. [11] explained that long-term CC scenarios which serve as pointers to extreme variations in climate, particularly water shortages, tend to disrupt human settlements, causing dwellers to move to areas (mostly urban centres) where the provision of water is certain. Nicholson [18,19] stressed that rainfall in Africa has witnessed a decline after reaching its peak around the early 1960s. Low rainfall events has negatively influenced agricultural production (especially the types that require rainfall for increased productivity) in rural areas, where the cultivation of crops is a major occupation. This situation potentially fuels migration from rural to urban areas. While CC may not be the main cause of such migration (with the exception of flooding and drought events), it has the potential of exacerbating already difficult living conditions in many rural settings [11]. By studying how the availability of water and security conditions influence migration from rural to urban areas in Kenya, Niger and Democratic Republic of Congo, Hassan and Tularam [17] observed a rapid urbanization situation in Niger and Kenya, where internal freshwater resources have now reached water scarcity levels. The study further revealed increasing temperatures in the three countries, a situation that may hinder access to clean water by rural dwellers, eventually leading to urban migration.

Erosion-prone lands may not be able to support the cultivation of crops [20]. Even when there are lands that are able to support cultivation, rainfall variations and increasing temperatures are other reasons that discourage farming in some sub-Saharan African nations [21,22]. This situation may lead to low farming output, and ultimately to food shortages.

Given the huge dependence on importation of goods to Africa, conventional small-scale production using non-renewable energy sources is on the rise [23]. The intensity of such small-scale production activities further increases the carbon concentration in the atmosphere [24], which in turn leads to the release of some forms aero-allergenic substances [25]. These substances are capable of causing diseases such as asthma [26]. Beggs [27] noted that abrupt changes in climate is able to trigger the presence and retention of aeroallergen such as pollen within the atmosphere. While there are few potential adaptive measures in place, activities such as aeroallergen monitoring, aeroallergen forecasting, and allergenic plant management, among others [27], are yet to attain full establishment in Africa [28]. In South Africa, Berman [29] reported that pollen mapping research has identified some pollen types linked to the vegetation and climate of the country. Vegetation and climate are part of the ecological make-up that may be negatively affected by CC.

Drought is another notable impact of CC in some parts Africa. Ghebregabher, Yang, and Yang [30] studied the relationship between CC and drought using temperature and precipitation data from Kenya, Djibouti, Ethiopia, Eritrea and Somalia. It was observed that for more than 80 years, CC has resulted in mild drought in these countries, causing farmers to opt for dry resistance, and genetically modified crops that can withstand lengthy days with little or no water. In South Africa, [31] explained that drought is the result of the relationship between physical factors such as the influence of the El Nino, the temperature of the surface of the sea, upper atmospheric waves' influence and the positioning of bands of cloud. Drought directly affects crop production on the African continent, so that countries who have yet to invest in CC research in relation to drought management may face serious food shortages, exacerbated by rising temperatures.

Beyond the forgone examples of CC impacts in sub-Saharan Africa, there are other challenges faced by developing countries in relation to climate change. These challenges require urgent action using the pillars of CC. While there are efforts to make progress in the processes and programs aimed at combating CC, it is important to note that CC discussions are often characterized by a general confusion of terms amongst stakeholders and researchers. Many climate change agents use adaptation and mitigation interchangeably; likewise, some alternate resilience with adaptation. While the latter comparison may be partially accepted, the former can be termed incorrect, specifically as a result of the operational scale of both terms. According to Huq [32], in high-level UNFCCC meetings, adaptation is the accepted word as it directly implies what all parties agree to understand as efforts geared toward reducing the impacts of CC. Not very many researchers have used the word “resilience”, as it is seen as the least common of the CC pillars, especially in relation to Africa [22,23]. The implication is that scientists, in their bid to be precise and not cause a confusion in the use of both terms, have mostly adopted adaptation. Within public domains, which include government dealings in developmental projects, Saleemul Huq, the head of an international CC and Development Centre in Bangladesh, explained that resilience is preferred [32]. The discourse on resilience and adaptation is wide, but often possesses contextual differences, especially as both are similar in definition. Mitigation is the only pillar that is distinctive in every aspect to the other terms [33,34]. While language remains a big issue surrounding the CC discourse [25–27], processes comprised within these actions are equally as important [28,29] as both the language and the results. On the basis of the confusion surrounding the language adopted as actions geared towards combating CC, the subsequent sections look at some of these actions with the objective of clarifying their meanings, and employing them to combat the challenges posed by climate change in Africa as a whole, and West Africa in particular.

### *2.1. Adapting to Climate Change*

Climate change is a serious threat and a reality we must all face, implying that humankind must live with the effects [35–38]. Deciding to live with these changes means that individuals, groups, and governments must develop strategies that will help communities respond positively to its impacts [39]. This can be achieved through the building of adaptive capacities throughout areas known to suffer from the CC-imposed challenges, especially in Africa.

In some parts of Africa (e.g., Niger), food shortage have recently emanated from the incidence of drought, and hence, an adaptive capacity would be to look at alternative sources of food production [10,31]. As such, the Food and Agriculture Organization of the United Nation proposed a newer set of adaptation practices in the realm of water and land management, where the test for effectiveness can first be carried out over a period of time, prior to potential scaling up of such practices [40].

In Ethiopia, Gashaw [41] explained that rainfall variation periods resulted in drought which affected farming activities in some rural areas. As a result, the World Bank recorded a reduction in the country's gross domestic product (GDP) by approximately 6% as of 2015, and this is projected to reach 10% by 2045 [42]. Ethiopia, in response to the situation, has empowered farmers to understand the impacts of CC through educational training and workshops [43]. This has improved the knowledge of many rural farmers, who now have a good understanding of climate variability, with over 80% adapting to the situation by practicing mixed cropping, and carefully monitoring and adjusting to new planting dates [43].

In Mozambique, Artur and Hilhorst [44] documented flood response practices as CC adaptation drive. The authors tried to build on the idea that the success of CC adaptation programs is a function of institutional frameworks and societal perceptions. As such, the study found that flood responses are a part of the so-called cultural, political and social processes which mainly have negative impacts on social ordering [44].

Ghana's farming population, particularly women farmers, have developed means of reducing the risk of CC on farming [45]. According to Ehiakpor [46], the strategies adopted include mixed cropping, inter-cropping and careful monitoring of planting seasons. These farming systems have received a boost with the adoption of the National Adaptation Strategy, a program through which government is able to provide seedlings at reduced rates, and also award grants/credit facilities to farmers.

In the Central African Republic, Brown et al. [47] reported that adaptive capacities, though present, are at the earliest phase, given many years of national conflict. Nevertheless, the authors noted that the awareness of CC is undoubtedly high, especially as it is seen to affect subsistent farming, which is popular in the war-torn nation. In-country adaptation programs such as "National Adaptation Programme of Action", and the "Reducing Emissions from Deforestation and Forest Degradation" have been useful in developing networking ties among stakeholders. These ties, as reported by Africa's Adaptation Gap Report [48], may be useful in building lasting peace in the country.

## 2.2. Mitigating Climate Change

Mitigation has been described as all activities and efforts directed at reducing emission of greenhouse gases [49]. The Intergovernmental Panel for Climate Change explains CC mitigation as a reduction in the flow of gases that trap atmospheric heat, or a further improvement of "sinks" that are able to hold on to these gases. A crucial goal of CC mitigation is to lower how humans interfere with the climate [50]. This can be achieved by maintaining a certain low level of GHG emissions, so that it allows the ecosystem to get used to changes in the climate [8].

As 2030 approaches, nations are continually faced with the challenges of reducing global greenhouse gas (GHG) emissions by 40%, a step in achieving an objective of the Paris Agreement [5]. Nationally determined contributions (NDC) are crucial mitigation measures that encompass all other forms, so countries must join in the fight against CC [51]. This commitment will not completely prevent CC, but will reduce the warming rate of the planet. A major aspect of mitigating climate change is developing action plans to reduce the extent of possible damage [52]. Hence, Tubiello [53] stressed that mitigation actions cover the conscious reduction in human-made emissions and the establishment of carbon sinks for limiting climate-induced damages on a long-term basis. Stringent legal and institutional mechanisms remain the foundation of mitigation plans [54]. In South Africa, for instance, the enactment of strong legal frameworks to support the process of CC mitigation has produced tremendous success. In many countries, the government is responsible for taking steps against the inaction of large-scale industries toward environmental protection [54]. Industries whose activities are



not completely green sometimes do not care much about the consequences of their actions [55]. This is particularly common in developing countries, where industries often need government policies to check their activities [56]. These policies must be rigid enough to hold industries responsible for their actions, thus reducing how susceptible the environment is to CC [55].

According to Nyiwul [57], when good institutional structures are lacking, accessing the benefits accruable from CC mitigation plans becomes difficult. The implication of this situation includes poor funding, lack of technological innovations, and insufficient capacity development programs, amongst others. A major setback to CC mitigation discussions in Africa was explained by Nelson in *Global Environmental Politics* [58]. Nelson [58] identified a lack of common position and plans by top African nations as some of the main challenges. Since most of these so-called “giants” of Africa differ significantly in opinions relating to the manufacturing and usage of energy, progress has been slow in relation to CC mitigation. This difference in opinions has resulted in African nations caring less about the prospects of mitigation [58]. As such, better representation of the continent by its superpowers in relation to CC mitigation projects is required.

### 2.3. Building CC Resilience

CC resilience refers to a set activities aimed at absorbing CC impacts in the presence of continuous progress [59]. This is the third pillar of climate change [5]. Just as adaptation and mitigation are used closely, resilience and vulnerability are also linked. A socio-ecological system’s capacity to effectively bear stresses without losing its key functions and structure is termed resilience [60], whereas, the extent to which a socio-ecological system is affected by the impacts of a changing climate, including climate extremes and variations in the average climatic statistics across various scales, is vulnerability [60]. It is also referred to as a function of the overall behavioral rate of CC, in addition to exposure level, and socioecological system’s sensitivity and adaptive capacity [60].

