Climate Change and Agricultural Export Supply in Nigeria: A co-integration analysis (1970 – 2015)

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Abstract

Climate change is one of the greatest threats to agricultural growth in developing economies of the world in the twenty first century. In Nigeria, substantial decline in agricultural export supply due to adverse climatic conditions has led to significant loss in revenue earned from the export of agricultural commodities. It is against this backdrop that this paper examined the effect of climate change on agricultural exports supply in Nigeria. Three (3) agricultural export crops (cocoa, seed cotton and palm kernel) and two (2) climatic variables (annual rainfall and temperature) were selected for the study. Secondary data spanning the period 1970 to 2015, on annual temperature, rainfall and annual output of the selected agricultural export commodities, were obtained from the Nigerian Metrological Agency (NIMET), the Food and Agricultural Organisation (FAOSTAT) database, the Central Bank of Nigeria (CBN) Statistical Bulletin, and the National Bureau of Statistics (NBS), Nigeria. Time trend analysis was used to examine the trends in the movement of climate variables and the output of the agricultural export crops, while co-integration analysis was used to understand the relationship between the output of the selected agricultural export crops and climatic variables. Results revealed that there were fluctuations in the trends of the export supply of the selected agricultural export crops. Palm kernel recorded the highest average annual domestic supply, followed by cocoa and seed cotton. Similarly, palm kernel recorded the highest average annual per cent growth, followed by cocoa and seed cotton. The highest mean annual rainfall of 96.54mm was estimated between 1990 and 1999 while the lowest of 88.55mm was estimated between 1980 and 1989. Similarly, the highest mean annual temperature of 27.44ºC was estimated between 2010 and 2012 and the lowest mean daily temperature of 26.63ºC was estimated between 1970 and 1979. The co-integration analysis revealed a long run equilibrium relationship between the annual rainfall and temperature and the export supply of the selected agricultural export crops. The resulting error correction model revealed that annual temperature positively affects export supply of seed cotton, but negatively affects export supply of cocoa and palm kernel. Also, annual rainfall positively affects the export supply of cocoa and palm kernel, showing that the climatic variables are significant determinants of export supply of agricultural export commodities.

Therefore, embarking on appropriate climate change mitigating and adaptation strategies will go a long way in minimizing the negative effect of climate change on agricultural export supply in Nigeria.

Keywords: Agricultural export crops, Climatic variables, Co-integration analysis.

Introduction

According to Parry et al. (2007), climate refers to the state of the atmosphere as dictated by weather events over a period of time, usually over a 30-year period. The Intergovernmental Panel on Climate Change (IPCC) refers to climate change as any alteration or change in climate over time, whether due to natural variability or as a result of human activity. Adeniyi and Ogunsola (2014) posited that climate change has wide-ranging effects on the environment, as well as on socio-economic and other related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Climate change poses serious environmental threats to mankind worldwide and affects agriculture in several ways, including direct impact on food production (Ziervogel et al., 2006). Also, the United Nations Environmental Protection Agency (UNEPA) (2017) posited that climate change is an inherently global issue but its impact will not be felt equally across the planet. Its impact is likely to differ in both magnitude and rate of change in different continents, countries, and regions. Some nations will likely experience more adverse effects than others. Morton (2007) stated that significant impacts of global climate will be felt by the people of developing countries. This vulnerability to climate change arises from their location in the tropics, and from various socio-economic, demographic, and policy trends limiting their capacity to adapt to change. Jagtap (1995) also stated that the impact of climate change, which is attributable to the natural climate and human activities is global but is mostly felt by developing countries especially those in Africa, due to their low level of coping capabilities.

Agricultural production is at the mercy of uncertainties driven by climate variation, including extreme events such as flooding and drought. Over the last fifteen years, climate change (in form of long-term changes in mean temperature or precipitation, as well as increased frequency of extreme climate effects) has gradually been recognized as an additional factor which, along with other conventional pressures, will have a significant bearing on the form, scale, and spatial and temporal impact on agricultural productivity (Adeniyi and Ogunsola, 2014).

