International Conference
Analysis and Management of Changing Risks for Natural Hazards
18-19 November 2014 l Padua, Italy

Abstract code: G02

Modeling the changes in exposure and vulnerability in Accra, Ghana for the future

Osei, P.

Institute of Local Government Studies, Accra, Ghana

Corresponding author details:
NADMO, Accra Central, 0233, Accra:

Keywords:
[Risk exposure, climate change, vulnerability, flood, social, drought, environmental factors, communities, Education, demographic changes,]

INTRODUCTION

Over the years, concerns have been raised and agitations made over expected climate-related issues in Accra, Ghana. Life in Accra is under severe threat from catastrophic climate change, which is being caused by humans through a constant production of greenhouse gases. Accra faces the threats in the form of flood and drought. In spite of all the happenings, the blame is been shift to witchcraft and political opposition for causing it while there is a dangerous climate change. The severity of the impacts of extreme and non-extreme weather and climate events depends strongly on the level of vulnerability and exposure of these events in Accra, which is one of the more vulnerable and exposure to climate change cities in the world. The trends in vulnerability and exposure are major drives of changes in disaster risk and of impacts when risk is realized. Vulnerability and exposure are dynamic; varying across temporal and spatial scales, and depends on economic, social, geographic, cultural, institutional, governance, and environmental factors. Individuals and communities are differentially exposed and vulnerable and this is based on factors such as wealth, education, race/ethnicity/religion, gender, age, class/caste, disability, and health status. High vulnerability and exposure are generally the outcome of skewed development processes such as those associated with environmental mismanagement, demographic changes, rapid and unplanned urbanization in hazardous areas, failed governance, and the scarcity of livelihood options for the poor. This paper will model the changes in exposure and vulnerability in the future in the context of wealth, education, race/ethnicity/religion, gender, age, class/caste, disability, and health status.

Accra Case study: Historical events of climate variability in the City of Accra

Accra is a coastal city that has been the capital of Ghana since 1877 with an estimated population of about 3 million. Their pattern of population distribution, livelihoods, and its dominant role within the national economy of Ghana makes it a good representative's case study of costal West Africa. This paper will first consider the historical context for continued urban growth and assess potential future impacts of climate change on existing settlement patterns and later model the change in exposure and vulnerable. As the potential impacts are difficult to gauge without historical context, we pose that only a site specific study can reveal the patterns to assess future scenarios.

Since its early history, Accra has grown rapidly and in concert with national and regional political- economic trends. Arguably it was the cocoa trade in the 19th century that brought relative prosperity and certainly after patterns of commercial lands use within the city and the

emerging urban system. During the 1870s, Accra occupied a land area of less than 10 square kilometers. After 1877, Accra hosted the British colonial headquarters which had been relocated from cape coast. Along with colonial administration came commerce, with African merchants occupying a growing "Native Town" to the north of the market and to the west ridge area which host the British. The higher elevation land of Ridge was kept exclusively European through a rigid policy of residential segregation. The expatriate areas of the ridge and cantonments were separated from the rest of the city through a cordon sanitary of vacant land. The native population, particularly the Ga people who are considered the original inhabitants of Accra, lived in crowded, disorganized area near the market and the sea coast – i.e., on areas of lower elevation and higher flood risk, a pattern that continues to today.

Into the 1920s the townscape of Accra clearly displayed the impact of the cocoa trade, also benefiting from trade in palm kernels and oil after the end of World War I. The indigenous Ga area continued to experience crowding. The neighborhood of Korle Bu was founded between 1919 and 1927. The big downtown market, Makola, was constructed in 1924. By 1927, area such as Tudu, Adabraka, korle Gonno, Mamprobi, Sabon Zongo and extensions to christianborg and Victoriaborg were founded. Sabon Zongo was founded in the 1920s as a muslim enclave and settled by migrants from the sahel and other coastal countries with Muslim populations. Sabon Zongo has been the subject of prevous studies, examining the communities infrastructure market and centripetal socio-spatial structures as residents adapt to a mixing of cultures.

