Original Research Article

Geographic Information System (GIS) Based Approach To Vulnerability And Adaptation Strategies By Rural Farmers To The Impact Of Flooding In Rivers State, Nigeria.

Abstract: The aim of the research was to examine the use of geographic information system (GIS) based approach to vulnerability and adaptation strategies adopted by rural farmers on the impact of flooding in Rivers state, Nigeria. Two specific objectives and one hypothesis guided the study. The survey method was employed whilst 399 copies of questionnaire were used to elicit information from 399 respondents. Purposive sampling technique was employed to choose the six communities affected by flooding .Pearson product moment correlation coefficient was employed to test the hypothesis. The findings showed that there was a significant relationship between knowledge of flooding and adaptation strategies of the farmers; also that rural female farmers are the most vulnerable groups affected by the impact of flooding. The major underlying cause of flooding was found to be farming in flood prone areas. On the adaptation measures, the study showed that majority of the respondents perceived that building of critical infrastructures have been a crucial measure in checkmating the impacts of flood; haphazard construction of houses along flood plains to be major factor militating against the efficient management of flooding in the respective communities. It was recommended that cluster groups should be organized so as to sensitize the people on the impact of flooding and possible adaptation measures.

Keywords; GIS, flood and rural farmers, adaptation strategies, vulnerability, impacts.

1 Introduction

Flooding is one of the greatest environmental, economic and social problems that the world is experiencing currently [1]. Its impact is often felt most by rural farmers. Much literature and documentaries on the impact of flooding exist in some libraries and the internet

The impact of flood impact is spatially heterogeneous across geopolitical scales in Nigeria. For instance, the risk is generally believed to be more acute in the South-South and Niger-Benue regions of the country, due to the fact that these areas rely heavily on climate-sensitive sectors, such as agriculture and fisheries, have low GDPs, high level of poverty, low levels of education and weak institutional, economic, technical and financial capacity to manage floods [3].

The implication is that vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climatic stress but also on the sensitivity and capacity of affected societies to adapt to or cope with such stress [6]. Therefore, vulnerability is the degree to which a system is susceptible or unable to cope with the adverse effects of climate change, and extreme weather. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed to, its sensitivity and its adaptive capacity [3].

An analysis of vulnerability adaptation to flooding is needed at the level that would enable policy makers to tackle flooding problems with the precision that is necessary [4]; after all it is by understanding, planning for and adapting to a changing climate that individuals and societies can take advantage of opportunities and reduce risks [10]. This is particularly necessary in Nigeria, the most populous country in Africa and 7th in the world with 162 million people, of which 51% reside in rural areas [7]. More importantly, there is no national-level analysis of flood vulnerability that provides the spatial picture that is needed to understand where and how flooding might constitute a threat to security in the country, even though studies indicate that Nigeria lies within a high vulnerability region in Africa.

2 Aim and Objectives of Study

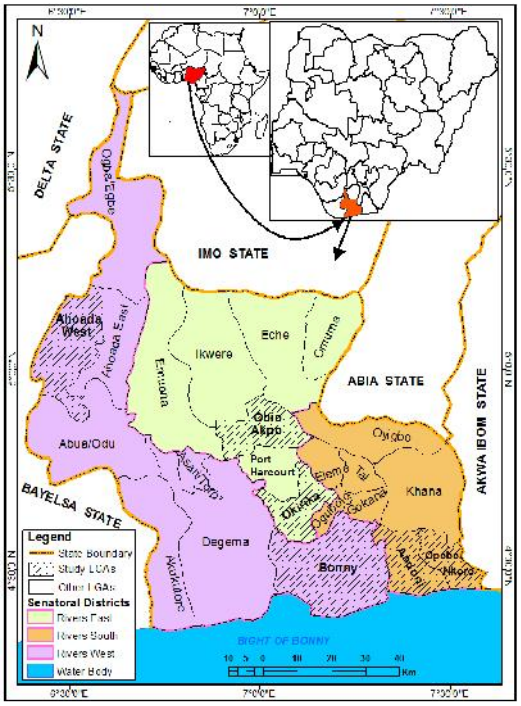
The aim of this research was to examine the Geographic Information System (GIS) based approach to vulnerability and adaptation strategies by rural farmers to the impact of flooding in Rivers state, Nigeria. The specific objectives of the study were to:

1. Identify the most vulnerable areas and groups affected by the impact of flood in the rural communities of Rivers state ;
2. Examine the different adaptation measures to the impact of flooding taken by rural farmers in Rivers state to reduce the impact of flooding on development

Research Hypothesis

H_{O1}: There is no significant relationship between knowledge of the impact of flooding and adaptation strategies used by the people of Rivers state.