Agricultural exports have played a critical role in Nigeria's economic growth and development. This sector directly or indirectly provides employment to over 50 per cent of the labour force involved in supply of food and raw materials to domestic and foreign industries, provision of income sources through backward and forward linkages and the provision of foreign exchange earnings for use in its sub-sector and other sectors of the economy (Omonona et al., 2007). Nigeria has been a major exporter of cocoa, palm kernel and seed cotton. These three export crops still remain the major agricultural commodity exports in terms of foreign exchange earnings. As a matter of fact, cocoa has remained the single most important agricultural export commodity for the country, followed by palm kernel and seed cotton (CBN, 2002; ICCO, 2007; Alabi and Alabi, 2009).

The contribution of the agricultural sector to Nigeria's foreign earnings fell from 62% before the discovery of petroleum to less than 3% in the 1990s (CBN, 2003). Despite the decline in the sector's contribution, cocoa, palm kernel and seed cotton still stand tall for their significance in foreign exchange earnings.

According to the International Trade Centre (ITC), (2015), climate change reduces the competitiveness of agricultural exports from developing countries, as rising temperatures and more rainfall hit agricultural productivity, while extreme weather events such as floods damage roads and other supply chain infrastructure. It can be safely concluded that climate change threatens to make agricultural exports, which are considered key sources of income, and major drivers of rural job creation and income growth in developing countries, unpredictable through declining harvests and post-production losses (ITC, 2015). This study therefore investigated the effect of climatic variables on the export supply of cocoa, palm kernel and seed cotton, in Nigeria.

Materials and Method

The study utilised secondary data for a 45-year period (1970 – 2015). Data on climatic variables such as mean annual rainfall and average daily temperature were collected from the Nigerian Metrological Agency (NIMET) while data on annual export supply of cocoa, palm kernel and seed cotton were obtained from the National Bureau of Statistics (NBS), Nigeria.

The time trend analysis was used to examine the trends in the movement of climate variables and export supply of the agricultural commodities while, co-integration analysis was used to understand the relationship between the export supply of the agricultural commodities and climatic variables. The error correction model employed in the study is represented thus:

$$Y = b_0 + b_1X_1 + b_2X_2 + ecm$$

where:

Y = export supply of the agricultural commodities (tonnes)

X_1 = annual rainfall (mm)

X_3 = annual temperature (°C)

ecm = error correction term

Results and Discussion

Trends in annual rainfall

As shown in Table 1, average annual rainfall fluctuated over the period of the study, with alternating fall and rise from 92.07 mm in the 1970-1979 sub-period to 88.55mm in the 1980-1989 sub-period, then rising to 96.54 mm in the 1990-1999 sub-period and 96.54mm in the 2000-2009 sub-period. It again fell to 96.40mm in the 2010-2015 sub-period. The average annual rainfall ranged from a low of 88.55mm in the 1980-1989 sub-period to the highest of 96.54mm in the 1990-1999 sub-period. The average annual rainfall over the study period was 93.09mm. The intra sub-period annual percentage changes in the annual rainfall were 1.34 per cent, 3.26 per cent, 1.03 per cent per year in the 1970-1979, 1980-1989 and 2000-2009 sub-periods respectively, but a negative growth of 8.99 per cent per year and 0.48 per cent per year were recorded in the 1990-1999 and 2010-2015 sub-periods respectively. The average annual growth rate of rainfall for the period covered by the study was 1.88 percent. There was a degree of instability in the average annual rainfall with the coefficients of variation ranging from 11.12 per cent to 13.40 per cent, with an average of 13.23 per cent over the study period.

Table 1: Trends in annual rainfall

Year	Mean (mm)	Annual Percent change	Coefficient of variation
1970-79	92.07	1.34	11.12
1980-89	88.55	3.26	12.43
1990-99	96.54	-8.99	12.30
2000-09	95.94	1.03	11.23
2010-15	96.40	-0.48	13.40
Total	93.09	1.88	13.23

Source: Author's computation from NIMET data, 2018.

