ECONOMIC EFFECT OF CLIMATE CHANGE ON RICE PRODUCTION: THE ARDL APPROACH

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Abstract

The study examined economic effects of climate change on rice production: The ARDL approach. The study used secondary data. The trends of the climatic variables (especially rainfall) were significant on the yields of crops, Rice. Crops were selected based on crops farmers grow predominantly in the area and by extension planted during excessive rainfall (flooding). This excessive rainfall led to spikes (a sharp rise in rainfall followed by a sharp decline). It was observed that the crop yields responded to the spikes which resulted in lower yields in such years, and the effect of the spikes were felt on yields of these crops one or two more years after. The unit root and diagnostic tests were conducted on the time-series variables. The empirical results showed the ARDL Co-integration test results as having the adjusted R^2 of Rice (0.709) which had significant effects on yields of these various crops. Based on these findings, it is therefore recommended that climatic variability awareness campaign with science–based data and combinations of rice yields' information should be the beginning for policy making.

Key words: Climate change, rice production, ARDL

INTRODUCTION

Climate change and its effect on crop production have become a very significant menace in Agricultural activities in the world, especially in tropical countries with Nigeria fast loosing most of the rural farming environments to it which have a lot of great consequence in Agriculture. It also creates a dis-balance on crop yields with a lower predictability on what farmers produce over the years. Economic losses caused by floods are rising in Africa (Hoppe and Gurenko,2013). Both researchers predicted that if nothing is done by way of mitigation, crop yields would drop by 50% in 2017. This scenario is already manifesting in Asia and other tropical countries where the rural farming households depend on agriculture for their livelihood. The effect of flooding reported in the last two decades have been significant and are estimated to be tens of billions of US dollars (Guha-Sapir, Hoyosi, 2013). Over 3700 flood disasters are recorded in the EM – DAT (Emergency Database), covering the period 1985 to 2014 (Emergency Event Database 2014). These events were responsible for hundreds of thousands of deaths mostly in Asia notably (China, Thailand and Bangladesh).The floods have adversely affected billions of people mostly through loss of farms and farmlands, rendering people homeless. There was mortality, injuries, faecal-oral and rodent borne diseases, vector-borne diseases (mainly in 1tropical areas) and psychological conditions through depression, anxiety and posttraumatic stress (Ahem.2015, Huntar 2003, Few 2004, Tapsell &Tunstall 2008, Keith 2013).

There are climatic events responsible for crop yields or otherwise on the farm and notable among them is flood. A flood is an overflow of water that submerges land, low-lying villages or towns or an unusual condition affected by inflow of the tide (Guha Sapir, 2013). Flooding may occur as an overflow of water from water bodies, such as a river or lake, or sea or large natural water basins, or it may occur due to an accumulation of rainwater on saturated ground in an aerial flood. Flooding resulting from extreme hydro and meteorological events and that takes place in unexpected

magnitudes and frequencies can cause loss of lives, farmlands, livelihoods and infrastructure (Ahem, 2015). Annual floods are fast becoming part of people's lives in various regions of the world, recurring with varying magnitudes and frequencies to which people have adapted for centuries (Huntar, 2003).

Economic losses due to the effects of damaging floods have increased significantly around the world (Integrated Flood Risk Management in Asia, (2015). The frequency of natural disasters has been increasing over the years, resulting in loss of life, damage to property and destruction of the environment. Flood losses reduce the assets of households, communities and societies through the destruction of standing crops, dwellings, infrastructure, machinery and buildings, apart from the tragic loss of life. In some cases, the effect of extreme flooding is dramatic, not only at the individual household level, but also in the country as a whole (Integrated Flood Management Concept Paper, 2009). The Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC) predicts "heavy precipitation events, which are very likely to increase in frequency, will augment flood risk". These floods will affect life and livelihoods in human settlements in all areas such as flood plains, coastal zones, river deltas and mountains. Flooding is also increasing in urban areas, causing severe problems for poor and vulnerable people.