The World Bank [61] reported that about USD 17 billion has so far been invested into resilience projects under the African Climate Business Plan (ACBP). Recent flooding episodes in Kenya led to serious environmental issues, causing the loss of valuable properties. Intervention funds as provided by the World Bank in the wake of the crises and to guide against similar future occurrence were estimated at around USD 200 million [61]. Such financial commitment is helping many countries regain balance and to build better environmental and social preparatory structures against CC.

In Botswana, the incidence of drought has caused water shortages, a key source of CC vulnerability in the country [62]. This situation is putting pressure on the country’s water resources, as the rate of ground water harvesting has since tripled. Nevertheless, given the nation’s economic stability, several CC resilience projects have been set up by the water resources department to provide alternative sources of water for agriculture and domestic uses. As reported by Crawford [62], a prolonged decrease in precipitation is predicted within the next decades, implying that more resilience measures must be put in place to arrest the situation.

### 2.4. Study Area

Niger is a landlocked country that lies in the Sahelian region of West Africa and is mostly covered by desert. The country has a land area of about 1,267,000 km<sup>2</sup> and approximately 19.3 million inhabitants, with annual projected population growth of 3.9% [63]. As of 2015, its GDP was estimated at USD 6.3 billion [63]. The unemployment rate is also very high, at 80%, with many persons involved in agro-pastoral agriculture [63]. Niger is one of the largest uranium producers worldwide [64] and one of the Africa’s poorest nations [65]. The majority of land surface areas being desert further aggravates the effects of CC in terms of resilience and adaptation. Drought has led to very poor agricultural output, a situation that is fast becoming a food shortage crisis [66]. A recent intervention by the United Nations Development Program (UNDP) in collaboration with Canada and Niger’s Institute of Agricultural Research (INRAN) gave rise to the development of agricultural seedlings, able to withstand drought and provide double to triple yields in one season [66]. As part of the program, purchases made by

animal farmers are subsidized so that they can manage a small number of sheep herds that can later be resold.

In 2013, a World Bank report showed that Niger may experience serious food insecurity in the coming years unless it is able to effectively management climate-imposed risks [67]. A critical look at Niger's position on the Global Risk Index also showed that the country is lagging behind, implying that much remains to be achieved, especially given that the index is calculated based on relevant indicators such as economy and population. A rank of 15 out of 185 with a risk score of 26.50 indicates that Niger is seriously at risk [68]. Given the current situation, the government, with the help of international organizations, are developing strategies to ensure that the impacts of CC are carefully managed. In 2011, the government of Niger introduced the 3N initiative to manage agricultural resilience, and also combat food shortages caused by drought in the country. Also known as "Nigeriens feed Nigeriens", the initiative, in collaboration with the World Bank, remains very active. As noted by the African Development Bank (AfDB), Niger has received over USD 350 million, which has mostly been pumped into boosting agricultural production since the beginning of 1980 [69].

Nigeria is the most populated nation in the whole of Africa (195,874,740 persons as of 2018) [70,71]. The country also boasts Africa's strongest economy, slightly above South Africa in the 2018 ranking. With respect to CO<sub>2</sub> emissions, Nigeria currently contributes about 0.546 metric tons of CO<sub>2</sub> per capita [42,70]. The country is located at the innermost corner of the Atlantic Ocean, sharing borders with Benin (westward), Niger Republic (northward), the Atlantic Ocean (southward), as well as Cameroon and Chad (eastward). Nigeria is an oil-rich nation, implying high emissions from fossil fuel processing. Its land area is approximately 923,768 km<sup>2</sup>, with Lagos being one of the smallest cities but the most commercialized and the most populated in Africa. Nigeria's CC issue is well-documented, with several studies showing how climate change is affecting its different developmental aspects, such as the environment [72–74], economy, agriculture [75–77], and business.

Unlike many other developing economies, technology transfer, which is the management of all kinds of technology-driven ideas, is gradually finding a place in Nigeria [78]. This implies that the country is receiving support in its climate fight, offering further improvement in CC resilience, mitigation, and adaption measures. The exchange of climate technologies with developed countries has fostered development in the fight against CC. Nigeria's Vision 20:2020 was initially set to meet specific development targets. CC, however, disrupted several plans, affecting agriculture yield drastically with a marked decrease in precipitation [75].

To understand the challenges to CC adaptation in the cultivation and distribution of food crops in Nigeria, Otitoju and Enete [77] used principal component analysis to evaluate the situation. It was observed that major constraints to improving adaptation measures in Nigeria include the high cost of agricultural tools and implements and ineffective strategies within agricultural programs. Within the Nigerian environment, flooding, such as the one that occurred in 2012 which killed over 400 persons, is still common [42]. As the temperature across Nigeria is predicted to reach higher values by 2050 [79], the country has implemented mechanisms to ensure safer communities. With the low-carbon report, Cervigni and Rogers [80] noted that partnership activities with organizations such as the UN, WHO, and World Bank will help boost plans for climate-resilient communities in Nigeria.

One of these activities was the Country Partnership Strategy (CPS), which ran from 2010 to 2013 in partnership with the World Bank. The project aimed to reduce emissions of carbon within the country and produced tremendous success. The CPS has since birthed other rewarding programs.

In combating gully erosion, which is another challenge caused by CC, the federal government of Nigeria initiated the Nigerian Erosion and Watershed Management Project (NEWMAP) [81], again in collaboration with the World Bank. The project has seen several re-construction projects in many areas that had earlier been destroyed by erosion. Some of the most significant efforts within recent years include the ratification of the Paris Agreement signed in 2017 [82] and the release of green bonds. These programs place Nigeria as one of the earliest nations to adopt climate bonding as a tool to mitigate CC [83].

Benin, the final case within the current study, is located between Nigeria and Togo, and shares land borders with Burkina Faso and Niger (to the north), Nigeria (to the west), Togo (to the east) and the Atlantic Ocean to the south. The country is one of the many former French colonies in Africa, with an estimated population of 11,485,048 inhabitants as of 2018 [84]. GDP is estimated at USD \$10.359 billion, CO<sub>2</sub> emissions reached 0.614 metric tonnes per capita in 2014, with the country already witnessing several climate-change-induced environmental challenges [84]. Benin covers an area of 114,763 km<sup>2</sup>, with agriculture being the most common occupation [85]. Although Benin remains one of the most proactive West African nations in terms of the enactment of laws to guide against the impact of CC [85], the country continues to face some challenges related to the impacts of CC. Cotonou (one of its major cities) lying on the coast increases its susceptibility to coastal erosion, caused by the rising sea level [86]. Flooding is also a common hazard due to CC in the country, mainly occurring after heavy rainfall events [87]. These impacts culminate into threatening economic activities within the country [86]. In mid-2018, Benin's parliament passed into law, a bill aimed at managing, preventing, and protecting the environment from the impacts of the global rise in temperature. This has so far helped the government to prioritize effective response to CC impacts, through the adoption of adaptive and mitigation measures, and setting socio-economic developmental goals to curb energy and security challenges, with provisions of the United Nations (UN) and Intergovernmental Panel on Climate Change (IPCC), respectively [85].

In the midst of its struggle for growth, Oyerinde et al. [88] noted that Benin, in the last 30 years, has witnessed cases of severe drought and a continued increase in population, both leading to excessive water usage, and impacting river basins in the West African nation. Studies have also shown that drought and variation in monsoon precipitation levels within the sub-Saharan region has resulted in low agricultural yield, with predicted further decreases within the next three decades [89,90]. This situation further exacerbates existing CC-imposed challenges to a region already on CC red-alert. Whereas West African climate models have hugely succeeded in accurate simulation and prediction of CC in the region [91–95], most of the studies constructing regional CC models have often adopted unique pathways to emission collation along historical domains. Some of the models focus on how precipitation and heat intensity change over time, without references to other crucial variables that may be useful for effective prediction [96,97]. Given the country's position on the list of countries that may be impacted the most by CC-related disasters, several efforts are underway to combat CC issues. For instance, in 2008, the country adopted the National Adaptation Program of Action (NAPA) to increase its adaptive capacity in line with the Paris Agreement. Several other actions (Table 1) have been taken in the fight against CC. In calculating the risk indices using a number of factors, Eckstein et al. [68] explained that Benin ranked 150 in 185 countries analyzed. This rank was derived from an index score of 135.67, which was mainly calculated using fatalities and GDP. Even though several CC challenges exist across Africa, many corresponding initiatives are ongoing for the continued fight against CC. Table 1 summarizes some of the actions and plans in Nigeria, Niger, and Benin Republic.



**Table 1.** Some climate actions in the selected countries in collaboration with international organizations.

| Country                    | Benin   | Nigeria  | Niger  |
|----------------------------|---|--|--|
| <b>Adaptation Projects</b> | (1) Benin National Adaptation Programme of Action in 2008<br>(2) The Adaptation Partnership (with United States Agency for International Development (USAID) Benin 2025,<br>(3) Agreement on Sustainable Development (ASD)<br>(4) National Biodiversity Strategy and Action of 2002,<br>(5) National Action Programme of 2000<br>(6) Project 2Scale (completed in 2017)<br>(7) Adapting agriculture to climate change | (1) National Adaptation Strategy and Plan of Action for Climate Change Nigeria (NASPA-CCN)<br>(2) Development of strategic and sustainable climate change and environmental advocacy program<br>(3) Development of national framework for ecosystem-based adaptation<br>(4) Development of toolkit for the establishment and capacity development of climate change desks/units in state ministries of environment and relevant ministries, departments, and agencies (MDAs)<br>(5) Development of a Climate Public Expenditure and Institution Review (CPEIR) | (1) Niger National Adaptation Programme of Action in 2006<br>(2) African Climate Change Adaptation Programme<br>(3) Community-Based Adaptation (CBA) project<br>(4) Food Security Support Project in the Maradi region<br>(5) Program for Integrated Development and Adaptation to Climate Change in the Niger Basin |
| <b>Mitigation Action</b>   | (1) Integrated adaptation program to combat the effects of climate change on agricultural production and food security  | (1) Nigeria Climate Change Policy Response and Strategy (NCCPSC, 2012)<br>(2) Reduce emissions from deforestation and forest degradation (REDD+)<br>(3) Clean Development Mechanism (CDM)<br>(4) Issuance of ₦10.69 billion (USD \$29.4 million) green bonds in 2017<br>(5) Issuance of ₦15 billion (USD \$41.6 million) green bonds in 2019   | -  |
| <b>Resilience Actions</b>  | Strengthening the resilience of rural livelihoods and sub-national government system to climate risks and variability in Benin 2018   | Nigeria Erosion and Watershed Management Project (NEWMAP)  | Resilience project 2010, The Strategic Programme for Climate Resilience (PSRC)   |
| <b>Other Actions</b>       | (1) Ratification of Kyoto Protocol in 2002; amended in 2018<br>(2) Ratifying Paris Agreement in 2017  | (1) Ratifying Kyoto Protocol in 2004<br>(2) Ratifying Paris Agreement in 2017  | (1) Ratification and amendment of Kyoto Protocol in 2004 and 2018, respectively<br>(2) Ratifying Paris Agreement in 2016   |

