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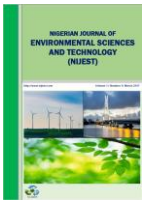

Ecological Effects and Vulnerability Assessment of Flooding in Udu Local Government Area, Delta State, Nigeria

Ndakara O. E.[1] and Atuma I. M.[2]

[1,2]Geography and Regional Planning Department, Delta State University, Abraka, Nigeria

Corresponding Author: *ndakaraoe@delsu.edu.ng

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ABSTRACT

This study is based on the ecological effects and vulnerability assessment of flooding within Udu Local Government in the Delta State region. This research adopted the survey design. Five (5) flood vulnerable communities which represent the major subdivisions in Udu were investigated. Stratified random technique of sampling was used to divide the communities into quarters for effectiveness in data collection, while simple random technique was adopted in the collection of data. Data collection was on the communities covered by flood, causative factors of flooding, and the resultant effects on human inhabitants, environment, and the prevailing economic activities within the region. Data collection was through direct field survey and the use of questionnaires. The instrument's level of reliability was achieved at 0.89 using the test-retest method; while instrument validity was determined by experts' judgements. Data collected were analysed using the descriptive, ANOVA and regression statistics. Results showed that the communities investigated are vulnerable to flooding; significant difference was not found in the observed causative factors of flooding among the vulnerable communities; the effect of flooding is high within the study area; the differences in the effects of flooding within the different flood vulnerable communities in the study area is not significant at 0.05 level of confidence; and no significant relationship exists between the causative factors and the effects of flooding at 0.05 level of confidence. Therefore, good settlement planning, construct of drainage, and selective terrain cultivation are recommended.

Keywords: Ecosystem, environmental hazard, flood, interaction, vulnerability

1.0. Introduction

Proper and healthy functioning of any given ecosystem is vital to effective interaction among the living components, as well as between the living components and the environment. Therefore, unhealthy interaction, like flood incidence, within human settlement, negatively affects ecosystem functioning (Ndakara and Ofuoku, 2020). For some decades now, there have been increasing concerns directed towards flood vulnerability assessment owing to the resultant effects on both the environment and the human component of the ecosystem (Udoh and Aniefiok, 2014; Dottori *et al.*, 2018). Vulnerability describes the extent to which humans and economic activities are susceptible to changes such as flooding, as well as their inability to cope in the face of exposure to the resultant adverse effects of flooding (Feloni *et al*., 2020).

Floods are environmental hazards which occur in most regions worldwide, resulting in damages and loss of lives and livelihood sources, deterioration of environment and retarded growth and development of regions (Nazeer and Bork, 2019; Kumar and Kumar, 2020). Within tropical environment, floods of high magnitudes have resulted to serious consequences induced by heavy incidence of hurricanes, snow melt, rainstorms and dam failures. With respect to flood vulnerability, studies by Ogunbodede and Sunmola (2014); Diaz-Sarachaga and Jato-Espino (2020) reported that Pacific and Asia regions had their fair share of flooding impacts which affected the social-economic and environmental stability of countries within the regions. Some worst case scenarios as reported by the World Bank (2013) include China, which in 1998 suffered a very high devastating flood hazard which affected about 223 million persons, thereby leading to the death of 3,004 inhabitants, while 15

million persons were rendered homeless. The economic loss amounted to over 23 billion dollars in financial quantification, for that year; Cambodia, as well as Vietnam suffered greatly in the year 2000, where reports conveyed that 428 people died from the flood hazard, with estimated economic loss of over 250 million dollars; Devastating flood hazard has also occurred in India, Pakistan, Korea, Australia, United States of America and Bangladesh, with their agricultural field, residential areas, and sources of livelihood critically affected (Sayers *et al*., 2013; Alnaimat *et al*., 2017; Nazeer and Bork, 2019).

