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Article

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Greenhouse Gas Emissions and Crop Production in West Africa: Examining the Mitigating Potential of Social Protection

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ABSTRACT

This study examined how the effect of greenhouse gas (GHG) emissions on crop production can be controlled in the West Africa sub-region. Social protection was used as a mitigating factor to absorb the effect of GHG emissions. The study engaged a panel data consisting of 14 Economic Community of West African States member countries to analyse the data which was sourced from the World Development Indicators and Country Policy and Institutional Assessments for the period 2000-2016, with the use of fixed and random effects econometric model. Results showed that an increase in greenhosue gas emissions reduced crop production by 0.13%, this is through the lowering of crop yields resulting from the emissions of GHGs. Therefore, based on the findings, the study recommended that effective social protection programmes such as the Linkage Assurance Crop Insurance Solutions that will provide cover against unavoidable loss of crops or resulting directly from the insured perils such as insurance against losses incurred from GHG emissions and other crop demaging activities shoud be implemented to reduce risks associated with farming.

Keywords: Greenhouse Gas Emissions, Social Protection, Crop Production, West Africa
JEL Classification: D13, Q15, R11, L98

1. INTRODUCTION

Agriculture is known to be the second largest producer of greenhouse gas (GHG) emissions, as emissions from the sector increased by approximately 8% for the period of 1990 and 2010 (Azuh and Matthew, 2010). These emissions are forecasted to rise to 15% from over the 8% of 2010 by 2030, which will result to about 7 billion tonnes per annum (Azuh and Matthew, 2010; Matthew et al., 2018). These increases will result mainly from high growth rate of population and changes in dietary preferences in underdeveloped countries. Agricultural emissions growth will be greatest in sub-Saharan Africa (SSA), which will account for two-thirds of the increase in overall food demand over first half of the 21st century (Matthew and Adegboye, 2010; Alege et al., 2017; Matthew et al., 2018).

In recent decades (especially from the 2000s), crop production has increased as a result of the expansion of arable land, an increase in cropping strength (frequency of crop harvesting) and an expansion in crop yield (Osabohien et al., 2018; Osabuohien et al., 2018). Since the 1960s, the increase in crop production has been driven by yield enhancement, with 78% of the growth; a further 15% came from arable land expansion and the remaining 7% from increased cropping strength. These trends will likely continue at least until 2030 and will average about 70% for yield enhancement, 20% for land expansion and 10% for increased cropping strength (FAO, 2003). The increase in food production was an important result of the Green Revolution (Pimentel, 1996; Snyder et al., 2009; Azuh and Matthew, 2010). A planned international effort to eliminate hunger by improving crop performance. In order to benefit from the new crop varieties, new agricultural practices were introduced, for example, the increased use of fertilizers and pesticides, irrigation and farm mechanization. These practices created environmental problems, such as land degradation, water and air pollution from carbon emissions. It has been discovered from literature that agricultural production is a major emitter of GHG emissions (Matthew et al., 2018; Osabuohien et al., 2018).

GHGs are those that take up infrared radiation in the environment, trapping heat and warming the surface of the earth. The three GHGs associated with agriculture are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Other important GHGs include water vapour and many halocarbon compounds, but their emissions are not considered to be influenced by agriculture. Fossil fuel combustion is considered responsible for >75% of human-caused CO_2 emissions. Land use change (primarily deforestation) is responsible for the remainder. Human activities are thought to have more than doubled the rate of emission of CH_4 over the last 25 years (Denman et al., 2007; Verge et al., 2007; Alege et al., 2017).

Major sources of GHG emissions in crop production include N_2O from fertilizer application in crop production and manure treatment in livestock production, and fertilizer induced N_2O emissions have increased in the West African sub-region from 47.7 Mt CO_2-eq in 1978 to 108.7 Mt CO_2-eq in 2010 (Cui et al., 2017). However, fossil fuel CO_2 emissions on crop lands from agricultural machinery use, such as tractors, irrigation pumps and so on, are generally attributed to the energy sector rather than agriculture. In addition, indirect emissions from the manufacture of agricultural inputs such as fertilizer, pesticide, amongst others, and electricity use in irrigation are also important though they do not occur on farm. As a result, agriculture and related activities contribute significantly more than the 10-12% estimated (Smith et al., 2014).

