MICRO-LEVEL ANALYSIS OF DETERMINANTS OF FARMERS' ADAPTATION MEASURES TO CLIMATE CHANGE IN THE NIGER DELTA REGION OF NIGERIA: LESSONS FROM BAYELSA STATE

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Abstract:

The broad objective of this study was to analyse the determinants of climate change adaptation measures by farmers in the Niger Delta region of Nigeria with particular focus on Bayelsa State. Primary data were collected with the use of questionnaire administered to two hundred farmers. Data collected were analysed using descriptive statistics and multinomial logit regression. The results indicate that most farmers perceived that long-term temperatures are increasing. Also, the overall perception on long-term changes in precipitation is that the region is getting wetter and that there are pronounced changes in the timing of rains, and frequency of rainstorms. These perceptions are in line with trend analysis results of data from the Nigerian Meteorological Agency. The result showed that use of resistant varieties, change from livestock to crop production and use of wetlands were the most commonly used method as 35.00%, 32.00% and 31.00% of the farmers respectively confirmed it. Farmers' socioeconomic characteristics significantly affected the probability of uptake of adaptation measures to counteract the negative effects of climate change. Farmers' access to free extension services, farm income, output, gender, awareness of climate change, experience, and education affected adaptation to changing climate. This result underlines the important role of increased formal and informal institutional support in promoting use of adaptation options to reduce the negative effects of climate change. It is recommended that government policies need to support research and development that develops and diffuses the appropriate technologies to help farmers adapt to changes in climatic conditions.

Keywords: Farmers' adaptation measures, Climate change, Niger Delta, Bayelsa State

Introduction:

The Niger Delta is a complex yet fragile environment with almost all oil production activities in Nigeria taking place in the region. Oil exploration in the region bring with them environmental degradation of monumental dimensions (Umoh *et al.,* 2011). Climate change is expected to increase with increased frequency and intensity of extreme weather conditions in Nigeria's Niger Delta. The implications for Niger Delta are that the region would generally experience wetter than average climate, more extreme weather conditions, particularly erosions, sea level rise and floods. Agriculture and fishing remain the main source of livelihoods for most rural communities in the Niger Delta. Climate change is expected to have greater negative impacts on poorer farm households as they have the lowest capacity to adapt to changes in climatic conditions and more vulnerable to vagaries in climate.

Adaptation measures are therefore important to help these communities to better face extreme weather conditions and associated climatic variations (Adger *et al.*, 2003). Adaptation has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socioeconomic conditions, such as volatile short-term changes in local and international markets (Kandlinkar and Risbey, 2000). Therefore, an analysis of perception to climate change and adaptation options is important for the agricultural communities of Nigeria's Niger Delta.

A few studies published to date investigated the determinants of farm-level adaptation options to climate change in the context of Nigeria. Onyeneke and Nwajiuba (2010) investigated socio-economic effects of crop farmers' adaptation measures to climate change in the South-eastern rainforest zone of Nigeria using multinomial logit model. The study found that the socioeconomic characteristics of farmers significantly affected the uptake of adaptation measures to counteract the negative effects of climate change. Though, they adopted the multinomial logit model in their analysis, their study did not cover the major Niger Delta States like Bayelsa where the bulk of environmental degradation has been observed. Umoh and Eketekpe (2010) employed production function approach to measure the impact of adaptation intensity on crop outputs. The study reported that labour and the level of education of the farmers were important determinants of the impact of adaptation on crop output. The advantage of using this approach is that it incorporates adaptation in the analysis of impacts of climate change. The cross-sectional Ricardian model implicitly assumes that farmers are rational and adapt to changes in climatic conditions in their decision making process. The limitation of this approach in analyzing adaptation is that the underlying assumptions that "historical choices made in the market implicitly map agricultural (and other sectoral) outputs to climate variables" fails to explicitly model adaptation in the agricultural sector (Kandlinkar and Risbey, 2000). Filling this gap in knowledge is the objective of this paper.