Arguably, the rate at which flooding incidences occur in recent times is quite unprecedented. With about 70 million humans globally exposed to flooding yearly, and more than 800 million living in flood prone areas (America's Climate Choices, 2010). Climate change with severe and frequent rainfall events, sea level rise, rapid population growth and urbanization, rate of development on floodplains, flood risk awareness level and the ineffectiveness of efforts towards tackling flooding in many places are factors of concern globally (America's Climate Choices, 2010; Basheer and Pandey, 2019). Over 3700 cases of flood disasters have been recorded globally, between 1985 and 2014. These events were primarily responsible for the death of several thousands of inhabitants in Thailand, China and Bangladesh. The flood events have also recorded adverse effects on billions of inhabitants, leading to homelessness, physical injuries, spread of diseases, mortality and psychological conditions such as anxiety, depression, as well as post-traumatic stress (Behanzin *et al*., 2016). Four different floods that hit cities in UK in 2012 caused a total loss of 2.9 billion dollars, with hundreds of affected inhabitants. In several African countries such as Nigeria, the incidence of flooding has greatly impoverished thousands of humans through loss of properties and displacement from homes (UNHRC, 2014).

In Nigeria however, flooding has often been much observed. There have been cases of flooding at different forms and types such as urban floods, flash flood, channel floods, back-swamp floods and coastal inundation for several years on records (Ogunbodede and Sunmola, 2014), including the national flood disaster that occurred in the year 2012. The year 2012 flood incidence, according to NEMA (2013), affected 30 States out of the 36 existing States of Nigeria. Over 7 million humans were affected within the 30 States (with 2.3 million displaced and 363 deaths); 597, 476 houses were destroyed; large tracks of farmland and other means of livelihood destroyed, animals and other biodiversity were also gravely affected (NEMA, 2013). Added to the challenges above is the threat from rising sea-levels with a global average of 3.2mm rise in sea level rise, Nigeria with over 853 km (530mi) of coastline with extensive low-lying areas, and heavily industrialized are more vulnerable to flooding than ever before and large numbers of people have become vulnerable to this threat and face being evacuated due to extreme flood events either astronomical or meteorological (Ogunbodede and Sunmola, 2014).

Flooding incidences in Nigeria can be traced to early part of 1950, and were mainly coastal, fluvial and pluvial in characteristics, which have been the root causes of flooding within the rural settlements within Nigerian region and environment (Bashir *et al*., 2012). Both fluvial and the coastal type of flooding affect coastal areas especially, and are often influenced by seasonal interruption and activities of major rivers leading to overflowing water within the region which are not typically submerged (Adebayo and Oruonye, 2013). Coastal floods seriously affect areas which are low in terrain within southern regions of country. This type of flooding has been severe because of the number of humans exposed to the effect of flooding, as well as the economic and environmental implications within the region (Adelekan, 2010; Obeta, 2009). Nigeria is globally ranked with the top 20 countries whose present population and future scenarios in the 2070s (including climate change activities and socio-economic factors) are exposed to flood hazard (Adelekan, 2010). The significance and marked importance of urban environment within both political and economic development of Nigeria is generally acknowledged (Houston *et al*., 2011). However, urbanization is a critical anthropogenic influence on the climate change activities and hydrological cycle in Nigeria owing to the fact that the non-uniform terrain producing quite impervious surfaces often increases the surface water runoffs thereby reducing the infiltration capacity of soil within the environment (Ndakara *et al*., 2021).

In Delta state, flooding has recorded high effects on both the environment and human inhabitants. During the 2012 national flood hazard, many areas of Delta State were severely affected. The inhabitants within affected areas were rendered homeless, farmlands and the crops grown were all destroyed, domesticated animals died by the flood water, while in several other parts within the state, humans lost their lives ((NEMA, 2013). Udu is one major sub-region that has constantly experienced the hazardous flood effects in Delta State. In every year, flooding takes place within this region, leading to loss of household properties, farmland areas, homelessness, and in extreme cases loss of lives. Floods have large social consequences for communities and inhabiting individuals. As well known, the immediate impacts of flooding include damages to properties, destruction of farm crops and livestock, loss of human lives, and exposure to unhealthy water consumption thus, diseases attack.

