New Findings on Food Security, Climate Change and Income Growth in West African Countries: P-VAR Approach

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Abstract

This paper examines empirically the interaction among per capita income growth, climate change and food security in fifteen West African Countries. We employ Panel VAR (PVAR) techniques on annual secondary data obtained from the World Development Indicator (WDI) between 1990 and 2013. The PVAR approach allows us to address the endogeneity problem by allowing the endogenous interaction among the variables in the system. Our results provide evidence of income growth spurring food security in the short run and reducing it in the long run, while climate change increased food insecurity throughout in West Africa. The study suggests that climate change is a necessary variable that needs to be controlled if food security is a desired goal in West Africa and that more priority should be given to agricultural sector in economic growth. Also, the leaders in West Africa should embrace a judicious and dynamic energy mix that will allow renewable sources to replace fossil fuels.

Keywords: Income Growth; Climate Change; Food security; West Africa; PVAR.

Introduction

One of the most vulnerable regions to climate change is West Africa. Its economy rests mainly on agriculture. Aside from Nigeria which relies on crude oil as the major source of revenue, countries in West Africa get their food supply and foreign exchange from agriculture. Agriculture also serves as the main employer of labour as well as source of raw materials to the few available industries in West Africa and some other foreign countries. What people will expect from countries in this region is food security. However, the opposite is the case. Although, World Food Summit (WSF) has commended the progress noted in the area of achieving the Millennium Development Goals (MDGs) in West Africa compared to other sub-Saharan

African countries, having reduced the number of undernourished people by almost 13 million between 1990-92 and 2014-16, (Benson, 2008), but improvement in this area is still needed, according to (Benson, 2008). It has been noted that, on average, out of 280 million people living in West Africa, 17 percent are still food insecure, about 30 percent live below the poverty line, thirty-three percent of children under five years of age are stunted, 28.3 percent are underweight, and 10 percent are wasted (Tol, 2002b).

According to (FAO, 2003), 'food security is defined as a 'situation [...] when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. Food security goes beyond availability. It includes ability to possess monetary and non-monetary resources by the population to gain access to adequate quantities and qualities of food (Schmidhuber and Tubiello, 2007). There are four identified dimensions of food security. They are: food availability; stability of food supplies; access to food; and food utilization.

Many studies have shown that there is a connection between climate change and these four dimensions of food security. Among these dimensions, only food availability and climate change was well studied, with little emphasis placed on other components that guarantee adequate consumption (Zewdie, 2014). Since the major source of income, especially for the rural households that constitute the majority of the population in West Africa is agriculture, any change that affects food security caused by climate change is likely to have an impact on their income growth.

While the relation between food security and climate change is direct, it has been found that climate change is also indirectly related to human development, economic growth, trade flows and food aid policy with less clear results (Keane, Page, Kergna and Kennan, 2009; Haggblade, Hazell and Brown, 1989), especially in countries where climate projections are ambivalent, such as in the Sahel zone in SSA. Studies have also shown that projections from climate models for temperature may converge, but this is not true for precipitation which is the major determinant of yield in Sahel (IPC, 2007a). Although, many studies have been done on the relation between climate change and food security, and climate change and income growth separately, few exist on the interaction among food security, climate change and income growth in West Africa. Thus, given the fact that climate change can affect food security, which in turn can affect income, understanding the dynamic interaction among climate change, food security and income growth in West Africa becomes imperative.