Methodology

The study was conducted in Bayelsa State. It shares boundaries with Delta State on the North, Rivers State on the East and the Atlantic Ocean on the West and South. Bayelsa is divided into eight local government areas (LGAs) namely Ogbia, Yenegoa, Kokokuma/Opokuma, Southern Ijaw, Nembe, Brass, Sagbama, and Ekeremor LGAs. It has a population of 1,703,358 persons (National Bureau of Statistics, 2006). Four out of the eight LGAs were randomly selected and two communities in each LGA were randomly selected. In each community, twenty five farmers were randomly selected from a list compiled by extension agents working in the communities. In all, 200 farmers were used for the study. The main tool for data collection was the questionnaire. Data collected were analyzed using descriptive statistics and multinomial logit model.

Analytical Techniques:

The multinomial logit model can be written as $P(Y= q/X_i) = [\exp (\beta_q X_i)] / [1+ \sum q \exp (\beta_q X_i)]$.

Where; P = Response Probability,
Y = Adaptation category; q = 1, 2, ……….11;
1= use of wetlands,
2= irrigation,
3= construction of drainage,
4= use of weather forecast,
5= use of resistant varieties,
6= change from crops to livestock,
7= migration from climate risk region,
8 = expansion of cultivated land,
9= afforestation,
10 = change from animal to crop production,
11 = No adaptation

$X_i = X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}$ = Independent variables

X_1 = Farmers' educational level (years)
X_2 = Farmers' gender (Dummy variable, male=1, female=0)
X_3 = Farmers' age (years),
X_4 = Farmers' household size (persons),
X_5 = Farmers' income (₦),
X_6 = Access to free extension services (Dummy variable; Yes = 1, No = 0),
X_7 = Farmers' experience (Years),
X_8 = Farmers' farm size (hectares),
X_9 = Farmers' Output (₦),
X_{10} = Farmers' awareness to climate change (Dummy variable; Yes = 1, No = 0)
u= Error term.

Bq = $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}$ = Respective parameter estimates of the independent variables

β_0 is the constant term.

Results and Discussion

Assessing Farmers' Perception to Climate Change:

Farmer perceptions regarding long-term changes in temperature and precipitation are presented in Figures 1 and 2, respectively. Perceptions on long-term temperature and precipitation changes were divided into six and four categories respectively as can be seen in the Figures. The results indicate that most farmers perceive that long-term temperatures are increasing. Also, the overall perception on long-term changes in precipitation is that the region is getting wetter and that there are pronounced changes in the timing of rains, and frequency of rainstorms.