Several researches have investigated flood incidences in Nigeria. Adelekan (2010) examined flooding impacts and its remedies in local communities, geopolitical regions and various states. Adeloye and Rustum (2011) and Aderogba *et al*. (2012) investigated climate change influence and anthropogenic activities, poor urban planning, and environmental management, on widespread flooding. Study by Bashir *et al*. (2012) considered the challenges of flooding and programmes design to salvage flood hazard. Other studies examined vital tools needed to address flooding in Nigeria, such as community based early warning systems (Agbonkhese *et al*., 2014), humanitarian aids from government and private sectors (Adeloye and Rustum, 2011), and appropriate level of preparedness and capacity building (Adedeji *et al*., 2012). The role of science and technology to embrace environmental education within Nigeria is posited (Terungwa and Torkwase, 2013). In Ajibade (2013), mapping flood hazard and assessment of vulnerabilities of lives together with properties to flooding are important procedures factors which play key roles towards building a sustainable community, resilience to flooding. Few studies considered modeling of flood by means of hydrodynamic, GIS, cellular automata and statistical techniques (Adegbola, and Jolayemi, 2012). The importance of reinforcing present strength and capacities of all agencies, including local communities within Nigeria to tackle flood hazard situations underlined (Obeta, 2014). The study investigated existing institutional approaches that deal with flood challenges in Nigeria with a view to more efficient, robust and satisfactory flood intervention strategies within the country.

The focus of this research is on ecological effects and vulnerability assessment of flooding in Udu, southern Nigeria. This is with a view to determining an effective and lasting panacea to salvage the region in the face of probable future occurrence of flooding. Therefore, the following hypotheses were tested: (i) There is no significant difference in the causative factors of flooding amongst vulnerable communities in Udu. (ii) There is no significant difference in the effects of flooding amongst the vulnerable communities in Udu. (iii) There is no significant relationship between the causative factors of flooding and its effects in Udu.

1.1. Study area

This flood vulnerability assessment was conducted in Udu region of southern Nigeria. This region lies between latitudes 6^0 28'N and 6^0 48'N, and between longitude 5^0 82'E and 6^0 21'E (fig. 1). This study area is located in the Delta State, within southern Nigeria. The topography of this region is a low plain thus, gives the opportunity for flooding because of closeness to the water table from above sea level. Udu region consists mainly of sedimentary formations deposited in three cycles of marine transgressions; with surficial geology comprising of the Sombreiro-Warri Deltaic plain formation. The lithologies of these surficial materials show evidence of different depositional environments that include deltaic, fluvial and ages that range from Miocene through Pleistocene to the recent (Ndakara and Ofuoku, 2020; Ukoji and Ndakara, 2021). Climatologically, Ndakara and Eyefia (2021) described this study area to be within the humid sub-equatorial climate; with annual rainfall ranging between 2000mm and 4000mm; and average temperature of about 30^0C with little variation year round. The soils according to Ndakara (2011); Ndakara (2012); Ndakara and Ofuoku (2020), are characterized with the alfisols, oxisols, ultisols and psalments. These soils are mainly derived from coastal deposits which consist of well drained sandy loam over coarse sandy clay loam subsoil. They have the characteristics of soils in the lowland rainforest ecosystems of the tropical region. The vegetation cover within Udu comprises the rainforest, the fresh-water swamp and derived savanna. The natural vegetal cover is lowland rainforest of the moist evergreen forest type.