Social protection refers to the policy, action and framework aimed at reducing shocks and weaknesses by mitigating the menace of poverty through the promotion of efficient labour market and reduce people's exposure to risk and build their ability to manage social and economic shocks such as financial exclusion, unemployment, disability, sickness and old age (Devereux, 2016; Osabohien, 2017; Matthew et al., 2018). Economic theory has pointed out that social protection policy is a set of public or government transfer which is in form of income redistribution from the rich to the poor to bridge the gap of inequality (Tirivayi et al., 2016). Social protection programmes have grown over the past three decades and benefited a large number of people. According to Devereux (2016), the term social protection is an initiative; both formal and informal, which provides social assistance to poor individuals and households.

The concept of social protection means the strategy of providing cash or in-kind supports to the less privileged, which is capable of protecting the vulnerable against risks and shocks (FAO, 2015). According to Dorward et al. (2006), social protection is a measure of a set of actions used in enhancing the control of stress by rural farmers, households and individuals. Export of agricultural commodities is the main source of Economic Community of West African States (ECOWAS)' external trade, in which about six billion Dollars (6bUSD) is generated, or approximately 16.3% of the tangible and intangible commodities are exported from the region (World Bank, 2015). The export potentials of the agricultural commodities generate a reasonable level of revenue that the governments use in paying for the importation of final products, equipment in terms of capital and intermediate goods for industrial use and services. With respect to employment opportunities, the agricultural sector in ECOWAS remains the largest provider of labour in which more than 60% of the region's active population is engaged in, despite the fact that the remuneration of the sector is less than that of the other sectors of their economies (FAO, 2015). Again, agriculture is an essential determinant in the race of ending poverty at all levels and achieve food security by 2030 (FAO, 2017; World Bank, 2017).

To the best of the knowledge of the authors, studies with respect to the absorption of the effect of GHG emissions through social protection to enhance crop production has not been conducted in West Africa, thus, this study is contributing to literature by filling this gap. It is in the light of the foregoing, that this study sets out to examine the effect of GHG emissions on crop production; in the face of social protection given to the farmers in order to improve on their welfare (as a mitigating factor). When there is efficient social protection in the agricultural sector such as the provision of safety nets and agricultural insurance for farmers, the effect of gas emissions will easily be absorbed and this will in turn reduce the effect of gas emissions on crop production. Therefore, this study comprises of five sections *viz.*; following this introductory section is section two which presents some insights from empirical literature and theoretical framework. Section three unveils the method engaged in the study; section four discusses the empirical analysis of the results and findings of the study; section five concludes the study by recommending policies that will improve on crop production in the face of GHG emissions when social protection measures are provided for the farmers.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

According to Bennetzen et al. (2016), they examined the major trends in agricultural production, land use change and GHG emissions between 1970 and 2007 in nine regions *viz.*; Central and Eastern Asia (CEA), Central and South America (CSA), Eastern Europe and Russia, Europe (EUR), Middle East and Northern Africa, North America (NA), Oceania (OCE), South and South East Asia and SSA. Using Kaya - Porter identity approach for crop production and animal production (a combination that gives total emissions in agricultural sector), the study showed that emission per unit of crop production reduced by 94% in OCE, 57% in CSA, 27% in SSA and 56% in EUR while emission per animal production reduced by 24% in SSA, 61% in CSA, 82% in CEA and 28% in NA. This implied that the lowest emissions from per unit production in agricultural activities are lower in developed countries than developing countries. Although the study investigated the total emission from the agricultural sector, it does not account for social protection that is the protection against poverty, vulnerability as well as social risk and insecurity.

According to Yue et al., (2017), they used carbon footprint of 26 major food and industrial crops and 6 livestock products quantified the climatic impact of GHG emissions on agriculture in China. They examined the supply and demand side effects of GHG emissions using six different scenarios; they found that emissions from supply side are far greater than the demand side. Meat production has the largest while vegetable production has the lowest production of contribution to carbon footprints. About 50% of GHG emission from crop production can be traced to the fertilizer applied while emission for livestock production was majorly from forage feeding. Thus, their study found out that GHG emission can be mitigated from agricultural production by improving management in farm and maintaining good consumption habits and balanced diets in the country. Though, this study examined GHG emissions from both the demand and supply sides, it did not focus on the vulnerability of the population to risk and shocks that may be associated with agricultural production and GHG emissions.