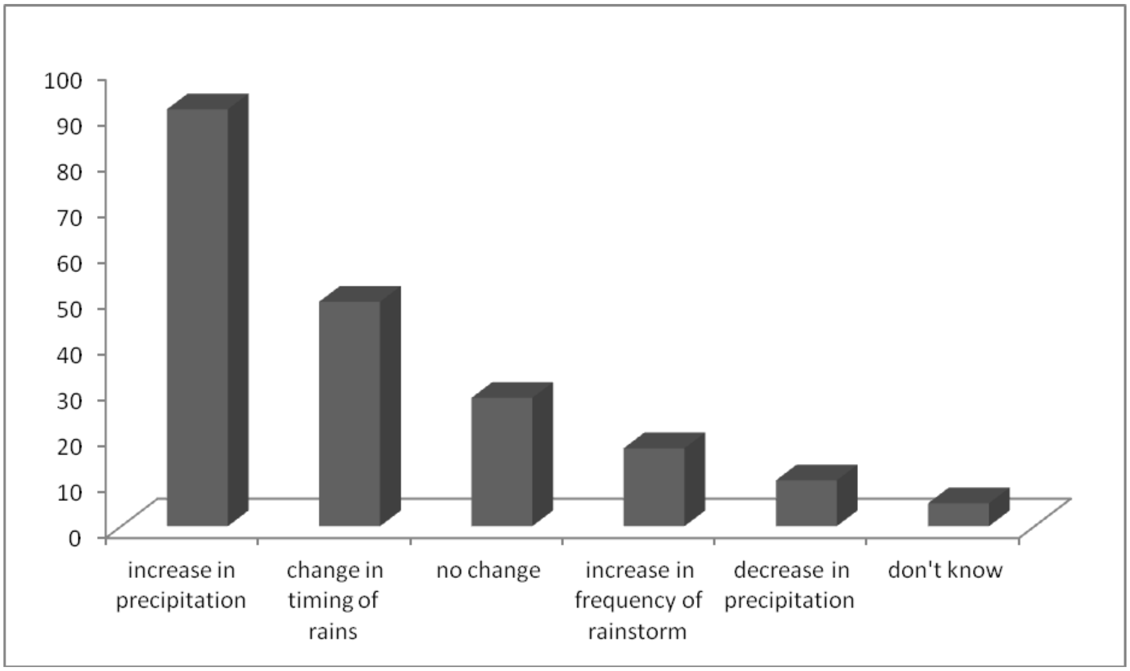

Figure 1: Farmers' perception on long-term precipitation changes

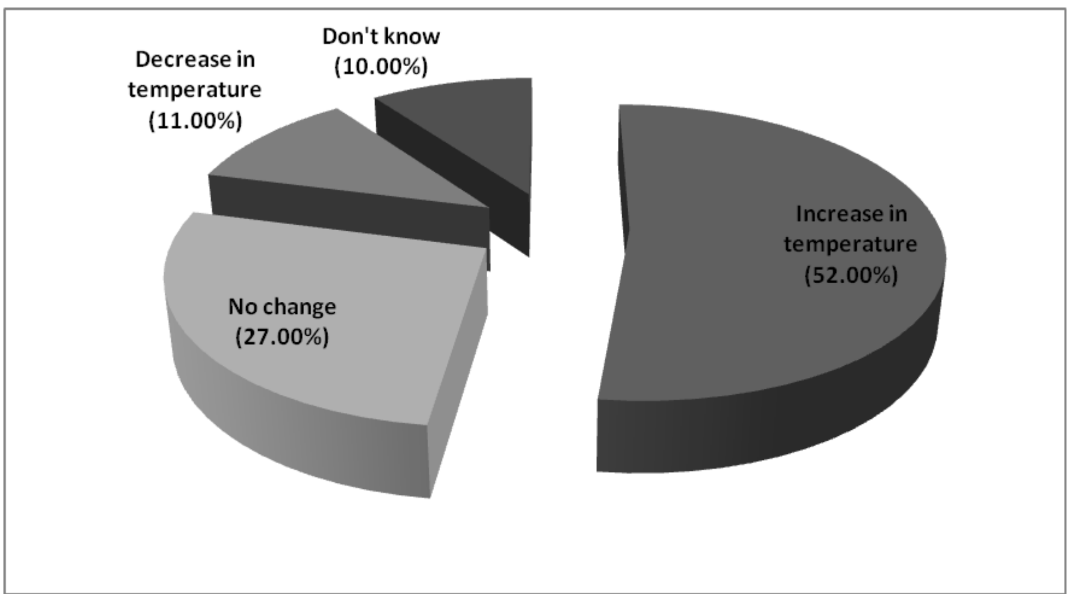

Figure 2: Farmers' perception on long-term temperature changes

These perceptions are in line with trend analysis results of data from the Nigerian Meteorological Agency by Rural Linkage Network (RULIN), 2011.

Farmers' Adaptation Measures to Climate Change:

The adaptation methods for this study are based on asking farmers about their perception of climate change and the actions they have taken to counteract the negative impacts of climate change. The adaptation measures that farmers report may be profit driven, rather than climate change driven. Despite this missing link, we assume that their actions are driven by climatic factors, as reported by farmers themselves (Maddison, 2006; Nhemachena and Hassan, 2007). The adaptation measures used by farmers in the area include use of wetlands, irrigation, construction of drainage, use of weather forecast, use of resistant varieties, change from crops to livestock, migration from climate risk region, expansion of cultivated land , afforestation , change from animal to crop production, no adaptation. As indicated in Table 1, use of resistant varieties, change from livestock to crop production and use of wetlands are the most commonly used method as 35.00%, 32.00% and 31.00% of the farmers respectively confirmed it. Use of irrigation and construction of drainage are the least practised among the adaptation methods identified in the area as reported by 6.50% and 5.50% of the farmers respectively (Table 1). Greater adoption of resistant varieties, changing from animal to livestock, and use of wetlands as adaptation methods could be associated with the lower expense and ease of access by farmers, while the limited use of irrigation and construction of drainage could be attributed to the need for more capital for irrigation and drainage systems and the dependence on rainfed agriculture in the zone.