Trends in annual temperature

The average annual temperature fluctuated over the entire period of the study as shown in Table 2. Annual temperature rose from an average of 26.63^{0}C in the 1970-1979 sub-period to 26.99^{0}C in the 1980-1989 sub-period, then to 27.07^{0}C in the 1990-1999 sub-period. This later increased to 27.31^{0}C in the 2000-2009 sub-period, and finally to 27.44^{0}C in the 2010-2013 sub-period. The average annual temperature ranged from a low of 26.63^{0}C in the 1970-1979 sub-period to a highest of 27.44^{0}C in the 2010-2012 sub-period. The average annual temperature over the study period was 27.03^{0}C. The intra sub-period annual percentage changes in the annual temperature were 1.34 percent, 0.34 percent, 2.34 percent, 0.97 percent and 0.56 percent per year in the 1970-1979, 1980-1989, 1990-1999, 2000-2009 and 2010-2013 sub-periods respectively. The average annual growth rate of temperature for the period covered by the study was 1.24 percent. There was some degree of instability in the average annual temperature with the coefficients of variation ranging from 11.34 percent to 14.44 percent, with an average of 13.12 percent over the study period.

Table 2: Trends in annual temperature

Year	Mean (^{0}C)	Annual Percent change	Coefficient of variation
1970-79	26.63	1.34	11.34
1980-89	26.99	0.34	12.32
1990-99	27.07	2.34	14.44
2000-09	27.31	0.97	12.38
2010-15	27.44	0.56	11.36
Total	27.03	1.24	13.12

Source: Author's Computation from NiMET data, 2018.

Trends in the export supply and nominal export growth of selected agricultural export commodities

Table 3 reveals that the average export supply of cocoa fluctuated over the period of the study. It declined from 179,761 tonnes in the 1970-1979 sub-period to 115,320 tonnes in the 1980-1989 sub-period, but rose to 149,450 tonnes in the 1990-1999 sub-period and then to 204,440 tonnes in the 2000-2011 sub-period. The average export supply of cocoa ranged from a low of 115,320 tonnes in the 1980-1989 sub-period to the highest of 204,440 tonnes in the 2000-2015 sub-period. The average export supply of cocoa over the study period was 161,959 tonnes. The intra sub-period annual growth rates of the export supply were negative in the 1970-1979 and 1980-1989 sub-periods, but were positive in both the 1990–1999 and 2000-2015 sub-periods. The average annual growth rate of the export supply of cocoa for the period covered by the study was 4.68 per cent. There was a high degree of instability in the export supply of cocoa. The coefficients of variation ranged from 13.60 per cent to 45.55 per cent, with an average of 40.50 per cent in the 1970-2015 period.

The average export supply of seed cotton over the study period as shown in Table 3 was similar to that of cocoa. It declined from 36,464 tonnes in the 1970-1979 sub-period to 23,703 tonnes in the 1980-1989 sub-period, but increased to 53,618 tonnes in the 1990-1999 sub-period and to 98,500 tonnes in the 2000-2013 sub-period. The average export supply of seed cotton ranged from a low of 23,703 tonnes in the 1980-1989 sub-period to the highest of 98,500 tonnes in the 2000-2015 sub-period. The average export supply of seed cotton for the period covered by the study was 73,858 tonnes. The export supply recorded negative intra sub-period annual growth rates in the 1970-1979 and 1980-1989 sub-periods, but positive intra sub-period annual growth rates were recorded in both the 1990-1999 and 2000-2013 sub-periods. The average annual growth rate of the export supply of seed cotton over the period of study stood at 2.07 per cent. The export supply of seed cotton was unstable. The coefficients of variation ranged from 43.36 per cent to 47.87 per cent, with an average of 45.38 per cent for the period under study.

The results in table 3 show that the average export supply of palm kernel decreased significantly from 213,180 tonnes in the 1970-1979 period to 24,609 tonnes in the 2000-2015 period and further dropped to 18,244 tonnes in the 1990-1999 sub-period. The highest average supply was recorded in the 1970-1979 period. The average export supply of palm kernel for the study duration was 84,064 tonnes. The intra sub-period annual growth rates of the export supply were negative in the 1970-1979 and 1980-1989 sub-periods, but were positive in both the 1990–1999 and 2000-2015 sub-periods. The average annual growth rate of export supply for the period covered by the study was 2.94 per cent. The coefficients of variation ranged from 34.96 per cent to 40.30 percent, with an average of 49.21 per cent, showing that the export supply of palm kernel was unstable for the period under study.