After displacements caused by an earthquake in 1939, new neighborhoods were built in Christiansborg, south Labadi, Kaneshi, Sabon Zongo, and Abossey Okai. After World War II, the muslim enclave of Nima in central Accra began to be occupied, along with the elite Airport Residential Area. By 1954, New neighborhoods including kokomlemle, Tesano, Achimota, and Kanda village were built. As the city grew through colonial time (see figure 1 derived from Harvey and Brand 1974, with the gray line labeled " contemporary urban extent" indicating the spatial reach of the city as estimated from Landsat imagery in 2000), the neighborhoods continued to display the extremes in living conditions, from the chaotic and unsanitary slums such as Chorkor and Nungua on the coast, to the emergent middle class areas such as Adabraka and Kaneshi, and exclusive expatriate European and elite African enclaves

This series of maps depicts growth in built-up area for Accra. The gray outline labeled ' contemporary urban extent' is derived from Landsat imagery to show the maximum boundary of physical growth in the year 2000.By the time of Ghana's first census as an independent country in 1960, Accra had a population of 388,000 . Its founding leader, Kwame Nkrumah, sought to reconfigure the colonial urban form based on prevailing notions of modernity and industrialization, and each subsequent administration had its own way of influencing the architecture and planning of the city. The British master city plan conceived during World War II created designated separate spaces for inner urban squatter settlements, commercial areas, and a new middle class. But this plan was pushed aside by Nkrumah in favor of a more all encompassing plan drawn up by international architects to encourage national rather than tribal identity. Evidence of this attempt is most apparent along Accra's water front where a large community center was built near a symbolic black star square. The beach was no longer reserved for only large European houses, but was open for the entire nation. Streets were also renamed and occasional rerouted through once inaccessible poor neighborhoods.

The housing situation in Accra as examined between 1950 and 1990 worsened. In their macro-economic development, the rulers of newly independent Ghana continued urban-

biased policies which favored Accra over other cities and regions in Ghana, which enhanced the city's ability to 'pull' migrants from other parts of the country and the greater region. By 1984, the year after a serious drought in Ghana, the city's population had reached 970,000, an estimate which is widely believed to be an undercount. Since the late 1980s, the city has experienced an average annual growth rate of 4.3 percent as compared with a national rate of 2.8 percent. This has put tremendous pressure on housing stock and infrastructure as the city filled with new residents.

Neighborhoods to the extreme north of Accra's central core such as Madina , Kasuwa, and New Fadama, are satellites from the inner city neighborhoods of Nima, Sabon Zongo, and Tudu. Formed through an intra-urban process of chain migration, these new satellite areas serve as gateway neighborhoods for both recent migrants from northern Ghana, Nigeria, Niger, Mali and Burkina as well as spillovers from the core areas. Residents are attracted to these farther out satellite areas because they are able to afford flats in relatively clean and safe areas. Continued urban expansion overruns rural and agricultural land surrounding the city and without regard to infrastructure or planning. This leads to an over-exploitation of natural resources to satisfy various demands.

This summary of Accra's settlement history sets the context for assessing contemporary vulnerability to climate change. One must ask what impact a city's particular socio-spatial conditions have on residents' ability to withstand periodic climatic shock including both flooding and drought. With a very long residency rate, dwellers in the oldest neighborhoods of Accra could be thought to possess social capital related to disaster preparedness that awaits additional exploration. In other, more recently settled areas of the city, urban residents may lack the roots but compensate by having a fuller stock of migration capital, having arrived in Accra from one or more other places, either other cities or rural areas. Vulnerability can thus be thought of as determined by a mixture of biophysical factors related to the actual location in the city, as well as socio-demographic factors such as dependency ratios and access to transportation. Those in poorer and more marginal lands will be more at a risk of flooding, and their plight will not be helped by their relative lack of social capital.
In Accra, there are an estimated 172,000 residents at risk of a 10 years flood. Of that total, 33,000 residents are located in the slums or substandard housing units.
Using nationally observed climate data for the period of 1960 to 2000, coupled with regional climate models together with IPCC scenarios, it is estimated that temperatures will continue to rise by on average about 0.6°C, 2.0°C, and 3.9°C by the year 2020, 2050 and 2080 respectively. Rainfall is predicted to decrease on average by 2.8%, 10.9% and 18.6% by 2020, 2050 and 2080 respectively in all agro-ecological zones except the rainforest zone, where rainfall may increase. Increasing aridity may cause reductions in groundwater recharge of 5-22% by 2020 and 30-40% by 2050.
Assessments indicate that climate change poses the greatest challenges for some of the poorest and most vulnerable groups in Accra, Ghana. This includes people living in the drought and flood-prone area in Accra; people living in slums; and people living in eroding coastal towns. The urban poor in many cases have fewer resources to adapt to climate change – for example, people living in large settlements on flood plains around Accra are extremely vulnerable to natural .There are a lot of defaults of climate change on natural resource-based livelihoods, climate change is likely to increase the incidence of certain diseases such as malaria, bilharzia cholera and ebola. Ebola :For instance, if we take the fruit bat as a possible conduit for Ebola, heavy rain can make fruit trees more prolific, and hence the bats too. Drought results in poor fruit crops, leading the hungry bats to forage farther for food. Again the potential is created for greater interface between man and nature. Reductions in rainfall and other factors mean that coastal towns are facing severe water shortages during the dry season, and hydropower capacity is dropping rapidly.