Literature Review

Findings on the connection among climate change, food security and economic growth are less clear. This could be due to the unpredictability nature of climate and its impact on various components of food security. For example, it has been noted that climate change can affect food availability and stability in an area, causing flooding and drought which can lead to serious damage in food supply. It can change land suitability and cause increase in suitable cropland in higher latitudes and reduce potential cropland in lower latitudes (Ludi, 2009; Nelleman, 2009). Also, it can affect food accessibility. When crops are destroyed by either flood or drought, income is reduced especially in highly vulnerable countries (i.e. developing countries such as in West Africa). Lower output is also associated with higher prices, which in consequence leads to fall in real income and causing accessibility to be extremely difficult (Brown, 2009). Climate change can also affect food utilization (i.e. micronutrient consumption) by altering the yields of important crop sources of micronutrients, changing the nutritional contents of some crops, or by influencing farmers' decision to grow various crops with different nutritional values or through utilizing different methods, (Badolo, Kinda, 2012). The implications of these effects have been noted in social and economic aspects of man. Based on the study of (Lam, Cheung, Swartz and Sumaila, 2012) in their model of economic and social implications of climate change-induced modifications in marine fisheries species availability, in terms of landed values of fish and fisheries-related jobs, in 14 West African Countries, it has been projected that, there will be a fall in landed fish value of 21 percent and a total annual loss of USD311 million by 2050 over 2000 values, and a significant loss in fisheries-related jobs of almost 50 percent, down to 390 000 jobs, with Côte d'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone and Togo suffering the most important impacts.

While some studies strongly emphasized the damaging impact of climate change on economic growth, some noted that their findings were over-emphasized. For example, in the study of (Pearce etal., 1996), it was first projected that doubling of greenhouse gases would cause damages equal to 2 percent of GDP by 2100. Other studies have queried this finding. They suggested that damages are smaller (closer to 0.2 percent of GDP (Tol,2002a; Tol, 2002b and Mendelsohn and Williams, 2004). Although, there is controversy on the level of detrimental effect of climate change on the economy, one thing that is sure, is the undoubted negative impact of climate change above certain level (2 degrees Celsius) and this cannot be underrated in West Africa that is highly vulnerable due to its location in the lower latitude as well as its dependency on agriculture as source of income.

Even though, agricultural growth is not the only stimulating factor of the economy in West Africa, but it is the most important contributor to manufacturing and service activity. It has also been noted that, each unit increase in agricultural activity leads to approximately 1.5 units of economic growth (Lam e tal., 2012] as cited in (Tol, 2002b; Swallow, 2005). Some studies have also noted the positive relation between economic growth and food security (Di Falco, Yesuf Khohlin and Ringler, 2011b; Nelleman, 2009), although, economic growth reduces income poverty more than promoting food security [Pearce etal., 1999), others find negative relation in some regions of the world (Love and Zicchino, 2006) and others find no relation between the two IFPRI, 2005).

However, one major contributing factor to the problem of food security is climate change (Keane etal., 2009; IPCC; 2007, Wheeler and Von Braum, 2013; FAO,2003). Climate change has also been noted to be one of the major drivers of income, especially the income of farmers who constitute the largest number of the poor in sub-Sahara Africa (Heady, 2013; Stoneman and Robinsom, 1988; Mendelsohn and Williams, 2004), Thus, an unfavourable change in climate is likely to aggravate unfavourable change in income, and this is expected to hinder food security.

Methods, Data Measurement, Sources and Model Specification

In this study, carbon dioxide (C02) is used to measure climate change. C02 here comprises of those emissions stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (CO_2 emissions kg per 2010 US$ of GDP). Data on climate change and income growth were obtained from World Development Indicators (WDI). Following the recommendation of the committee on World Food Security hosted at FAO headquarters in 2011, food insecurity indicators were classified under four core sets. They are availability, accessibility, utilisation and stability. These four dimensions of food security have been noted for their dependence on climate change. This study used per capita food production variability which is a component of stability set to measure food security. Per capita production variability corresponds to variability of the "food net per capita production value in constant 2004-2006 international $" as disseminated in Food and Agriculture Statistics (FAOSTAT). The dataset comprises 15 West African Countries, over the period 1990-2013.