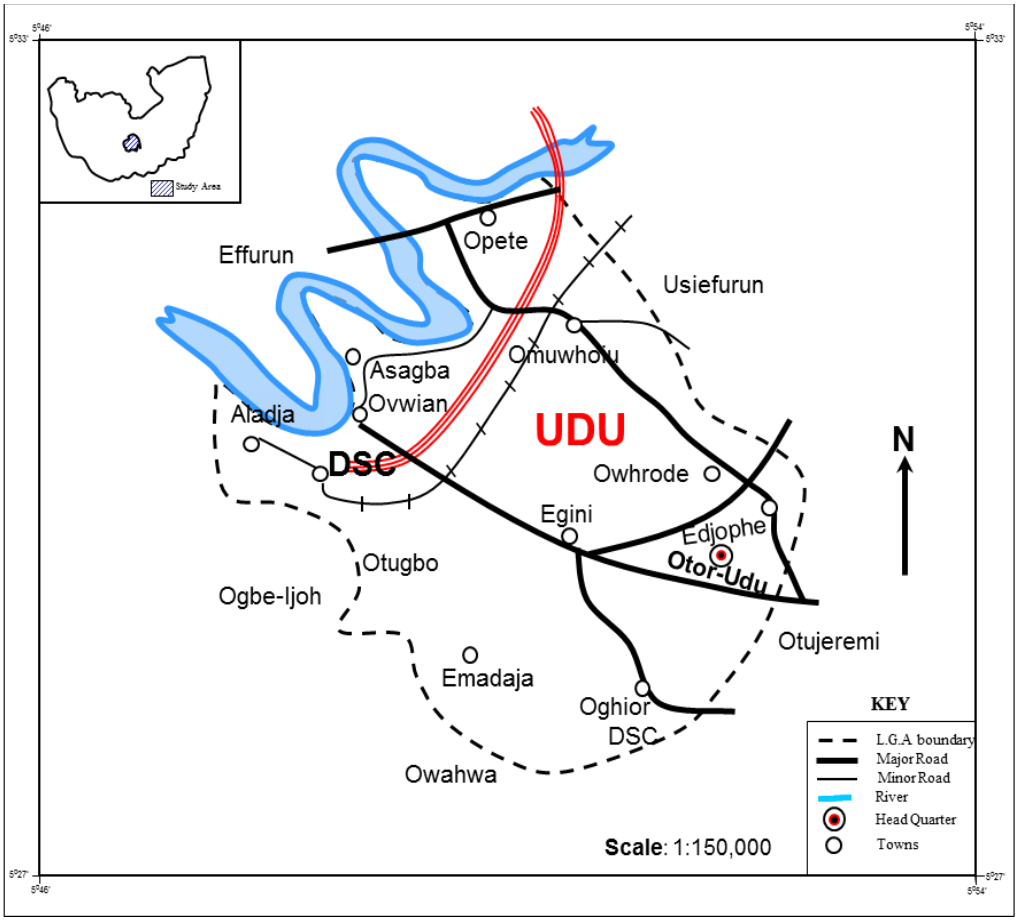

Figure 1: Map of Udu L.G.A. showing study area

2.0. Methodology

This research is based on survey design, and adopted the method of vulnerability assessment. Information regarding flood vulnerability was got from the communities within Udu, which have experienced flooding. The communities are Emadadja, Ekete, Egini, Opete, and Edjophe. Therefore, this research was conducted within these communities as they represent major subdivisions within the study area which have been more vulnerable to flooding. Data collected for this research were about the area covered by flood, causative factors of flooding, and the resultant effects of flooding on the inhabitants and prevailing economic activities within the region. These data were collected through direct field survey and observation, direct interview, and the administration of questionnaires. The stratified random sampling technique was used to divide the communities into quarters for effectiveness in data collection, while simple random sampling technique was adopted in the collection of data. Therefore, each of the communities was divided into four (4) based on the existing quarters thus, gave the opportunity for equal assessment coverage pattern, using the stratified random sampling technique. In each of the communities, 8 copies of questionnaires were administered (2 copies in each quarter within one community), making a total of 40 copies of the questionnaires administered for the study. Only these copies were administered because of time, distance covering the communities, and the time available for this study. However, the questionnaires were administered to only residents of the study area who have lived within the settlements for a minimum of 1-15 years range. The number of years lived in a given settlement by a respondent accounts for his knowledge and perception of reality about the occurrences of events in the given region. In addition, the respondents cut across all works of life thus, includes the perception of professional who live within the study area. The reliability of the instrument was determined using the test-retest method; where 20 copies of questionnaire were administered to 4 respondents in each of the five selected communities. These 20 copies of questionnaire were administered outside the ones sampled for the study, within an interval of two weeks. The Pearson Product Moment Correlation Coefficient technique was used to

determine the correlation between the two tests which was 0.89. Both face and content validity were determined by experts' judgements. Data collected were tested using the mean, standard deviation, coefficient of variation, analysis of variance (ANOVA), and regression statistics.

