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Climate Change Adaptation Strategies Towards Reducing Vulnerability to Drought in Northern Ghana

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ABSTRACT

The impacts of climate change especially on water resources are beginning to manifest both globally and regionally. More disturbing is the fact that developing countries, particularly those in sub-Saharan Africa, are the most affected by these impacts due mainly to their high exposure, sensitivity, and low adaptive capacity. For Ghana, the general climate change has manifested in rising temperatures, declining rainfall, high extreme weather conditions, and rising sea levels. In response to these challenges, the country has developed national adaptation strategies for implementation at regional, district, community, and individual levels. Key among the strategies for reducing the impacts of climate change on the water are the conservation of water resources, improving and sustaining the quality of water, and increasing the availability of water for domestic and agricultural purposes. However, the level of vulnerability to climate change is influenced by both social and spatial factors because of the different ecological zones whose characteristics significantly influence both the physical and socio-economic dimensions of the various areas differently. Additionally, the decentralized implementation of the national climate change adaptation strategy has largely failed to achieve any significant results due to a lack of capacity on the part of the implementation partners at the various levels, as well as the overambitious nature of the strategy. A more ecologically tailored approach with an emphasis on the district and community levels is recommended for going forward. Improvements on the various components of vulnerability with regard to water management are recommended for reducing the effects of droughts.

Keywords: Adaptation, Climate Change, Drought, Ghana.

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I. Introduction

Undoubtedly, the effects of climate change remain the biggest global challenge of the 21st century. Observed trends of rising temperatures and declining annual rainfall have been predicted by several Global Climate Models (GCMs) to continue into the future with subsequent attendant effects at global, continental, and regional levels [1], [2]. Africa, despite being the lowest contributor to global fossil fuel emissions, is projected as one of the most vulnerable continents to climate variability and change due to its high exposure, sensitivity, and weak adaptive capacity [3], [4]. In particular, countries in sub-Saharan Africa are likely to suffer the most devastating impacts of climate change because of their geographical location, low incomes, low technological and weak institutional capacity to adapt to rapid changes in the environment, as well as their greater reliance on climate-sensitive renewable natural resources sectors such as water [5]-[7]. According to climate model analyses, the number of people at risk due to water scarcity increased rapidly towards the second half of the century, with impacts in arid and semi-arid regions expected to be much larger than the global averages suggest [8], [9]. Thus in regions already under water stress today, including Africa, climate change will exacerbate the situation. For many of the water-distressed regions, global means temperature increases above 1.5 ºC are identified as leading to decreases in water supply and quality [8]. For Ghana, an increase in evaporation and drought spells are expected to be more frequent and pronounced within the White Volta basin where Navrongo Municipality (the study area) is located. The total annual rainfall of the area is projected to decline by 12.3% and 19.6% in 2020 and 2050 respectively [2]. Early termination of rainfall in the transitional zone and likely conversion of the current bimodal regime in the south to a unimodal one has also been predicted, thereby increasing the level of vulnerability to these changes [10].

A. Vulnerability

According to [11], vulnerability is the characteristics of a person or a group in terms of their capacity to anticipate, copes with, and recover from the impact of a natural hazard. It is also defined as the sensitivity of a system to some degree of stress and disturbance or the extent to which a system is likely to experience perturbation [12]. In the context of climate change, vulnerability is the consequent decline in

well-being attributed to the change in climate simply because people are unable to cope and adapt positively [13]. Clearly, two sides of vulnerability can be distinguished: the first is the extent to which an area is susceptible to unfavorable climate impact changes, and the second is the extent to which the population can adapt to these changes. The vulnerability of a society is influenced by its development path, physical exposures, the distribution of resources, prior stresses, and social and government institutions. Reference [14] concludes that vulnerability at the level of community is dynamic and comprises a multitude of components, which determine the degree of severity to which it is revealed. The reverse side of the coin is capacity, which can be described as the resources available to individuals, households, and communities to cope with a threat or to resist the impact of a hazard. Such resources can be physical or material, but they can also be found in the way a community is organized or in the skills or attributes of individuals and/or organizations in the community.

In Ghana, the level of vulnerability to climate change varies depending in part on the ecological zone within which a community lies. Ghana is divided into six agro-ecological zones, namely Sudan, Guinea, and Coastal Savanna zones, the Forest-Savanna Transitional zone, the Semi-deciduous Forest, and the High Rainforest Zones (Fig. 1). The three northern regions fall within the first two agro-ecological zones which record the lowest amount of rainfall with the. unimodal distribution. In southern Ghana, where the rainfall distribution is bimodal, vulnerability to drought is less as compared to the north.

