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Carbon Emissions, Agricultural Output and Life Expectancy in West Africa

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ABSTRACT

Carbon emissions are basically gaseous substances that are generated from human activities such as the burning of fossil fuels, into the atmosphere, and these emissions affect agricultural output and human health. The rising level of carbon emissions into the atmosphere has become a problem worldwide. Thus, this study examined the effect of carbon emissions on agricultural output and life expectancy in West Africa using data that spanned the period between 2000 and 2018. The study employed the two stage least squares econometric technique. The findings from the study revealed that a 1% increase in carbon emissions bring about a 3.818% reduction in agricultural output, that is, carbon emissions adversely affect agricultural output in West Africa. Also, a 1% increase in carbon emissions bring about a 0.123% increase in life expectancy, that is, carbon emissions boost life expectancy in West Africa. Therefore, this study recommends that the governments of the West African countries should formulate environmental policies that will help mitigate the adverse impact of carbon dioxide emissions on the agricultural sector, and also improve on healthcare delivery in the hospitals so as to reduce the mortality rate, this will help increase life expectancy in West Africa.

Keywords: Carbon Emissions, Agricultural Output, Two Stage Least Squares, West Africa
JEL Classifications: Q4, R11, L98

1. INTRODUCTION

Carbon emissions are essentially gaseous substances generated by human activities, such as fossil fuel burning, cement production and agricultural land use (IPCC, 2007). Rising carbon emissions into the atmosphere has become a global issue. Anderson et al. (2008) stressed that since the industrial era, these emissions have grown significantly. The main issue with carbon emissions is that they cause climate change that could have a negative impact on the environment and on human and economic activity. Carbon emissions pose a threat to an economy, as they have led to a massive fall in agricultural output, according to Jiang and Li (2017). The decline in agricultural output definitely affects the level of agricultural supply to the market, and once supply is adversely affected, demand will also be affected adversely (Alege et al., 2017; Matthew et al., 2018).

According to the Food and Agriculture Organization (2003), food safety is characterized as a situation in which all people have access to sufficient, safe and nutritious foods that satisfy their dietary needs and food preferences for an active and healthy life at all times. Food safety goes beyond accessibility. It includes people's ability to have monetary and non-monetary resources to gain access to adequate quantities and qualities of food (Schmidhuber and Tubiello, 2007). Four dimensions of food security viz.: Quality of food; safety of food supply; access to food; and use of food. Numerous studies have shown a correlation between these four dimensions of food safety and carbon emissions. Only food

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availability and carbon emissions were well studied among these dimensions, with little emphasis on other components that ensure adequate consumption (Bulto et al., 2014).

Because agriculture is the main source of income, especially for rural households which make up the majority of the population of West Africa, any changes affecting food safety caused by carbon emissions are likely to have an impact on people's health since, without adequate food, malnutrition would affect people's lives (Matthew et al., 2018; Matthew et al., 2019). The global estimates in 2018 have put the average life expectancy for males and females at 70 years and 74 years respectively, however, in Africa the life expectancy estimates are lower being put at 61 years for males and 64 years for females (Statista, 2018).These lower rates in Africa can be attributed to poor medical facilities, terrorist attacks, malnourishment due to poverty and the harsh environment as a result of emissions amongst other factors.

Although the relationship between food safety and carbon emissions is strong, CO_2 emissions have also been found to be indirectly related to human development, economic growth, trade flows and food aid policies, with less clear results (Keane et al., 2009; Haggblade et al., 1989), Particularly in countries where climate forecasts are uncertain, for example in the SSA Sahel region. Studies have also shown that temperature predictions for the climate model converge, but this is not true of the central yield-determining Sahel precipitation (IPCC, 2007). Although there have been many studies on the relationship between carbon emissions and food safety and separate climate change and income growth, in West Africa there are few on the interaction between food security, carbon emissions and life expectancy. Consequently, it becomes imperative to recognize the complex relationship between carbon emissions, food security and life expectancy in West Africa given that carbon emissions can affect food security, which in turn can affect income.

