CO2 EMISSIONS, TEMPERATURE CHANGES, PRODUCTIVITY AND LABOUR SUPPLY: NEW EMPIRICAL EVIDENCE FROM FARMERS IN NIGERIA

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ABSTRACT
Temperature changes, variability in the climatic conditions of Nigeria is putting agriculture under serious food security and production under serious treat. Studying these changes in temperature and co2 emission has very critical to the Nigerian agricultural sector. Robust OLS model and Cointegration techniques were used to analyse the study objectives using time series data and interesting results were found in the course of the analysis. We found that the impact of temperature changes and that of rainfall on agricultural productivity in Nigeria is positive. Further results showed labour supply and CO2 emissions has significant and positive impacts on agricultural output in Nigeria. It is recommended that the government should provide adequate support to farmers in Nigeria by building irrigation systems to boost production especially during the dry seasons when rainfall is very rare. Agricultural innovations and technologies are encouraged so as to regulate climatic changes.
Keywords: temperature changes, agricultural productivity, CO2 emissions, agricultural innovations

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1. INTRODUCTION
The impact of agricultural productivity on an economy cannot be overemphasized as a result of the linkages that exist between food security and the standard of living standard. The Agricultural sector over the years has contributed about 18% of Nigeria's GDP, with about 23% of the total value of exports and also employing 69% of the active labour force. Adofu Abula & Audu (2020). In Nigeria the roles of agriculture in the economy are; first to provide basic food requirement for the teeming population; second, to contribute to the country's foreign exchange earnings, which in turn provides for the importation of other needed commodities including raw materials; third, to provide employment to a greater part of the working population; fourth, agriculture serves as a source of local raw materials for industries. Finally, agriculture ensures a high per capita real income for the farmers or farm workers in the rural areas. Deficiency in any of these roles is a great challenge to the economy which is also applicable in every other sub-Sahara Africa that 90 percent of their staple food production are under direct rainfall agriculture. Nwachukwu (2003) says, over the years, the Nigeria's Agricultural sector has not been able to perform these roles effectively due to a lot of factors militating against its practice.

Apart from inadequate technical know-how, the major cause of low agricultural labour productivity is deficiency in rainfall which may be too much or less than required for cropping as a result of the depletion of the ozone layer caused by carbon dioxide emission. This is because many manufacturers do not give attention to the environmental impact of their production activities. In the early years of development, policymakers paid little or no attention to the environment. Economic growth was the priority and imposing any restrains on the growth was seen as erroneous. Of course, some controls on emission of CO_2 were introduced, but the level of effort that went into environmental regulation remained very low. The same thing also happened to investment in infrastructure in clean technology, and in collection and treatment of industrial wastes. The public sector simply did not treat these as a priority category and the incentives on the private sector to undertake such investment remain weak or non-existences (Elsadig 2012). This led to the continuous deterioration of the ozone layer causing harm to both the environment and the human factors with its consequent effect on agricultural labour productivity.

It has been established that high temperature caused by CO_2 emission could lead to losses in labour productivity. The agricultural, mining and quarrying, manufacturing and construction sectors have been identified as the sectors of the economy most vulnerable to this heat exposure. These sectors account for 73 percent of low-income countries of African and Southern American output. These countries are also more vulnerable because a greater percentage of their work force is employed in these sectors and because they have less ability to implement infrastructural changes that deal with a changing climate Yann C. at el (2019).

Also, as a result of global warming caused by CO2 emission, the world's climate is changing and its effect is felt in the different countries. One of the most important parameters for measuring the state of the climate is rainfall. Just as there is a direct relationship between climatic condition and agriculture, so is there a direct relationship between rainfall and agricultural labour productivity. So, when the pattern of rain changes, it affects the pattern of crop growth worldwide. Again, as the ozone layer depletes, there will be more hat trapping gases in the atmosphere, which according to climate models will shift rainfall pattern. This will either cause too much rainfall which can lead to flooding and washing away the earth surface. All these will lead to fall in agricultural productivity.

This paper hence focuses on the relationships that exist between CO_2 emission, temperature changes, agricultural productivity and labour supply. The specific objectives of the paper are; to determine the effect of temperature changes on agricultural productivity, examine the long-run effect of co2 emission and labour supply on agricultural output in Nigeria, and finally, to establish the long-run effect of temperature changes and labour supply on Agricultural output in Nigeria.

Therefore, the remaining structure of this paper is organized as follows; review of relevant literature, section 3 focuses on methodology and section 4 provides conclusion and some recommendation on how to curb the emission of CO_2 emission and improve agricultural output and labour supply.