3 The Study Area



Map. 1: Map of Rivers State Showing Study Local Government Area (Source: Rivers State Surveyor General Office, 2017)

Rivers State occupies an area of about 37,000 square kilometers that lies between latitude 4^0 40`38`North and longitude 6^0 25`42` East. It is bounded in the south by the Atlantic Ocean, to the north by Imo and Abia States, to the east by Akwa Ibom State and to the west by Bayelsa and Delta States. Its shores form part of the West African coastline [3]. Over one third of the State is occupied by water with a low land stretching from Bonny in the South to Ndoni in the north. A network of creeks spans the riverine south, emptying into the Atlantic Ocean through numerous tributaries of Rivers state

4 Materials and Methodology

The population of the study area as seen in Table 1 was 2,738,331 persons which consisted of rural farmers of the selected thirty (30) communities in the six (6) local government areas. These were the areas affected most by flooding in Rivers state which represented 33% of the entire Rivers state population of 8,201,591 [5]. Furthermore, the National Population Commission data of 2006 was used as the base year and projected to 2016 using an annual growth rate of 3.2%.

Data for this work was from both primary and secondary source. The sample size was determined through the use of the Taro Yamane (1967) sample size determination formula.

The Purposive sampling technique was used to elicit information from the rural farmers in the rural areas for the study. In the context of this research, rural areas have few people who are mostly into farming and businesses spread out over a large area [2]. In the first stage, the State was grouped into three Strata (Senatorial Districts); Rivers East, Rivers West and Rivers-South East senatorial districts. The second stage involved the stratification of the Senatorial Districts into Local Government Areas and two (2) Local Government Areas from each of the Senatorial districts (Okirika and Obio-Akpor LGAs - Rivers East, Opobo/Nkoro and Andoni LGAs - Rivers South and Ahoada West and Bonny

LGAs-Rivers west) that were vulnerable to flooding were randomly selected to give a total of six (6) LGAs. The rationale behind the selection of the LGAs was as a result of the in depth interview carried out by the researcher which indicated that the LGAs have been impacted by climate change greatly.

The third stage involved the stratification of each LGA into Communities. Five (5) rural communities were purposively chosen from each of the six (6) LGAs making a total of thirty (30) communities with reference to Table 1**.** The rationale behind the selection of the communities was based on the rural nature of such communities and also the primary livelihood pattern which included farming and fishing.

Furthermore, the data that was used for the research was derived largely from field survey through the use of 399 copies of questionnaire and field observation. The purpose of this method or design was to acquire information from a sample population in order to make an inference on the entire population (sample frame) of the study area [2].

Table 1; Population distribution

S/NO	LGAs	Senatorial district	Communities	2006 Population	2016 Population Projection	Questionnaire distributed	Retrieved questionnaire
1	Okirika	Rivers East	1.Ibaka	295,325	404,666	20	18
			2.Sarrah			19	13
			3.Owuambo Kiri			30	20
			4.Biebele			20	20
			5.Owuigono			15	15
						Total;104	**Total:86**
2	Obio Akpor	Rivers East	1.Rumuigbo	535,800	734,175	21	10
			2.Woji			30	15
			3.Oginigba			25	15
			4.Elelenwo			21	13
			5 Elioparanwo			10	5
						Total;107	**Total:58**
3	Opobo/Nkoro	Rivers South	1.Epelema	173,228	237,367	6	5
			2.Queens Town			7	5
			3.Minimah			8	6
			4.Kalibiama			9	9
			5.Aya-ama			5	4
						Total; 35	**Total:29**
4	Andoni	Rivers South	1.Ataba	248,532	340,548	15	13
			2.Ayama			11	10
			3.Dema			8	8
			4.Ikuru			9	9
			5.Ngo			7	7
						Total;50	**Total:47**
5	Ahoada west	Rivers west	1.Akinima	285,116	390,676	12	10
			2.Edeoha			9	9
			3.Idoki			8	8
			4.Oboh			9	9
			5 Ochigba			18	16
						Total;56	**Total:52**
6	Bonny	Rivers west	1.Finima	237,299	325,156	16.	15
			2.Oloma			12	11
			3.Abalama			.9	8
			4.Abaja			5	4
			5.Bonny			.5	4
						Total;47	**Total:42**
	GRAND TOTAL			**2,098,431**	**2,738,331**	**399**	**314**