It has been a consensus in the literature that, for growth to promote the nutrition of the poor, the poor must be involved in the growth process and the benefits therein. The implication is that growth should involve and benefit the poor in terms of increased income which must be spent to improve both the quality and quantity of consumption goods such as food, education and health. Also, government must use the proceeds from growth to produce public goods and services such as education, infrastructures and public health that will benefit the poor. Since governments can make the poor to benefit from increased growth through vigorous pursuit of adequate implementation of policies, we can base our contemporaneous relationship among a set of possibly endogenous variables and employ Panel Vector AutoRegressive (PVAR) method in this study. This method is an extension of traditional vector autoregression (VAR) introduced by (Di Falco, Veronsi and Yesuf, 2011a) with a panel data approach. The approach is a flexible method that treats all the variables in the system as endogenous and independent, without concern on causality direction. It is a system of equation model that allows for unobserved individual heterogeneity and improves asymptotic results**.** Panel Vector Autoregressive Model employs General Method of Moment in its estimation and each variable is regressed on its own lag(s) as well as the lags of all other variables in the system. The three variable vectors that include all endogenous variables can be set as:

$$Z_t^v = \phi_o + \phi_1 Z_{t-1}{}^v + f^v + d_t + \varepsilon_t \qquad (1)$$

Where Z_t^v is the three variable vectors that include all endogenous variables

ϕ_1 is the 3 X 3 matrix of coefficients to be estimated

f^v is the vector of country-fixed effects

d_t is the vector of time-fixed effects; and

ε_t is the white-noise error term

We can then express our 3-Equation model as:

$$\begin{bmatrix} 1 & a12 & a13 \\ a21 & 1 & a22 \\ a31 & a32 & 1 \end{bmatrix} \begin{bmatrix} Y_t^k \\ \Delta Fud_t{}^k \\ \Delta CL_t{}^k \end{bmatrix} = \begin{bmatrix} a10 \\ a20 \\ a30 \end{bmatrix} + \begin{bmatrix} \beta 11 & \beta 12 & \beta 13 \\ \beta 21 & \beta 22 & \beta 23 \\ \beta 31 & \beta 32 & \beta 33 \end{bmatrix} \begin{bmatrix} Y_{\_1k} \\ \Delta Fud_{\_1k} \\ \Delta CL_{\_1k} \end{bmatrix} + \begin{bmatrix} \varepsilon Y_{tk} \\ \varepsilon Fud_{tk} \\ \varepsilon CL_{tk} \end{bmatrix}$$

Where β ii's refer to the coefficients of model to be estimated

Y is income growth

Fud is food security

CL is climate change

Z_t^v is the 3-variable vector including all the 3 endogenous variables: (Food security, Income growth and Climate change

$$\begin{bmatrix} Y_t^k \\ \Delta Fud_t{}^k \\ \Delta CL_t{}^k \end{bmatrix}$$

ϕ_1 is the 3 X 3 matrix of coefficients of contemporaneous relationships among Y, Fud and CL

$$\begin{bmatrix} \beta 11 & \beta 12 & \beta 13 \\ \beta 21 & \beta 22 & \beta 23 \\ \beta 31 & \beta 32 & \beta 33 \end{bmatrix}$$

The GMM results were obtained using untransformed variables as instruments for Helmert-Transformed variables (country fixed effects removed). Specifically, STATA PVAR code developed by Dr. Inessa Love of the World Bank was used for the study. Since all the variables were regarded as endogenous, we regress our one system of equation as follows:

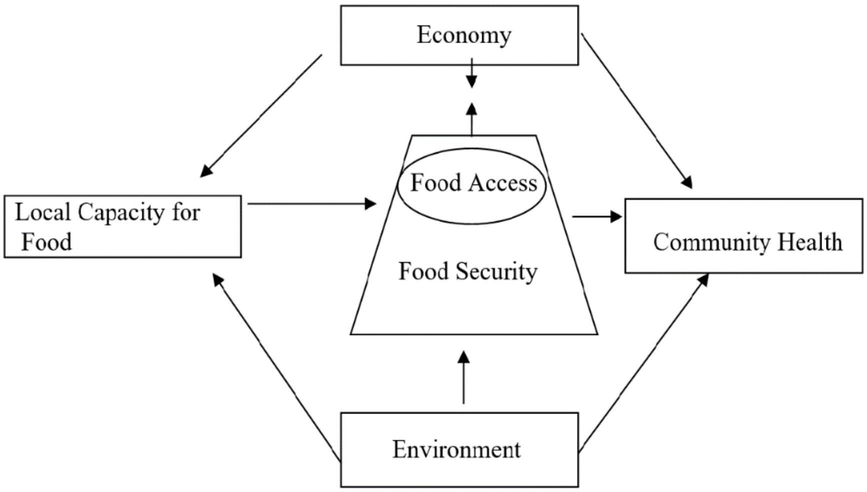
$$\begin{bmatrix} Y_t^k \text{ is regreesed on } Y_{t-1}^k, \Delta Fud_{t-1}{}^k, \text{ and } \Delta CL_{t-1}{}^k \\ \Delta Fud_t{}^k \text{ is regreesed on } Y_{t-1}^k, \Delta Fud_{t-1}{}^k, \text{ and } \Delta Cl_{t-1}{}^k \\ \Delta CL_t{}^k \text{ is regreesed on } Y_{t-1}^k, \Delta Fud_{t-1}{}^k, \text{ and } \Delta CL_{t-1}{}^k \end{bmatrix}$$