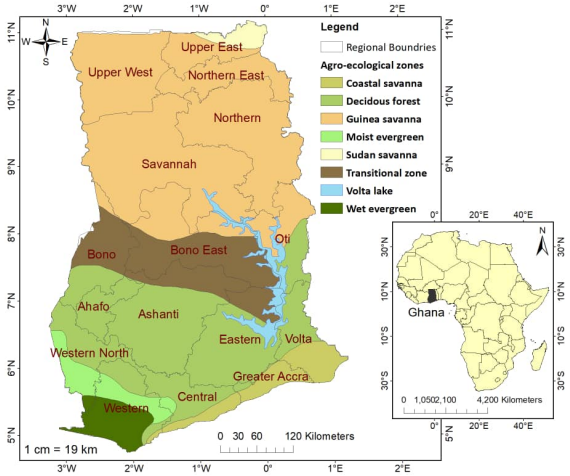

Fig. 1. Location of the study area and Agro-ecological zones of Ghana

B. Components of Vulnerability

The vulnerability has been determined to comprise four main components namely: threshold capacity, coping capacity, recovery capacity, and adaptive capacity [15]. Threshold capacity refers to the ability of a society to build up a threshold against variation in order to prevent damage from natural disasters including floods and droughts. Based on this understanding, the objective of building threshold capacity is basically to prevent damage. Generally, the ability of a society to build, operate and maintain threshold capacity is determined by its environmental resources and its social, institutional, technical and economic abilities [16]. Coping capacity refers to the capacity of a society to reduce damage in case of a disturbance that exceeds the damage threshold. For water supply, coping capacity is determined by the availability of emergency backup water supply facilities that can be used in case of droughts and disasters. The overall objective of developing coping capacity is the reduction of damage, by either reducing the drought impacts or reducing loss of service. Similar to threshold capacity, the ability to build, operate and maintain coping capacity is determined by the social, institutional, technical, and economic abilities of the community. The third component of vulnerability is recovery capacity. This refers to the capacity of a society to recover to the same or to an equivalent state as before the emergency [15]. For water supply, it is the capacity to achieve a functioning water supply and sanitation system again. Therefore, it is important to develop and build this capacity so as to be able to quickly and effectively respond after the disaster.

Adaptive capacity is the capacity of a society to anticipate uncertain future developments, including floods and droughts that are not frequently occurring [15], [16]. In addition, human and environmental developments, both from inside and outside the system are considered. These include climate change, population growth, and urbanization. Central to the importance of adaptive capacity is the acknowledgment that these processes may be influenced but cannot be predicted, engineered, or controlled. A reason to develop adaptive capacity is the acceptance that dealing with these uncertain future developments might require more than improving threshold, coping, and recovery capacity. From this perspective, adaptive capacity is clearly a precautionary principle.

For Ghana, the resultant effects of the inability to build the various capacities are enormous social, economic, and environmental challenges at both the individual and national levels due mainly to the nation's over-dependence on climate-sensitive sectors, especially agriculture. In response to these, the National Climate Change Adaptation Strategy (NCCAS) was developed in 2010, with adaptation programs implemented at regional, district, and community levels.

C. Aim and Objectives

The aim of this research was to assess the level of implementation of adaptation strategies and their effectiveness in reducing vulnerability to droughts at the level of the community in Northern Ghana, specifically in the Navrongo Municipality. The specific objectives are to inform policy and propose preparedness measures intended at building capacity against vulnerability to climate change.

II. Materials And Methods

A. Description of Study Area and Ecology

The study was conducted in Navrongo Municipality in the Upper East region of Ghana which lies within the Sudan savanna ecological zone (Fig. 1). The municipality lies within the Sudan savanna woodlands and is covered mainly by vegetation consisting typically of a ground cover of grasses of varying heights interspersed with fire-resistant, deciduous, broad-leaved trees at the forest margins [17]. The Sudan savanna zone experiences a unimodal rainfall regime lasting for about 5 - 6 months and a long dry period of about 6 - 7

months in a year with average annual rainfall, temperature, relative humidity, wind speed, sunshine hours, and solar radiation respectively as 885 mm, 28.6 ºC, 54%, 81 km/day, 7.9 hours and 20.4 MJ/m2/day. The zone has potential evaporation of 1652 mm per annum and an annual aridity index of 0.60 [17]. The topography of the zone consists of undulating land and gentle slopes of less than 10%. The dominant activity in the municipality is agriculture which is the backbone of the local economy. According to the 2010 population and housing census, 82.7% of the population depends on agriculture for their livelihood, with 96.1% of those engaged in agriculture in crop farming. The municipality also has a very young population with 50.4% of the population falling between the ages of 0-19 years.