Source: [2]

The following procedure and statistical technique was employed for the analysis which included the Geographic information system using the choropleth technique of mapping and descriptive statistics, Pearson product moment correlation coefficient was employed so as to establish the relationship among variables under consideration in order to arrive at a good decision. Apart from

investigating causal relationships between the variables, it was helpful in measuring the actual impact of each independent variable in predicting the outcome of the dependent variable. This technique could only be applied to make generalization about a larger sample size. [8] recommended a sample size if 15, to arrive at a fairly accurate result. Hence, the adoption of this statistical technique was justified.

5 Result and Discussion

Identification of the Most Vulnerable Areas and Categories of People that are Most Vulnerable to the impact of flooding in the Rural Communities

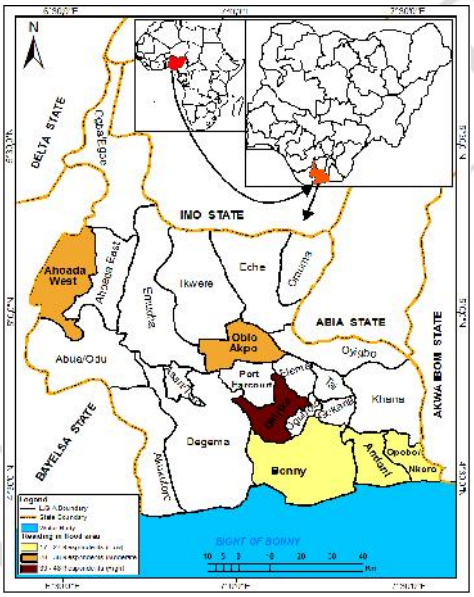


Figure 1: Residing in flood prone area as the Underlying cause of Vulnerability in the Study area

Source: Author (2017)

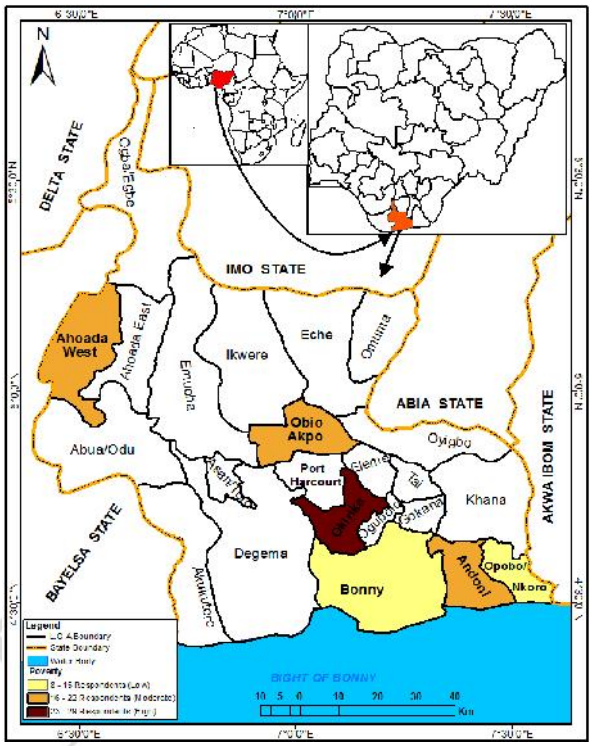


Figure 2: Poverty as the Underlying Cause of Vulnerability towards the impact of Flood in the Study Area

Source: Author (2017)

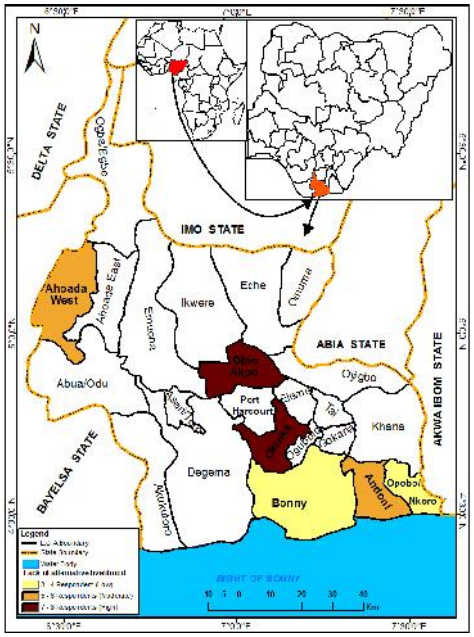


Figure 3: Lack of Alternative Livelihood as the Underlying Cause of Vulnerability towards the impact of flood in the Study Area