The carbon emissions phenomenon is global, but its impacts are diverse and predominantly detrimental to the mainly tropical arid and semi-arid regions, as in the most vulnerable sub-Saharan Africa (SSA), with negative effects on the continent and its populations. This is because about 70% of Africans live in rural areas and depend for their livelihoods mostly on agriculture and natural-resource activities. These livelihood choices are based on the factors that make people vulnerable to climate change. Growth in the population is already putting pressure on food production and greater stress is producing carbon emissions, as food production is highly environmentally dependent. Consequently, carbon emissions are occurring for Africa, a continent that is more dependent on climate-sensitive resources and has a negative impact on its natural ecological systems in order to delay human development potential and food security. Adequate food production on the continent must ensure an improved living and nutritional security in order to achieve sustainable development and the overall well-being of the people. Carbon emissions are therefore a crucial development issue for Africa and not just a concern for the environment (Matthew et al., 2018; Osabohien et al., 2019).

In light of the above, this study examined the impact of carbon emissions on agricultural output and life expectancy in the West African sub-region. This research adds to knowledge limits by exploring the effect of carbon emissions on agricultural output and the health of people in West Africa that was not previously explored to the best of the authors' knowledge. So the hypothesis of this study stated in its null form is; H_0: Carbon emissions in West Africa do not have a significant impact on agricultural output and life expectancy. The thesis consists of five sections; after this introductory section, section two presents some findings from scientific literature and conceptual context, section three discusses both the study method and the data sources; section four deals with the empirical analysis of the study data and the study results; section five concludes the report with recommendations for policies that will help improve agricultural production and life expectancy given the gaseous emissions in West Africa.

2. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

The African continent accounts for only 3.6% of global CO_2 emissions (the main sources are coal power generation in South Africa and gas flaring in Niger), and the continent's forests are declining at an alarming rate, leading to a reduction in carbon absorption – a catastrophic development both for Africa and for the global climate. Compared to other regions, the CO_2 emissions from Africa are very low but due to unique vulnerabilities the continent is at greater risk of negative impacts from extreme weather conditions. Two-thirds of the terrain is dry land or desert, the arid and semi-arid regions of Shelian land in West Africa, Sudan in East Africa and South Africa. Economic activities rely on climate-sensitive sectors such as rain-fed agriculture, fisheries, mining, oil and gas, forestry, tourism and so on. Rain-fed agriculture supports the economy, with agriculture accounting for about 70% of jobs, 30% of gross domestic product (GDP) and 50% of exports (Matthew et al., 2019). Agricultural sector also offers a safety net for rural poor. Increased frequency and intensity of extreme weather in many regions such as the countries around the Rift Valley, Mozambique, Senegal and Gambia make people more vulnerable (Osabohien et al., 2019).

According to Osabohien et al. (2020), the factors that account for African countries ' vulnerability include; (i) use of energy – land grabbing and production of biofuels could have negative impacts on food security if rural communities are not well managed and displaced from their land and income; (ii) weak social and economic infrastructures; (iii) Poverty-low per capita GDP, life expectancy; and high infant mortality, starvation, illiteracy. More Least Developed countries also have Africa; (iv) Environment, social, economic and political instability conflicts and (v) Current stresses on health and wellbeing (for example, HIV/AIDS, illiteracy). These factors are very important to the continent and the survival of its people and their social and economic growth, including the achievement of the Sustainable Development Goals (SDGs). The SDGs that succeeded the Millennium Development Goals (MDGs) foreseen by 2030, there would be enough food for all (ensure that there is food security which is the crux of SDG Goal 2).

Food insecurity and hunger are precursors to problems of any nation's nutrition, health, human, economic and sustainable development which can lead to premature death and thus reduce life expectancy (Fasoyiro and Taiwo, 2012; Afolayan et al., 2019). How far these goals can be realized will be unfolded inthe process of time just as the MDGs were not adequately attained in Nigeria at the dawn of the end period of December 2015 (Chen and Kates, 1994). For instance, in West Africa, more than 75 million of its citizen has little or no access to food which is required to meet their daily energy needs (Obayelu, 2015; Bamisaye, 1987; Matthew et al., 2020).