Determinants of Climate Change Adaptation:

The estimation of the multinomial logit model for this study was undertaken by normalizing one category, which is normally referred to as the "reference or base category". In this analysis, the last category (no adaptation) is the reference category. The model was run and tested for the validity of the independence of the irrelevant alternatives (IIA) assumption by using the Hausman test for IIA. The test accepted the null hypothesis of independence of the climate change adaptation options, suggesting that the multinomial logit specification is appropriate to model climate change adaptation practices of crop farmers (Chi Square (χ2) ranged from 0.0001 to 5.101, with probability values ranging from 0.361 to 1.000 for the Hausman test. The estimated coefficients of the multinomial model, along with their respective Wald Chi Square (χ^2) values, are presented in Table 2. The likelihood ratio statistics as indicated by Chi Square (χ^2) statistics is significant ($P<0.00001$) at $p<0.01$, suggesting that the model has a strong explanatory power. The significance of this likelihood ratio statistics shows that farmers' characteristics significantly affected adaptation to climate change. Consequently, the interpretation of the multinomial logit result indicates the following:

Educational level of farmers (X_1): Education of the farmers is positive and significant across all adaptation options indicating the positive relationship between education and adaptation to climate change.

Gender of farmers (X_2): Female-headed households are more likely to take up adaptation options. The result indicates that female-headed households adapt more readily to climate change than male-headed households as there is positive sign across all adaptation options with gender. The possible reason for this observation is that in most rural smallholder farming communities in Bayelsa much of the agricultural work if done by women. Since women do much of the agricultural work and men are more often based in towns, women have more farming experience and information on various management practices and how to change them based on available information on climatic conditions and other factors such as markets and food needs of the households. The important policy message from this finding is that targeting women groups and associations in smallholder rural communities can have significant positive impacts for increasing the uptake of adaptation measures by smallholder farmers.

Age of farmers (X_3): Age of the farmer affected adaptation to climate change. Age of the farmers is positive across use of wetland, use of irrigation, change from animal to crop production, and construction of drainage indicating a positive relationship between farmers' age and the likelihood of choosing these adaptation options. This relationship could be because; the options here have been practised for a long period of time. On the other hand, age of the farmers had negative effect on the likelihood of using resistant varieties. Household size of farmers (X_4): For all the adaptation methods, household size has a positive coefficient on all of them. Household size of farmers significantly increases the likelihood of expanding the area cultivated. This indicates that household size increases the probability of uptake of adaptation measures to climate change especially expanding the area cultivated which requires added labour from the farmer.

Farm income of farmers (X_5): The farm income of farmers surveyed had a positive and significant effect on the likelihood of using all the adaptation options. This is because higher-income farmers are less risk averse and have more access to information, a lower discount rate, a longer-term planning horizon and wealthier than less-income farmers (Franzel, 1999; CIMMYT, 1993; Knowler and Bradshaw, 2007). Also, with more financial and other resources at their disposal farmers are able to change their management practices in response to changing climatic and other factors and are better able to make use of all the available information they might have on changing conditions both climatic and other socioeconomic factors.

Contact with extension agents (X_6): Contact with extension agents which denotes access to information had a positive effect across all adaptation options indicating that extension contact increases the likelihood of adapting to climate change. Access to free extension services significantly increases the probability of taking up all adaptation options. Extension services provide an important source of information on climate change as well as agricultural production and management practices. Farmers who have significant extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions. Improving access to extension services for farmers has the potential to significantly increase farmer awareness of changing climatic conditions as well as adaptation measures in response to climatic changes.

Farmers' experience (X_7): Farmer experience increases the probability of uptake of all adaptation options. Highly experienced farmers are likely to have more information and knowledge on changes in climatic conditions and crop and livestock management practices. Experienced farmers are usually leaders and progressive farmers is rural communities and these can be targeted in promoting adaptation management to other farmers who do not have such experience and are not yet adapting to changing climatic conditions. Making use of local successful lead farmers as entry points in promoting adaptation among smallholder farmers can have significant positive impacts in increasing use of various adaptation options.