Source: Author (2017)

Category

The percentage scores of respondents (65%) as shown on Table 2 indicated that the female respondents are the most vulnerable to the impact of climate change while the male respondents are the least vulnerable with a response rate of 35%. Meanwhile, it is important to stress that women generally tend to be more vulnerable to the impact of climate change due to limited access to resources (wealth, knowledge and skills, technology, infrastructure and information) than men. This limitation has the potentials to increase vulnerability and thus limit their ability to cope.

Underlying Cause of Vulnerability

Investigation reveals that the underlying cause of vulnerability posed some consequences on the respondents. For instance 56% of the surveyed respondents opined that residing in an area prone to the impact of climate change was the major cause of vulnerability. Their reasons for their opinion were borne out of the fact that most of the rural communities under study lack adequate land for building/construction and they are close to the floodplain. Furthermore, based on this fact that most of them reside in flood prone areas, it was discovered that the major reason for this was poverty and this correlates with the second highest opinion which reveals that poverty was the major underlying cause of vulnerability as 34% of the respondent concurred to that. Thus, if poverty exists, then definitely there would be no way they could have an alternative livelihood and this accounts for the 10% of respondents who agreed that lack of alternative livelihood was a major factor of vulnerability.

Figure 1 shows the choropleth map on residing in flood-prone areas which was carried out by the researcher based on the surveyed local government areas. The legend indicates that 17-27 respondents had the opinion that their location is less prone to vulnerability, 28-38 respondents are located in moderate flood-prone area and 39-48 respondents are located in high flood-prone area.

Furthermore, Figure 2 shows the choropleth map on poverty as the underlying cause of vulnerability which was carried out by the researchers based on the surveyed local government areas. The legend indicated that 8-15 respondents had a low opinion as poverty being a major cause of vulnerability while 16-22 respondents had a moderate opinion that poverty was a major cause of vulnerability in their location and 23-29 respondents had a high opinion that poverty was a major cause of vulnerability

Figure 3 shows the correlate mapping on lack of alternative livelihood as the underlying cause of vulnerability which was carried out by the researcher based on the surveyed local government areas. The legend indicates that 3-4 respondents had a low opinion that lack of alternative livelihood was a major cause of vulnerability while 5-6 respondents had a moderate opinion that lack of alternative livelihood was a major cause of vulnerability in their location and 7-8 respondents had a high opinion that lack of alternative livelihood was a major cause of vulnerability.

Areas Most Vulnerable to Flooding

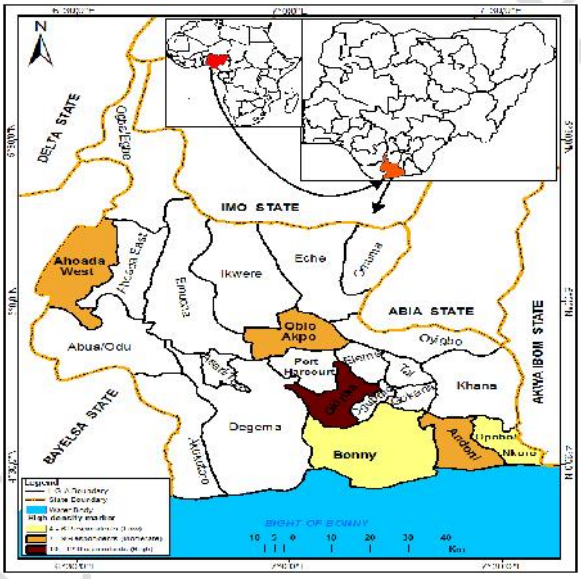


Figure 4: High Density Market as Areas Most Vulnerable to the impact of flood in the Study Area.

