ENERGY AND CLIMATE CHANGE: IMPACT OF FOOD, WATER AND ENERGY NEXUS ON ECONOMIC GROWTH IN NIGERIA

IYABO M. OKEDINA

DEPARTMENT OF ECONOMICS, BABCOCK UNIVERSITY, ILISHAN-REMO, OGUN STATE, NIGERIA

DASAUKI M.C.

DEPARTMENT OF ECONOMICS, BABCOCK UNIVERSITY, ILISHAN-REMO, OGUN STATE, NIGERIA

EBERE CHDINMA E.

DEPARTMENT OF ECONOMICS, BABCOCK UNIVERSITY, ILISHAN-REMO, OGUN STATE, NIGERIA

&

YEWANDE O. OLATUNDE

CENTRE OF PETROLEUM, ENERGY ECONOMICS AND LAW, UNIVERSITY OF IBADAN, IBADAN, OYO STATE

Abstract

The study test the simultaneous relationship of Food, water and Energy on Economic growth in Nigeria and develop an integrated model for sustainable development in these three sectors. Annual data from 1990 – 2017 was gathered from World development Index: Nigeria, and CBN Statistical bulletin on food productivity index, energy use per capita, water productivity and GDP per capita. The Johansen co-integration, Error correction model and Simultaneous equation model was used to show the long run relationship and test the speed of adjustment that it took all the variables to converge in the long-run. The Johansen co-integration test showed that there was long-run co-movement among the variables. Thus, this result showed there was a convergence relationship among the variables in the long-run. The result of the ECM indicates that the deviation of the economic growth model from the long-run equilibrium level is corrected by 0.009%. The simultaneous equation result showed that both energy use and water productivity are significant in explaining gross domestic product. For a nation like Nigeria to attract foreign direct investment, there has to be a synergy of these three sectors such that the vast resources on water, agricultural abundance in arable lands and energy resources (especially renewable sources of energy such as sun, wind, water) can be utilized internally with improved processes and technologies. Improvements should be worked out in all three sectors in the nexus approach such that no sector is lacking input, policies, government interventions, private organization and citizen involvement to allow for internalization of this development, this will in turn encourage foreign direct investment.

Key words: food-water-energy nexus, economic growth, sustainable development

Introduction

Technological development is on a speedy rise with no provision for counter measures to the pollution and release of Greenhouse Gases (GHGs) into the atmosphere. The combustion of fossil fuels, deforestation, urbanization and industrialization has released high carbon dioxide ($C0_2$) into the atmosphere. In the past 10 years, energy usage has increased by 236%. This process has caused series of problems to the world most especially climate and atmospheric change. Nigeria, with a vast land space of 923,768 sq km, spanning across different climatic regions is understood to be highly vulnerable to climate change. There is no gain saying the fact that the country is threatened with extinction by a myriad of environmental problems, especially those triggered by climate change. Indeed, each of the 36 States and the Federal Capital is beset by one climate change problem or the other. Water, Agriculture, Environment and Energy share a significant relationship among them. However, this relationship continues to fall out of balance resulting in increasing concerns for food, Energy and water security.

Energy is very vital in driving the growth and development of any economy as it is an essential

input to a nation's growth and development (Akinbami, 2009)and also strategic to increasing the competitiveness of any economy (Adenikinju, 2008). The energy sector plays a key and central role in the growth and development of any nation, therefore, the reliable and adequate supply of energy is essential to support economic activities and industrialization efforts that will enhance income and standard of living. Nigeria is a land as popularly said "flowing with milk and Honey" but then the nation still lacks supply of basic needs such as safe and clean water, adequate supply of energy (electricity, transportation and cooking energy) and abundant and affordable food all through the year. Due to a search for best methods to improve these major sectors, the F-W-E Nexus approach seemed like a very good shot at substantial economic development, easier to handle and carve out policies from compared to the other methods such as causality analysis of energy consumption on economic growth, impact of agriculture on economic growth, in which a lot of literatures can be found on.