Ackerman [98] explained that available funding for climate impact management under the partnership of the UNFCCC and Kyoto Protocol is below USD 10 billion annually, with most of this funding made available through the so-called Clean Development Mechanism (CDM). Similarly, there is an annual funding pledge of USD 100 billion by the Paris agreement signatories [99]. Undoubtedly, finance is at the center of the climate fight, contributing to efforts that cover capacity building [100], and the transfer of knowledge/technology as related to all climate actions [101]. Nevertheless, Kono and Montinola [99] noted that research on climate aid has raised several questions. In fact, researchers like Qian [102] doubted whether financial aid from foreign partners is effective, while Kono [99] argued that aid is ineffective, but noted that changes in data related to climate policies could lead to a different research outcome. In contrast, Barnett [103] observed that well-designed foreign aid programs did help improve policy framework in Niue

In Nigeria, Abraham [104] stressed that funding will lead to a reduction in the effect of post-harvest losses. As reported by Nzeadibe [105], indigenous innovations may be improved with access to well-planned and effectively expended funding. Furthermore, malnutrition, Niger's most severe challenge, resulting from low crop yield, can be curbed with properly channeled foreign aid [69]. The same is the case of flooding in Benin [85]. Across Africa, the African Development Bank (AfDB) [106] explained that climate funding can help in the improvement of energy generation, creation of smart cities, adoption of agricultural systems that are climate-resilient, and upscaling forest financing, among other things. While third party aid may have a positive influence in the fight against CC, Moyo [107] in a Wall Street journal publication explained that corruption continues to hurt the ultimate goal of this aid.

### 2.5. Hypothesis Development

Given the forgone information on the challenges imposed by climate change in sub-Saharan Africa, and all efforts geared toward reducing CC impacts through the adoption of adaptation, resilience and mitigation procedures. This study seeks to verify the best perceived solution through the lenses of climate change actors. As a result, the following hypotheses are put forward for verification in Nigeria, Niger and Benin respectively.

- $H_{01}$ : Mean number of CC actors is the same in Nigeria for all climate actions types against CC-imposed challenges.
- $H_{02}$ : Mean number of CC actors is the same in Niger for all climate actions types against CC-imposed challenges.
- $H_{03}$ : Mean number of CC actors is the same in Benin for all climate actions types against CC-imposed challenges.
- $H_{04}$ : Mean number of CC actors is the same in Nigeria, Niger and Benin, for all climate actions types against CC-imposed challenges.

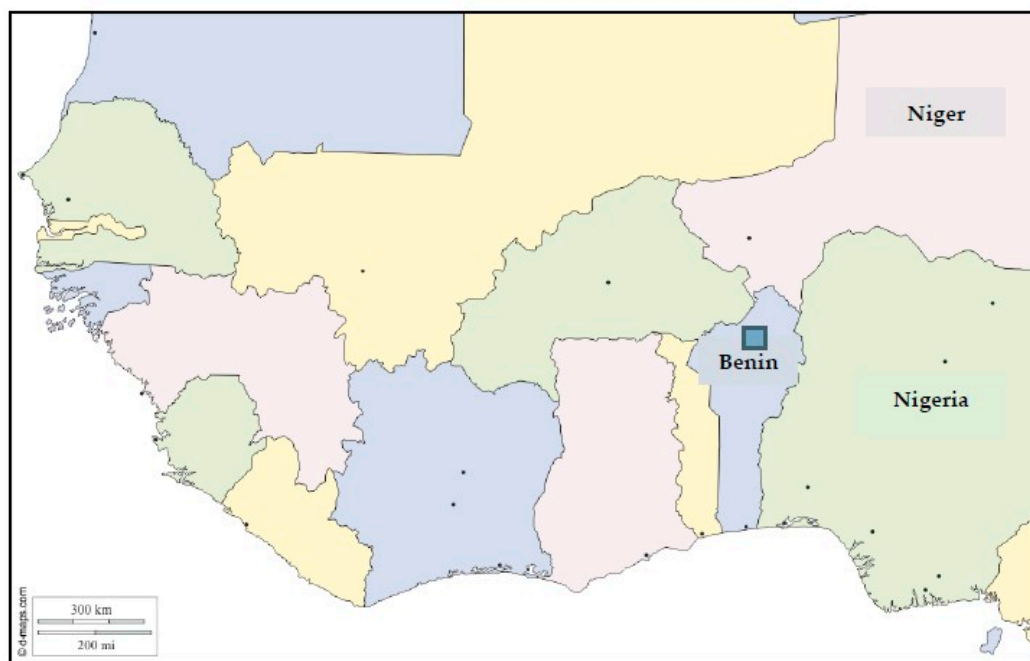
## 3. Method

The rate of warming in and around West Africa is ahead of the global average [91], a pattern that may not slow down in the coming years, except there are serious commitments to combating CC. The Sahel has also been projected to reach its highest temperatures [108]. As a result, this study aims at gathering the views of CC actors (advocates, experts, activists, representatives of government, climate change civil right groups, NGOs, and concerned individuals) across Nigeria, the Republic of Niger, and Benin, respectively.

### 3.1. Research Design

The current study adopts a case study method which comprises three unique cases from sub-Saharan Africa. The choice of study cases is partly because the current study is related to CC, whose impacts are believed to vary across countries and regions. As such, there is a general perception

that poorer countries may suffer more from CC impacts [4]. Hence, we set out to examine what CC actors view or perceive as the most appropriate actions to reduce the impacts of CC in their respective countries. A major reason for selecting the three countries is their proximity one to another (see Figure 2), which is useful for the ease of data gathering by the researchers, especially given the limited funding available to execute the research. Nigeria shares boundaries with Niger to the North, and with Benin to the South. Consideration was also given to the research time. Additional cases would probably attract a longer research time-length.



**Figure 2.** Map of West Africa showing study areas.

Furthermore, the selection of Nigeria stems from its huge hydrocarbon reserve which it continues to trade [109]. Hence, it would be interesting to know how the impact of CC is perceived in a country where fossil fuel trading is a major source of income. The selection of Niger within this study is mainly due to the country being one of the world's poorest nation with a fast-growing population projected to reach 50 million in the next thirty years [110]. This issue has raised concerns on how the growing population will cope with extreme poverty exacerbated by CC impacts [110,111]. For Benin, sea level rise has often times resulted in erosion of urban centers, and has led to the breakdown of economic activities at different times [112]. For a developing country, these disruptions in economic activities can affect economic prosperity amongst the citizens, and could be a pointer to the number of person living below the poverty line. It is on the above premises (environmental and socio-economic concerns) that the present study seeks to explore how CC actors in Nigeria, Niger, and Benin are working towards the challenges created by CC through perceived prioritized actions using the pillars of CC.

Purposive sampling ensured that only individual samples that fit into the study objectives were selected [113]. We targeted organizations interested in climate change research, discussions and issues in the three countries. Based on these selection criteria, questionnaires completed by persons who did not meet selection criteria were rejected. The study, which was initially planned to be a one-off data collection process, was further elaborated based on the request of approximately 46% of the first group of respondents across the different countries using the feedback form attached to the questionnaire. Further elaboration meant that questionnaires were sent to recruited participants every six months, starting from April 2017. The six-month interval was mainly because there were ongoing CC intervention projects in the different countries, which the researchers perceived could influence the results of the study. As such, there was a chance for the completion of some of the projects while data

gathering was ongoing. Overall, a total of 475 respondents participated, of which 205 were surveyed in Nigeria during the two-year period, 151 in Benin, and 119 from Niger. Since organization-specific emailing systems and social media handles were used to gather responses, only a single response was recorded per participant; as such, no participant was allowed to respond to the questions more than once.

Lastly, we used chi-square and Fischer tests to rank all three pillars of CC already described based on the perceived socio-economic situation and environmental needs in the countries. Respondents' perceived classification of specific climate challenges, and the interpretation of the most feasible solution formed responses to individual questions. The choice of chi-square and Fischer tests was to effectively compare responses across countries, and to identify the most significant, the most useful, or the most popular technique. Post hoc tests, as developed by [114], were employed for multiple results comparison.