Source: Author (2017)

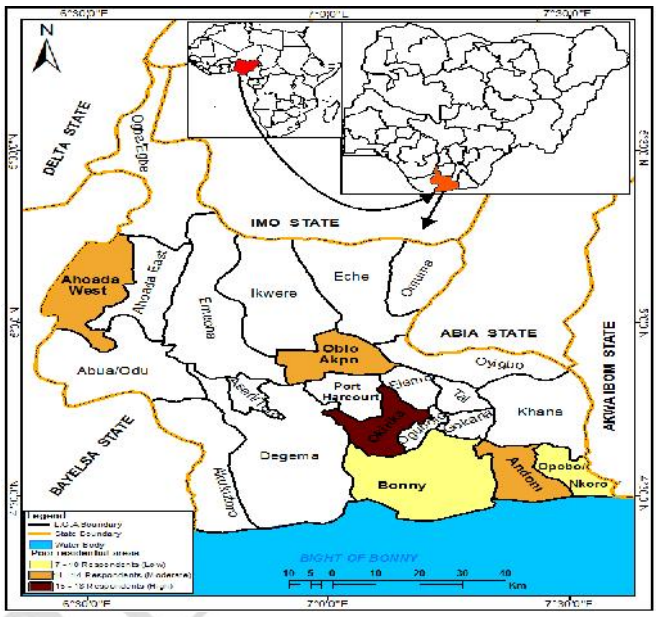


Figure 5: Poor Residential Areas as Areas Most Vulnerable to the impact of flooding in the Study Area

Source: Author (2017)

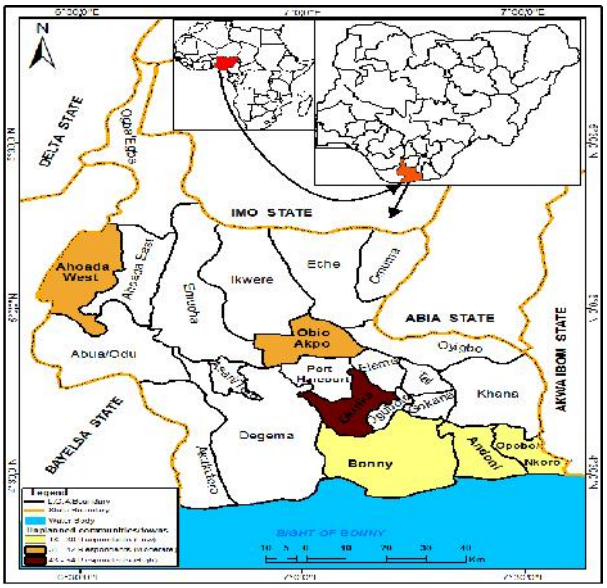


Figure .6: Unplanned Communities/Towns as Areas Most Vulnerable to the impact flooding change in the Study Area

Source: Author (2017)

Table 2: Category of People Vulnerable to the impact of flooding (n=314)

Response	Frequency	%
Category		
Male	109	35
Female	205	65
Underlying cause of Vulnerability*		
Residing in flood prone area	177	56
Poverty	106	34
Lack of alternative livelihood	31	10
Areas Most Vulnerable to the impact of flood*		
High density market	45	14
Poor residential areas	73	23
Unplanned communities/towns	196	62

Source: Data Analysis, 2017

- **Multiple Response**

The areas which are vulnerable to flooding had impact on the respondents who lived in those locations. About 62% of the respondents as seen on Table 2 adjudged that unplanned communities and towns are highly vulnerable to the impact of climate change. In expatiation to the reason given, based on observation, it was seen that these communities are unplanned due to the fact that there are no existing building laws that regulate the construction of building in the communities. Further investigation revealed that most of the buildings are carried out haphazardly with no proper plan on ground. Hence, if the communities are unplanned, it will definitely lead to poor residential environment which is clearly visible in almost all the surveyed locations of study. This accounts for the 23% of responses which relied on the fact that the poor residential areas are prone to flooding because they neglect building codes and ethics. The least percentage of responses was on high density markets as revealed by 14% of the respondents.

Subsequently Fig. 4 shows the choropleth mapping on high density mapping

of areas most vulnerable to the impact of flooding which was carried out by the researchers based on the surveyed local government areas. The legend indicates that 4-6 respondents had a low opinion that high density markets are areas most vulnerable to the impact of climate change while 7-9 respondents had a moderate opinion that high density markets are areas most vulnerable to the impact of flooding and 10-12 respondents had a high opinion that high density markets are areas most vulnerable to the impact of flooding.