In Nigeria, flooding and solution to its effects are critical issues (Obeta, 2014). With history of devastating floods which affected millions of human populations and caused fiscal losses amounting to millions of Naira, the importance of exploring more realistic flood risk mitigation measures for Nigeria should be paramount. Flooding in Nigeria are Pluvial (resulting from rivers over topping their natural and manmade defense), coastal (affecting mainly the coastal areas) and flash, arriving unannounced, following a heavy storm in nature and have been a major cause of concern for rural areas and cities within the country (Andjelkovic, 2001, Bashir, 2012, Douglas,2008, Houston,2011). Whilst stake holders' efforts towards tackling the hazard have not yielded satisfactory results, being ad-hoc, poorly coordinated, non-generalizable and not well established, it is, in the light of 'best practices' in flood risk reduction and 'lessons learned' from other countries experiences of flooding, that it can be argued that such stake holders' efforts are limited by lack of quality data, which are needed to systematically tackle flooding, poor perception of flooding among the general population, lack of funds and improved technology as well as poor political will power (Obeta, 2014). More so, the growing numbers of flood victims and the constrained sustainable development caused by flooding within the country suggest that much of what is known regarding flooding within the county is deficient on remedies. More critical is the subject matter of Nigeria being one of the most populous countries of the world with population size estimated at over 170 million people (World Bank 2013). Considering the theory that future population growth will decide future flood risk, the population size along with future estimate spurs for good planning to check the menace of flooding and the resultant effect on food production in any nation that must feed her population (Guha-Sapir,2013).

Benue State is proudly referred to as the 'food basket of the nation' since the rich nutrients deposits of alluvial soils that support bumper harvest have helped farmers in producing crops on large scale. However, with the climate change and River Benue overflowing its bank, flooding has become a critical issue in recent years. Therefore, climate change and its attendant climate events (especially floods) have become what farmers will have to cope with, since it is fast becoming unpredictable to give accurate account of crop yields on farms. Farmers therefore need adequate knowledge on the nature and causes of climate change with the attendant climatic events and the various mitigation, adaptation and coping strategies to use. This of course, depends on their access to credible information sources and their capacity to apply the information. A major problem for crop production in Nigeria (at large), and Benue State (in particular), as it concerns climate change is the reduction of arable lands which arises from the incursion of sea to arable land for farming.

OBJECTIVE OF THE STUDY:

The Objective of the study is to estimate the effect of climate change on rice production

METHODOLOGY

Theoretical and empirical literature analysed the economic effect of climate change on rice production. The estimation of Effect of Climate Change on Rice Production: The multiple regression model showed:

The implicit Form of the model is stated as: $Y = \beta_0 + \beta_1 Rain + \beta_2 Temp + \beta_3 R.Hum + E_t$

Where Y = Crop Yield in Metric Tonnes (mt), (in years)

β_0 = Constant

β_1-β_3 = Coefficients

X_1 = Annual mean rainfall

X_2 = Annual Mean temperature

X_3 = Annual Mean relative humidity

e_1 = Error term or unexplained variables

The functional form of the model will be as:

$Y = \beta_0 + \beta_1 Rain_t + \beta_2 Temp_t + \beta_3 Rel\ Hum + E_t$

Where ΔY is the Total Yield is the yield of each of the crops, Rain is rainfall as measured in mm, Temp is the temperature as measured in °C, and R.Hum is the relative humidity, while t is the time trend and e is white noise error term. The parameters are β_1, β_2 ,β_3. We have employed the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001) to ascertain the long-run relationship between Total yield, Rainfall and Temperature. The ARDL approach has several advantages. First, The ARDL approach is that it can be used even in cases when different variables have different orders of integration. Second, when compared to the Johansen and Juselius co-integration test, the ARDL test ensures more consistent estimates in the case of small samples. Third, given that it is free of residual correlation, the ARDL test can handle the eventual phenomenon of endogeneity among variables. Fourth, short-run adjustments can be integrated with the long-run equilibrium in ARDL by deriving the error correction mechanism (ECM) via simple linear transformation without trailing the information about long-run.