In a similar study on demographic, land use and productivity factors affecting agriculture (food production) in six regions by Verge et al. (2007), they recommended that the quality of food should be improved to enhance good digestion, efficient use of nitrogen as well as proper manure management and water management should be put in place in order to mitigate the effect of agriculture on climate. This study focused on only the crop production aspect of agriculture, and did not capture the entire emission from the agricultural sector as well as the associated risk. According to Necpalova et al., (2018), they estimated the crop productivity simulation model of the long run effect of soil management practices, GHG emissions and intensity on Switzerland cropping system. The study asserted that net soil GHG emissions can be reduced in Swiss cropping system by embracing organic farming as well as managing soil tillage although this approach to reducing GHG emission is time bound and reversible if not maintained. Their approach, however, considered only GHG emissions from soil.

In the study by Kijewska and Bluszcz (2016) on differentiation of emissions of four GHGs (CO_2, CH_4, nitrogen oxides and N_2O) in European Union member states using cluster analysis - agglomerative algorithm. The study distinguished each homogenous country by their total emissions level and per capita emissions level and found that Germany, United Kingdom, France, Turkey, Poland, Italy and Spain are the largest emitters of GHGs while Denmark and Ireland are top negative per capita emitters. According to Vetter et al. (2017) used cool farm tools, which incorporated several empirical models from farm activities into one tool for estimating GHG emissions. Their study in India related and analyzed GHG emissions of major food commodities and livestock production. Their results showed that livestock and rice production were the main causes of GHG emissions. They concluded that increased consumption in animal foods particularly milk and egg in India leads to a greater production of GHGs from agriculture. Thus, the study recommended a reduction in the livestock production (in order to reduce GHG emissions) which may however be detrimental to the health of the people. The short fall of their study is that it fails to incorporate social protection.

Similarly, O'Brien et al. (2011) examined GHG emission from nine livestock farm system using intergovernmental panel on climate change (IPCC) and life cycle analysis (LCA) approach. Their study discovered that the two approaches produced different results. The result of LCA approach for estimating GHG emissions were greater than that of IPCC because IPCC excludes indirect GHG emissions from production although the amount of livestock production for both methods reduced GHG emissions. The methodologies also showed that milk producing livestock produced higher GHG emissions. However their study only focused on livestock production which is only an aspect of agricultural production thus not accounting for the total emissions from the agricultural sector.

According to Matthew et al. (2018), they employed the auto-regressive distribution lag for the period 1985-2016 to examine the effect of GHG emissions on health outcomes in Nigeria. The results of their study showed that an increase in GHG emissions by one percent reduces life expectancy by 0.04% and thus bringing mortality rate to 146.6%. The study's major shortcoming is that it focused only on health outcomes of the people which was captured by life expectancy in relation to GHG emissions. In summary, existing studies have focused on production (either crop or livestock or both) from cradle to farm gate in the analysis of GHG emissions without putting social protection into consideration. Therefore, this study sets out to fill the gap in existing literature by incorporating social protection into the picture and analysis.

2.1. Stylised Facts

This sub-section of the study presents the nature of GHG emissions. Agriculture is the second largest contributor of GHG emissions. Globally; in 2011, emissions from agricultural activities was reported to be approximately 6 billion tonnes of GHG emissions (World Resource Institute, 2012). This emissions is more than 12% of the total World GHG emissions. This rate makes the sector the second on the ladder of the sectors with the highest rate of GHG emissions, with the energy sector as the highest.The net primarry producer of GHG emission is the emission of CO_2 to the atmosphere, this is through agricultural burning which emits CH_4, nitrous dioxide, N_2O and so on; as well as synthetic fertilizers application, consumption and wastes to soils causes respiration problems. This represents the largest sources of the emissions (65%) of agricultural GHG emissons globally. Crop residues emitting CH_4 to the atmosphere contributes to these emissions. During harvest, cultivation of rice, field burning of crop residues and fuel use on farms contribute to gas emissions (Figure 1).