Food safety is a multidimensional term, and a challenge to development. Food safety occurs when all individuals have physical and economic access to adequate safe and nutritious food at all times for an active and healthy life to meet their dietary needs and food preferences. That was introduced at the World Summit on Nutrition in 1996. Food security occurs at all levels of social and economic cadres, and describes assess to sufficient, safe, nutritious food to meet their lives (Osabohien et al., 2018; Urhie et al., 2020). For a family, food security simply implies that all members of the family have enough food to eat when it is needed to enable them continue living in good health and vitality. By 2050, global population is expected to rise above 9 billion and this rise in World's population will no doubt increase the demand for food which will be driven by the hiked population and variations in climatic conditions in the coming decades. In West Africa, more than 35% of the total population is undernourished, which has contributed to the low life expectancy recorded in the sub-region (Osabohien et al., 2018; Osabohien et al., 2019; Babajide et al., 2020).

A country that is food-sufficient is one where food is made as a human right to enhance its access. Most countries in West Africa are greatly endowed with vast resources, there is indeed a lot of food and it is believed that the issue of hunger results not from the shortage of food but mainly from the mis-distribution of food (Longe, 2005; Matthew et al., 2020). Allocated according to dietary need, the lactovegetarian supply of food supply along with the production reared animals will support up to 85% of West Africa's population (Fan et al., 2000; Alderman and Haque, 2007; Olopade et al., 2020). Researchers found that if poor nations and their people had more purchasing power, they could produce more food. The West African sub-region has unutilised and unharnessed ability for the adequate production of food. Without citizens' purchasing power, food would not be available to the people except given as aids. Thus, it is suggested that for West Africa that has a growing population, the availability of food just have to be increased more than two-fold to commensurate food requirements and expectation of improved diets of a food sufficient nation and households' income can also influence food security (Messer and Heywood, 1990; Matthew et al, 2018). Put differently, household income can directly affect the level of food security (UNDP, 2005).

According to Osabohien et al. (2018), they examined food security, institutional framework and technology using an econometric approach to ARDL in Nigeria. The study noted that one of the major factors for increasing food production was the availability of arable land to solve the food insecurity challenge. Therefore, efforts in this regard are crucial to reducing the rate of food insecurity. The study highlighted the need for active cooperation between government and farmers to ensure food safety in order to contribute to important food production-related planning issues in the country. With a view to protecting farmers vulnerable to shocks and the agricultural threats, social protection policies should be adapted or channeled to the agricultural sector. We used the ARDL approach in a report by Osabohien et al. (2018) to research the econometric analysis of the food safety and agricultural credit facilities in Nigeria. Researchers found that loans from commercial banks and the agricultural loan guarantee scheme improved food security by 8.12% and 0.002% respectively, while food security dropped by 0.001% among the population.

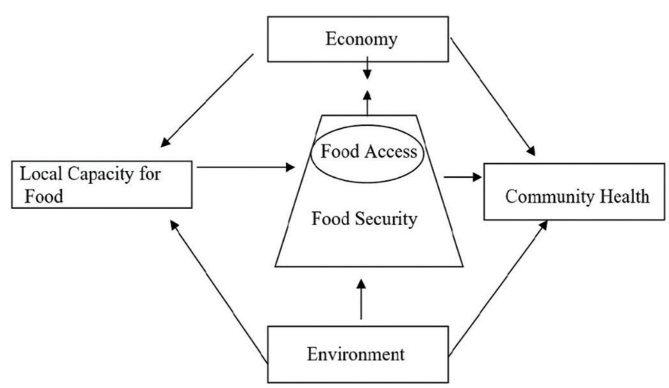
2.1. Conceptual Framework

This study is based on the network of rural food as shown in Figure 1. The scheme demonstrates that local food efficiency is supposed to vary from local production, which is the potential production, manufacturing and import capacity of the particular local region. This then means that access to food will directly impact food security. Therefore, in urban centers where food production potential is lower than in rural areas, food security is projected to be negatively impacted. Food access is also the ability of people to gain access to healthy food, to be able to afford individual payments as well as cultural appropriateness; thus, food security is the access of people at all times to sufficient food for an active and healthy lifestyle that will help to increase their lives. It also asserted that access to food is a major component of food safety (micro concept) and considered food safety as a macro concept. The result is that food security guarantees food access, and vice versa. In addition, the general health of the local area or region is known as community health. This consists, according to the California Center for Rural Policy, of the community's physical, social and economic well-being, which is characterized by population, climate, and food security. It is claimed that the climate is robust and fecund (which is devoid of gaseous emissions) will help boost diverse agricultural products and increase food security to a large extent, thereby promoting health in the community. If people's health is taken care of, their life spans will be increased thereby raising the life expectancy.