Cocoa recorded the highest average annual export supply of 161,059 tonnes. This was followed by palm kernel and seed cotton with average annual export supplies of 84,064 tonnes and 73,858 tonnes respectively. Also, cocoa recorded the highest average annual percent export growth of 4.68 per cent. This was followed by palm kernel and seed cotton with average annual per cent growth of 2.94 per cent and 2.07 per cent respectively. The highest instability occurred in the export supply of palm kernel with an average coefficient variation of 49.21 per cent, followed by seed cotton and cocoa with average coefficient variations of 45.38 per cent and 40.50 per cent respectively.

In general, the export supply of the selected agricultural export commodities plummeted between the 1970-1979 and 1980-1989 sub-periods, but increased between the 1990-1999 and 2000-2015 sub-periods. Similarly, negative intra sub-period average annual per cent growth was recorded in the 1970-1989 sub-period, while a positive intra sub-period average annual per cent growth was recorded in the 1990-2011 sub-period.

According to Oyejide (1986), the major reason for the decline and the high degree of instability in the export supply of agricultural export commodities, especially cocoa, seed cotton and palm kernel, in the 1970-1989 sub-period was the oil boom of 1973. With the windfall from the oil boom, government totally neglected the agricultural export sector which used to be a major source of government revenue; consequently, the domestic production and export supply of agricultural export commodities declined significantly. On their part, Olayemi and Dittoh (1995) postulated that the persistent decline and high degree of instability in agricultural export commodities supply was connected with random influences of weather, pests, diseases and other vagaries of nature on production; the absence of effective counter-vaulting agricultural trade policies to permit the orderly release of supplies to the export market; and, probably, fluctuations in the domestic demand for agricultural commodities traditionally produced for export.

Table 3: Trends in the export supply and annual export growth (percentages) of selected agricultural export commodities

Sub-period	Average supply per annum (tonnes)	Annual Export Growth (%)	Coefficient of variation
Cocoa			
1970-79	179,761	-5.26	**14.05**
1980-89	115,320	-3.93	**33.44**
1990-99	149,450	+2.87	**45.55**
2000-15	204,440	+5.04	30.85
All periods	**161,059**	**+4.68**	13.60
			40.50
Seed cotton			
1970-79	36,464	-2.10	43.36
1980-89	23,703	-1.98	45.66
1990-99	53,618	-2.48	45.68
2000-15	98,500	+2.52	45.83
All periods	**73,858**	**+2.07**	47.87
			45.38
Palm kernel			
1970-79	213,180	-9.45	34.96
1980-89	68,334	-10.27	40.30
1990-99	18,244	+3.68	37.18
2000-15	24,609	+4.38	36.44
All periods	**84,064**	**+2.94**	**49.21**

Source: Computed from Food and Agriculture Organisation database (FAOSTAT), 2017.

Results of Time Series Analysis

Unit root test

The results of the Augmented Dickey-Fuller (ADF) unit root tests for non-logged variables used in this study presented in Table 4 show that annual export supply of cocoa, seed cotton and palm kernel, annual rainfall and annual temperature were not stationary at their original values but, stationary at first difference, indicating that using their original values for regression analysis will give spurious results.

Table 4: Results of ADF Unit Root Test for Variables

Variables	Augmented Dickey Fuller (ADF) Values (Level)	Augmented Dickey Fuller (ADF) Values (First difference)	Order of integration
Cocoa	-1.762	-4.506	1
Seed cotton	-1.772	-4.508	1
Palm kernel	-1.771	-4.507	1
Rain	-2.464	-4.411	1
Temp	-2.476	-3.762	1
Critical values			
1%	-4.265	-2.373	
5%	-2.953	-3.568	
10%	-2.613	-3.723	

Source: Author's computation, 2018.

Co-integration tests

The results of the co-integration analysis for the regression equation used in the study for non-logged variables presented in Table 5 show two co-integrating variables. The variables are annual export supply of cocoa, annual temperature and annual rainfall, confirming a long-run relationship among the variables.

Table 5: Result of Co-integration Analysis of Non-logged Variables for Regression Equation (cocoa)

Eigen Value	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)	Co-integrating Variables
0.649	127.380	94.250	104.180	None **	cocoa
0.613	86.527	68.420	77.070	At most 1 **	temp
0.459	50.441	47.310	54.460	At most 2 *	rain

Source: Author's Computation, 2018.

CE(s) means co-integration(s).

* and** denote rejection of hypothesis of no co-integration at 1% and 5% significance levels respectively.