The mathematical representation of the ARDL approach is as follows

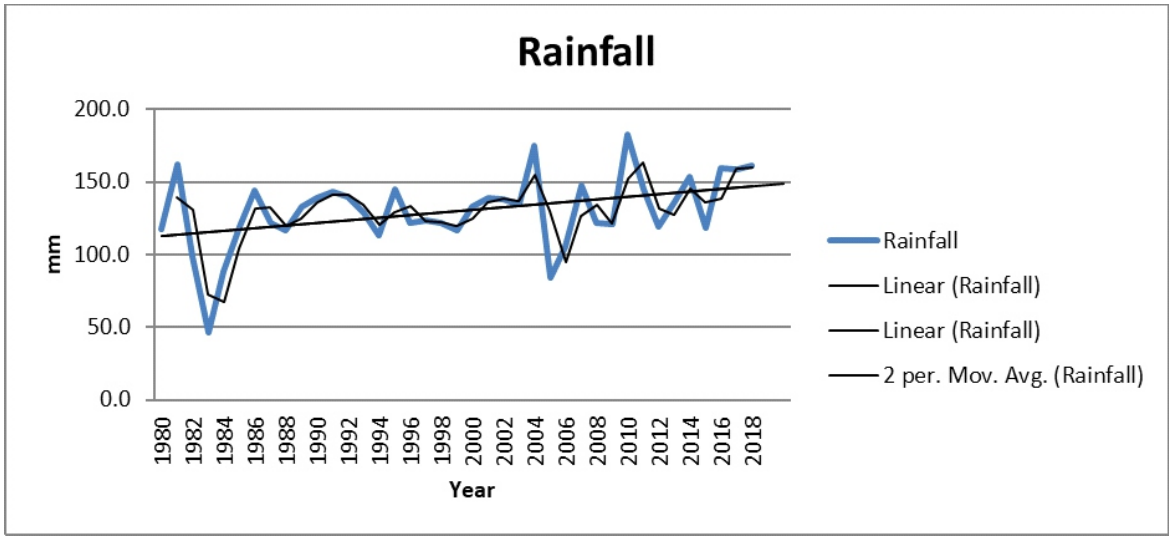
$$\Delta Y = \beta_0 + \beta_1 \sum_{i=1}^{n} \Delta Y_{t-1} + \beta_2 \sum_{t=0}^{n} \Delta Temp_{t-1} + \beta_3 \sum_{t=0}^{n} \Delta Rain_{t-1} + \beta_4 \sum_{t=0}^{n} \Delta Rel\ hum_{t-1} + \beta_5 \Delta Y_{t-1} + \beta_6 Temp_{t-1} + \beta_6 Temp_{t-1} + \beta_7 Rain_{t-1} + \beta_8 Rel.Hum_{t-1} + E_t$$

Where Δ represents change. n is the optimum delay lengths. The existence of co-integration relationship between variables from Eq. 3 is examined by testing the significance of the lagged levels of variables using the F-statistic or Wald-coefficient test. Pesaran et al. (2001) propose testing which means that we cannot reject the absence of co-integration, against the alternative, which implies that the hypothesis of the existence of such a relationship cannot be rejected.

ARDL approach is based on two steps. First step, one is to determine the existence of a long run co-integrating relationship among the variables by using the Wald-coefficient test or F-statistics and by comparing them with critical values set out by Pesaran et al. (2001). Pesaran et al. (2001) reported two types of critical values: lower bounds and upper bounds. The critical values for the I(0) variables are referred to as lower-bound critical values while the critical values for the I (1) variables are referred to as upper-bound critical values. If the calculated F-Statistic is higher than the upper bounds, it means the null of hypothesis of no co-integration is rejected, indicating evidence of a long-run co-integrating relationship between the

variables, regardless of the order of integration of the variables. If calculated F-statistic is below the lower bound, we cannot reject the null hypothesis of co-integration, indicating the absence of a long-run equilibrium relationship. If calculated F-statistic is between lower and upper bounds, a conclusive inference could not be made without knowing the order of integration of the underlying regressors. The second step is estimation of long-run and short-run coefficient. According to the estimation results of ARDL calculate long term coefficients. In order to investigate the short-run relationship between the variables, the error correction model based on the ARDL approach is established as follows.