METHODS

The research combined both quantitative and categorical data for the analysis. Secondary data was taken from NADMO for flood prone communities in Accra. Questionnaires were issued out to the people in the flood and drought prone areas. Data analysis would be done using Microsoft Excel Minitab and SPSS Statistical packages.

RESULTS

Flood modelling analysis and people expose and vulnerable from flooding

Flooding is a serious environmental issue affecting Accra, and with rising sea levels it may become an even greater problem. It is expected that an increased level of cyclonic storms to a great extent and storm surges to a lesser extent will be associated with future climate change and may increase flood occurrence in spatial patterns similar to those of the present. Floods currently are usually of short duration and are caused by heavy rains that generally occur in June and July. Significant flood events have been recorded in 1973,1986,1995,1999, 2001, 2002, 2004, 2005, 2007, 2009, 2010, 2011, and 2013. Along with property damage, the ability of flood waters to spread pollution from solid waste, industrial waste, and sewage is an important health and environmental issue particularly in poor areas.

The Odaw River is the major stream draining central Accra, with its outlet into the korle Lagoon, while smaller streams lead into lagoons to the east and west of central Accra. Much of the Odaw catchment area is built up and many of the streams are channelized. Rainfall in Accra occurs in the form of intensive storm events, which cause local flooding.

Several factors contributed to the flooding problem; first, the massive growth of the city of Accra has increased the extent of impervious surfaces. Impervious surfaces are materials that prevent infiltration of water into the soils, and include roads, rooftops, sidewalks bedrock outcrops and compacted soil. This leads to increased discharge that overloads drainage channels. Associated with this rapid urbanization are flaws in the drainage network such as undersized, limited garbage collection and disposal block channels and sewers, which slow drainage through the city. In addition, field reconnaissance has indicated substantial uncontrolled development occurs in low-lying or unsafe areas – often immediately adjacent to and even directly over drainage channels.

Table 1: New Rating of Localities, 3 classes' outcome

Locality	Flood	Sanitation	Water Supply	New Rating
Nima	1	3	2	1
Kotobabi	1	2	2	1
Alajo	1	2	1	1
Kaneshine	2	1	2	2
Old Fadama	2	3	2	1
Sabon Zongo	2	3	1	2
Gbegbeyiye	2^{+}	3	2	2
James Town	1	1-2	2	3
Darkuman	1	2	2	3
Mallam	2	3	2	2
Mataheko	2	3	1	2
Nungua	2	3	1	2
South Teshie	2	3	2	2

Table 1 above is 13 high exposure area identified which I visited the areas. Interviews were conducted on the following types of the community members .I had interview with the key persons (Assembly Men) , interviews with non exposed ordinary inhabitants of the area and lastly interviews with victims (of flood, for example). The results was re – ranked.

Ranking based on selected criteria:

Flood

1. 0 represents No flood problem
2. 1. Represents severe problem under extreme circumstances (Water enters houses and stays at the street longer than a few hours, extreme circumstances : rain longer than 24 hours)
3. 2. Severe problem under normal circumstances

Sanitation: categorized into 3 distinct groups

1. 1. Represent No sanitation problem
2. 2. Represent only waste problem, not so much open defecation
3. 3. Represent severe problem with both waste open defecation (and animals on the streets etc)

Water supply: areas classified with an either / or rating

1. 1. Represent Not considered as a problem
2. 2. Considered as a problem.