Similarly, the results of the co-integration analysis for the regression equation used in the study for non-logged variables presented in Table 6 show two co-integrating variables. The variables are annual export supply of seed cotton, annual temperature and annual rainfall, confirming a long-run relationship among the variables.

Table 6: Results of the co-integration Analysis of Non-logged Variables for Regression Equation (seed cotton)

Eigen Value	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)	Co-integrating Variables
0.648	127.381	94.251	104.181	None **	Palm kernel
0.614	86.528	68.421	77.071	At most 1 **	temp
0.458	50.442	47.311	54.461	At most 2 *	rain

Source: Author's computation, 2018.

CE(s) means co-integration(s).

* and** denote rejection of hypothesis of no co-integration at 1% and 5% significance levels respectively.

Finally, the results of the co-integration analysis for the regression equation used in this study for non-logged variables presented in Table 7 show two co-integrating variables. The variables are annual export supply of palm kernel, annual rainfall and annual temperature confirming a long-run relationship among the variables.

Table 7: Result of Co-integration Analysis of logged Variables for Regression Equation (palm kernel)

Eigen Value	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)	Co-integrating Variables
0.658	128.381	94.151	103.181	None **	Seed cotton
0.624	87.528	68.521	76.071	At most 1 **	temp
0.448	50.442	47.211	54.461	At most 2 *	rain

Source: Author's computation, 2018.

CE(s) means co-integration(s).

* and** denote rejection of hypothesis of no co-integration at 1% and 5% significance level respectively.

Results of Error Correction Analysis

An error correction model was estimated to establish the relationship between the climate variables (annual temperature and annual rainfall) and annual export supply of cocoa, seed cotton and palm kernel. The parsimonious results are presented in this section.

The results of the ECM analysis are presented in table 8. The coefficient of determination (R^2) ranged from 0.467 to 0.628 for all the commodities. The F-values were statistically significant at 1 percent level showing that the models fit the data well. The error correction coefficients were negative and statistically significant at 1 percent level. The significance of the error correction term supports co-integration and suggests the existence of long-run equilibrium between the climate variables and annual export supply of cocoa, seed cotton and palm kernel. The coefficients of the ECM indicate that the deviation in the export supply of cocoa, seed cotton and palm kernel from the long-run equilibrium level is corrected by about 75.9 per cent, 41.6 per cent and 50.2 per cent respectively, in the current period.

Table 8 reveals that the coefficients of annual rainfall lagged by one year is positive and statistically significant at 1 per cent level for cocoa and palm kernel, showing a positive relationship between the previous year's annual rainfall and the export supply of cocoa and palm kernel. The implication of this result is that the export supplies of cocoa and palm kernel in the current year are dependent on the intensity of rainfall in the previous year.

Similarly, the coefficient of annual temperature is positive and statistically significant at 1 percent level for seed cotton, implying a positive relationship between annual temperature and the annual export supply of seed cotton. This result implies that the annual export supply of seed cotton is determined by that year's annual temperature.

In contrast, the coefficients of annual temperature are negative and statistically significant at 1 per cent and 5 per cent levels respectively for cocoa and palm kernel. This shows that there is a negative relationship between the export supply of cocoa and palm kernel and that year's annual temperature. The implication of this result is that the export supplies of cocoa and palm kernel are negatively influenced by the year's annual temperature.

Table 8: Results of error correction analysis (cocoa, seed cotton and palm kernel)

Variable	Cocoa	Seed Cotton	Palm Kernel
ECM_t (-1)	-0.759 (-2.296)*	-0.416 (1.853)*	-0.502 (-2.033)*
Ln rain	-0.355 (-0.400)	-0.231 (-0.203)	-0.032 (-0.245)
Ln rain (-1)	0.177 (3.995)*	-0.281 (-1.410)	1.148 (-9.209)*
Ln rain (-2)	-1.131 (-0.711)	-0.494 (-0.813)	-0.048 (-0.300)
Ln temp	-0.388 (-5.622)*	11.543 (2.876)*	-3.136 (-2.772)**
Ln temp (-1)	-0.034 (-0.453)	-0.532 (0.087)	-0.531 (0.085)
Ln temp (-2)	-0.332 (-0.056)	-0.432 (0.453)	-0.433 (0.452)
C	-8.031 (-0.334)	86.550 (0.065)	-10.822 (-0.765)
R^2	0.556	0.467	0.628
Adj. R^2	0.452	0.479	0.512
Sum sq .res.	2.336	6.908	7.964
S.E. equation	0.326	0.536	0.631
F-statistic	7.003*	4.000*	5.988*
Log likelihood	-0.927	-21.526	-24.228
Durbin Wat.	1.93	1.87	1.81
Akaike AIC	9.571	9.161	10.431
Schwarz SC	0.580	2.473	2.998
Mean Dep.	-0.021	-0.058	-0.047
S.D. Dep.	0.377	0.592	0.761

Source: Author's computation, 2018.