### 3.2. Data Collection and Analytical Technique

We collected quantitative data in this study using a structured questionnaire. The questionnaire included 15 questions related to some of the most common and/or possible challenges posed by CC in a setting typical of a developing country. Crucial terms were defined according to the UNFCCC [59] (see Appendix A). The choice of the UNFCCC definition is partly due to the fact that the framework is a tool that helps to measure national progress in the CC fight using nationally determined contributions (NDC), and partly because the selected nations within the current study have all ratified the UN's Paris Agreement and Kyoto Protocol, respectively (Table 1). Furthermore, CC research in these countries is still in its growing phase. Respondents were asked to select what they feel is/are the best solutions/options, i.e., whether to adapt to the problem, mitigate it, or try to build resilience against the challenge. Respondents were pre-informed that choice selection should be based on the prevailing socio-economic conditions and the country's environmental needs. The options of choice are thus represented as; "adapt, mitigate, or be resilient". Since Niger and Benin are French-speaking nations, the questionnaire forms sent to respondents in these countries were translated to the countries' official language (French). The study population included various CC actors who are mainly concerned citizens, advocates, analysts, writers, CC monitoring groups, civil right groups, members of country-specific international CC organizations with offices, as well as government departmental representatives saddled with the responsibilities of monitoring and managing the effects of CC. The criteria for sample selection from the population include:

- (1) CC organizations or groups with tremendous and visible contributions within a country-specific environment;
- (2) CC actors who have created awareness in the selected countries for at least 2 years;
- (3) Social-media-based (internet) CC actors with at least one online climate awareness program, and individuals concerned about climate change who represent the citizen population in each of the countries

It was important to merge the number of respondents classified as internet-based CC commentators/advocates with those of concerned citizens. This is due to the observation that social media CC personalities provided the platform for concerned individuals to make their opinions known on many CC-imposed challenges. A link to the questionnaire was created using Google Forms (a product of Google LLC, Menlo Park, CA, USA), so that respondents could have access regardless of the country from which they were participating. A social media account was created by the researchers on Twitter, Facebook, and Instagram, the three most-popular social platforms in the three countries. This was important for easy distribution of the questionnaire to most of the internet-based CC actors/enthusiasts. A number of selected government parastatals, NGOs, and international organizations were informed prior to the data gathering procedure. As such, data from these sources were gathered through the central e-mail distribution network of individual organizations.

### 3.3. Ethical Considerations

Respondents provided informed consent before participating in the survey and prior to the inclusion of their opinions/responses for further analysis. Although this study is based on CC information, the researchers adopted guidelines of the Declaration of Helsinki [115], with protocols approved by the ethics committee of federal/national ministries of environment in all three countries (with project code CCR/XX017/084 for Nigeria; PCC0104-2017-01 for Benin; no unique codes for approval from authorities in Niger). Approval covered in-country ethical collection and the usage of CC-related data. Authorities in smaller agencies and organizations across the countries duly cross-checked the content of the questionnaire so as not to undermine guidelines governing the distribution of such research items within the organizations. In all cases, the researchers requested and were granted written approvals. For respondents with no affiliation, a clause of anonymity was attached to the form so that the individual could reserve the right to ignore the link and choose not to answer the questions, even after reading. All respondents were informed that data are needed for the purpose of research and policy improvement to further reduce the effects of CC impacts in the selected countries. The respondents did not need to input their names on the questionnaire forms, as only job classification information was useful.

## 4. Data Analysis

Figure 3 shows that within the first six months of data collection (April 2017–October 2017), 82 persons completed the questionnaire from Niger, more than in Benin (51) and Nigeria (77), respectively. However, this figure dropped drastically after the survey was completed, with Niger contributing the fewest respondents of all three countries across the entire survey period. Overall, 220 questionnaires were sent to respondents in each of the countries. A total of 151 respondents were surveyed in Benin (68% return rate), 119 in Niger (54% return rate), and 205 in Nigeria (93% return rate). In total, out of 660 questionnaires sent out across the three countries, 475 were duly completed and returned, accounting for 71.9% return rate. Tables A1–A3 (Appendix B) portray the breakdown of the survey results for Nigeria, Benin, and Niger, respectively. The tables provide the responses of CC actors in the different countries in terms of specific CC impacts and challenges.

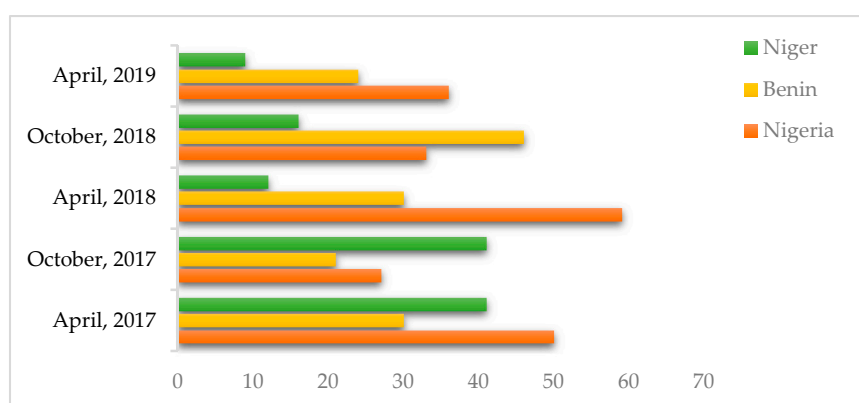


Figure 3. Number of respondents to CC challenges in the selected countries.

Figure A1 (Appendix C) gives the analysis of results gathered from Nigeria. For the first five months of the survey, all stakeholder groups were well represented. Initial responses were received from 12 government representatives, 11 persons representing civil right groups and international organizations, 9 individuals from NGOs and 7 internet-based climate change advocates/concerned individuals. There were no responses from government officials between 6 and 11 months. Similarly, no responses were recorded for civil right groups from the eighteenth month to the end of the survey. Overall, data gathered from Nigeria revealed that of the returned 205 questionnaires gathered



from Nigeria, 23.4% were found to have been completed by persons affiliated to international organizations, against the 16.0% completed by government representatives. In Niger, internet-based advocates/concerned citizens' accounted for the largest respondent group, accounting for 30.5% of the 118 eligible questionnaires. Similar to results from Nigeria, the percentage (11.8) of government representative who participated is quite low. Overall, 152 questionnaires were found eligible for further processing from data gathered from Benin. It was observed that members of civil right groups made up the largest respondents' fraction in this case (25.6%). Furthermore, data gathering periods from 18 months to the end of the survey recorded very low outcomes in Niger. During this time, only eight respondents provided answers to the questionnaire as compared to the 24 respondents in Benin (see Figures A2 and A3). Internet-based advocates/concerned citizens' account for the highest number of respondents' group, contributing 23.3% of data gathered across the three countries, while government representatives were the lowest group with 13.6% data contribution.

#### 4.1. Individual Results

Questionnaire items are denoted as "It1" to "It15". Tables 2–4 are the breakdown of responses provided by climate change actors in Nigeria, Benin and Niger, respectively.

**Table 2.** Responses from CC actors in Nigeria.

| Options    | It1 | It2 | It3 | It4 | It5 | It6 | It7 | It8 | It9 | It10 | It11 | It12 | It13 | It14 | It15 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| adapt      | 109 | 128 | 71  | 66  | 147 | 159 | 102 | 70  | 150 | 133  | 159  | 158  | 55   | 134  | 154  |
| mitigate   | 46  | 35  | 44  | 106 | 26  | 29  | 76  | 105 | 30  | 37   | 23   | 23   | 30   | 40   | 25   |
| resilience | 50  | 39  | 90  | 34  | 32  | 16  | 26  | 30  | 25  | 35   | 23   | 23   | 120  | 31   | 26   |

**Table 3.** Responses of CC actors in Benin.

| Options    | It1 | It2 | It3 | It4 | It5 | It6 | It7 | It8 | It9 | It10 | It11 | It12 | It13 | It14 | It15 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| adapt      | 95  | 94  | 61  | 34  | 107 | 116 | 63  | 37  | 83  | 94   | 103  | 114  | 31   | 94   | 107  |
| mitigate   | 26  | 34  | 25  | 88  | 28  | 25  | 58  | 80  | 34  | 34   | 28   | 11   | 22   | 34   | 20   |
| resilience | 30  | 23  | 63  | 29  | 16  | 10  | 30  | 34  | 33  | 23   | 20   | 26   | 98   | 23   | 24   |

**Table 4.** Responses of CC actors in Niger.

| Options    | It1 | It2 | It3 | It4 | It5 | It6 | It7 | It8 | It9 | It10 | It11 | It12 | It13 | It14 | It15 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Adapt      | 72  | 73  | 28  | 29  | 99  | 92  | 27  | 24  | 91  | 99   | 92   | 83   | 30   | 66   | 93   |
| Mitigate   | 19  | 24  | 29  | 55  | 12  | 18  | 72  | 80  | 4   | 7    | 8    | 18   | 17   | 18   | 12   |
| resilience | 28  | 22  | 62  | 35  | 8   | 9   | 20  | 15  | 24  | 13   | 21   | 18   | 72   | 35   | 14   |

Chi-square tests and the Fisher tests using R gave rise to the same results for all three countries

- Chi-square test:  $p < 0.0001$ .
- Fisher's exact test  $p$ -value = 0.0004998 (alternative hypothesis: two sided).

In Tables 5–10, expected counts and residuals are presented as calculated from the gathered data. Given that the  $p$ -value was found to be  $<0.05$  in all the countries, it was expedient to compare the interaction between individual items of the questionnaire. As a result, a post hoc test was adopted based on the ideas of Benjamini and Hochberg [114]. The post hoc test utilized the "fdr" adjustment, which manages the rate of false discovery, and not as stringent at the family-wise error rate. It was observed that in all the countries, comparison amongst questionnaire items was found to be significant.