Fig 5 reveals the choropleth mapping on poor residential areas as areas most vulnerable to flooding which was carried out by the researcher based on the surveyed local government areas. The legend indicates that 7-10 respondents had a low opinion that poor residential areas are most vulnerable to flooding while 11-14 respondents had a moderate opinion that poor residential areas are areas most vulnerable to flooding and 15-18 respondents had a high opinion that poor residential areas are areas most vulnerable to the impact of flooding .

Figure 6 reveals the choropleth mapping on unplanned communities/towns as areas most vulnerable to the impact of flooding which was carried out by the researcher based on the surveyed local government areas. The legend indicates that 18-30 respondents had a low opinion that unplanned communities/town are most vulnerable to the impact of flooding while 31-42 respondents had a moderate opinion that unplanned communities/town are areas most vulnerable to the impact of flooding and 43-54 respondents had a high opinion that unplanned communities/town are areas most vulnerable to the impact of flooding.

Different Adaptive Measures to Flooding Taken by the Rural Communities

Table 3: Multiple Responses on the Different Adaptive Measures to the impact of flooding Taken by the Rural farmers to Reduce the Impact (n=314)

Adaptive measure*	Frequency	%
Indigenous Ways Adopted by the People		
Use of sand bags	31	10
Formation of local groups	67	21
Planting of trees	32	10
Construction of drainage channels	252	80
Building of soak pit	87	28
Adaptation Measures Used to Cushion Flooding		
Building of critical infrastructure in the community	278	88
Training of volunteer on flood, capacity building etc.	38	12
Movement from a flood prone area	77	25
Listening to information about flooding through mass media such as radio, newspaper etc.	99	32
Others	62	20
Factors Militating Against Efficient Management of Flood Disaster		
Lack of implementation of existing flood policies	98	31
Poor town planning such as haphazard construction of houses in the community	124	40
Rising population and increased density	67	21
Others	23	7
Information Needed to Adapt to Flooding		
Cause of flooding	190	61
Effect of flooding	65	21

Adaptive measures		209	67

Source Data analysis 2017

Indigenous Ways Adopted by the People.

Data analysis shows that the commonest indigenous measures undertaken by majority of the respondents in the communities as seen in Table 3 were the construction of drainage and building of soak pits. These two measures were applied by 80% and 28% of the surveyed respondents in the sampled communities respectively. Such high success rate in the adaptation measures can be explained by (i) the drainages constructed by the locals with high gradient and proper layout; likewise the soak pits formed from the runoff from the drainage channels. However, on careful observation carried out by the researchers, it was found that majority of the drainages constructed were not made with solid materials, leading to an imminent collapse within a short time frame. Furthermore, rural dwellers found in the various communities have resulted to a self-help effort by the formation of local groups which account for the 21%. This self-help effort groups are headed by well exposed individuals who are, most times, trained by volunteers on the impact of flooding. The duty of these heads is to enlighten other members of the groups found in the community on recent adaptation measures. This correlates to the preceding 10% who said they have adopted the planting of trees as an adaptation measure towards flooding. The reason for this percentage is as a result of the activities and the effort of the local groups in educating the rural dwellers on different adaptation measures. Moreover, the least percentage went to the use of sand bags. The reason for this low response from the respondents was based on the fact that from a careful observation, flooding often washes away the sand easily , it might also lead to erosion which may become disastrous for the communities.

Adaptation Measures to Cushion Flooding

Almost all respondents adapted to one or more measures so as to cushion the effect of flooding. Results as seen in Table 3 reveal that the commonest adaptive measure to cushion the impact of flooding was the construction of critical infrastructures in the community. About 88% of the respondents had this opinion and obvious findings show that most of these critical infrastructures were carried out by external assistance and in other times by the locals. Also, it was discovered that most of the ancient infrastructures that were put in place by the past administration have been overstretched by the inhabitants. Furthermore, since these critical infrastructures have been provided, the respondents are of the opinion that they have started listening to programmes and documentaries on the impact of floods through the mass media which include flood forecasting from the radio and television, etc. This attests to the 32% of respondents who have an opinion on this factor. In the same vein, in putting what they have heard through

the mass media into action, respondents have decided to liaise with internal/external organizations who are willing to train those who have decided to become volunteers. These volunteers are trained on pre-requisite knowledge on flood control with global practice on how to adapt to flood disaster. Lastly, enlightenment on movement to a flood prone area is seen as the last option and this attests to the 25% of respondents having opinion on this. The reason for this low percentage is as a result of poor linkage of nearby communities in the area and also that relocation is not a good strategy; thus, making them reside where they have been used to.