3. METHODOLOGY

This study adopts fixed effects instrumental variables estimation in testing the hypothesis of this study. The estimation technique will

Figure 1: Rural food system schema



Source: Adapted from Steinberg, Stubblefield and Ybarra, (2010) measure the impact of carbon dioxide emissions on agricultural output and also the effect of carbon dioxide emissions on life expectancy of all West African countries on a panel of data. The fixed effects estimation is preferred for the instrumental variable estimation in this study on account of the panel data nature of this study and also because fixed effects estimation in being applied to this study will give rise to estimates that are devoid of bias as a result of controlling for unobserved country-specific heterogeneity which are time-invariant. Furthermore, the choice of instrumental variable estimation for this study is informed by the potential for omitted variable bias as time-variant variables may be omitted from the estimated model determining each of agriculture output and life expectancy respectively, and also endogeneity bias may arise as a result of reverse causality between carbon emissions and each of agriculture output and life expectancy respectively.

The fixed effects instrumental variables model for determining agriculture output in this study featuring both time and country fixed effects is as shown in equations (1) and (2). From the equations, a carbon dioxide emission enters the model log-transformed on account of the need to standardize estimates following regression and as the variable is not a percentage or an index. Equation (1) is the first stage of the stated model while equation (2) is the model's second stage phase.

$$Log\,CO_{2it} = \alpha_0 + \alpha_1 Log\,CO_{2it-1} + \alpha_2 X_{it} + \upsilon_i + \varepsilon_{it} \quad (1)$$

$$AGQ_{it} = \beta_0 + \beta_1 Log\,CO_{2it} + \alpha_2 X_{it} + \upsilon_i + \varepsilon_{it} \quad (2)$$

Where; CO_2 is carbon dioxide emissions in Kilo tonnes, AGQ is agriculture output as a percentage of GDP, X is a vector of control variables namely rainfall (which enters the model log-transformed), and civil liberties index, υ = country fixed effects, ε = stochastic error term. The subscripts i refer to respective West African countries (i = 1-16), and the subscripts t refer to the time period of observations which is 2000 to 2018. The subscript $t-1$ refers to the one period time lag. Log refers to the Logarithm operandi.

The fixed effects instrumental variables model for determining life expectancy in this study as shown in equations (3) and (4) is similar to that of equations (1) and (2) on account that the independent variables that determine agricultural output likewise will determine life expectancy based on the arguments of this study. Equation (3) is the first stage of the specified model similar to that of equation (1), while equation (4) is the second stage of the model determining life expectancy similar to equation (2) in respect its independent variables. Carbon dioxide emissions based on similar arguments to that applying to equations (1) and (2), enters the model log-transformed. In like manner life expectancy enters equation (4) log-transformed.

$$Log\,CO_{2it} = \alpha_0 + \alpha_1 Log\,CO_{2it-1} + \alpha_2 X_{it} + \upsilon_i + \varepsilon_{it} \quad (3)$$

$$Log\,LEXP_{it} = \varphi_0 + \varphi_1 Log\,CO_{2it} + \varphi_2 X_{it} + \upsilon_i + \varepsilon_{it} \quad (4)$$

Where; CO_2 is carbon dioxide emissions, $LEXP$ is life expectancy, X is a vector of control variables namely rainfall (which enters the model log-transformed), and civil liberties index. υ = country fixed effects, ε = stochastic error term. The subscripts i refer to respective West African countries (i = 1-16), and the subscripts t refer to the time period of observations which is from 2000 to 2018. The subscript $t-1$ refers to the one period time lag. Log refers to the Logarithm operandi.

From the specified models in this study, carbon dioxide emissions as an endogenous explanatory variable of interest in the second stage is predicted in the first stage with one period lagged Carbon dioxide emissions which constitute the instrument in the model estimation. The choice of one period lagged carbon dioxide emissions as an appropriate instrument in this study is on account that the variable is exogenous as it is unlikely to have any significant correlation with omitted variables of concern related to the outcomes of either agriculture output or life expectancy, and it also does not suffer from bias resulting from reverse causality emanating from current values of either of agriculture output or life expectancy. The vector X in pairs of models determining agricultural output and life expectancy respectively contains similar control variables.