New Rating for exposed and vulnerable community

1. 1 represent low change in exposure and Vulnerability
2. 2 represent severe change in exposure and Vulnerability
3. 3 represent moderate change in exposure and Vulnerability

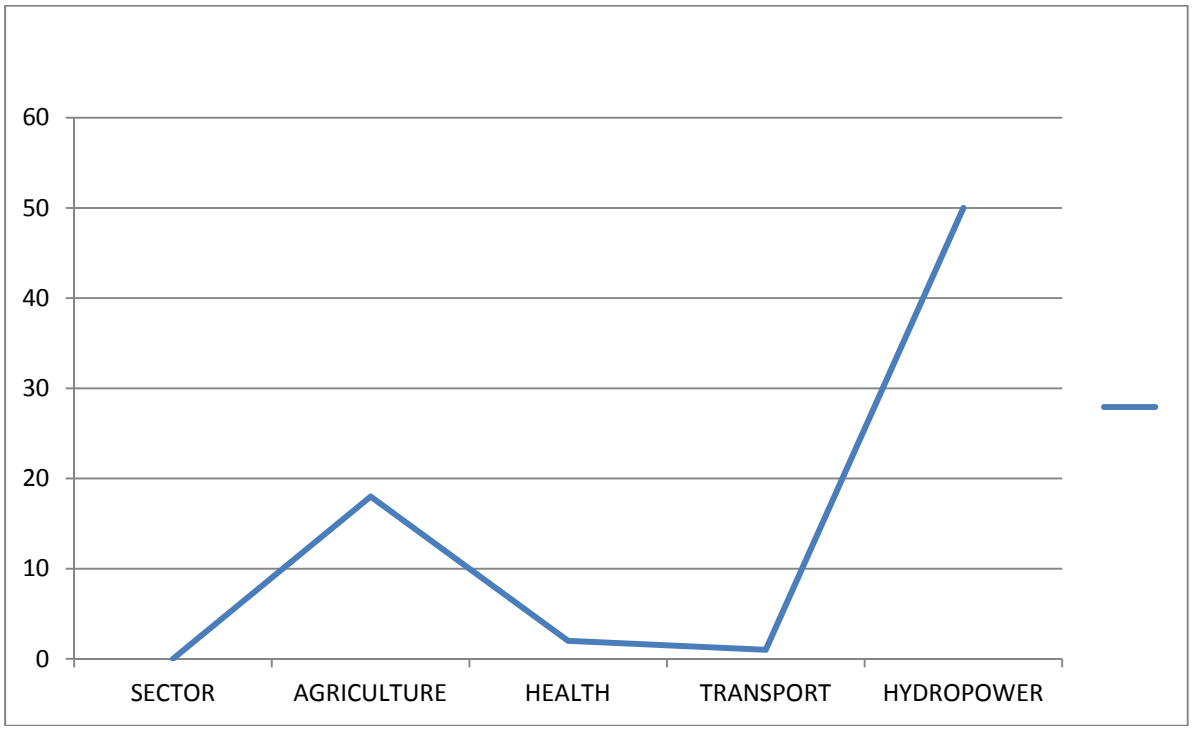

Figure 1: The graph indicates a summary of the varied reasons respondents give to explain why they continued to stay in the flood prone area under study.

From Figure 1, it is clear that most people lived in these areas because of affordability of housing or accommodation. Their income is very small for them to rent in a nice community and a non flood prone area.