Literature

Water, energy and food are vital for human well-being, poverty decline and sustainable expansion (Food and Agriculture Organization of the United Nations (FAO) 2014). Bizikova et al. (2013); Hoff (2011) in their book on the water-food-energy security nexus observed through study that water, energy, and food will become scarce in future. With limited resources, inadequate energy supply, and growing water stress, the challenge of providing enough water and energy to grow enough food for the growing population will be faced. The demands for water, energy, and food are estimated to increase by 40%, 50% and 35%, respectively, by 2030. Adenikinju (2008) examined the efficiency of the energy sector in enhancing competitiveness of the Nigerian economy. Nnaji et al. (2013) investigated the causal relationship among electricity supply, fossil fuel consumption, CO2 emissions and economic growth in Nigeria for the period 1971-2009 in a multivariate network. Their findings indicated that economic growth is associated with increased CO2 emissions while a positive relationship exists between electricity supply and CO2 emissions, revealing the poor nature of electricity supply in Nigeria.

According to Brune, (2011), "Globally the energy industry accounts for eight percent of water withdrawals, all energy generation technologies need adequate water at some point, and usually in substantial amounts. Water shortage will reduce hydro-electrical energy generation capacity as nations turn towards this environmentally friendly option to mitigate carbon emissions and diversify their energy generation capacities" Decreasing hydropower energy generation capacity can force nations to increase their reliance on the conventional energy generation capacities that are not climate-friendly.

The main problems of Nigeria stem from the fact that they are unable to access the natural and human resources (Muhammed, & Atte, 2006). In the study, they observed growth in many different sub sectors of agriculture and their contribution to the Nigerian economy during the years 1981 to 2003. They also identified the various factors that have an impact on the national agricultural production in Nigeria. They specifically examined the sectors of crops, livestock, fishery and forest.

(Diao et al., 2009) examined the effect of other channels of growth on the decrease in poverty and the overall growth rate in six low-income countries of Africa. The findings of that research can be applicable to Nigeria as well. According to the study, industrial growth is less effective in reducing poverty than agricultural growth because a major percentage of the population (about 70%) live in rural areas. The agricultural sector is favorable as it allows greater employment opportunities for the poor. It was also noted by Diao et al, (2009) that even though the industrial sector is important for boosting the economy, it fails to create sufficient employment opportunities for the poor and unskilled workers. In addition, the study stated that there was little evidence to prove that

African countries could launch a successful economic transformation without going through an agricultural revolution on a country-wide basis.

According to Adeniji, (2016) Climate change poses serious risks and threats to the energy security of developing nations that lack "resilience". Nigeria, where the evident lack of resilient energy systems intensifies the level of its energy security risks, is over-dependent on fossil sources for its energy supply. Similarly, the reliance on hydropower for close to a third of electricity generation is normally under pressure as dams dry up, particularly during rainless periods. Extreme weather conditions and accidents linked to climate change are capable of disrupting the Nigerian energy system. Increased temperatures, particularly in northern Nigeria will cause increased energy demands in urban areas for cooling purposes. Also, declining rainfall in the northern part of Nigeria will cause reduction in biomass availability for energy generation. It is projected that increased rainfall intensity in the coastal zones of southern Nigeria may lead to system disruptions, interruptions in the distribution of electricity, and widespread destruction of power lines as a result of severe erosion. (Adeniji, 2016).

Uzoma et al. (2012) related with sustainable development in Nigeria and asserted that no single energy mix can sustainably meet the energy demands of any country. Therefore, integrating all exploitable energy resources is a viable way of achieving stability in energy supply in Nigeria. Using linear regression (Ordinary Least Square) estimation procedure, they found that existing energy mix has not significantly influenced sustainable development given that electricity generation is inadequate and coal is no longer in use. Ubi and Effiom (2013) who explored the relationship between electricity supply and economic growth in Nigeria found per capita GDP, lagged electricity supply, technology and capital to be significant variables that influence economic development in the country. Ubi et al. (2012) carried out an econometric analysis of the determinants of electricity supply in Nigeria using a parametric econometric methodology of OLS and their results showed technology, government funding and the level of power loss to be the statistically significant determinants.

Therefore, it is necessary to take a nexus approach when developing strategies. The nexus approach illustrates how and where the three systems interconnect (Hanlon et al. 2013). Using a nexus approach to exemplify water resources sustainably in energy supply chains and food supply chains is seen as a promising approach towards sustainable economic growth and development.