3.0. Results and Discussion

3.1. Demographics

In this study, a total of 40 persons were investigated, which comprises 23 male representing 58% of the total population, and 17 female representing 42% of the population sampled. Out of the 40 respondents to the questionnaire administered, 58% of them were male while 42% were female. The number of respondents in each vulnerable community (Emadadja, Ekete, Egini, Opete, Edjophe) were 4, 6, 3, 4 and 6 for male while female were 4, 2, 3, 4 and 2 respectively in each vulnerable community (see Figure 2). While equal numbers of male and female were sampled in Emadadja and Opete, the number of male was higher in Ekete and Edjophe, while the number of female was higher in Egini. This shows that there was no special target to the expected number of male or female that was administered questionnaire in each vulnerable community.

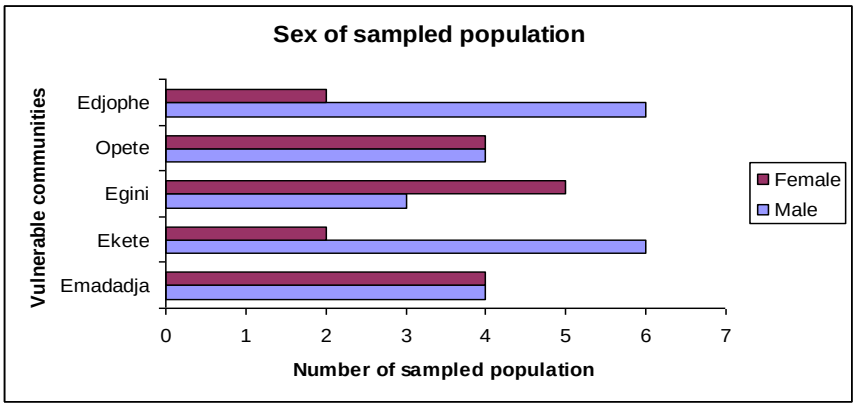

Figure 2: Sex of sampled population within the vulnerable communities

Figure 3 presents the percentage of respondents with respect to the number of years which they have lived within Udu region. 35% of the total respondents have lived within Udu region for up to 30 years; 33% has lived within the study area for up to 15 years; 25% has lived within Udu region for up to 45 years, while only 7% of the total respondents has lived within Udu region for up to 60 years respectively. These values show that highest number of respondents have lived within Udu region for a period of up to 30 years, indicating that the respondents should have knowledge of flood activities within their communities and environment if it has ever occurred. Therefore, they are not strangers to Udu regional environment thus, the information provided by them were adjudged valid. In Emadadja, Ekete, Egini and Edjophe, 3 respondents each have lived within the communities for a period between 1 and 15 years. While 3 respondents each have lived in Emadadja and Egini for a period between 16 and 30 years, 2 respondents each have lived in Ekete and Edjophe for a period between 16 and 30 years; and 4 respondents have lived in Opete same number of years. For duration of 31 to 45 years, 2 respondents each have lived in Emadadja, Opete and Edjophe, 3 respondents have lived in Ekete, while only 1 respondent has lived for same period in Egini. However, while only 1 respondent each has lived in Egini, Opete and Edjophe for a period between 46 to 60 years, no respondent has lived up to same number of years in Emadadja and Ekete. The number of years lived by the respondents indicates a true reflection of their knowledge about their environment, with respect to flood incidences.

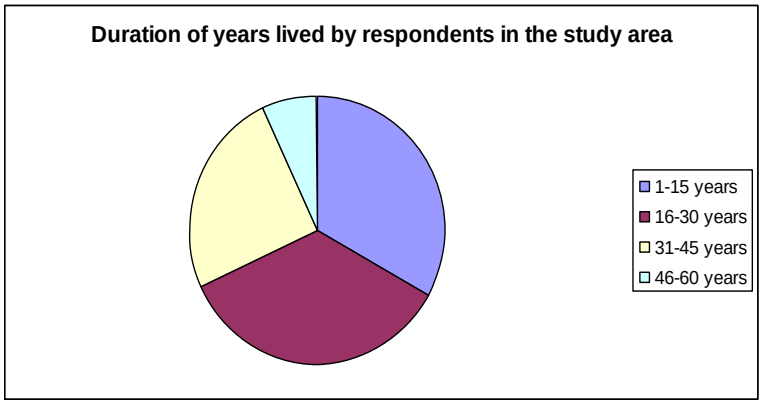

Figure 3: Duration of years lived by respondents in the study area

The knowledge and levels of awareness of the respondents regarding the incidence and occurrence of flooding within the study area is shown in figure 4. The responses were 100% for the respondents' knowledge of flood incidence within the study area. This shows that the total number of sampled persons have experienced the occurrence of flooding within the communities thus, shows the vulnerability levels of the communities to flood hazard.