Farm size (X_8): Farmers' land area cultivated is positively related to adaptation to climate change as it had positive sign across all adaptation options. Land area cultivated significantly increases the likelihood of expanding the land area cultivated, changing from livestock production to crop production and using irrigation to reduce the negative effect of climate change. This could be because these options need large land area to be practised.

Farmers' output (X_9) increases the probability of uptake of adaptation options across all the options. This is because the options chosen were intended to have beneficial effect to the farmers.

Awareness of climate change (X_{10}): Awareness of climate change significantly increases the probability of uptake of adaptation measures. Farmers who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to observed changes. It is an important precondition for farmers to take up adaptation measures (Madison, 2006). Raising awareness of changes in climatic conditions among farmers would have greater impact in increasing adaptation to changes in climatic conditions. It is therefore important for governments, meteorological departments, and ministries of agriculture to raise awareness of the changes in climatic conditions through appropriate communication pathways that are available to farmers such as extension services, farmer groups, input and output dealers, radio and televisions among others. This needs to be accompanied by the various crop and livestock management practices that farmers could take up in response to forecasted changes in climatic conditions such as varying planting dates, using irrigation, or growing crop varieties suitable to the predicted climatic conditions.

Conclusion and Recommendation

This study was based on micro-level analysis of adaptation that focuses on strategic decisions farmers make in response to vagaries in climate. These decisions are influenced by a number of socioeconomic factors that include household characteristics, household resource endowments, and access to information (seasonal and long-term climate changes and agricultural production). Farm-level decision making occurs over a very short time period, usually influenced by climate change, the local agricultural cycle, and other factors. Adaptation is important for farmers to achieve their farming objectives such as maximizing profit and production for food and livelihood security. Descriptive statistics were used to characterize farmers' perceptions on changes in long-term temperature and precipitation changes. Perception results indicate that farmers are aware that the region is getting wetter and warmer with increased frequency of rainstorm and changes in the timing of rains. Observed trends of temperature and precipitation support farmers' perceptions. The implication is that farmers need to adjust their management practices to ensure that they make efficient use of the excess rainfall and water resources for food production and other needs.

Important adaptation options being used by farmers include: use of resistant varieties, change from animal to crop production, and use of wetlands. Others are changing from crops to livestock production, use of weather forecast migration from climate risk region, expansion of cultivated land, afforestation, irrigation, construction of drainage. This paper explored the determinants of household use of different adaptation measures using a multinomial logit model. The model permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories. Multinomial logit results confirm that income, free extension services, farming experience, education, farm output, gender and awareness of climate change are some of the important determinants of farm-level adaptation options. Use of different adaptation measures significantly increase for household with more access to these factors. Designing policies that aim to improve these factors for smallholder farming systems have great potential to improve farmer adaptation to changes in climate. For example, more access to land for female farmers, information (climatic and agronomic) as well as access to education and output markets can significantly increase farm-level adaptation. Government policies need to support research and development that develops and diffuses the appropriate technologies to help farmers adapt to changes in climatic conditions. Government responsibilities are usually through conscious policy measures to enhance the adaptive capacity of agricultural systems. Examples of these policy measures include water tolerant crop technologies, improving climate information forecasting and dissemination, or promoting farm-level adaptation measures, such as the use of irrigation and drainage technologies. Accessibility to key agricultural production information like these water and soil conservation techniques as well as the other adaptation options identified above is essential in promoting farmer adaptation to changes in climate. Government should also ensure that extension services of the Ministry of Agriculture reach the poor farmers in rural areas particularly information and packages that will help them adjust and readjust to climate change. It must be emphasized that while most agricultural adaptation response to climatic event and climate change will ultimately be characterized by responses at the local level, the encouragement of responses by government at the national, eco-regional and state levels will affect the speed and extent of adaptation. Thus, response at these levels will be necessary, especially to encourage research, training and communications concerning the most appropriate adaptive options. It is also significant to note that selecting preferred strategies will almost always involve trade-offs between meeting different objectives.