* Coefficient significant at 1% level.

** Coefficient significant at 5% level.

Figures in parentheses are the t-statistics.

Conclusion and Recommendation

Based on the results of the empirical analysis from this study, it is concluded that climate change significantly affected the export supply of the selected agricultural commodities in Nigeria. Thus, embarking on climate change mitigating and adaptation strategies such as significant reduction in the emission of greenhouse gases, investment in irrigation facilities and water harvesting, as well as the adoption of improved crop and soil management techniques would go a long way in minimising the negative effects of climate change on agricultural export supply in Nigeria.

References

Alabi, R.A. and Alabi, O.F. (2009). Effect of economic liberalisation on chicken meat production in Nigeria. *European Journal of Social Sciences* 7(4): 173–180.

Adeniyi, O. R. and Ogunsola, G.O. (2014). Cocoa production and related social-economic and climate factors: A case study of Ayedire Local Government Area of Osun State, Nigeria. *Agricultural Science*, 2(4): 01-13 ISSN 2291-4471 E-ISSN 2291-448X Published by Science and Education Centre of North America.

Central Bank of Nigeria (CBN). (2002). *Statistical Bulletin*, 3(2). Abuja, Nigeria: CBN.

Central Bank of Nigeria (CBN). (2003). *Statistical Bulletin*, 13. Lagos: CBN Press.

ICCO. (2007). Project Proposal on Improvement of Cocoa Marketing and Trade Liberalisation, Cocoa Producing Countries. International Cocoa Organisation. Ex/96/7/Rev.3 (1CCO).

International Trade Centre (ITC). (2015). Climate Change and the Agri-Food Trade: Perceptions of Exporters in Peru and Uganda, in Trade Impacts for Good Report, pp.13-29.

Jagtap, S. S. (1995). Changes in annual, seasonal and monthly rainfall in Nigeria during 1961-1990 and consequences to agriculture. *Discovery and Innovation*, 7(4): 337-348.

Morton, J. F. (2007). *The Impact of Climate Change on Smallholder and Subsistence Agriculture.* Proceedings of the National Academy of Sciences of the United States of America, 104, 19680-19685. doi:10.1073/pnas.0701855104.

Olayemi, J.K. and Dittoh, Saah. (1995). Macroeconomic policies and the agricultural sector. In: Iwayemi, A. (ed.) *Macroeconomic Policy Issues in an Open Developing Economy A Case Study of Nigeria*. Ibadan: NCEMA.

Omonona B.T., Oni, O.A. and Akpan, E. (2007). The Determinants of Demand for Nigeria's Agricultural Export Commodities. *Pakistan Journal of Social Sciences,* 4(2): 247-251.

Oyejide, T.A. (1986). The effects of trade and exchange policies on agriculture in Nigeria. Report 55. Washington D.C.: International Food Policy Research Institute, pp. 42-58

Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (Eds.). (2007). Climate change 2007b – Impacts, adaptation and vulnerability—Contribution of Working Group II to the Fourth Assessment report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge: Cambridge University Press, pp. 1-60.

United Nations Environmental Protection Agency (UNEPA). (2017). International Climate Change Impacts. Retrieved from www.epa.gov on 08/02/16.

Ziervogel, G., Nyong, A., Osman, B., Conde, C., Cortes, S., and Dowing, T. (2006). Climate variability and change: Implications for household food security. Assessments of Impacts and Adaptations to Climate Change (AIACC), Working Paper No. 20. Retrieved from http://www.start.org/Projects/AIACC_Project/working_papers/Working%20Papers/AIACC_ WP_20_Ziervogel.pdf.retrieved on 18/02/161 July 2019.