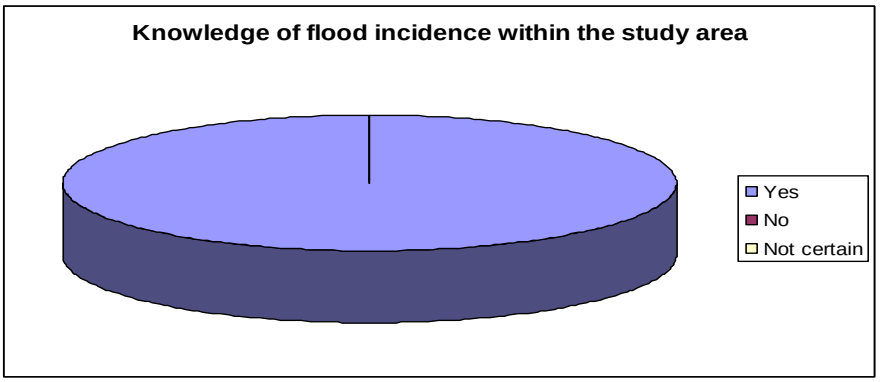

Figure 4: Respondents knowledge of flood incidence within the study area

3.2. Incidence of flooding within the study area

Flooding incidences have been a reoccurring event within several communities in Udu. Field observations during the survey exercise of this study presents different sites where flooding covered different areas of the vulnerable communities within the study area.

Plate 1 is a picture of residential areas within Udu, where the incidence of flooding covered several areas, including houses and roads. Inhabitants of this area were rendered homeless as the waters filled their homes. Cars packed within the homes were affected, while the movement of people was restricted to walking their ways through the water. Plate 2 shows the areas within Udu which are typically affected by flood. The incidence of flooding here has impact on the inhabitants in many ways. Market areas were flooded thus, made it difficult for effective marketing activities. This also affected movement of people as well as homes for their living. Plate 3 presents a picture of compounds flooded within the study area. Occupants of the compounds were rendered homeless, with their properties fully covered by flood water.

Plate 1: Residential areas submerged by flood within the study area

Plate 2: Flooded residential and market areas within the study area

Plate 3: Compounds affected by flood within the study area

3.3. Causes of flooding in the study area

Flooding which involves the overflow of water within the environment can be caused by different factors. While some of the factors may be natural, it is important that many of the factors are induced by human activities. This is why many parts of the environment which have not been originally exposed to flooding now experience flooding. The observed causes of flooding within this study area

are low terrain, heavy rainfall amount, lack of drainage system, poor settlement pattern, blockage of drainage channels, and overflow of water from adjoining basin.

Figure 5 presents the causative factors of flooding in Udu region. The main causative factors of flooding were observed to include lack of drainage system with 35 responses which represents 88% of the total respondents; low terrain with 34 responses which represents 85% of the total respondents; heavy rainfall within the communities with 31 responses which represents 78% of the total responses; poor settlement planning with 29 responses which represents 73% of the total respondents; overflow from the adjoining basin with 21 responses which represents 53% of the total respondents; and blockage of drainage channels with 14 responses which represents 35% of the total respondents.