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Table 1: Distribution of the adaptation options by farmers in Bayelsa state

Adaptation Option	**Frequency**	**Percentage***
Use of resistant varieties	70	35.00
Change from animal to crop production	64	32.00
Use of wetland	62	31.00
Change from crop to livestock production	51	25.50
Expansion of cultivated land	48	24.00
Afforestation	21	10.50
Migration from climate risk region	19	9.50
Use of weather forecast	15	7.50
Irrigation	13	6.50
Construction of Drainage	11	5.50
No Adaptation	9	4.50

* Multiple responses
Source: Field Survey, 2011

Table 2: Multinomial logit estimates of the determinants of farmers' adaptation options to climate change in Bayelsa State.

Variable	Use of wetland		Irrigation		Construction of Drainage		Use of weather forecast		Use of resistant varieties		Change from crops to livestock		Migration from climate risk region		Expansion of cultivated land		Afforestation		Change from animal to crop production	
	Coeff. Wald		Coeff.	Wald	Coeff.	Wald	Coeff.	Wald	Coeff.	Wald	Coeff.	Wald	Coeff	Wald	Coeff	Wald	Coeff	Wald	Coeff	Wald
1	17.1**	20.6	33.9*	4.3	3.1**	20.0	6.9**	18.0	7.9**	16.6	24.1**	18.7	6.5**	19.1	2.3**	14.9	1.9**	17.5**	1.1**	17.0
2	12.0**	9.3	21.0*	4.0	12.0**	10.0	10.0	0.1	12.0**	9.0	14.0**	11.1	3.1**	20.0	6.9**	18.0	7.9**	16.6	24.1**	18.7
3	34.8	0.0	1.2	0.0	21.2	0.0	-28.8**	10.0	-16.2	0.1	-14.0	0.1	-1.3	0.9	-3.2	1.2	-2.1	0.8	14.0	0.1
4	9.5	0.1	18.5	0.1	16.5	0.1	33.5	0.1	34.6	1.2	0.8	0.1	10.0	0.1	3.1**	20.0	2.3	1.1	1.5	0.6
5	15.7*	4.9	113.1*	4.8	12.3**	17.0	23.1**	22.3	2.3**	12.0	4.3**	20.0	17.1**	20.6	33.9**	4.3	3.1**	20.0	6.9**	18.0
6	17.1**	20.6	33.9*	4.3	3.1**	20.0	6.9**	18.0	12.0*	5.0	12.1**	10.1	12.0**	9.0	14.0**	11.1	3.1**	20.0	6.9**	18.0
7	13.0*	3.9	120.0**	6.7	11.0	0.1	21.0**	100.0	13.0	0.1	9.1	1.2	113.1*	4.8	12.3**	17.0	23.1**	22.3	2.3**	12.0
8	1.000	0.2	10.0**	20.0	1.0	0.1	121.0	1.0	1.0	0.2	6.0	1.2	13.0	0.1	12.0**	10.0	9.1	1.2	121.0**	10.0
9	1.1**	20.6	3.9*	4.3	3.1**	2.0	6.9**	1.0	7.9**	1.6	24.1**	1.7	6.5**	1.1	2.3**	1.9	1.9**	1.5**	1.1**	17.0
10	17.1**	20.6	33.9*	4.3	3.1**	20.0	6.9**	18.0	7.9**	16.6	24.1**	18.7	6.5**	19.1	2.3**	14.9	1.9**	17.5**	1.1**	17.0
Intercept	48.4	0.3	34.1	0.3	-33.3	0.2	35.2	0.1	6.2	0.0	2.4	0.1	-33.3	0.2	35.2	0.1	6.2	0.0	2.4	0.1

Base/Reference Category	**No Adaptation**
Likelihood Ratio Chi Square	**1736.344****
Pseudo R-Square (Co* and Snell)	**0.660**

Hausman Test			
Least Chi Square Value	**Level of Significance**	**Highest Chi Square Value**	**Level of Significance**
0.0001	1.000	5.101	0.361

** Significant at 1% level, * Significant at 5% level; Field Survey, 2011