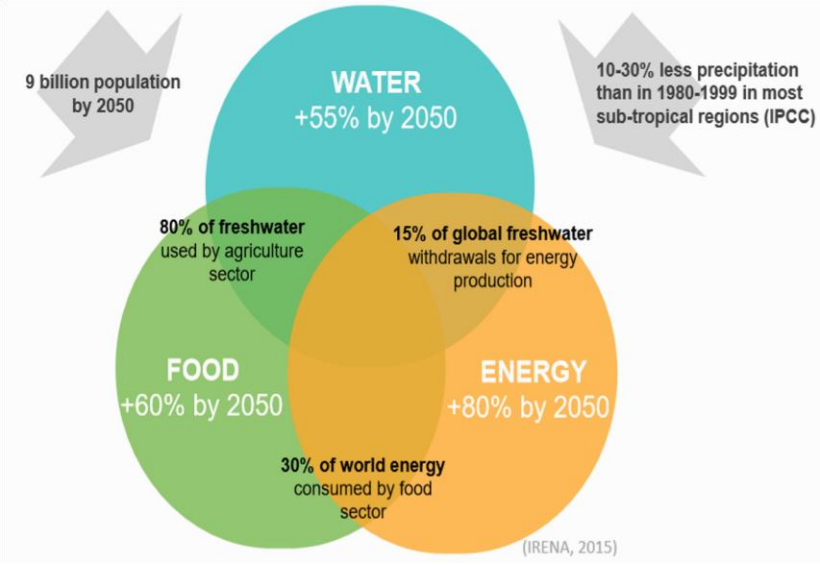

Figure 1 (Global Pictogram of WEF percentages) Source: (https://irena.org/irena water-energy-food nexus/2015)

Methodology and Result

Data

The study gathered annual time series data from World development Index: Nigeria, and CBN bulletin on food productivity index, energy use per capita, water productivity and GDP per capita from 1990 – 2017.

Model Specification

The Simultaneous equation is-

$LGDP = \beta_0 + \beta_1 LENR + \beta_2 FPI + \beta_3 LWP + \beta_4 LHCE + \beta_5 LEIL + \beta_6 LPOP$

Where:

GDP – Gross Domestic Product, ENR - Energy Use, FPI - Food productivity Index, WP – Water Productivity, HCE – Household Consumption Expenditure, EIL – Energy Intensity level, POP – Total Population.

The Simultaneous equation comprise of two equations -

The Baseline equation and the experiment equation

Baseline Equation:

$LGDP = \beta_0 + \beta_1 LENR + \beta_2 FPI + \beta_3 LWP$

Experiment Equation:

$LENR = \beta_0 + \beta_1 LGDP + \beta_2 LWP$

Pre-Estimation Results:

Table 1 Unit Root Test Result.

Variables	Augmented Dickey-Fuller		Phillips-Perron		Order of Integration
	Level	First Diff	Level	First Diff	
Lenr	-2.4952	-4.6294	-2.5190	-4.9555	I(1)
Fdp	-2.6153	-4.2035	-4.1932	-10.4126	I(1)
Lwp	0.6482	-4.0052	1.3443	-3.9952	I(1)
Lgdp	-2.0593	-3.9605	-2.0774	-3.9417	I(1)

Mackinnon (1996) one-side p-values)

The results of the unit root test showed that none of the variables was stationary at level as presented in the table 1 above. Evidence from the table shows that all the variables were stationary at first difference at 5 percent level using Mackinnon (1996) one-side p-values. This therefore called for further long-run co-movement among the variables using Johansen cointegration technique.

Table 2- Johansen Co-integration Result

Johansen Co-integration Result

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
r≤0	53.6865*	47.8561	22.2515	27.5843
r≤1	31.4350*	29.7970	21.3873*	21.1316
r≤2	10.0477	15.4947	9.3644	14.2646
r≤3	0.6832	3.8414	0.6832	3.8414

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Source: Author Computations 2017, E-views 7.0

The results of the Johansen co-integration test showed that there was long-run comovement among the variables. This was evidenced from the Trace statistic which showed that the Johansen co-integration had two co-integrating equations emanated from the statistic. Thus, this result showed there was a convergence relationship among the variables in the long-run.