In dynamic panel, fixed effects estimator is not consistent because they are correlated with regressors due to lags of the dependent variables. We employ forward mean differencing or othorgonal deviations (the Helmert technique), following (Skoufias etal., 2009). This technique allows us to remove the fixed effects through the transformation of all variables in deviations from forward means. This is an alternative to the first difference in the sense that it has the capacity to preserve sample size in panels with gaps (Arellano and Bover, 1995). In this transformation (i.e. orthogonal deviation), each observation is expressed as a deviation from average future observations and weighted so that the variance can be standardised. This enables us to compare the original errors with the transformed errors so as to ensure they exhibit the same properties. With this transformation, homoskedasticity is preserved and serial correlation is not provoked (Maddala and Wu, 1999). Additionally, the technique allows the use of the lagged values of regressors as instruments, and estimates the coefficients by the GMM.

Although, the code allows us to obtain the GMM, impulse response and variance decomposition results, we report only the results from impulse response and variance decomposition.

Conceptual Framework of The Study

This study rests on the Rural Food System Conceptual Framework below.



Source: S. Steinberg, D. Stubblefield and A. Ybarra (2010).

In the model, starting from where we have the local capacity for food, which is defined as potential ability of the particular local area to produce, process as well as import, it is assumed that output in different local areas can differ. This then implies that food security can be impacted directly by food access. Thus, in urban centres where there is lower capacity for food production compared to rural areas, it is expected that food security will be impacted negatively.

Furthermore, in the model, food access is defined as ability of people to gain access to healthy food, being able to afford payment as well as cultural appropriateness to individual, while food security is the access of people at all times to enough food for an active and healthy lifestyle. The model assumed that food access is a major component of food security (micro concept), and regard food security as a macro concept. The implication of this is that when food security is buoyant, food access is assured and vice versa.

Also, the model regards community health as the general health of the local area or region. According to California Center for Rural Policy, it consists of the physical, social and economic well-being of the community which is determined by the economy, the environment and food security. It is argued that agile and fertile environment conducive to diverse agricultural product, will largely enhanced food security and thereby promote community health. According to the model, the two overarching contextual factors influencing everything in the model are the economy and the environment. Economy is taken to be the general flow of commercial activities. It impacts local capacity for food either positively or negatively. For example, a healthy economy provides access to capital, marketing opportunities and production choices to food producers. It also provides food security and food access through its positive influence on individual purchasing power which allows greater selection of diverse healthy and nutritious foods and vice versa.

Other major contextual factor that influences the entire model is the environment. It consists of the physical context of the place, including aspects such as whether the community is rural, the types of crops that grow best in the region, the existed climate, as well as the topography. Thus, the model highlighted the role of place through environment.

Discussion of Results and Recommendations

Before the commencement of our estimation, we examine the summary statistics of our variables to determine the normality of the distribution of our variables. The results of the mean and the median suggest normal distribution of our variables. We also test for the presence of unit root in our data using the first and second generation unit root test of (Ecker and Qaim, 2011, World Bank, 2014) for the variables in the system. The results show that all variables are not stationary in levels, but in first difference. The results are presented in Table 1 in the appendix. Our PVAR includes only three-order lags, which is selected using the Bayesian Information Criterion (BIC). We also present the residual correlation matrix of our estimation in Table 4 in the appendix.