B. Data Collection Procedure

This study was conducted in two phases between January and April 2018. Phase one considered the climate change impacts and adaptation strategies within the area. A combination of research methods was employed in phase one to gather data on the impacts of climate change on water resources and also the level of success of the national climate change implementation strategy. Interviews were conducted with farmers and community members within the study area for the purpose of assessing their opinions on the effect of climate change on water availability within the area and the measures put in place by them to adapt to these changes. Secondly, interviews were conducted with focal persons and program officials so as to observe the strategies adapted and also ascertain the level of implementation within the area. Finally, farmers and community members were interviewed to determine the level of success of the adaptation strategy based on the impact it has had with respect to their water resources. Phase two comprised a comparative assessment of measures adapted for reducing vulnerability to drought in Ghana and the Netherlands, with a focus on the applicability of the Netherlands approach to the Ghanaian situation.

III. Results And Discussions

The outcomes of the interviews with the farmers and community members clearly showed that most of them believed there has been an impact on water resources over the years. For instance, the respondents indicated that there has been a change in the duration of the rainy season. The start of the rainy season has changed from between late April and early May to between late May and early June while the rains now terminate between late August and early September instead of between late October and early November. This has translated to a reduction in the number of rainy months from an average of 6 to 4 months. In addition, they contended this reduction in the number of rainy months has been accompanied by a general reduction in the quantity of rain. Their main reason for this conclusion is the fact that the volumes of water they used to see in the rivers and streams during the rainy season have significantly reduced, resulting in the drying up of these water bodies during the dry season; a situation that used not to occur. Others based their conclusion on the fact that certain crops that used to give them very good yields are no more planted because water is not available throughout the season. In the Upper East Region (study area) decline in rainfall has been reported by [18]. They observed that between 1950 and 1959, the mean decadal rainfall was 1,081 mm but declined to about 979 mm between 2005 and 2014. Other research findings also confirm the observations of the community members and farmers. For instance, a field survey conducted in northern Ghana by [19] reported narratives by local residents of reductions in both rainfall period and volumes. According to the NGHDR field survey, over 90% of residents within northern Ghana observed a change in rainfall patterns.

On adaptation measures to mitigate the effects on water resources, the farmers indicated that they have resorted to several measures including digging shallow wells in their farms (Fig. 2) and farming in low-lying areas that hitherto were considered flood-prone and so were not cultivated. These results agree with the findings of [17] that in northern Ghana, rural poor people affected by frequent droughts and annual flooding are forced to adopt non-sustainable measures such as migration, farming, and building in flood plains. These practices in turn increase their vulnerability and make the fight against poverty increasingly difficult. Together, these projections make the country, and in particular the Northern regions, highly vulnerable to the devastating effects of this phenomenon of climate change.

Another new technique adopted to store water is the construction of walls under bridges to serve as a dam. This ensures that an amount of water stays at that point which is then used for irrigation. According to [20], most farmers in the northern sector of Ghana use shallow wells or hand-dug wells alongside boreholes and rainwater collection during the rainy season for use during the dry season. This finding confirms the results of the current study and also indicates that this practice is widespread and a proven adaptation strategy for water conservation in northern Ghana because of the unimodal rainfall pattern.

Also, the farmers have started planting non-traditional crops such as maize which takes a shorter period to mature. Dry season gardening (Fig. 2) has also become a major adaptation strategy; with most farmers farming right inside the rivers and streams when they dry up since the moisture zone is not very deep there. Most of these farmers grow vegetables such as okra, tomato, and pepper, as they do not require a long period to mature. Findings by other researchers, based on field surveys, agree with those of this study. For instance, a survey conducted by [20] reported that about 90% of respondents indicated the growing of vegetables as a good strategy for climate change adaptation. By so doing, the farmers can sell the vegetables and then buy other basic needs for the family.

In addition, the farming system has seen some level of modification as a way of mitigating the climate change impacts. Some farmers, for instance, have adopted a method of preparing their farms by making ridges and gullies. Plants that need a lot of water are planted in the gullies whilst those requiring less water are planted on the ridges. These gullies are further used for vegetable farming during the dry season (Fig. 2) as some level of moisture is maintained in them. Also, it helps with watering as the water is retained in the gullies for a long period.