Furthermore, from the specified models in this study, the control variable, rain fall, is measured in milimetres, while Civil liberties as an institutional measure captures the freedoms enjoyed by all to life, security, amongst other freedoms which will affect agriculture output and life expectancy respectively. Further, civil liberties index, given its design with higher values reflecting lower freedom and vice versa is transformed in this study in that it is multiplied by (−1) so that lower values indicate less free countries and higher values indicate more free countries. The potential for institution quality indicators to be strongly correlated with each other informs the use of civil liberties as the only institution quality indicator employed in this study although the study acknowledges the roles played by other institution quality measures.

The sample of countries examined in this study were all sixteen West African countries namely Benin, Burkina Faso, Cape Verde, Cote D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. The countries represent a major gateway to Africa especially for international trade, on account that, the countries are respectively members of the Economic Community of West African States (ECOWAS) which is a strategic market for trade for non-ECOWAS countries on account of peculiar appealing characteristics of the West African sub-region which include high GDP growth rate and population size. Therefore, there is need agricultural output to be boosted and related to that life expectancy of the respective countries in the West African sub-region so that the sub-region as a whole experiences economic prosperity through its use of agricultural resources.

Data spanning the period of 2000 to 2018 on each of the West African countries and employed for this study were respectively sourced from the World Bank's World Development Indicators, besides rainfall from the World Bank's Climate Change Information Portal and the Civil Liberties Index from Democracy in the United States of America's International Freedom House

Database (USA). Civil liberties index in particular enters this study as an institutional measure affecting agricultural output and life expectancy respectively and by design it ranges from 1 to 7 with 1 being the highest and 7 being the lowest level of civil liberties. The factors, agricultural output and life expectancy at birth are the dependent variables of this study respectively. On the other hand, the variables, carbon dioxide emissions, rain fall and civil Liberties respectively constitute the independent variables of this study. Further, while a carbon dioxide emission is the central independent variable of interest in this study; all other variables constitute control variables for the study.

4. DISCUSSION OF RESULTS

Each portion of the report discusses the findings of the data analyzes and the conclusions addressed. The starting point for the analyzes is to give the variables descriptive statistics. The descriptive statistics of all the above variables used for the present study are presented in Table 1. The results reflect low values for the West African countries that constitute the sample of countries under study on average agricultural output, life expectancy and civil freedoms. However, the mean values of carbon dioxide emissions of 8477.60 kilo tonnes and rain fall of 91.65 milimetres indicate high levels of carbon dioxide emissions and rain fall in West Africa on the average over the period of this study.

Table 2 highlights variation across the West African countries in terms of selected variables of central importance for this present study. The results reveal that there is considerable variation across West African countries in terms of the mean of each of carbon dioxide emissions, agricultural output and life expectancy at birth. While Nigeria has the highest mean carbon dioxide emissions at 94,200 kilo tonnes, her agricultural output as a percentage of GDP with a mean of 24.81% and life expectancy at birth with a mean of 49.54 years, is one of the lowest in the region. This contrasts with Cape Verde with the third lowest mean carbon dioxide emissions over the period of 2000 to 2018 on average of 435.73 kilo tonnes, is the lowest mean agricultural output as a percentage of GDP of 9.05% but having the highest mean life expectancy at birth of 71.55 years. Furthermore, Sierra Leone with the lowest mean life expectancy of 46 years has the fifth lowest mean carbon dioxide emissions at 838.88 kilo tonnes, and one of the highest mean agricultural output as a percentage of GDP at 51.57%.

Table 3 presents the results of estimation of carbon dioxide emissions based on the first stage model specification of the fixed effects instrumental variable model as in equations (1) and (3). Fixed effects instrumental variable estimation results presented are in respect of the first stage of the estimation (as specified in equations (1) and (3) respectively) which seek to estimate carbon dioxide emissions, and the two respective second stage estimations of the model (as specified in equations (2) and (4) respectively) which estimate agricultural output and life expectancy at birth.