Table 3 – ECM Result

Error Correction Mechanism

Dependent Variable: DLOG(GDP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
ECM(-1)	-0.008502	0.230369	-0.036905	0.9710
C	0.013290	0.009533	1.394172	0.1802
D(FDP)	0.001097	0.000985	1.113106	0.2803
DLOG(ENR)	-0.946350	0.643556	-1.470503	0.1587
DLOG(WP)	0.115931	0.185296	0.625652	0.5394
R-squared	0.179664	**Akaike info criterion**		-4.048279
Adjusted R-squared	-0.002633	**Schwarz criterion**		-3.801432

F-statistic	0.985556	**Durbin-Watson stat**	1.601635

Source: Author Computation 2017, E-view 7.0

Having established the long-run relationship and co-movement among the variables, there was a need to examine the speed of adjustment that took all the variables to converge in the long-run. This test was done using error correction mechanism (ECM) and was used to calculate the speed of adjustment. That is, the time it takes the variables to converge in the long-run. Therefore, the coefficient of the ECM was negative and not significant at 5% as evidence in the table 3 above. The co-efficient of -0.008502 indicates that the deviation of the economic growth model from the long-run equilibrium level is corrected by 0.009%.

Table 4 - Estimated Result of Food Production, Energy use - Economic Growth Nexus in Nigeria

Dependent Variable: LOG(GDP)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(ENR)	2.551810	1.073103	2.377974	0.0261
FDP	0.005867	0.001139	5.151233	0.0000
C	-7.185558	2.992790	-2.400957	0.0248
R-squared	0.875271	Durbin-Watson stat		0.949513
Adjusted R-squared	0.864425	F-statistic		80.70019

Source: Author Computation, E-views 2017

The estimated result presented in table 4 above explained the relationship between food production, energy use and economic growth in Nigeria. The independent variables explained approximately 86% of the total variations in the dependent variable. This showed that the model had high goodness of fit. The value of the F-statistic was statistically significant at 5% level indicating that the model was significant.

The coefficient of energy use was positive and statistically significant at 5% level. The positive sign exhibited by the coefficient of energy use showed that a unit percent change in energy use would lead to 2.5 percent increase in gross domestic product in Nigeria which would increase growth of the economy. Hence, the more the energy use, the higher the economic growth in Nigeria through productivity of other sectors of the economy. The coefficient of food production was positively signed and statistically significant at 5% level. This showed that food production has significant impact on economic growth. Thus, a unit increase in food production would lead to increase in gross domestic product in Nigeria by 0.005 percent.

Table 5 - Estimated Result of Water Productivity, Energy use - Economic Growth Nexus in Nigeria

Dependent Variable: LOG(GDP)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(ENR)	1.776558	0.876065	2.027884	0.0543
LOG(WP)	0.518258	0.070694	7.331024	0.0000
C	-5.188147	2.427079	-2.137609	0.0434
R-squared	0.919493	DurbinWatson stat		0.610294
Adjusted R-squared	0.912492	F-statistic		131.3439

Source: Author Computation, E-views 2017

The estimated result presented in table 5 above explained the relationship between water productivity, energy use and economic growth in Nigeria. The independent variables explained approximately 91% of the total variations in the dependent variable. This showed that the model had high goodness of fit. The value of the F-statistic was statistically significant at 5% level indicating that the model was significant.

The coefficient of energy use was positive and but not statistically significant at 5% level. The positive sign exhibited by the coefficient of energy use showed that a unit percent change in energy use would lead to 1.77 percent increase in gross domestic product in Nigeria which would increase growth of the economy. Hence, the more the energy use, the higher the economic growth in Nigeria through productivity of other sectors of the economy.

The coefficient of water productivity was positively signed and statistically significant at 5% level. This showed that water productivity had significant impact on growth of the economy. Thus, a unit percent change in water productivity would lead to increase in gross domestic product in Nigeria by 51 percent. Hence, the results shows that water productivity helps in the growth of the economy.

Table 6 - Estimated Result of Water Productivity, Food Production, Energy use - Economic Growth Nexus in Nigeria

Dependent Variable: LOG(GDP)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(ENR)	1.029097	0.837155	1.229280	0.2320
LOG(WP)	0.385845	0.081605	4.728225	0.0001

FDP	0.002720 -3.096050	0.001056	2.574906 -1.333261	0.0173
C		2.322164		0.1961
R-squared	0.938136	Durbin-Watson stat		0.716241
Adjusted R-squared	0.929700	F-statistic		111.2070

Source: Author Computation, E-views 2017

The estimated result presented in table 4.6 above explained the relationship between water productivity, food production, energy use and economic growth in Nigeria. The independent variables explained approximately 93% of the total variations in the dependent variable. This showed that the model had high goodness of fit. The value of the F-statistic was statistically significant at 5% level indicating that the model was significant.