Figure 1 presents the nature of agricultural GHG emissions to the global GHG emissions. Results from related studies such as MacCarthy et al. (2018) showed that, generally, GHG emissions are aftermaths of warming and climate change. Studies have shown that the rate at which underdeveloped countries, especially, West African countries contribute to the emission of GHGs is not fully acertained. This is validated in this study (Table 1). MacCarthy et al., (2018) in their empirical study showed that ECOWAS countries, contribute to GHGs in various ways. For example, it was observed in Ghana that, diverse system of land use contributed to GHG emissons especially, CO_2 in two major farm sites, site one (located at Kpong) contained a heavy clay soil while site two (located at Legon) contained a light-textured sandy soil. The system of land use is made up of cultivated maize fields, and rice paddy fields at site one, and natural forest, woodlots, and cultivated soya bean fields at site two.

2.2. Theoretical Framework

The theoretical premise upon which this study is based, is the Solow model as developed by Solow (1956). The model is based on the fact that output in an economy is produced by a combination of labour (L) and capital (K), under constant returns, so that doubling input results in doubling output. Thus, the quantity of output (Y) is also determined by the efficiency of productivity (A) otherwise called "technical progress" with which capital and labour is used. Mathematically specified as;

$$Y=Af(L,K) \quad (1)$$

Solow assumed that this production function exhibits constant returns to scale, that is, if all inputs are increased by a certain multiple, output will increase by exactly the same multiple.

The Solow neoclassical model uses a standard Cobb-Douglas production function in which:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \; 0<\alpha<1 \quad (2)$$

In this case, Y is the level of output, K is stock of capital, L is labour and A represents a measure of productivity, assumed to grow at exogenous rate n. The model further assumes that:

$$L_t = L_0 e^{nt} \quad (3)$$

$$A_t = A_0 e^{nt} \quad (4)$$

$$A_t L_t = e^{nt}\left(L_0 A_0\right) = L_0 A_0 e^{nt} = \varphi e^{nt} \quad (5)$$

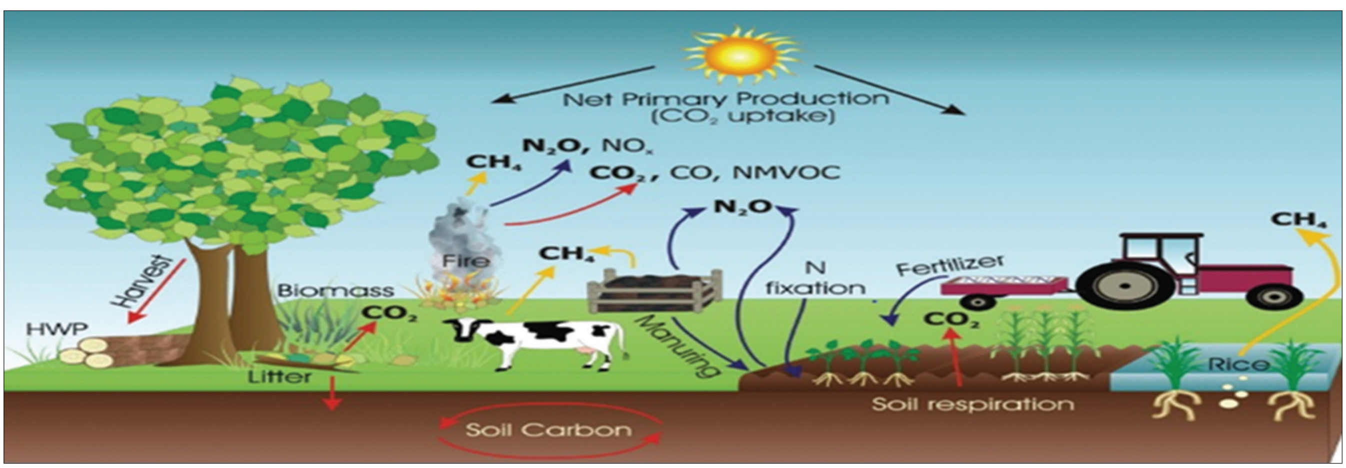
Where; $\varphi = L_0 A_0$, means the effective units of labour, $A_0 L_0$ grows at rate n.