2. Literature Review

2.1.1. Increasing Global Temperature as a Result of Co2 Emission

The annual mean global temperature is likely to be at least 1" Celsius above pre-industrial levels (1850-1900) in each of the coming five years (2020-2024) there is a 20 per cent chance that it will exceed 1.5^{o}c in climate predictions issued by the world Meteorological Organization (WMO). The Global Annual to Decadal Climate update, led by the united kingdom's Met Office, provides a climate outlook for the next five years updating annually. It harnesses the expertise of internationally acclaimed climate scientists and the best computer models from leading climate centers around the world to produce actionable information for decision-makers. The earth's average temperature is already 1.0c above the pre-industrial period. The last five-year period has been the warmest five years on record.

"This study shows – with a high level of scientific skill- the enormous challenge ahead in meeting the Paris Agreement on climate change target of keeping a global temperature rise this century well below 2 degree Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degree Celsius" said World Meteorological Organization Secretary-General Peter Taalas.

The prediction takes into account natural variations as well as human influences on climate to provide the best possible forecasts of temperature, rainfall, wind patterns and other variables for the coming five years. The forecast models do not take into consideration changes in emission of greenhouse grass and aerosols as a result of the corona virus lockdown.

World Meteorological Organization has repeatedly stressed that the industrial and economic showdown from COVID-19 is not a substitute for sustained and coordinated climate action in the atmosphere. The impact of the drop in emission this year was not expected to lead to reduction of CO2 atmosphere concentrations which are driving global temperature increase. Failure to tackle climate change may threaten human well-being, ecosystems and economies through reduced agricultural output. Government should use this opportunity to embrace climate action as part of recovery programmes" he said (WMO report, Sept. 2020).

2.1.2. The Relationship Between CO_2 Emission and Agricultural Output

The relationship between CO_2 emission and agricultural productivity can be traced through the effect of CO_2emission on rainfall. An important aspect to be understood regarding the effect of rainfall on agriculture is that rainfall is the major factor in the growth and production of food crops both at the point of germination till the stage of fruit development. As a result of depletion of the ozone layer caused by CO_2 emission, there will be more heat trapping gases in the atmosphere, which will cause temperatures to rise and rainfall will increase in some places. In other places, rainfall will decrease.

Currently, about 60 percent of the world and 90 percent sub-Saharan African staple food production are under direct rainfall agricultural Fasinmirin and Braga (2009). If we go by predicted climate models, then in central and Eastern African increased yields of 10 to 30

percent are possible if rainfall increases and improved agricultural technologies are adopted. In North America, on the other hand, projections show that average rainfall in central North America will be 15 percent lower than normal. It is such regional variations that makes it difficult to propose general strategies for adopting new agricultural technologies to combat this change.

In general, those parts of the world where water availability is set to increase due to higher rainfall, there would not be much problem. This water can be stored, efficiently if the facilities are available in check dams, bunds, ponds and reservoirs. It will help irrigation in the surrounding areas and increase crop production. Unfortunately, a good part of this excess rainfall comes with nature disasters such as hurricanes, and floods, doing more damage than good. This was what happened in 2009 in the Philippines, where two back-to-back typhoons unleashed heavy rains. Many of the farmers in this country lack post-harvest storage and drying facilities and they spread their unhusked grains on concrete streets to dry in the sun. owing to these typhoons, the grain was of poorer quality and fetched lower prices. This damage and excess rain made it difficult for them to plant the next crop. The cumulative loss as a result of these typhoons was to the tune of USD 27 Million.

Hurricanes like EI Mino is another example patterns and food securities are impacted. In 2016, in southern Africa, it "severely weakened" crop prospects, causing a 25 percent cut in wheat production. In India too, as a result of poor monsoon, the area of wheat crop was cut. Nevertheless, its effect is much less than in southern African because India has enormous volumes of wheat and rice in stock. So, it did not affect India like southern Africa. Therefore, cropping patterns and food security are affected in different ways in different part of the world.

Apart from the effect of high and low rainfall on cropping patterns, it has been proved that other phenomena associated with high rainfall such as coastal flooding will reduce the amount of land available for agriculture. Farmers are already finding it difficult to cope with these environmental changes as almost all crops are seasonal and dependent on the pattern of rainfall. Temperature and rainfall changes caused by CO_2 emission are likely to further react with other parameter of plant growth like atmospheric gases, fertilizers, insects, plants pathogens, weeds, and the soils organic matter. This again is likely to produce unanticipated responses.

2.2. Empirical Literature

Ackerman and Elizabeth (2012) found a significant positive relationship between carbon dioxide (Co2) and variation in annual rainfall, while studying the effect of energy consumption and its effect on climate change using U.S data and applying OLS technique. Again, in another work, Fischer, Ermolieua, and Vethuizen (2006) noted that the social cost of carbon (or marginal damage caused by an additional ton of carbon dioxide emissions) has been estimated by a U.S. government working group at $21 per ton of Co2 in 2010. Hence, their result shows that there exists a positive relationship between carbon dioxide emissions and climate change.