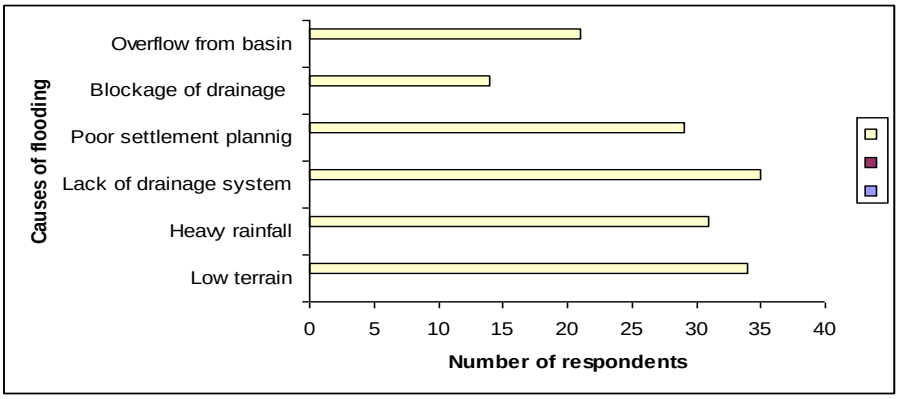

Figure 5: Causes of flooding in Udu Local Government Area

These results show that this study area is quite vulnerable to flooding. With low terrain and heavy rainfall amount experienced in the region, effective drainage system would have been able to channel the flow of water away from the built up ecosystem, but in this case, lack of drainage is a major cause as identified by the respondents. These findings are similar to the findings reported by Adegbola and Jolayemi (2012). While this study identified poor settlement planning as one of the major causes of flooding in the study area, the result is in line with findings earlier reported in different studies carried out by Adelekan (2010), Adeloye and Rustum (2011) in southwestern region of Nigeria. Lack of drainage system is identified as the highest cause of flooding in this study. This is in agreement with the observations reported by Aderogba *et al*. (2012), and Ajibade *et al*. (2013). Overflow of water from adjoining basin was also identified as one of the causes of flooding in this study. This finding is in line with the report of water overflow reported by Adedeji *et al*. (2012). However, the overflow of water from adjoining basin affects interaction between and amongst the components of the human ecosystem thus, leading to displacement and other negative effects in the region.
The mean differences in the causative factors of flooding amongst the 5 vulnerable communities were tested with the ANOVA statistics (Table 1).

Table 1: ANOVA results for the causes of flooding in the study area

Variable	Groups	Sum of squares	d/f	Mean square	F	Sig.
Causes of flooding	Between	7.375	4	1.844	.554	.698
	Within	79.867	24	3.328		
	Total	87.241	28			

Table 1 shows the results of ANOVA test for the differences in the causes of flooding within the communities in the study area. The mean values varied among the five communities. However, the differences in the mean values are not significant at the 0.05 level of confidence. This is because the F-value is 0.55 while the significant test value is 0.69. Therefore, there is no significant difference in the causes of flooding among the communities in the study area. This shows that, the causative factors of flooding within the vulnerable communities are the same.

3.4. Effects of flooding in the study area

The effects of flooding within this study area were examined with respect to what the resultant impacts of flooding cause the inhabitants of the ecosystem. In this study area, flooding has led to the displacement of people from their homes, death of human humans and animals, loss of properties, loss of farmlands and agricultural produce, poverty, exposure to social vices such as rape.

Figure 6 presents the effects of flooding in the study area. The main effects of flooding were observed to be loss of farmland areas with 39 response which represents 98% of the total respondents, social harassment with 37 responses which represents 93% of the total respondents, loss of properties and displacement of people had 35 responses each which represent 88% of the total respondents each, increased poverty had 34 responses which represents 85% of the total respondents, while loss of lives had 16 responses which represents 40% of the total responses. These responses show that the effects of flooding within the study area are high. High effect of flooding on farmlands and social harassment resulting from displacement was also observed in the studies by Adedeji *et al*. (2012), Ajibade *et al*. (2013), and Agbonkhese *et al*. (2014). When people are displaced due to flooding, they become homeless, while the means of subsistence becomes extremely difficult. In this condition, the females are exposed to social harassment such as rape. Where 98% revealed that farmland areas are destroyed by flood is a very high effect to the production of food. Although the responses varied among the different communities, the differences in the effects among the vulnerable communities were tested with the ANOVA statistics (Table 2).