In order to address the shortcomings of the Solow model, Mankiw et al. (1992) specified the augmented version of the Solow model. In this augmented version of the model, a Cobb-Douglas production function is assumed. This started off by adding human capital accumulation (divided into physical capital, human capital and productivity - augmented labour) into the Solow model. Thus, the Cobb-Douglas production function is written as:

$$Y(t)=K(t)^{\alpha}H(t)^{\beta}[A(t)L(t)]^{1-\alpha-\beta} \quad (6)$$

Where; Y, K, H and L are respectively output, physical capital, human capital and labour, α and β are the elasticities of output with respect to physical and human capital, and A(t) is the level of technological and economic efficiency. H is measured by education and L includes both skilled and unskilled labour. Cellini (1997) however observed that, A(t) can be decomposed into two elements namely; an economic efficiency part I(t), that depends on a set X of institutions and public policies, and an exogenous technological progress component Ω(t) assumed to grow at the rate g(t). $\alpha,\beta \in [0,1]$, while $\alpha+\beta \in [0,1]$, and t denotes time. This implies that the production function exhibits constant returns to scale in its three factors: Physical capital (K), human capital (H) and a measure of productivity (A).

Figure 1: Agricultural Greenhouse Emissions



Source: World Resource Institute, 2012

Table 1: Results from regression Model: (Dependent variable: Crop production)

Random effect estimates				Fixed effect estimates			POLS estimates		
Variable	Coefficient	Standard error	Probability value	Coefficient	Standard error	Probability value	Coefficient	Standard error	Probability value
Greenhouse gas emissions	−0.0013	0.0002	0.534	0.0006	0.0008	0.449	−0.0013	0.0001	0.438
Social protection	15.0047	5.5299	0.007	18.8194	7.6216	0.015	9.4212	4.4452	0.036
Arable land	0.1782	0.2490	0.474	3.6256	0.8178	0.000	0.0448	0.16563	0.787
Fertilizer consumption	−0.1814	0.4569	0.691	0.6844	0.6278	0.278	−0.4442	0.3929	0.260
Labour	0.1383	0.2550	0.587	0.6140	0.6245	0.328	0.1555	0.1821	0.395
Capital	9.7811	2.1710	0.653	1.9310	2.0810	0.356	1.6510	2.3310	0.481
_Cons	54.3490	26.0869	0.037	−63.1541	46.0502	0.173	79.87807	19.8244	0.000

Source: Authors using stata 13. POLS: Pooled ordinary least squares

However, this study adopted the model as specified in the works of Matthew, (2013); Matthew et al. (2018) in line with the theoretical underpinnings of Mankiw et al., (1992). The explanatory variables in the model specified in this study were modified to suit the objective of the study (which is to examine the nexus between GHG emissions and crop production using social protection as a mitigating factor in ECOWAS countries). These variables include; social protection, GHG emissions, gross fixed capital formation (proxy for capital), agricultural employment (proxy for labour) and fertilizer consumption. While the dependent variable is crop production which represents agricultural output.

3. METHODOLOGY

3.1. Data Source

The data used for this study was sourced from the World Development Indicators and the Country Policy and Institutional Assessment (CPIA) for the period between 2000 and 2016. The study focused on the ECOWAS which is made up of fifteen member countries which are: Benin Republic, Burkina Faso, Cape Verde, Côte D'ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. But in this study, data for 14 member countries were used for the analysis, excluding Cape Verde due to the unavailability of data. The variables engaged and their respective measuremens are presented in Table 2.

3.2. Method of Analysis

In order to attain the desired long-term sustainable growth in the West African agricultural sector, the regional agribusiness needs social protection in form of insurance to maintain stability as well as achieve the vision of enhancing growth (Famuyiwa, 2018). In line with the above, this study focused on how the effect of GHG emissions on crop production in ECOWAS can be mitigated. Therefore, social protection is seen as a mitigating mechanism through which the harmful effect of GHG emissions on agriculture which damages crop and other agricultural related products and activities can be absorbed, where social protection policies are structured to mitigate the effect of gas emissions. For this study, social protection is in the area of the Linkage Assurance Crop Insurance Solutions in providing cover against unavoidable loss of crops or resulting directly from the insured perils, such as emissions of GHGs, flood and drought, pests and disease, and so on; with covers including carbon index crop insurance, area yield-index crop insurance and multi-peril crop insurance to reduce risk of low yields experienced by farmers in the ECOWAS sub-region, as a result of the harmful effect of these shocks (Famuyiwa, 2018).