**Table 5.** Expected counts of data for Nigeria.

|            | It1    | It2    | It3    | It4    | It5    | It6    | It7    | It8    | It9    | It10   | It11   | It12   | It13   | It14   | It15   |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Adapt      | 119.86 | 118.11 | 119.86 | 120.45 | 119.86 | 119.28 | 119.28 | 119.86 | 119.86 | 119.86 | 119.86 | 119.28 | 119.86 | 119.86 | 119.86 |
| Mitigate   | 45.07  | 44.41  | 45.07  | 45.29  | 45.07  | 44.85  | 44.85  | 45.07  | 45.07  | 45.07  | 45.07  | 44.85  | 45.07  | 45.07  | 45.07  |
| Resilience | 40.07  | 39.48  | 40.07  | 40.26  | 40.07  | 39.87  | 39.87  | 40.07  | 40.07  | 40.07  | 40.07  | 39.87  | 40.07  | 40.07  | 40.07  |

Table 6. Residuals of data for Nigeria.

|                   | It1   | It2   | It3   | It4   | It5   | It6   | It7   | It8   | It9   | It10 | It11  | It12  | It13  | It14  | It15  |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|
| <b>Adapt</b>      | −0.99 | 0.91  | −4.46 | −4.96 | 2.48  | 3.64  | −1.58 | −4.55 | 2.75  | 1.2  | 3.57  | 3.55  | −5.92 | 1.29  | 3.12  |
| <b>Mitigate</b>   | 0.14  | −1.41 | −0.16 | 9.02  | −2.84 | −2.37 | 4.65  | 8.93  | −2.25 | −1.2 | −3.29 | −3.26 | −2.25 | −0.76 | −2.99 |
| <b>Resilience</b> | 1.57  | −0.08 | 7.89  | −0.99 | −1.27 | −3.78 | 2.20  | −1.59 | −2.38 | −0.8 | −2.70 | −2.70 | 12.63 | −1.43 | −2.22 |

Table 7. Expected counts of data for Benin.

|                   | It1   | It2   | It3   | It4   | It5   | It6   | It7   | It8   | It9   | It10  | It11  | It12  | It13  | It14  | It15  |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Adapt</b>      | 82.31 | 82.31 | 81.22 | 82.31 | 82.31 | 82.31 | 82.31 | 82.31 | 81.76 | 82.31 | 82.31 | 82.31 | 82.31 | 82.31 | 82.31 |
| <b>Mitigate</b>   | 36.52 | 36.52 | 36.03 | 36.52 | 36.52 | 36.52 | 36.52 | 36.52 | 36.27 | 36.52 | 36.52 | 36.52 | 36.52 | 36.52 | 36.52 |
| <b>Resilience</b> | 32.18 | 32.18 | 31.75 | 32.18 | 32.18 | 32.18 | 32.18 | 32.18 | 31.96 | 32.18 | 32.18 | 32.18 | 32.18 | 32.18 | 32.18 |

Table 8. Residuals of data for Benin.

|                   | It1   | It2   | It3   | It4   | It5   | It6   | It7   | It8   | It9   | It10  | It11  | It12  | It13  | It14  | It15  |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Adapt</b>      | 1.40  | 1.29  | −2.24 | −5.32 | 2.72  | 3.71  | −2.13 | −4.99 | 0.14  | 1.29  | 2.28  | 3.49  | −5.66 | 1.29  | 2.72  |
| <b>Mitigate</b>   | −1.74 | −0.42 | −1.84 | 8.52  | −1.41 | −1.91 | 3.56  | 7.20  | −0.38 | −0.42 | −1.41 | −4.22 | −2.40 | −0.42 | −2.73 |
| <b>Resilience</b> | −0.38 | −1.62 | 5.55  | −0.56 | −2.85 | −3.91 | −0.38 | 0.32  | 0.18  | −1.62 | −2.15 | −1.09 | 11.60 | −1.62 | −1.44 |

Table 9. Expected counts of data for Niger.

|                   | It1   | It2   | It3   | It4   | It5   | It6   | It7   | It8   | It9   | It10  | It11  | It12  | It13  | It14  | It15  |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Adapt</b>      | 66.46 | 66.46 | 66.46 | 66.46 | 66.46 | 66.46 | 66.46 | 66.46 | 66.46 | 66.46 | 67.58 | 66.46 | 66.46 | 66.46 | 66.46 |
| <b>Mitigate</b>   | 26.17 | 26.17 | 26.17 | 26.17 | 26.17 | 26.17 | 26.17 | 26.17 | 26.17 | 26.17 | 26.61 | 26.17 | 26.17 | 26.17 | 26.17 |
| <b>Resilience</b> | 26.37 | 26.37 | 26.37 | 26.37 | 26.37 | 26.37 | 26.37 | 26.37 | 26.37 | 26.37 | 26.81 | 26.37 | 26.37 | 26.37 | 26.37 |

Table 10. Residuals of data for Niger.

|                   | It1   | It2   | It3   | It4   | It5   | It6   | It7   | It8   | It9   | It10  | It11  | It12  | It13  | It14  | It15  |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Adapt</b>      | 0.68  | 0.80  | −4.72 | −4.59 | 3.99  | 3.13  | −4.84 | −5.21 | 3.01  | 3.99  | 2.97  | 2.03  | −4.47 | −0.06 | 3.26  |
| <b>Mitigate</b>   | −1.40 | −0.42 | 0.55  | 5.64  | −2.77 | −1.60 | 8.96  | 10.52 | −4.33 | −3.75 | −3.61 | −1.60 | −1.79 | −1.60 | −2.77 |
| <b>Resilience</b> | 0.32  | −0.85 | 6.94  | 1.68  | −3.58 | −3.38 | −1.24 | −2.21 | −0.46 | −2.60 | −1.12 | −1.63 | 8.89  | 1.68  | −2.41 |

#### 4.2. Combined Results

Following the similar data arrangement as before, Table 11 shows data gathered across all three countries with respect to CC challenges. In Tables 12 and 13, data are re-arranged for ease of comparison

Table 11. Responses gathered across the three countries.

| Options           | Nigeria | Benin | Niger |
|-------------------|---------|-------|-------|
| <b>Adapt</b>      | 1795    | 1233  | 998   |
| <b>Mitigate</b>   | 675     | 547   | 393   |
| <b>Resilience</b> | 600     | 482   | 396   |

Table 12. Expected counts for combined data.

| Options           | Nigeria | Benin   | Niger   |
|-------------------|---------|---------|---------|
| <b>Adapt</b>      | 1736.17 | 1279.23 | 1010.60 |
| <b>Mitigate</b>   | 696.45  | 513.45  | 405.39  |
| <b>resilience</b> | 637.37  | 469.62  | 371.01  |

Table 13. Residuals for combined data.

| Options           | Nigeria | Benin | Niger |
|-------------------|---------|-------|-------|
| <b>Adapt</b>      | 1.41    | −1.29 | −0.40 |
| <b>Mitigate</b>   | −0.81   | 1.49  | −0.62 |
| <b>Resilience</b> | −1.48   | 0.57  | 1.30  |

By carrying out both the chi-square test and the Fisher tests on the combined data, the following results are obtained;

- Chi-square test:  $p < 0.021$
- Fisher's exact test  $p$ -value = 0.02399 (alternative hypothesis: two sided)

As before, chi-square and Fischer test values were found to be  $<0.05$ . As such, a post hoc test was done to check which countries show similarities or differences (Table 14). As before, the idea developed by Benjamini and Hochberg [114] was again adopted, with "fdr" adjustment. For the chi-square test results;  $X^2 = 11.295$ ,  $df = 4$ ,  $p$ -value = 0.02344.

**Table 14.** Comparing results across the three countries.

| Comparison     | p. Fischer | p.adj Fischer |
|----------------|------------|---------------|
| Nigeria: Benin | 0.0155     | 0.0465        |
| Nigeria: Niger | 0.0778     | 0.1170        |
| Benin: Niger   | 0.2570     | 0.2570        |

#### 4.3. Interpretation

The chi-square and Fischer tests'  $p$ -values of 0.0001 and 0.0004998 are both  $<0.05$ . As a result, hypotheses  $H_{01}$ ;  $H_{02}$ ;  $H_{03}$  are rejected and restated thus;

- $H_{01}$ : Mean number of CC actors is not the same in Nigeria for all climate actions types against CC-imposed challenges
- $H_{02}$ : Mean number of CC actors is not the same in Niger for all climate actions types against CC-imposed challenges
- $H_{03}$ : Mean number of CC actors is not the same in Benin for all climate actions types against CC-imposed challenges

For hypothesis  $H_{04}$ , which is the combined results for all three countries, the  $p$ -values of the chi-square and Fischer tests are respectively calculated as 0.021 and 0.02399. Both values are  $<0.05$ . Hence;

- $H_{04}$ : Mean number of CC actors is not the same in Nigeria, Niger and Benin, for all climate actions types against CC-imposed challenges

It is important to note that in country by country interpretation, responses across the different items of the question differ significantly from one to another. However, the combined interpretation of the data shows that only results from Benin and Nigeria differ (Table 14). By observing the data across rows and columns, adaptation seems a popular option in Nigeria. Nevertheless, for the challenges posed by low agricultural yields/food shortage (item 3) and outbreak of diseases (item 13), respondents opted for resilience. Mitigation was selected ahead of the other options for the problems of aeroallergen levels (item 4) and social conflicts (item 8). Similar to the selection in Nigeria, results show that Benin resilience was again the most preferred option for issues related to low agricultural yields/food shortage (item 3) and outbreak of diseases (item 13) respectively. Again, mitigation was preferred as the way to combat the challenges of aeroallergens, social conflicts, and disease outbreak. For rising sea levels, there seem to be a close preference for both mitigation and adaptation in Benin. In Niger, mitigation is clearly preferred for CC-imposed challenges such as rising sea level, aeroallergens, and social conflicts. In contrast, resilience is seen as the most suited action to combat.

## 5. Discussion

The questionnaire results show that adaptation is the favored method to address CC challenges within the context of this study. Although all three climate actions are important, the desire to build

adaptive capacities appears to be preferable amongst stakeholders in Nigeria, Benin, and Niger, mainly due to the socio-economic situations and environmental needs in the countries [116], and a possible lack of framework that could produce long-term mitigation plans. This causes mitigation projects to be seen as investments that are too expensive given the lack of financial strength of these three countries. From these results, we infer that some of the low-income and lower-middle income economies in West Africa may not have structures in place to push toward climate resilience and mitigation. Rather, they tend to embrace adaptation projects [117]. On a case-by-case basis, more funding appears to be available for adaptation projects within the three countries in comparison to mitigation and resilience projects [118]. The results of the questionnaire responses show that stakeholders in Nigeria think that increasing adaptive capacities to address issues, such as drought, is crucial to ensuring the continuous availability of food [119]. Drought, in the context of Nigeria, has been described as a climatological phenomenon [120], so several irrigation projects, which are mostly adaptation inclined, have been implemented. Similarly, coastal erosion is seen as one of the most visible impacts of CC in Benin [121]. Again, the results of this study show that stakeholders see adaptation as a tool to ward against flooding in cities like Cotonou. This is the result of the steps taken by the government to construct huge embankment in 2008, an adaptation project that cost about USD 4.4 million to complete [121]. Decreases in the amount of rainfall in Niger over long periods have resulted in drought, which in turn has caused prolonged food shortages in the country [122]. In the context of this study, stakeholders think that building resilience could be used to address this challenge. As reported by Bharwani [122], one of the CC resilience projects in the country is the cultivation of food crops that can thrive in areas prone to drought. CC resilience projects of this nature have mostly been funded by the World Bank.