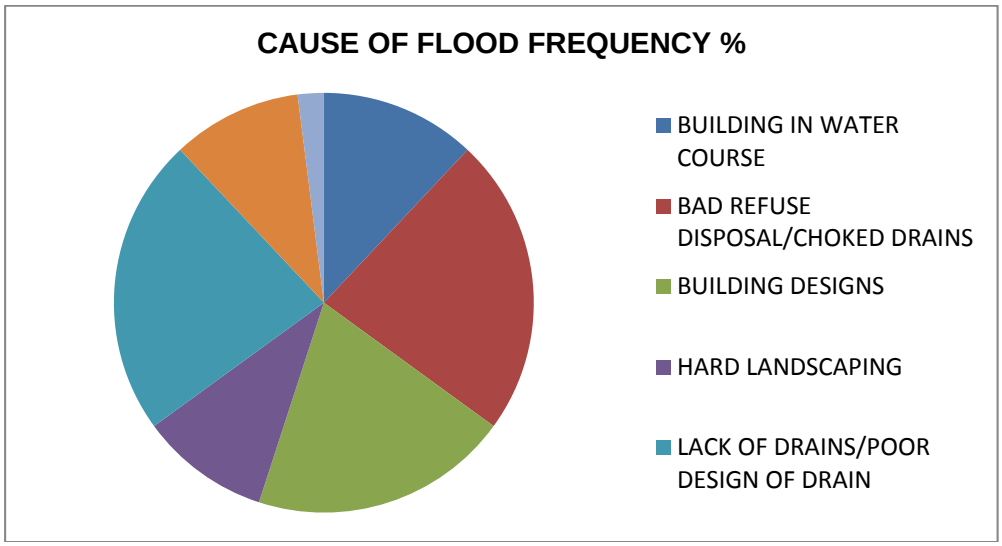

Figure 2 : The graph indicates a summary of the varied reasons respondents give to explain why the causes of flood in the flood prone area under study

From the Figure 2, Bad refuse disposal/choked drains are the higher causes of flood in Accra.

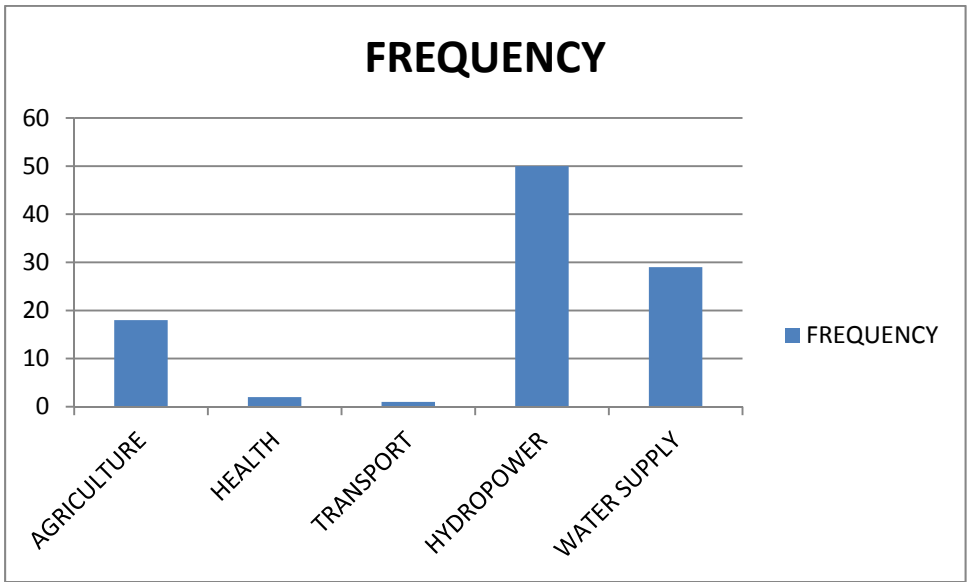

Figure 3: Vulnerable Sector for flood

From the Figure 3, 67% of the respondents assert that the Agricultural sector is most vulnerable to flooding in Accra. This may imply that, the runoff causes mostly by compacted soil e.g. clayey soil, strips away some vegetation and topsoil thereby adversely impacting plant/ crop growth. To be healthy, soils need to be able breath and water needs to be able to move through it reasonably easy; however, compacted soils do not allow much air to

circulate to the root Zone and causes runoff which makes the soil more vulnerable. This runoff also affects the sea by polluting the sea and kills fishes.