In another study aimed at assessing the effect of carbon dioxide (Co2) emission growth on productivity growth on selected 5 countries of Association of South East Asian (ASENAS) of Malaysia, Indonesia, Philippines, Singapore and Thailand, plus 3 East Asian countries of Japan, China and South Korea) Elsadig (2012) discovered that there was difference in the contribution of labour productivity, capital deepening and Co2 intensity emissions. Also, in another work by Elsandig (2006) which was aimed at an extended productivity measure that takes pollutants into account by internalization of carbon dioxide (Co2) as a measure of air pollutant, emissions into the production function as an unpriced input. The result shows that there is a showdown in the contribution of total factor productivity (TFP) growth in general and a negative impact of Co2 emission produced by the sector in particular compound to other productivity indicators of the sector when Co2 is not internationalized in the model.

In a work which evaluated Ghanaian agriculture, for the past, present and challenges vis-à-vis the Brazilian type of agriculture that fosters sustainable development, in food and energy production, Fasinmirin and Braga (2009) use qualitative analysis to council the main reason for the slow agricultural development in Ghana despite the volumes of scientific information to engender improvement. Their findings were traced to poor government involvement in agriculture at the level of policy for formulation and implementation. The very poor approach to the adoption of appropriate technology and scientific information in agriculture has resulted to loss of arable upland soils to the forces of erosion and floods and increase in green house gab emission trees and bush burning.

Also, a qualitative analysis to examine the effect of climate change on agricultural output in Nigeria was carried out by Ifeanyi-Obi Etuk & Jike-Wai (2012). Their findings show that tackling climate change is one of the biggest challenges Nigeria faces. In their work, they found Nigeria to be vulnerable to climate change because of their fossil fuel dependent economy and rain-fed agriculture, high levels of poverty, and low levels of human and physical capital, inequitable land distribution and poor infrastructure. In a nutshell, Ifeanyi-Obi, Etuk & Jike-Wai (2012) findings revealed that climate change is already affecting agriculture activities with the most devastating adverse effects in Nigeria as extreme weather condition. Frequent drought, increased environmental damage, increased infestation of household asset, etc. these conditions emanating from climate change are bound to militate against agricultural production.

In another qualitative research by Fatile & Adejobi (2012) it was emphatically demonstrated that Nigeria's vulnerability to climate change is growing and they may be a threat to human development and survival and might lead to competition for scarce resources, which will enhance and create socio-environmental conflicts. Their study shows that socio-environmental conflicts happens when two or more interdependent actors disagree as to the distribution of certain material or symbolic elements related to the control use or, and access to natural resources and act on the basis of these inconsistencies.

Climate change is an adverse environmental phenomenon that is causing enormous concern all over the world as reported in the qualitative findings of Idowu, Ayoola, Opele & Ikemeiuwe (2011). It refers to some anomalies in the climate system that is a result of human activities. These anomalies include increase in the concentration of CHCs in earth's

atmosphere, which will ultimately lead to global warming has already began, as earth's temperature has risen between 0.4^{o} and 0.8^{o}c in the last 100 years. They also find that, Nigeria is one of the world's most densely populated countries with a population of 180 million people, half of which are considered to be in abject poverty. They insist that, climate change and global warning if left unchecked will cause adverse effect on live livelihoods in Nigeria, such as full in crops production, livestock production, fisheries because the rainfall regimes and patterns will be altered.

On the country, according the Davis et al (2000) carbon CO2 emission does not have only negative effect on the economy. According to them, this occurs when we consider the auxiliary benefits. These benefits occur as a side effect of targeted policies and are also known as secondary benefits, policy spill over effector co-benefits.

William (2002) shown theoretically through the use of general equilibrium analysis, that this is especially true when health effect link to changes in labour productivity. He finds that the benefits-side tax interaction effect results in a welfare gain when reduced pollution boosts labour productivity.

3. Methodology

The data for this study were sourced from the world development index (2019). In order to capture the objectives of this study, we adopted the Robust Ordinary Least Square Model using the study period from 1970 to 2019. On this premise, variables such as CO2 emission, rain fall, temperature change, agricultural output, labour supply and Real Gross Domestic Product in order to model the objectives of the study. Agricultural output is used as the dependent variable in the model and all other variables were used as the independent variables. The choice of the study period is as a result of data availability and the variables employed are believed will capture the objectives of the model.