From the results in Table 3, carbon dioxide emissions were lagged at the coefficient of one period (Log CO_2 (−1)) which constitutes the instrument in this study is positive and highly statistically significant given the P-value of zero (0.000). A 1% point increase in lagged carbon dioxide emissions is associated with a 0.93% point increase in current carbon dioxide emissions and the increase in lagged carbon dioxide emissions is significant. The validity of lagged carbon dioxide emissions as an instrument in the first stage regression for determining both agriculture output and life expectancy in the respective second stage regressions of this study is justified by correlation analysis performed where in one period lagged carbon dioxide emissions is found to have a low correlation with agriculture output and life expectancy of −0.3219 and −0.1584 respectively, but is highly correlated with current carbon dioxide emissions with a correlation coefficient of 0.9972 and hence qualifies as an appropriate instrument for this study.

Table 1: Descriptive statistics of variables

Variables	Obs.	Mean	SD	Min	Max
Agriculture output (% of GDP)	272	30.14	13.44	7.75	79.04
Life expectancy (in years)	272	56.61	6.32	38.69	72.68
Carbon emissions (in kilo tonnes)	272	8477.60	22472.17	146.68	106068
Rain fall (in milimetres)	272	91.65	58.75	6.51	253.61
Civil liberties	272	3.71	1.29	1	6

Source: Authors' computation, 2020

Table 2: Mean values of carbon emissions, agricultural output and life expectancy of West African countries from 2000 to 2018

Country	Carbon emissions (in kilo tonnes)	Agricultural output (as a % of GDP)	Life expectancy at birth (in years)
Benin Republic	4254.80	23.27	58.28
Burkina Faso	1822.93	32.72	55.38
Cape Verde	435.73	9.05	71.55
Cote D'Ivoire	8080.77	23.66	49.53
The Gambia	389.56	24.28	58.83
Ghana	9873.94	28.81	59.89
Guinea	2187.90	18.66	55.27
Guinea Bissau	224.77	43.60	54.45
Liberia	715.71	56.48	57.50
Mali	1042.29	33.69	53.58
Mauritania	2001.75	25.43	61.38
Niger Republic	1210.36	37.26	55.22
Nigeria	94200.92	24.81	49.54
Senegal	6394.39	14.38	62.52
Sierra Leone	838.88	51.57	46.00
Togo	1966.91	34.51	56.46

Source: Authors' compilation, 2020

Table 3: First stage regression: Carbon dioxide emissions

Dependent variable: Log CO_2	
Constant	0.0318 (0.920)
Log CO_2 (−1)	0.930*** (0.000)
Controls	Yes
R-Square within	0.8695
Countries	16
Observations	256
F-Stat (3, 237)	526.30*** (0.000)

Source: Authors' computation, 2020. P-values are in parenthesis. All models include country and year fixed effects; ***, **, *Denote significance at 1%, 5% and 10% levels respectively

Hence, the lagged carbon dioxide emissions are exogenous to the estimated model. Note that control variables namely, rainfall and civil liberties were included in the estimated first stage regression for carbon emissions. However, in the coefficients of the control variables not shown only rainfall was statistically significant.

Table 4 presents the results of the second stage estimation for the fixed effects instrumental variables estimation procedure for determining agriculture output having used one period lagged carbon dioxide emissions as the instrument in the first stage regression. From the results in Table 4, predicted Log CO_2 has a negative and a highly statistically significant coefficient given the P-value of 0.001. In particular, an increase in CO_2 by 1% point is associated with a 3.818% point reduction in agricultural output. Therefore, carbon dioxide emissions adversely affect agricultural output in West Africa. Agricultural output which include crops, livestock, fish, and so on, are subjected to the carbon dioxide emissions in the atmosphere resulting from various economic activity especially that of industrial activity. Crops may utilize carbon dioxide in the atmosphere for their photosynthesis only to the extent of that required, while that not utilized remains in the atmosphere and has adverse effects on crops as they result in increased temperatures which crops may not be able to survive. Livestock, fishes, and other agriculture output on account of exposure to carbon dioxide emissions in the atmosphere suffer health challenges on account of inhaling carbon dioxide which is harmful to health and also the high temperatures associated with carbon dioxide emissions in the atmosphere.