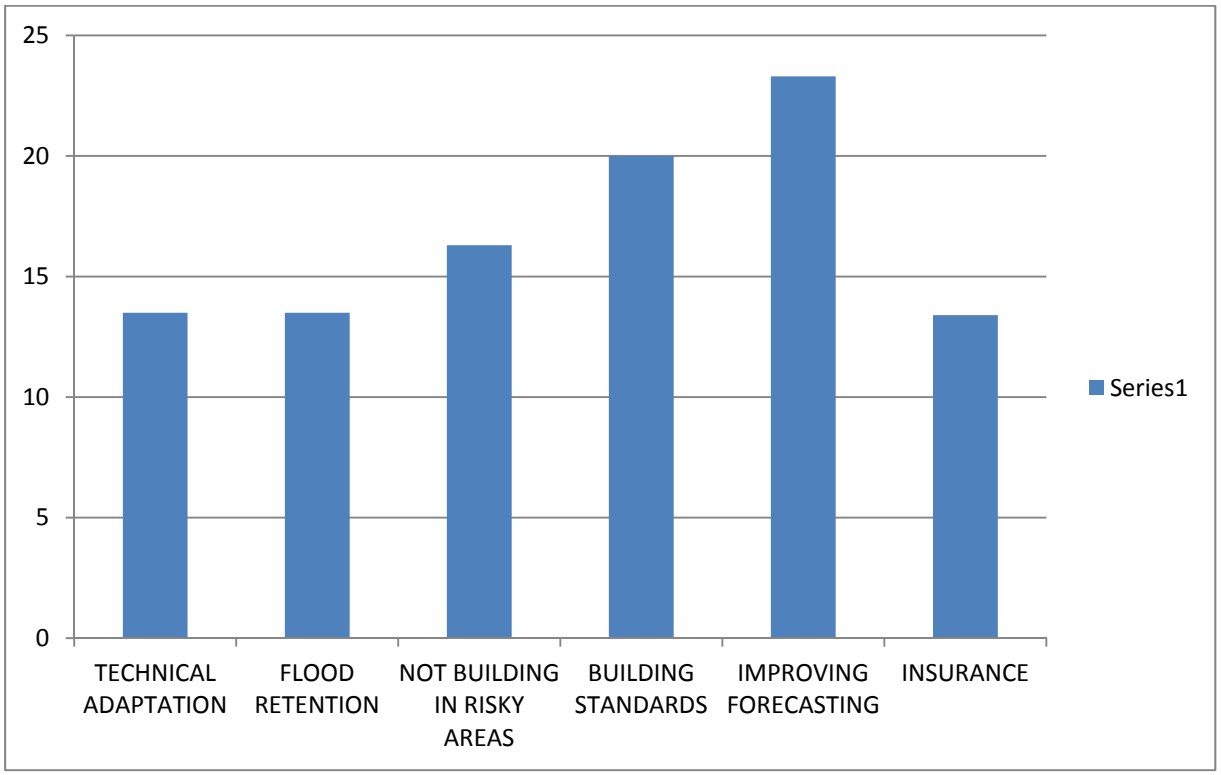

Figure 4: Flood mitigation measures

Figure 4 shows that 23.3% of the respondents believe that increase forecasting and early warning system should be the major flood mitigation measure in Accra. 20% prefer improved building standards, 16.3% favour not building in flood prone areas, and the 13.3% of the respondents like better either flood retention, insurance schemes or any technical adaptation (eg. Water reservoirs, water transfer, water desalinization etc.) Measure of means of building community flood resilience.