Based on NCCAS, various adaptation measures have been proposed. From the interviews with the focal

persons/program officials, the following were listed as intervention measures: construction of smallholder dams, construction of small-scale irrigation schemes, provision of boreholes, and research into and provision of drought-resistant crops and early maturity crops. However, the implementation of adaptation strategies is hampered by economic and political factors. For instance, Dam constructions are behind schedule due to financial constraints and the unavailability of improved seeds for distribution to farmers. Farmers have therefore resorted to the digging of shallow wells to irrigate the crops as a climate change adaptation strategy and farming on low-lying plains (water courses) during the dry season (Fig. 2, Fig. 5). In addition, farmers have changed from planting traditional crops such as millet and guinea corn to maize which matures early as compared to the traditional crops.

Fig 2. Drawing water from a shallow well.

Fig 3. Watering the crops (garden eggs).

Fig 4. Crops are planted in gullies (garden eggs) because they require more water

Fig. 5. Crops (pepper) are planted on normal plowed land because they need less water.

IV. Strategies For Reducing Vulnerability To Drought In Ghana

The approach most often followed by development especially for managing drought is post-impact interventions. These interventions are normally relief measures in the form of emergency assistance programs with the aim of providing money or other specific types of assistance (i.e., clothing, food, shelter) to the affected people [21]. However, this approach has proven not to address the challenges of droughts effectively. Another approach is the development of pre-impact programs and interventions that are intended to reduce vulnerability and impacts, commonly referred to as mitigation measures. A third and final type of policy response is the development and implementation of preparedness plans and policies, including organizational frameworks and functioning arrangements developed in advance in anticipation of drought. These normally are normally sustained by the government or other organizations and agencies related to drought management [21]. In response to the expected changes as a result of drought in Northern Ghana, the following strategies are suggested to reduce the vulnerability based on improving capacity (Table I).

TABLE I: SUGGESTED STRATEGIES FOR REDUCING VULNERABILITY TO DROUGHT IN NORTHERN GHANA

Capacity type	Water Supply Adaptation Measures
Threshold capacity	More water storage More efficient water delivery infrastructure Demand management, e.g. permanent water restrictions Use of multiple sources of water as part of day-to-day water supply
Coping capacity	Emergency plans, drought forecasting Backup water supply facilities Water restrictions during droughts Use of multiple sources of water during droughts
Recovery capacity	Recovery planning and training Establishment of disaster response units and departments Disaster funds Use of multiple sources as recovery
Adaptive capacity	Flexible and reversible water supply infrastructure Start a social learning process by developing experience and knowledge of multiple sources to building diversity Awareness creation at level of community and local government. Zoning of areas susceptible to droughts

A. Rainwater Harvesting

The effectiveness of rainwater harvesting in reducing vulnerability to drought has been evaluated as a useful threshold capacity-building measure with the potential to reduce water demand [22]. This can help decrease significantly drinking water demand during long dry periods, especially in areas where there are no water supply systems and Boreholes. Rainwater harvesting will reduce the cost of water supply and reduce time in areas where there is the need to supply water with water tankers or where the inhabitants have to travel or walk long distances to get water.

In the Netherlands for example, about 50% of the water demand in the City District only could be realized with the installation of rainwater harvesting tanks [23]. This indicates that rainwater harvesting is a promising technology to reduce drinking water demand and the dependency of urban areas on the centralized drinking water system. For a country like Ghana, this measure is expected to achieve even better results because most houses are even not served by a centralized water system. Therefore, this will assist such houses to have a water source for drinking during periods of drought thereby reducing their vulnerability.

V. CONCLUSION

Climate change impacts on water resources have been predicted for sub Saharan Africa with the predictions expected to worsen with time. This study assessed the adaptation measures adopted by Ghana towards reducing the level of vulnerability to these predicted impacts in the Upper East region. The interviews with stakeholders clearly point to the fact that reduction of vulnerability to drought remains to be achieved due to challenges with the implementation of adaptation strategies. The main reasons for this include bureaucratic bottlenecks and financial constraints on the part of the implementing agencies as well as a lack of capacity on the part of some of the stakeholders, particularly at the community level. This has the potential to even increase the population of vulnerable people to water shortages in the face of long periods of droughts.

Although several measures have been adopted at the individual level to combat these climate change effects, this may not be adequate on a larger scale. Strategies have been suggested as a way to reduce this vulnerability in addition to the current efforts. However, the ability to build, operate and maintain such strategies will require social, institutional, technical, and economic investments and reforms.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest situation with regard to this study.

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