Results of variance decomposition

The row for each variable: Fud, Y and CL provide variance decomposition of food security, income and climate at 10, 20 and 30 year intervals. Throughout the year interval, more than 23% variation in food security is explained by climate change, while about 2% variation in food security is explained by income change and the remaining percentage by food security itself. This result shows that climate change is the dominant factor that is affecting food security in West Africa. This is expected in a region where access to modern electricity consumption is inadequate. For example, it has been noted in the Africa Progress Report that electricity consumption in Sub-Saharan Africa is less than that of Spain and that current trends will take up to 2080 for every African to have access to electricity and that universal access to non-polluting cooking will not happen until the middle of the 22nd century (Gitau etal., 2005). This result corroborates the findings of (Badolo, Kinda Somlanare, 2012; Tol, 2002a) where it was noted that climate related shocks (particularly droughts) could affect dietary diversity and reduce overall food consumption with long-term detrimental effects on stunting. This result is presented in Table 2 in the appendix.

Results of impulse response function.

The impulse response shows the predicted effect of response of one variable to a shock in another variable over time holding others constant. From Table 4, it is noted that a positive shock to income causes food insecurity to fall only in the first year, and from the beginning of the second year till the sixth year, food insecurity increased. This result is logical for an economy whose government is giving less priority to agricultural sector in economic growth. The result of this study is in contrast with the findings of (Benson, 2008) where it was noted that, for direct reduction of hunger to take place, priority should be given to economic growth in agriculture sector which hosts the majority of the poor in order to ensure resilient livelihoods and achieve food and nutrition security. Again, this result is logical in a country where increased income serves as an opportunity for movement of people from rural areas to urban centres where higher income can be earned through white collar job and consequently demanding for more imported goods to improve well-being, domestic food production is likely to fall. Not only this, more income is an avenue to improve other areas of human welfare. It is a way of improving healthcare, providing education for the children and seeking to enjoy amenities that can only be found in the urban centers. This then implies that income may promote food security in the short run and reduce it in the long run especially where large mechanized agriculture is absent as existed in West African Countries.

The results of the study also show that, a positive shock to climate change causes food insecurity to rise throughout the sixth year period. This result shows the level of importance of climate change to food security in West African Countries. The results of impulse response are also presented in Figure 1 and Figure 2 in the appendix.

The study recommends that West African leaders should vigorously support the international efforts of reducing greenhouse gas emissions. They need to embrace a judicious, dynamic energy mix that will allow renewable sources to replace fossil fuels. There are substantial opportunities for ensuring cleaner energy in West Africa. The use of natural gas and hydro, solar, wind and geothermal power should be encouraged and made available at cheaper rate to people in West Africa. Energy-sector bottlenecks, power shortages and high electricity tariff should be addressed. In the Africa Progress Report on energy, it was noted that a woman living in a village in northern Nigeria spends around 60 to 80 times per unit more for her energy than a resident of New York City or London (Gitau etal., 2005). Also, modern methods of farming that will reduce the effect of climate change on agricultural output; breeding and improvement of management of heat-resistant varieties; and advance farming practices more appropriate for hotter growing conditions (e.g., agro forestry and the cultivation of shade crops) should be encouraged. Mechanized farming should also be encouraged to substitute for the number of people moving away from farming in the rural areas to urban centres as soon as their income improves.

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Appendix

Table 1. Unit Root Test

(A) Maddala and Wu (1999) Panel Unit Root test (MW)				(B) Pesaran (2007) Panel Unit Root test (CIPS)			
Specification without trend				Specification without trend			
Variable	lags	chi_sq	p-value	Variable	lags	Zt-bar	p-value
Y	0	292.737	0.000	Y	0	-12.760	0.000
Y	1	136.140	0.000	Y	1	-6.910	0.000
Y	2	117.953	0.000	Y	2	-4.055	0.000
Y	3	105.477	0.000	Y	3	-4.075	0.000
CL	0	302.639	0.000	CL	0	-12.527	0.000
CL	1	170.119	0.000	CL	1	-6.599	0.000
CL	2	117.953	0.000	CL	2	-4.552	0.000
CL	3	91.548	0.000	CL	3	-1.753	0.040
Fud	0	253.831	0.000	Fud	0	-10.786	0.000
Fud	1	161.510	0.000	Fud	1	-6.926	0.000
Fud	2	106.350	0.000	Fud	2	-2.458	0.007
Fud	3	51.272	0.009	Fud	3	0.071	0.528

Null for MW and CIPS tests: series is I(1).