Factors Militating against the Efficient Management of flood Disaster

According to the perception of respondents, a combination of factors has militated against the efficient management of flooding disaster. These factors were lack of implementation of existing policies on the impact of flooding , poor town planning such as haphazard construction of houses in the communities, rising population and increased density and other factors.

As stated earlier majority of the respondents (40%) stated that poor town planning such as haphazard construction of houses in the communities had been a major factor militating efficient management of climate change disaster in their communities. Careful observation by the researcher to find out why there is a haphazard construction of buildings show that those who are to implement these laws are not even coming to work as most of them reside in the urban areas and come only when there is verification of staff by their local government council secretariats. Thus, if those who are supposed to ensure the strict compliance of these laws are not on ground, it will lead to lack or poor implementation of the existing climate change policies (if even they have any). This fact concurs to the 31% respondents who agreed to the existing views of the researcher. A critical evaluation of the flood policies in the local council shows that there is no existing flood policy document in the study area as it was discovered that the process of domesticating the existing flood policy document of the state is still in the process and bureaucracy has been a bottle neck in its enactment.

This, therefore, poses a serious challenge as there has been rising population resulting in an increase in density of the area which accounts for 21% of the respondents. It is pertinent to note that on careful observation, a large number of the populace is yet to be acquainted with the state policy on the impact of climate change. This calls for more effort in the sensitization of the rural populace. 7% of the respondents claimed that other factors not mentioned in the data collecting instrument

hindered the efficient management of the impact of flooding.

Information Needed to Adapt to the impact of flooding

Observation revealed that the source of information needed to adapt to the impact of flood has substantially changed over the past years. This perception was corroborated by the data as seen in Table 3.

When respondents were asked on the appropriate information needed to adapt to the impact of flooding, 67% of them felt that information on adaptive measures are very vital in adapting to the impact of climate change. They are of the opinion that the existing source of listening to the impact of flooding information needs to be expanded and its content expatiated on adaptive measures as they were already feeling the impact. Furthermore, on a careful observation of the content of the information about the impact of flooding which was made available to the rural farmers, it was discovered that it lacked critical information needed for adaptation in line with global best practices and this concurs to the percentage of the respondents. In the same vein, 61% are of the opinion that they still need to be abreast with information on the cause of flooding so as not to contradict their local knowledge as can be seen in the percentage of respondents who attested to this factor; while 21% of the respondents preferred having information on the effect since most of them are already conversant with the cause and adaptive measures.

Testing of Hypothesis

Ho: There is no relationship between knowledge regime and adaptation strategies.

H1: There is a significant relationship between knowledge regime and adaptation strategies.

Result on Table 4 indicates that there is a significant relationship between knowledge of flooding regime and adaptation strategies ($r=0.612$; $p<0.01$) which resulted in rejection of null hypothesis at 0.05 level of significance. Given strong positive correlation of 0.612, this implies that a percentage change (increase or decrease) in knowledge of flooding regime would lead to a corresponding change in adaptation strategies and vice versa.

Table 4: Pearson's Product moment Correlation Matrix Showing relationship between Knowledge of Flooding Regime and Adaptation Strategies

		Indigenous ways	Adaptation strategies
Knowledge of flooding regime	Pearson Correlation	1	.521**
	Sig. (2-tailed)		.000
	N	290	290
Adaptation strategies	Pearson Correlation	.521**	1
	Sig. (2-tailed)	.000	
	N	290	290

**Correlation is significant at the 0.01 level (2-tailed).

Source: Data Analysis, 2017

6 Conclusion and Recommendation

The study assessed the vulnerable groups and impact of flooding on the rural farmers and the different adaptive measures taken to reduce the impact. On identifying the most vulnerable groups that are often affected, the study revealed that the rural female farmers are the most vulnerable groups affected by flooding and also that the major underlying cause of vulnerability is residing in flood areas.

On the adaptation measures the study showed that majority of the respondent perceived that building of critical infrastructures has been a crucial measure in adaptation while poor town planning such as haphazard construction of houses were perceived as a major factor militating against the efficient management of the impact of flooding in the respective communities. Furthermore, the study showed that information on adaptive measure is what is highly needed by the respondents to adapt to the impact of flooding. It was recommended that there should sensitization on the utilization of the impact of climate change and the issue of adaptation; rural dwellers should be assisted to ensure that mal-adaptation does not occur. There should be efficient capacity building and massive investment in climate change measures

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