Generally, resilience is better built alongside adaptation, mainly due to the cost involved in a typical CC resilience project, which are mostly similar to what is expended for adaptation projects. Having to adapt means living with the challenges. However, living with issues like drought will mean that communities have to look for alternative water sources, such as in the case of Nigeria, where irrigation projects have been embraced [119]. This may lead to migration to other areas and, putting pressure on the water resources in these new areas. Another possible reason for the popularity of adaptation is that all three countries have other national priorities at the moment, so that investing in mitigation, for instance, may be impossible. The popular belief in Nigeria is that other societal challenges are more pressing, such as the issue of Boko Haram's insurgence, so adapting to current CC-imposed challenges is the best option.

While adaptation may be popular for combating issues such as rural-urban migration, pressure on resources due to population increase, gully erosion, etc., respondents strongly believe that the only way out of specific problems such as the decrease in agricultural yields/food shortage, as well as outbreak of diseases exacerbated by CC, is to put in place climate-resilient structures and plans. The same is the case for social conflicts arising from shortage of resources in some parts of West Africa, as well as the release of aeroallergens from industrial processes, for which mitigation is strongly support in the three countries.

Developing countries are most vulnerable as far as CC impacts are concerned. This may be due to attention being mostly focused on adaptation, resulting in high vulnerability to the threat of CC in the countries surveyed [123]. Since adaptation is the method of choice, these nations may remain vulnerable to some of the challenges listed in Table 3, especially those that may be better resolved by mitigation and resilience projects. We used Tukey's comparison to understand specific differences between all three climate actions. We observed that stakeholders rated mitigation and resilience equally, as we found no significant difference in the comparison of the results generated from the choice of both actions.

By gathering the opinions of CC stakeholders in the selected countries, this study makes a case for the importance of datasets gathered from individuals on the field, who see CC from a non-scientific point of view. The information shared by this study can be useful in the design of programs aimed at

combating CC, not only in the countries surveyed, but in other low- and middle-income countries, especially within sub-Saharan Africa.

## 6. Conclusions

Due to the income level of many African countries, CC projects are sometimes carried out in partnership with third parties, who sometimes provide the funds for such projects. As a result, better and more effective plans are only guaranteed when developing countries establish and run their own initiatives that are rooted in their value systems. Although CC is seen as a global challenge, conscious efforts, actions, plans, and activities of several small groups are required to achieve the total reduction in its impacts. Whereas adaptation seems to be the dominant solution to a number of challenges as opined by stakeholders in Nigeria, Niger, and Benin, CC action plans are incomplete without mitigation and resilience projects in place [5], as seen in the cases of management of industrial release of aeroallergens, food shortages, social conflict, and outbreak of diseases. By focusing mainly on adaptation projects, Nigeria, Niger and Benin may not promptly reach their desired levels in the fight against CC. This is because certain environmental needs of the societies can only be met with CC mitigation and resilience projects in place. Poor socio-economic situation makes a case for the lack of sophisticated and up-to-date plans in the area of planned CC resilience and mitigation programs. Isolating and choosing to adhere only to the definition of CC adaptation as shown in Figure 1 would imply having an ineffective plan for combating the challenges posed by CC. This is because, typically, an effective global warming or CC framework has to combine activities relating to adaptation, mitigation, and resilience [6].

The aim of this study was to reveal the priorities of CC actors in developing countries, by comparing the meanings of the different climate actions; adaptation, mitigation and resilience. All three climate actions represent contrasting but complimentary ideas to climate change. For instance, most local and regional governments are already responding to localized effects of CC through adaptation; however, these local communities may not have the capacity to initiate mitigation as they first must be part of a well-organized global initiative. Only successful adaptation activities can encourage communities to engage in building resilience over time. Furthermore, the pace-setting features of developed countries for addressing the global reduction in GHG emissions are necessary for planned mitigation projects in developing countries. When the actions of developed nations cover all aspects of the climate action plans, developing countries in the world will have a blueprint to work with. Campbell-Lendrum and Corvalán [124] noted that low- and middle-income countries contribute much less to global GHG emission incidence. In contrast, per capita GHG emissions within the U.S. is six times higher than in China and approximately 20 times higher than in Africa [125]. This further stresses the responsibility level of developed countries.

### 6.1. Limitations and Future Work

While CC actions are generally perceived to be complimentary, there are several challenges related to the use of the terms [33,35]. Furthermore, the current study only considered definitions of the three pillars of CC as put forward by UNFCCC [59] to guide selection choices in relation to each of the listed CC challenges (see questionnaire), whereas there are other existing definitions of the terms. The responses are only based on environmental and socio-economic situations of the different countries, amidst other issues such as political challenges and war.

Based on the above limitations of this study, future research may consider an all-encompassing approach to seeking solutions to climate change challenges to ultimately reduce vulnerability. However, achieving this goal requires increased institutional capacities [126] that will address and manage the associated implications, costs, and risks. In addition, it would be useful to qualitatively study and explore people's understanding of the pillars of CC (adaptation, resilience and mitigation). This may also prove useful for design of programs aimed at combating CC in future. Further research considerations can also be given to definitions of adaptation, resilience and mitigation, outside the



description by the UNFCCC. This will show how research results differ. As a complementary work to the current study, it would be interesting to see the preferences in CC choices along professional lines only—for instance, the preferences of representatives of international organizations, in comparison to non-governmental organizations.

## 6.2. Policy Implications

While it looks promising that the opinions of CC actors (especially in developing countries) may be useful and gradually gain considerations, there is a need for continuous work to better harness these opinions. Based on the analysis of data gathered for this study, the following implications can be drawn;

1. Governments should begin to attach more importance, not only to scientific CC-related instructions, but also to activities and admonitions by local CC actors. This can be achieved through better management and control of the kind of information transmitted with respect to CC-related issues.
2. Climate change actors in developing societies need to understand that their positions remain sensitive in the fight against climate change; hence, information transmission of CC-related issues has to be practical and without bias.
3. While freedom of speech remains popular around the world, social advocates for CC must follow the path of dialogue in seeking practical solutions to CC-imposed challenges. Acts that can spur societal divisions and catalyze violent demonstrations should be shunned.
4. It may be useful to identify and encourage CC programs organized by some CC actors at local levels. Funding for such programs can be invaluable toward increased CC education.

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## Appendix A. Questionnaire

### Title: “Prioritized Climate Action”

#### Instruction

1. This form contains questions related to some known environmental challenges within West Africa. You are required to tick the most appropriate solution to combating these challenges, particularly as it relates to your understanding of the situation, i.e., the way the challenge affects your country, bearing in mind the socio-economic situation and environmental needs of the nation.
2. Please ensure you belong to at least one of the listed groups and country (these are mandatory prerequisites to participate). Should you not belong to any of the listed classifications, kindly return the form to the researcher.

Please tick (✓) appropriately

Classification: CC Actors

| S/N | Group  |
|-----|--|
| 1   | International organizations                                |
| 2   | Civil right group with focus on climate change             |
| 3   | Non-governmental organization with focus on climate change |
| 4   | Internet-based advocates/concerned citizens                |
| 5   | Government representatives                                 |

Location: Country

| S/N | Country |
|-----|---------|
| 1.  | Nigeria |
| 2.  | Niger   |
| 3.  | Benin   |

3. Please note there is no field for “name(s)”, as names are not required. Please DO NOT insert your name on any part of the form

4. Opinions herewith supplied are strictly for research purposes and will not be shared with a third party, sold or distributed for any other form of usage.

5. You are provided with three options, adaptation, mitigation, and resilience, as a response to each of the explained environmental challenges. To assist with your thought/understanding of the meanings of each of the terms, you are also provided with the following unified definitions of the terms as stated by the United Nations Framework Convention for Climate Change (UNFCCC, 2019);

- Adaptation: Adjustment of natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploits beneficial opportunities;
- Mitigation: Efforts tailored toward the reduction in emissions through increasing carbon sinks;
- Resilience: the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

6. The three options as restated as “Adapt”, “Mitigate”, or “Build resilience”, respectively.

| S/N | Item   | Adapt | Mitigate | Build Resilience |
|-----|--|-------|----------|------------------|
| 1.  | Gully erosion is a serious environmental threat in some parts of the country. How best can the incidence of gully erosion be managed?                        |       |          |                  |
| 2.  | Climate change has triggered increased rural–urban migration, how can society contain this problem?  |       |          |                  |
| 3.  | What solution would you suggest to low agricultural yield/food shortages?  |       |          |                  |
| 4.  | Industrialization and continuous burning of conventional fuels is rapidly increasing aeroallergen levels. What would be the best way to manage this problem? |       |          |                  |
| 5.  | Population pressure seems to put stress on available resources. What could be the best option to address this issue?   |       |          |                  |
| 6.  | What is the best climate change plan to tackle drought?  |       |          |                  |
| 7.  | Rising sea level is a global CC challenge. How can the problem be managed?   |       |          |                  |
| 8.  | Social conflicts due to shortage of resources is common in most parts of Africa. What solution would you suggest to combat the problem?                      |       |          |                  |
| 9.  | Heatwaves are rapidly becoming a common phenomenon. What would you suggest as a best way to manage it?   |       |          |                  |
| 10. | How can the challenges of biodiversity loss be controlled?   |       |          |                  |
| 11. | How can the severe pressure put on environment/ecological resources be controlled?   |       |          |                  |
| 12. | Changes in rainfall patterns are prominent in most societies nowadays. How can society tackle this problem?  |       |          |                  |
| 13. | Climate change is known to exacerbate the outbreak of disease. What could be the best solution to combat this challenge?                                     |       |          |                  |
| 14. | Extreme temperature is causing rapid loss of water in rivers. How can society address this problem?  |       |          |                  |
| 15. | Flooding is a serious threat to lives and property in major cities across the country. How best can the incidence of gully erosion be managed?               |       |          |                  |