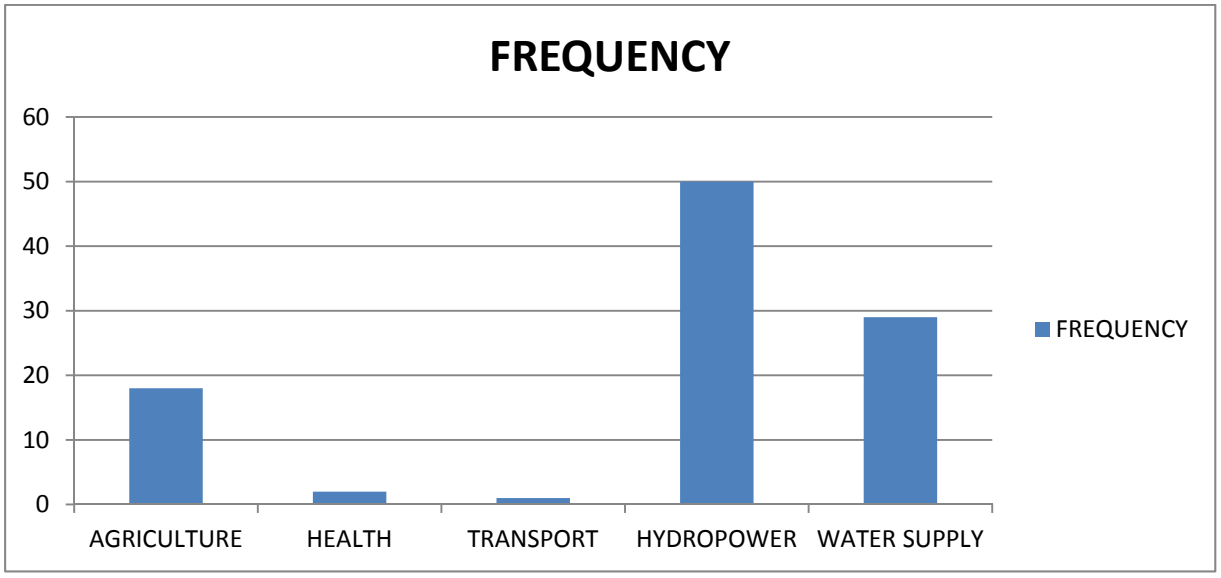

Figure 5: *Vulnerable Sector for drought*

Figure 5, hydropower is the most vulnerable sector in Accra represented by 50% follow by the water supply sector representing 29% , Agriculture sector represents 18%, and health sector is 2% whiles the least is the transportation sector. Now there has been nationwide power outage that occurred on three different occasions in this year.