The robust OLS modelling approach is modelled below and the choice of model is as a result of its flexibility in handling small size sample data. The robust OLS is specified below as thus;

$$AO = f\ (LS, TEMP, RF, CO2, POP) \quad \ldots\ldots 1$$

$$AO = \alpha_0 + \beta_1 TEMP + \beta_2 RF + \beta_3 LS + \beta_4 CO2 + \varepsilon \quad \ldots\ldots 2$$

The expressions with summation sign (β_1-β_4) represents the coefficients of the explanatory variables in the model and ε_t is the serially uncorrelated disturbance with zero mean and constant variance. AO represents Agricultural value added, CO2 represents carbon dioxide emissions, RF represents rain fall, TEMP represents temperature changes, while LS represents labour supply.

Variables	Definitions	Source
Labour	Population ages 15-64, total	WDI, 2020
Temperature	Average Annual Rainfall in degree Celsius	WCD, 2019
Rainfall	Average Annual Temperature in millimetres	WCD, 2019
Agric	Agriculture, forestry, and fishing, value added (constant 2010 US$)	WDI, 2020
co2	CO2 emissions (metric tons per capita)	WDI, 2020

WCD means World Climate Data.

4. Result and Discussion of Findings

This section begins with the report of the descriptive statistics and checking of the time series properties of our data. Table 1 reveals the descriptive statistics. The average temperature in Nigeria is reported to be around 27.3 degrees Celsius, while the average rainfall is 95.3 millimeters. The Phillips Perron (1989) unit root test was adopted and reported in Table 2. The results reveal that some of the variables are $I(0)$: temperature and rainfall, some are $I(1)$: agricultural value added and CO2 emissions, while labour supply is $I(2)$. Given the order of integration of these variables, the Autoregressive Distributed Lag (ARDL) model is inappropriate, as it requires integration points to be $0\ and\ 1$. Hence, the study applies a parsimonious methodology known as the Ordinary Least Square (OLS) and the Engel and Granger cointegration test.

Table 1: Descriptive Statistics

Variables	Lnagric	co2	Rainfall	temperature	Lnlabour
Mean	24.7108	0.5693	95.3355	27.2946	18.1084
Obs	28	28	28	28	28

Authors.

Table 2: Phillips Perron Unit Root Test

Variables	$I(0)$		$I(1)$		$I(2)$	
	rho	$Z(t)$	rho	Z(t)	rho	$Z(t)$
Ln_Agric	-6.661	-1.744	-24.840*	-4.688*		
Ln_CO2	-6.318	-1.499	-27.110*	-5.060*		
Ln_Rainfall	-38.413*	-6.798*				
Ln_Temperature	-23.484*	-4.523*				
Ln_Labour	-5.147	-2.076	-9.993	-2.110	-25.556*	-6.343*

Authors. *, denotes significance at 1% respectively

Table 3: Engel-Granger Cointegration Test and Robust OLS Results

Agricultural value added	E-G test	(OLS)	(Robust)
	0.0643		
Lnrainfall		0.168	0.168
Lntemp		3.303	3.303
lnco2		0.232***	0.232***
Lnlabour		2.338***	2.338***
Constant		-29.18***	-29.18***
R_2		0.9699	0.9699
Observations		28	28

Authors. *, **, *** denotes significance at 10%, 5% and 1% respectively. Note: E-G mean Engel and Granger p-values

Table 3 results show no long-run effect of temperature changes and labour supply on agricultural output in Nigeria. This is reported by the p-values of Engel and Granger test. Thus, we proceed to report the OLS results. We find that the impact of temperature changes and that of rainfall on agricultural productivity in Nigeria is positive. This is in line with Ayinde O.E, Muchie M & Olatunji G.B (2011), who found a positive relationship between rainfall and agricultural productivity in Nigeria. However, this impact is generally insignificant. Further results reveal that labour supply and CO2 emissions has significant and positive impacts on agricultural output in Nigeria. Many works in literature have reached on similar or contrast these findings Ackerman. F. & Elizabeth A.S. (2012), Elsadig M.A. 2012, Ifeanyi-Obi, Etuk & Jike-Wai (2012)

5. Conclusion and Policy Recommendations

This study set out to check for the long-run effect of temperature changes, CO2 emissions, labour supply on agricultural output in Nigeria. The results revealed no cointegration and significant positive impacts of CO2 and labour supply, but insignificant impact of temperature changes on agricultural outputs. Therefore, stakeholders in the agricultural sector should design policies in order to harness the full potential of favourable temperature changes and adequate rainfall to boost agricultural production in the country. More government support is needed by farmers in Nigeria to boost agricultural production. This could be done by providing adequate financial support such as building irrigation systems for farmers to support the impact of rainfall especially during the dry season due to lack of rainfall during such time. Moreover, the current policies on CO2 emissions for the agricultural sector should continue to be implemented to the latter, as well as the training of labour supplied to this sector. All these are in a bid to boost productivity of the agricultural sector in Nigeria.

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