## Appendix B

Table A1. Breakdown of questionnaire results for CC challenges in Nigeria.

| S/N | Item                                 | April 2017<br>(0 month) |          |                  | October 2017<br>(6 months) |          |                  | April 2018<br>(12 months) |          |                  | October 2018<br>(18 months) |          |                  | April 2019<br>(24 months) |          |                  |
|-----|--------------------------------------|-------------------------|----------|------------------|----------------------------|----------|------------------|---------------------------|----------|------------------|-----------------------------|----------|------------------|---------------------------|----------|------------------|
|     |                                      | Adapt                   | Mitigate | Build Resilience | Adapt                      | Mitigate | Build Resilience | Adapt                     | Mitigate | Build Resilience | Adapt                       | Mitigate | Build Resilience | Adapt                     | Mitigate | Build Resilience |
| 1.  | Incidence of gully erosion           | 24                      | 10       | 16               | 16                         | 4        | 7                | 27                        | 13       | 19               | 23                          | 10       | -                | 19                        | 9        | 8                |
| 2.  | Massive rural–urban migration        | 25                      | 14       | 11               | 21                         | -        | 3                | 30                        | 17       | 12               | 27                          | -        | 6                | 25                        | 4        | 7                |
| 3.  | Low agricultural yield/food shortage | 15                      | 15       | 20               | 12                         | -        | 15               | 20                        | 19       | 20               | 14                          | -        | 19               | 10                        | 10       | 16               |
| 4.  | Increase in aeroallergen levels      | 21                      | 16       | 13               | 6                          | 20       | 1                | 20                        | 28       | 11               | 8                           | 25       | -                | 11                        | 17       | 9                |
| 5.  | Population pressure                  | 40                      | 5        | 5                | 19                         | 1        | 7                | 39                        | 10       | 10               | 30                          | 1        | 2                | 19                        | 9        | 8                |
| 6.  | Drought                              | 41                      | 8        | 1                | 17                         | -        | 9                | 46                        | 10       | 3                | 29                          | 4        | -                | 26                        | 7        | 3                |
| 7.  | Rising sea level                     | 11                      | 33       | 6                | 23                         | 1        | 2                | 40                        | 13       | 6                | 20                          | 11       | 2                | 8                         | 18       | 10               |
| 8.  | Social conflicts                     | 23                      | 23       | 4                | 9                          | 16       | 2                | 24                        | 29       | 6                | 8                           | 17       | 8                | 6                         | 20       | 10               |
| 9.  | Heatwaves                            | 46                      | 4        | -                | 15                         | 5        | 7                | 50                        | 9        | -                | 17                          | 10       | 6                | 22                        | 2        | 12               |
| 10. | Loss of biodiversity                 | 38                      | 7        | 5                | 22                         | 1        | 4                | 35                        | 16       | 8                | 15                          | 9        | 9                | 23                        | 4        | 9                |
| 11. | Pressure on resources                | 42                      | -        | 8                | 22                         | 5        | -                | 45                        | 3        | 11               | 21                          | 12       | -                | 29                        | 3        | 4                |
| 12. | Changes in rainfall patterns         | 48                      | 2        | -                | 18                         | 6        | 3                | 49                        | 8        | 1                | 19                          | 2        | 12               | 24                        | 5        | 7                |
| 13. | Disease outbreak                     | 9                       | 8        | 33               | 9                          | 9        | 9                | 16                        | 10       | 33               | 9                           | 3        | 21               | 12                        | -        | 24               |
| 14. | Loss of water in rivers              | 34                      | 10       | 6                | 23                         | 3        | 1                | 38                        | 11       | 10               | 18                          | 12       | 3                | 21                        | 4        | 11               |
| 15. | Flooding                             | 44                      | 1        | 5                | 17                         | 6        | 4                | 39                        | 11       | 9                | 26                          | 7        | -                | 28                        | -        | 8                |

Table A2. Breakdown of questionnaire responses/results for CC challenges in Benin.

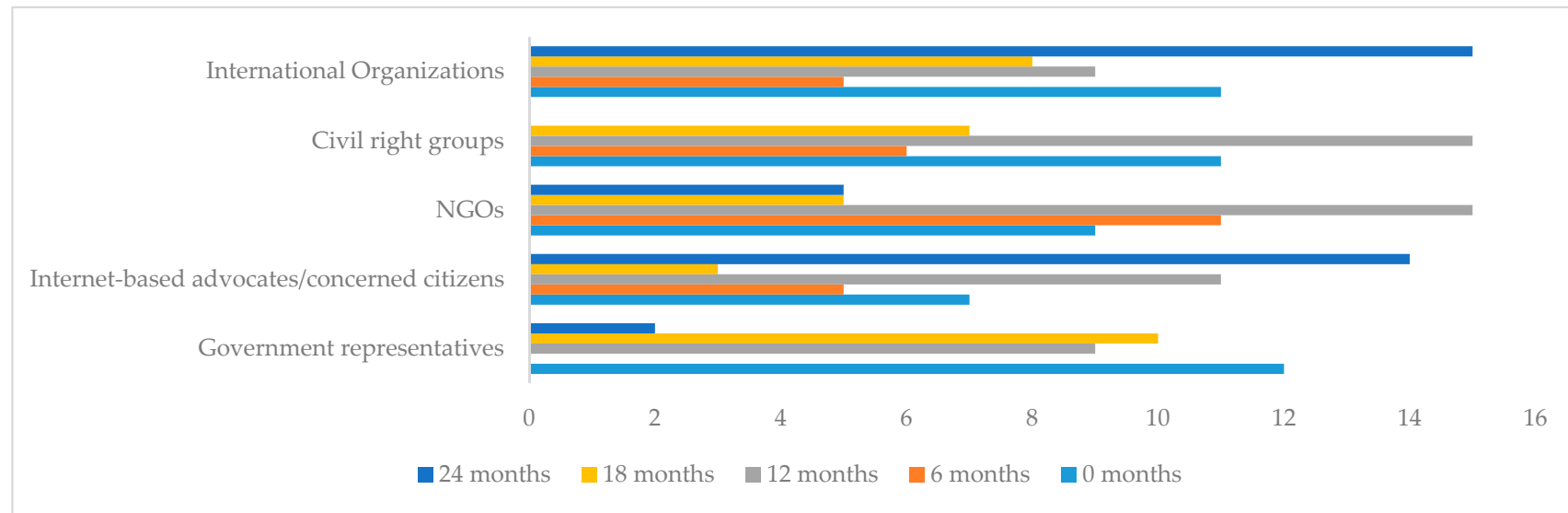
| S/N | Item                                 | April 2017<br>(0 month) |          |                  | October 2017<br>(6 months) |          |                  | April 2018<br>(12 months) |          |                  | October 2018<br>(18 months) |          |                  | April 2019<br>(36 months) |          |                  |
|-----|--------------------------------------|-------------------------|----------|------------------|----------------------------|----------|------------------|---------------------------|----------|------------------|-----------------------------|----------|------------------|---------------------------|----------|------------------|
|     |                                      | Adapt                   | Mitigate | Build Resilience | Adapt                      | Mitigate | Build Resilience | Adapt                     | Mitigate | Build Resilience | Adapt                       | Mitigate | Build Resilience | Adapt                     | Mitigate | Build Resilience |
| 1.  | Incidence of gully erosion           | 19                      | 6        | 5                | 20                         | -        | 1                | 17                        | 7        | 6                | 23                          | 9        | 14               | 16                        | 4        | 4                |
| 2.  | Massive rural–urban migration        | 20                      | 7        | 3                | 14                         | 1        | 6                | 18                        | 8        | 4                | 23                          | 13       | 10               | 19                        | 5        | -                |
| 3.  | Low agricultural yield/food shortage | 13                      | 3        | 14               | 9                          | 4        | 8                | 14                        | 2        | 12               | 14                          | 14       | 18               | 11                        | 2        | 11               |
| 4.  | Increase in aeroallergen levels      | 7                       | 23       | -                | 3                          | 11       | 7                | -                         | 20       | 10               | 20                          | 15       | 11               | 4                         | 19       | 1                |
| 5.  | Population pressure                  | 20                      | 4        | 6                | 13                         | 6        | 2                | 19                        | 6        | 5                | 38                          | 5        | 3                | 17                        | 7        | -                |
| 6.  | Drought                              | 21                      | 9        | -                | 15                         | -        | 6                | 19                        | 7        | 4                | 40                          | 6        | -                | 21                        | 3        | -                |
| 7.  | Rising sea level                     | 17                      | 7        | 6                | 1                          | 17       | 3                | 17                        | 4        | 9                | 10                          | 30       | 6                | 18                        | -        | 6                |
| 8.  | Social conflicts                     | 6                       | 18       | 6                | 6                          | 13       | 2                | 7                         | 16       | 7                | 18                          | 21       | 7                | -                         | 12       | 12               |
| 9.  | Heatwaves                            | 14                      | 9        | 7                | 6                          | 10       | 5                | 13                        | 8        | 9                | 36                          | -        | 9                | 14                        | 7        | 3                |
| 10. | Loss of biodiversity                 | 15                      | 8        | 7                | 19                         | 2        | -                | 16                        | 9        | 5                | 32                          | 8        | 6                | 12                        | 7        | 5                |
| 11. | Pressure on resources                | 18                      | 10       | 2                | 12                         | 4        | 5                | 17                        | 9        | 4                | 38                          | 1        | 7                | 18                        | 4        | 2                |
| 12. | Changes in rainfall patterns         | 21                      | -        | 9                | 20                         | -        | 1                | 19                        | 3        | 8                | 42                          | 2        | 2                | 12                        | 6        | 6                |
| 13. | Disease outbreak                     | 6                       | 2        | 22               | -                          | 5        | 16               | 11                        | 2        | 17               | 9                           | 8        | 29               | 5                         | 5        | 14               |
| 14. | Loss of water in rivers              | 19                      | 11       | -                | 10                         | 6        | 5                | 19                        | 5        | 6                | 28                          | 9        | 9                | 18                        | 3        | 3                |
| 15. | Flooding                             | 16                      | 7        | 7                | 10                         | -        | 11               | 23                        | 4        | 3                | 44                          | 1        | 1                | 14                        | 8        | 2                |