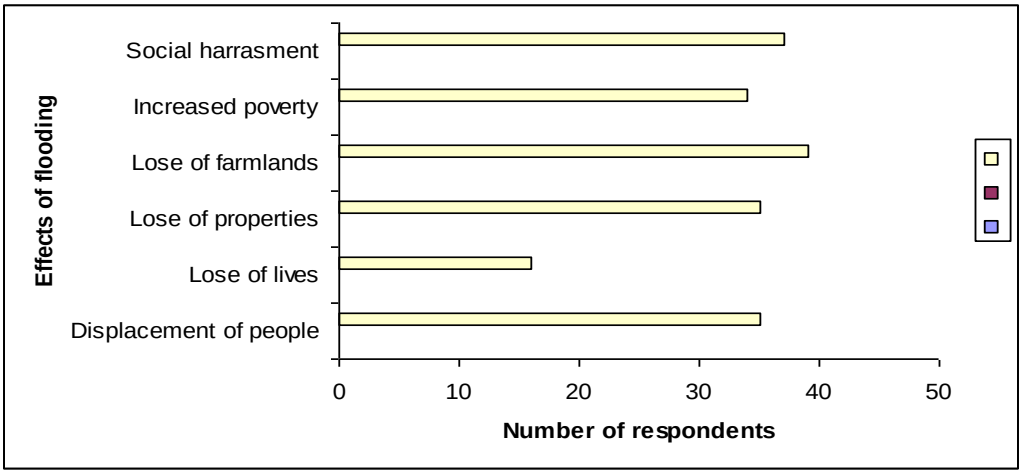

Figure 6: Effects of flooding in Udu Local Government Area

Table 2: ANOVA results for the effects of flooding in Udu Local Government Area

Variable	Groups	Sum of squares	d/f	Mean square	F	Sig.
Effects of flooding	Between	1.467	4	.367	.118	.975
	Within	78.000	25	3.120		
	Total	79.467	29			

Table 2 presents the results of the ANOVA statistics for the effects of flooding among the five communities within the study area. The mean values for the responses in all the vulnerable communities are closely varied. However, with F-value of 0.12 and significant value of 0.98, the mean differences in the effects of flooding within the vulnerable communities is not significant at the 0.05 level of confidence. Therefore, there is no significant difference in the effects of flooding observed within the different flood vulnerable communities in Udu Local Government Area. This shows that, the resultant effects of flooding within the vulnerable communities are the same.

3.5. Relationship between the causes and effects of flooding in the study area

The relationship between the causes and effects of flooding in Udu Local Government Area was tested with the regression analysis statistics at the 5% confidence level (Table 3).

Table 3: Regression analysis results for the relationship between the causes and effects of flooding in Udo Local Government Area

Model	Sum of square	Df	Mean Square	F	Unstandardized coefficient (B)	Standardized Coefficient (t-value)	Sig.
Regression	65.672	1	65.672	.128	82.764	2.041	.739
Residual	2059.661	4	514.915		-172	-357	
Total	2125.333	5					

From the results in Table 3, the F-value is 0.128 while the significant test value is 0.739. From these results, the regression analysis which tested at the 0.05 level of confidence is not significant. Therefore, there is no significant relationship between the causes and the effects of flooding within Udu Local Government Area at the 5% level of confidence. This shows that the extent to which flood affects the study area is not determined by the causes of the flood activities. This finding is in line with the findings reported in the studies by Aderogba *et al*. (2012), Ajibade *et al*. (2013), and Agbonkhese *et al*. (2014).

4.0. Conclusions

This study focused of the ecological effects and vulnerability assessment of flooding in Udu Local Government Area. The study is of paramount importance in the management and control of the environment to avoid flood hazards within the human ecosystem. In this study, it was observed that the communities examined are all vulnerable to flooding; while the main causes of flooding, in order of highest ranking to the lowest were observed to be lack of drainage system, low terrain, heavy rainfall, poor settlement planning, overflow from the adjoining basin, and blockage of drainage channels. The resultant effect of flooding within the study area is high. The main effects of flooding in order of highest ranking to the lowest were observed to be loss of farmland areas, social harassment, loss of properties and displacement of people, increased poverty, and loss of lives.

Therefore, it is recommended that good settlement planning should be effectively followed; there should be good efforts to construct drainage channels to control water from the surface; while the rural arable farmers should be made to understand the need to cultivate only the upland areas where the need for their crop production will take a little longer time to get matured for harvest.

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