Consequently, the livestock, fishes, and other agricultural output die and this result in a decline in the agricultural output realized from utilization of respective West African countries' agricultural resources. In relation to the progress of West African economies, it is evident from the findings that carbon emissions has dire implications for the economies in general and for the agricultural sector of respective West African economies in particular, as it adversely affects agriculture which is the livelihood of most developing economies, including the West African countries. Furthermore, from the regression results in Table 4, once again only rain fall was significant out of the control variables which were also the case in the first stage regression.

Table 5 presents the results of the second stage estimation for the fixed effects instrumental variables estimation procedure for determining life expectancy having used one period lagged carbon dioxide emissions as the instrument in the first stage regression. From the results in Table 5, predicted Log CO_2 has a positive and statistically significant coefficient given the P-value of zero (0.000). In particular, an increase in CO_2 by 1% point is associated with a 0.123% point increase in life expectancy. Therefore, carbon dioxide emissions boost life expectancy in West Africa. This finding is quite interesting because it does not agree with the research findings of studies such as Matthew et al. (2018); Oguntoke and Adeyemi (2017) and Usikalu (2009) that posited that carbon emissions as well as air pollution in general adversely affects health. However, a rationale for the finding in this study may be found as carbon dioxide emissions result from industrial activity amongst a variety of sources. Consequently, as industries in respective West Africa countries engage in economic activity and thereby increase emissions in the atmosphere, the industries will contribute to increasing the aggregate income of the respective West African countries as the GDP of the countries increase. The increased incomes of the respective West African countries are then used to improve the health care of individuals and consequently individuals in West Africa live longer resulting in an improvement in life expectancy as found by this study. Observing the control variables employed in the present regression and which were also employed in the first stage regression, regression results revealed that civil liberties was the only significant variable out of the control variables.

Table 4: Second stage regression: Agricultural output

Dependent variable: Agricultural output	
Constant	37.572*** (0.010)
Predicted Log CO_2	−3.818*** (0.001)
Controls	Yes
R-Square within	0.6042
Countries	16
Observations	256
Wald Chi-Sq.	8589.68*** (0.000)

Source: Authors' computation, 2020. P-values are in parenthesis. All models include country and year fixed effects; ***, **, *Denote significance at 1%, 5% and 10% levels respectively

Table 5: Second stage regression: Life expectancy

Dependent variable: Log (LEX)	
Constant	3.049*** (0.000)
Predicted Log CO_2	0.123*** (0.000)
Controls	Yes
R-Square within	0.5979
Countries	16
Observations	256
Wald Chi-Sq. (3)	4610000*** (0.000)

Source: Authors' Computation, 2020. P-values in parenthesis. All models include country and year fixed effects; ***, **, *Denotes significance at 1%, 5% and 10% levels respectively

5. CONCLUSION AND RECOMMENDATIONS

This study had examined the effect of carbon emissions on agricultural output and life expectancy in West Africa. In conclusion, the study observed that carbon dioxide emissions adversely affect agricultural output and positively affect life expectancy; therefore, the study posits that reduction in the emissions of carbon dioxide should be seen as a thing of importance in improving agricultural output in West Africa. This reduction can be done through the reduction of deforestation and conservation of land, controlling of wildfire, adopting better methods of combusting residues of crops and effective use of energy by forest dwellers amongst other measures. This will in turn help to reduce the rate at which people fall sick as a result of respiratory diseases. Also, this study also posits that an increase in agricultural output would help provide raw materials for the manufacturing industries, which would in turn increase aggregate output resulting in an increase in the GDP of these West African countries. The increased GDP in these respective West African countries are then used to improve the health care of individuals and consequently the life expectancy of individuals in West Africa would witness an improvement.

The study therefore recommends the following: Firstly, environmental policies should be formulated with a view to mitigating the impact of carbon dioxide emissions should be directed towards the agricultural and industrial sectors (to bring about an increase in productivity in both sectors) rather than the environment which poses risks to human health. Second, the government should increase public health expenditure so that the health of the individuals in the society will be adequately taken care of and the mortality rate will reduce. This will ensure that the citizens would get good medical treatments in the hospitals when such need arises. This will in turn improve life expectancy in the West African countries. Lastly, in order to increase life expectancy, there should be an increase in the GDP of these West African countries; one way to achieve this is to ensure that there is an increase in industrial output and also encourage industrialization.

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