MW test assumes cross-section independence.
CIPS test assumes cross-section dependence in form of a single unobserved common factor

Table 2.

***variance-decompositions: percent of variation in the row variable explained by column variable.**

Varname	S	Fud	CL	Y
Fud	10	.75658767	.23883246	.00457987
CL	10	.02752387	.93589873	.0365774
Y	10	.0015278	.01395386	.98451834
Fud	20	.74345457	.23710044	.01944498
CL	20	.02758485	.93581007	.03660508
Y	20	.00121504	.01052926	.9882557
Fud	30	.7385285	.23552894	.02594256
CL	30	.02758489	.93580895	.03660617
Y	30	.00115947	.00973979	.98910073

Table 3.

Impulse-responses of variable in varname to the shock in column variable

varname	s	order	Fud	CL	Y
Fud	0	1	0.3024	0.0000	0.0000
Fud	1	1	0.2547	0.0615	-0.0075
Fud	2	1	0.1560	0.0909	0.0102
Fud	3	1	0.0914	0.1154	0.0127
Fud	4	1	0.0582	0.1181	0.0119
Fud	5	1	0.0429	0.1027	0.0090
Fud	6	1	0.0345	0.0803	0.0085

Table 4.

Residuals correlation matrix

	u1	u2	u3
u1	1.0000		
u2	-0.0863	1.0000	
	0.1361		
u3	-0.0176	-0.0248	1.0000
	0.7618	0.6689	

Figure 1.

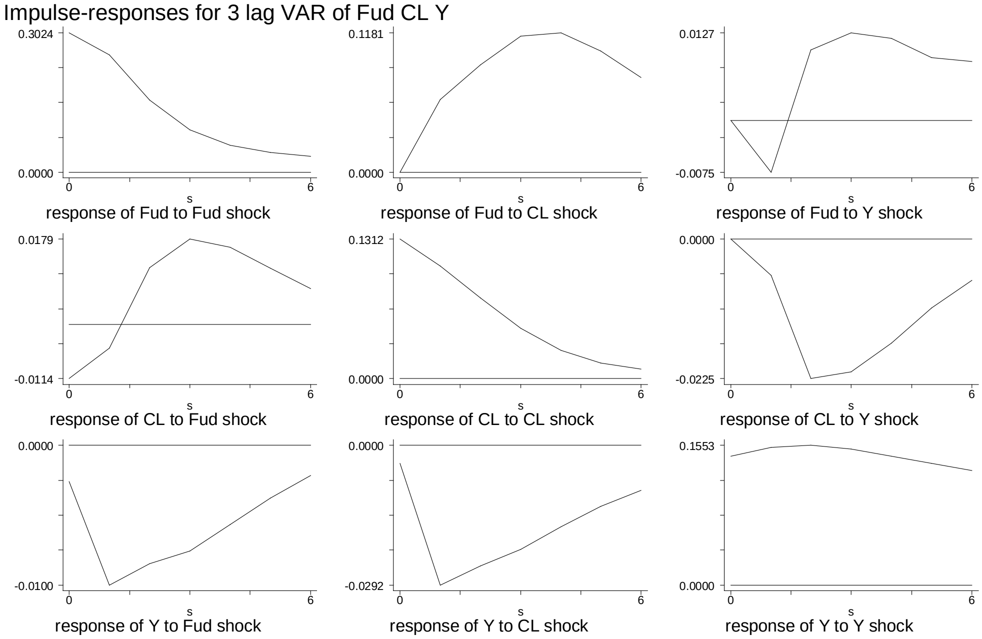

Figure 2