$$\Delta Y = Y_0 + Y_1 \sum_{t=1}^{n1} \Delta\, Y_{t-1} + Y_2 \sum_{t=0}^{n2} \Delta\, Temp_{t-1} + Y_3 \sum_{i=0}^{n3} \Delta\, Rain_{t-1} + Y_4 \sum_{i=0}^{n4} \Delta\, Rel.Hum_{t-1} + Y_5 ECM_{t-1} + E_t$$



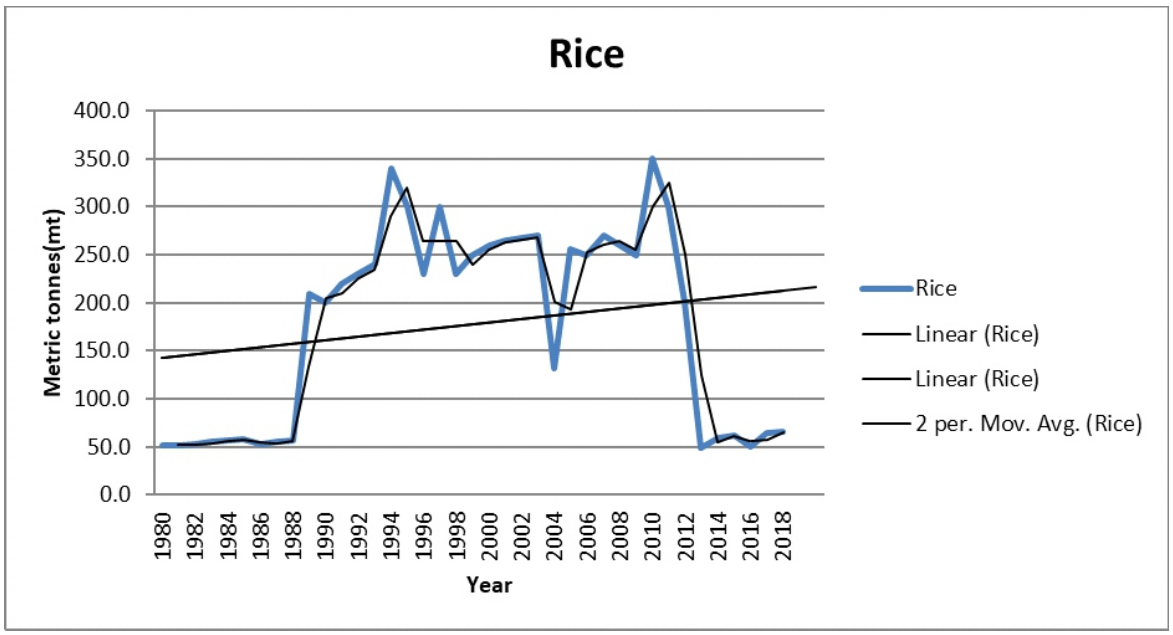


Table 1 contains ARDL co-integration test results. Critical values for F-Statistic are presented according to critical bounds table of Pesaran (2001).On the bases of F-test at 1%,5%, 10% levels of significance, with the critical values stated below which are less than the F-calculated of 11.02056,we reject the null hypothesis and conclude that the regression line for crop yield is statistically significant. From the economic theory it means explanatory variables (rainfall, temperature and relative humidity) are influential factors that can explain a larger percentage of rice yield for the period (1980-2018) in Benue State and it is good for forecasting. The bottom part of Table 2 contains diagnostic test results of the selected ARDL model. The adjusted R^2 value of 70% suggests that rainfall, temperature and relative humidity jointly explain a significant part of the variation in rice yield and 30% was explained by unknown variables that were not included in the model. This means the predictive power of this model is very high and good for policy making. The Durbin Watson test showed that there is no serial correlation in our rice yield model. Next are the results of the short run ARDL estimate presented in Table 3 The effect of climatic variables on rice yield was estimated using the Autoregressive Distributed Lag (ARDL) approach. In this study, the increase in precipitation had a positive effect, while the increase in temperature has a negative effect on rice yield. The coefficient of temperature implies that an increase of 1% in temperature will cause a decrease of 15.05% in yields of Rice in the long run in Benue State. However, the results show that the rainfall has a positive and significant effect on the yield of Rice, in the long run. The coefficient of rainfall implies that an increase of 1% in rainfall leads to a decrease of 55.0% on Rice yield, in the long run in Benue State. The coefficient of relative humidity implies that an increase of 1% in relative humidity leads to a decrease of 456.88% on Rice yield. The bottom part of Table 1 contains diagnostic test results of the selected ARDL model.