The coefficient of energy use was positive and but not statistically significant at 5% level. The positive sign exhibited by the coefficient of energy use showed that a unit percent change in energy use would lead to 1.03 percent increase in gross domestic product in Nigeria which would increase growth of the economy. Hence, the more the energy use, the higher the economic growth in Nigeria through productivity of other sectors of the economy.

The coefficient of water productivity was positively signed and statistically significant at 5% level. This showed that water productivity had significant impact on growth of the economy. Thus, a unit percent change in water productivity would lead to increase in gross domestic product in Nigeria by 39 percent. Hence, the results shows that water productivity helps in the growth of the economy.

The coefficient of food production was positively signed and statistically significant at 5% level. This showed that food production has significant impact on growth of the economy. Thus, a unit increase in food production would lead to increase in gross domestic product in Nigeria by 0.002 percent. Hence, the results shows that food production aid growth in the economy but at a minimal rate

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Simultaneous Equation 1:

Dependent Variable: LGDP

Method: Two -Stage Least Squares

Date: 12/13/17 Time: 16:08
Sample (adjusted): 1 25
Included observations: 25 after adjustments
White heteroskedasticity-consistent standard errors & covariance

Instrument specification: LENR LHCE LEIL LPOP

Constant added to in strument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.

LWP	0.951475	0.127184	7.481115	0.0000
FPI	-0.002906	0.000947	-3.067991	0.0058
LENR	0.347658	0.831199	0.418261	0.6800
C	-1.444155	2.268885	-0.636504	0.5313

R-squared	0.883901	Mean de pendent var	0.618167
Adjusted R-squared	0.867316	S.D. dependent var	0.163954
S.E. of regression	0.059722	Sum squared resid	0.074900
F-statistic	60.25446	Durbin-Watson stat	0.453486
Prob(F-statistic)	0.000000	Second-Stage SSR	0.000418
J-statistic	5.87E-05	Instrument rank	5
Prob(J-statistic)	0.993888		

Equation 2:

Dependent Varia ble: LENR

Method: Two -Stage Least Squares

Date: 12/13/17 Time: 16:17
Sample (adjusted): 1 25
Included observations: 25 after adjustments
White heteroskedasticity-consistent standard errors & covariance
Instrument specification: LENR LHCE LEIL LPOP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.789476	0.057983	48.10885	0.0000
LGDP	0.076516	0.139198	0.549687	0.5881
LWP	0.018571	0.103366	0.179665	0.8591
R-squared	0.708855	Mean dependent var		2.862441

Adjusted R-squared	0.682387	S.D. dependent var	0.019696
S.E. of regression	0.011100	Sum squared resid	0.002711
F-statistic	26.85467	Durbin-Watson stat	1.055234

Constant added to instrument list

Prob(F-statistic)	0.000001	Second-Stage SSR	0.002693
J-statistic	21.85434	Instrument rank	5
Prob(J-statistic)	0.000018		

Conclusion

Nigeria is a nation blessed in water resources up to a point where the total area covered is almost the total area of the nation. The water resources are in such a way that every geopolitical region have significant body of water around that can be properly utilized for food, energy and even improved water accessibility and use. Presently, 70% of water withdrawn is used for Agricultural purposes alone, this can become a dynamic process such that the percentage of water used for Agriculture can also be utilized by other purposes such as waste water management, sewer management, etc. Likewise, some of the crops we eat and livestock are good raw materials for biofuel and biogas which is a form of Energy generation such as cassava, sugarcane, palm, cattle and poultry waste etc.

It was observed from the results of the econometric tests run that a nexus between food, water and energy productivity will have significant roles to play in the growth and development of the economy. As much as focusing on only two sectors (especially energy and water), the additional percentage contribution development in the agricultural or food sector will have in Nigeria cannot be neglected. For a nation like Nigeria to attract foreign direct investment, there has to be a synergy of these three sectors such that the vast resources on water, agricultural abundance in arable lands and energy resources (especially renewable sources of energy such as sun, wind, water) can be utilized internally with improved processes and technologies. From the research and a further verification carried out by the world bank, we can see that with the BAU scenario of climate change and food-water-energy use, Nigeria will have more wet lands and areas, agriculture and food productivity will have a negative impact on GDP and so a nexus where these resources can be used interdependently needs to be developed. Improvement should be worked out in all three sectors in the nexus approach such that no sector is lacking input, policies, government interventions, private organization and citizen involvement to allow for internalization of this development, this will in turn encourage foreign direct investment.

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