**Table A3.** Breakdown of questionnaire responses/results for CC challenges in Niger.

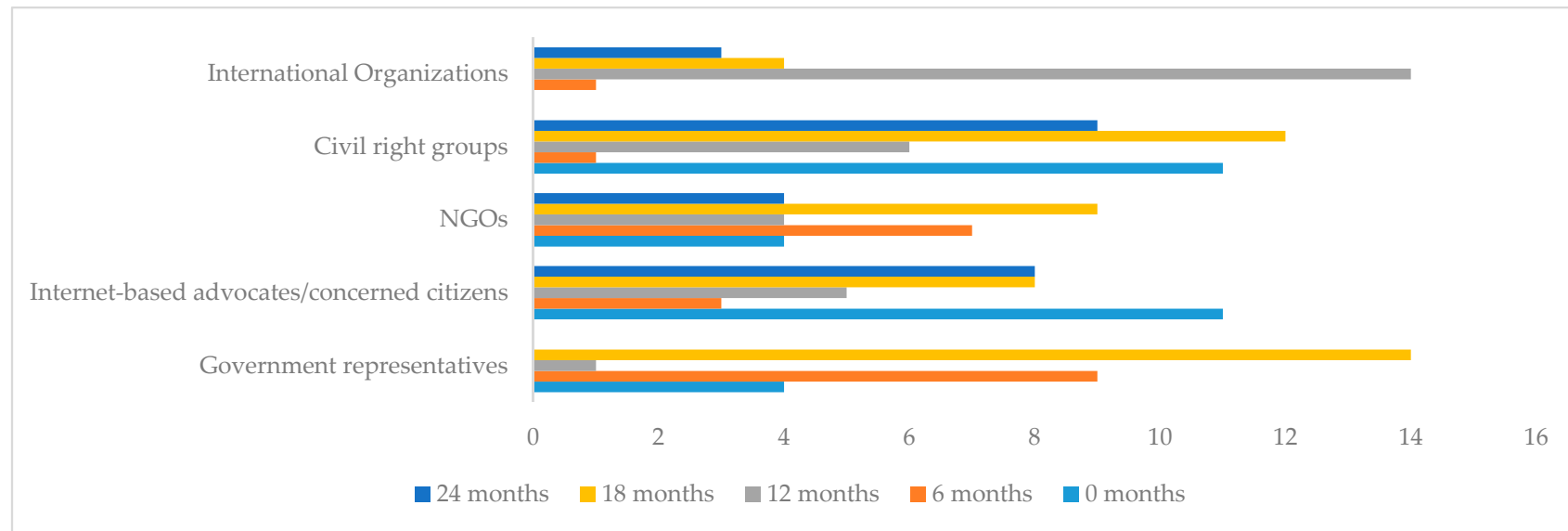
| S/N | Item                                 | April 2017<br>(0 month) |          |                  | October 2017<br>(6 months) |          |                  | April 2018<br>(12 months) |          |                  | October 2018<br>(18 months) |          |                  | April 2019<br>(24 months) |          |                  |
|-----|--------------------------------------|-------------------------|----------|------------------|----------------------------|----------|------------------|---------------------------|----------|------------------|-----------------------------|----------|------------------|---------------------------|----------|------------------|
|     |                                      | Adapt                   | Mitigate | Build Resilience | Adapt                      | Mitigate | Build Resilience | Adapt                     | Mitigate | Build Resilience | Adapt                       | Mitigate | Build Resilience | Adapt                     | Mitigate | Build Resilience |
| 1.  | Incidence of gully erosion           | 23                      | 7        | 11               | 21                         | 8        | 12               | 12                        | -        | -                | 8                           | 4        | 4                | 8                         | -        | 1                |
| 2.  | Massive rural–urban migration        | 27                      | 6        | 8                | 18                         | 13       | 10               | 10                        | 1        | 1                | 9                           | 4        | 3                | 9                         | -        | -                |
| 3.  | Low agricultural yield/food shortage | 9                       | 9        | 23               | 12                         | 13       | 16               | 3                         | 3        | 6                | 2                           | 4        | 10               | 2                         | -        | 7                |
| 4.  | Increase in aeroallergen levels      | 10                      | 15       | 16               | 17                         | 14       | 10               | 1                         | 9        | 2                | 1                           | 11       | 4                | -                         | 6        | 3                |
| 5.  | Population pressure                  | 27                      | 8        | 6                | 39                         | 2        | -                | 12                        | -        | -                | 13                          | 1        | 2                | 8                         | 1        | -                |
| 6.  | Drought                              | 29                      | 8        | 4                | 37                         | 4        | -                | 11                        | 1        | -                | 10                          | 3        | 3                | 5                         | 2        | 2                |
| 7.  | Rising sea level                     | 9                       | 21       | 11               | 12                         | 28       | 1                | 1                         | 8        | 3                | 4                           | 8        | 4                | 1                         | 7        | 1                |
| 8.  | Social conflicts                     | 7                       | 21       | 13               | 15                         | 25       | 1                | -                         | 11       | 1                | 1                           | 15       | -                | 1                         | 8        | -                |
| 9.  | Heatwaves                            | 24                      | 3        | 14               | 34                         | -        | 7                | 8                         | 1        | 3                | 16                          | -        | -                | 9                         | -        | -                |
| 10. | Loss of biodiversity                 | 28                      | 2        | 11               | 35                         | 4        | 2                | 11                        | 1        | -                | 16                          | -        | -                | 9                         | -        | -                |
| 11. | Pressure on resources                | 30                      | -        | 11               | 34                         | 2        | 5                | 9                         | 2        | 1                | 12                          | 2        | 4                | 7                         | 2        | -                |
| 12. | Changes in rainfall patterns         | 20                      | 9        | 12               | 39                         | 1        | 1                | 7                         | 4        | 1                | 10                          | 3        | 3                | 7                         | 1        | 1                |
| 13. | Disease outbreak                     | 12                      | 5        | 24               | 11                         | 12       | 18               | -                         | -        | 12               | 4                           | -        | 12               | 3                         | -        | 6                |
| 14. | Loss of water in rivers              | 23                      | 6        | 12               | 19                         | 11       | 11               | 7                         | 1        | 4                | 11                          | -        | 5                | 6                         | -        | 3                |
| 15. | Flooding                             | 25                      | 6        | 10               | 33                         | 4        | 4                | 12                        | -        | -                | 15                          | 1        | -                | 8                         | 1        | -                |



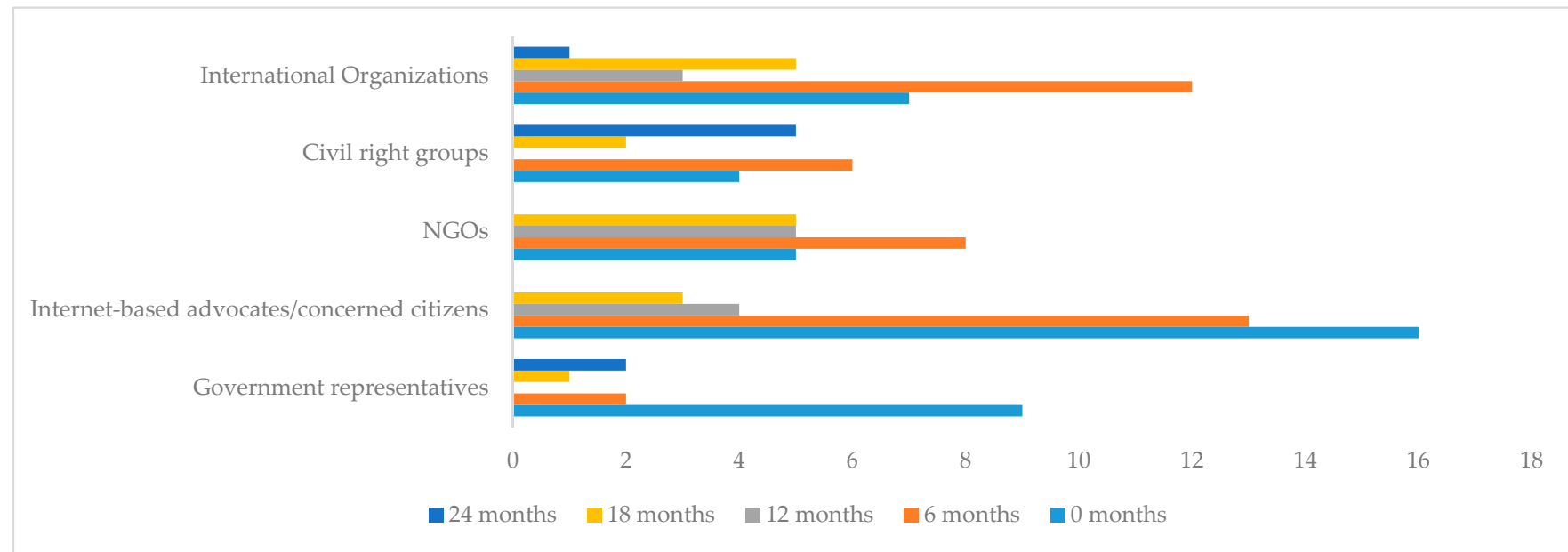
## Appendix C



**Figure A1.** Distribution of respondents in Nigeria.



**Figure A2.** Distribution of respondents in Benin.



**Figure A3.** Distribution of respondents in Niger.

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