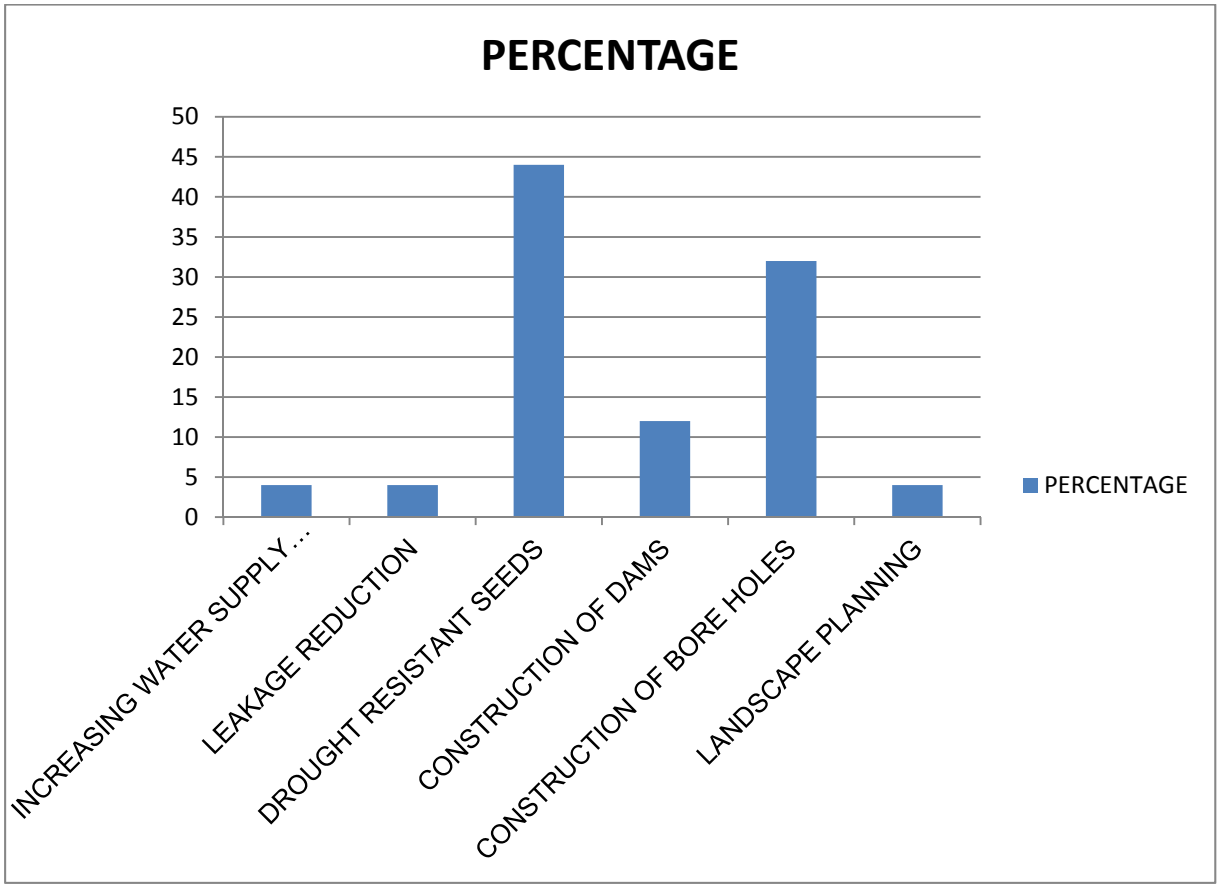

Figure 6: Drought mitigation measures

Figure 6, twelve percent (12%) of the respondents choose construction of dams, thirty-two percent (32%) want the construction of boreholes, forty percent (44%) prefer increased use of drought resistant seeds, eight percent (8%) choose increase in water supply (reservoir volumes, water transfer, desalinization –purify or distil), and 4% opted for landscape planning and leakages reduction.

CONCLUSIONS

1. The Government should involve in Emergency Planning and Community Right to Know Act (EPCRA), which is designed to provide information necessary to protect the public health of local communities by proper notification of the natural hazards associated with flood present in those communities.
2. The 13 localities are at a very high exposure risk for climate change effects and therefore very vulnerable, therefore the Government should educate them on climate change and the preparedness to climate related risk. All the people interview did not have any ideas about climate change and see flooding and drought as a witchcraft event.
3. Projects to decrease Accra's vulnerability to climate change should focus on these 13 most expose areas. The Government should construct a better drainage system,

good culvert / bridges and a better road network. These will reduce the change in exposure and vulnerability.

4. Better sanitation policies should be design to regulate the residence of the 13 communities with very high exposure risk. Community clean up exercise should be conducted once a month. Better waste disposal companies should be contracted to manage the waste in the various communities
5. NGOs, Civil societies need to train the 13 communities with very high exposure risk because the residents lack knowledge on climate change, better sanitation and good environment.

ACKNOWLEDGEMENTS

In offering this document to the general public, I should be ungenerous if we did not make full acknowledgement of the strength, soundness of mind, and understanding given to us by God Almighty to accomplish this task. I would like to use this opportunity to tell everyone that faith in God is the key that can unlock the door of success.
Next is my indebtedness to the management of NADMO and the Staff of Institute of local Government studies for their guidance throughout the whole research. I sincerely thank the People of the 13 flood prone area in Accra for their time and energy during the research period. I thank anybody who contributed in no small measure to this document but whose name could not be mentioned.
However, I am responsible for any error in this document. Any suggestion aimed at enriching this work shall be most welcome.

REFERENCES

Afeku, k. (2005) *Urbanization and Flooding in Accra, Ghana,* Master's Thesis, Department of Geography, Miami University

Boadi, K. O. and Markku, (2002) '*Urban Water Pollution in the Korle Lagoon, Accra, Ghana*,' The Environmentalist, 22(4): 1573-2991

Grant, R. and P. Yankson, (2003) '*City Profile: Accra.' Cities*, 20(1): 65-74

Gyau-Boakye, P. (2001) *'Environmental Impacts of the Akosombo Dam and Effects of Climate change on the Lake Levels' Environmental, Development and Sustainability*, 3(1) : 17-29

Hulme, M. (1992) *Rainfall changes in Africa*: 1931-1960 to 1961-1990, International Journal of Climatology, 12: 685-699

Konadu-Agyemang, K, (2001) '*A survey of housing conditions and characteristics in Accra*, an African city,' Habitat International, 25:15-34

Chakraborty. (2001) *Acute exposure to extremely hazardous substances: an analysis of environmental equity.* Risk Anal 21:883–95.

Benjamin A. Gyampoh and Winston A. Asante. (2011) *Mapping and Documenting Indigenous Knowledge in Climate Change Adaptation in Ghana*.