Table 1: ARDL Co - integration Test Results Test statistic	Value	k
F Statistics	11.02056	3
Critical Value Bounds (Pesaran 2001)		
Significance	I0 Bound	I1 Bound
10 %	3.38	4.02
5%	3.88	4.61
1%	4.99	5.85

Table 2: Long -Run ARDL Estimates Dependent variable is Rice		
Regressor	Coefficient	T-statistics (Probability)
RAF	-0.550007	-1.101481(0.2801)*
TEMP	-15.05546	-1.147287 (0.2610)**
REH	-456.8786	-1.655619(0.1090)*
Diagnostic test statistics		
R^2	0.779848	
Adj.R^2	0.709085	
F-statistic	11.02056(0.000000)	
Durbin-Watson	2.327882	

Note: * and ** indicate significance levels of 5% and 10%, respectively.

Table 3: Short -run ARDL Estimate Dependent variable is Rice		
Variable	Coefficient	T-statistics (Probability)
RICE(-1))	0.881952	9.291311 (0.0000)
RICE(- 1)	0.84997	8.645599(0.0000)
TEMP	-15.05546	-1.147287(0.2610)
TEMP(-1)	0.713514	0.051381(0.9594)
REH	-456.8786	-1.655619(0.1090)
REH(-1)	-1.185350	-0.004386(0.9965)
C	302.3004	0.941910(0.3533)

Source: Data Computed (2019)

Conclusion:

From the findings of this study, it can be concluded that farmers in the study area are challenged by flooding which has effected significantly on crop yields. A statistical significant relationship existed between climatic events (flooding) and crop production in the study area. This means flooding is a very important parameter and having adverse effects to crop production in Benue state. Notwithstanding, farmers engaged in adaptation strategies in the area but these were not effective due to constraints faced by them in the employment of these strategies. The decrease in crop yields is a threat to crop production in the state in particular and Nigeria in general.

Recommendations

Based on these findings, the following recommendations are made:

1. Climatic variability (change) awareness campaign with science – based data and combination of crop yields' information should be the beginning for policy making and implementation targeted at effective dissemination to reduce the effect of flooding on crop production.
2. A large number of farmers in Benue State are poor and adaptive capacity is limited. Therefore, there is need to provide relief services for them to be able to adapt to the effects of flooding. Furthermore, Agricultural Extension Service should play a critical role of informing farmers on how best to adapt to flooding effects. This will require some further training on the part of the extension personnel in order to build their capacity to effectively strengthen farmers' capacities. In line with this, the extension agents must in turn strengthen the confidence of farmers by helping them to express faith in such adaptive measures for sustainable farming activities.
3. The socio-economic factors influence or drive adaptation strategies in Benue State, therefore, it will be important that the Government policies should be aimed at raising the economic status of farmers such as level of education of the household heads and improving access to education for farmers. This will help in empowering the labour force on farms and reduce the dependency rate. Also, it will be necessary to raise the low weekly spending of farmers by providing sustainable loans through the establishment of Agricultural-based micro-finance banks that will be charged with the provision of these loans. In addition, Farmers should be encouraged to join co-operative societies and organise one in area where none exists since these co-operative societies often help in raising farmers' income.

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