Thus, the baseline model for this study in hinged on the Solow's theory where it was observed that production t in any sector resulted from the combination of two variable inputs (labour [L] and capital [K]), under constant returns, so that doubling input results in doubling the unit of quantity produced. Thus, the quantity of output (Y) is also determined by the efficiency of other factors included in our baseline model such as arable land, and so on. The baseline model for this study is closely related to the empirical works of Matthew et al., (2018), Osuma et al. (2018), Verge et al. (2007) and Yue et al., (2017). Verge et al., (2007) examined agricultural production, GHG emissions and mitigating potentials and noted the three factors affecting food production as crop intensity, land use and population. Thus, the model from the Solow model as specified is:

$$Y=f(L,k) \tag{7}$$

Equation (7) is in respect of Solow model where it was noted that production (Y) is due to two main variable inputs (L and K), therefore, modifying the Solow model in order to suit the objective of this study, the authors' implicit baseline model is specified as:

$$Y=f(ghge,sop,arable,fertc,L,K) \tag{8}$$

Applying the log transformation to equation (8) in order to reduce the incidence of multicollinearity and ensure that results are not spurious or nonsensical by obtaining estimates which are Best Linear and Unbiased (Matthew et al., 2018) as represented in equation (9) replacing Y, the dependent variable with crop production (*cropp*) to form the panel explicit log linear model gives:

$$logcropp_{it}=\beta_0+\beta_1 logghge_{it}+\beta_2 logsop_{it}+\beta_3 logarable_{it}+\beta_4 logfertc_{it}+\beta_5 logL_{it}+\beta_6 logK_{it}+\mu_{it}+\varepsilon_{it} \tag{9}$$

Where: *Cropp* represents crop production as the dependent variable and proxied by crop production index (2004-2006 = 100), *ghge* is greenhous gas emissions proxied by total GHG emissions (*kt* of CO_2 equivalent), sop is social protection proxied by the overall CPIA. Social Protection is made up of policies which aimed at reducing vulnerability by reducing people's exposure to risk and shocks, such as gas emissions, flood, pest and disease out break, and so on Social protection is rated from the range of 1 = low to 6 = high; 1 applies to where the system is weakly protected, and

Table 2: Variable sources and measurements

Variable	Sign	Source of data	Definition and measurement
Crop production	Cropp	WDI, 2017	Crop production index (2004-2006=100)
Greenhouse gas emissions	Ghge	WDI, 2017	Total greenhouse gas emissions (kt of CO_2 equivalent)
Social protection	Sop	CPIA, 2017	Overall CPIA
Arable land	Arable	WDI, 2017	Arable land (% of land area)
Fertilizer consumption	Fertc	WDI, 2017	Fertilizer consumption (kilograms per hectare of arable land)
Labour	L	WD, 2017	Employment in agriculture (% of total employment) (modeled International Labour Organisation) estimate)
Capital	K	WDI, 2017	Gross fixed capital formation (% of GDP)

Source: Authors' Compilation, 2018. CPIA: Country policy and institutional assessment

6 applies to where the system is strongly protected (Osabohien et al., 2018).

Arable represents arable land proxied by the availability of arable land (% of land area), fertc is fertiliser consumption proxied by kilograms per hectare of arable land, *L* is labour proxied by employment in agriculture (% of total employment) modeled International Labour Organisation estimate, and *K* is capital proxied by gross fixed capital formation (% of GDP), (Table 2 for the description of the variables), *log* is logarithm transformation to reduce the incidence of multicollinearity, *i* and *t* represents entities and time respectively. Entities are the fourteen ECOWAS countries used in this study, while time is the period under study (2000-2016). μ and ε are the error terms (between-entity error and within-entity error respectively). The error term captures other explanatory variables such as irriation, technology, weed control, and so on; that have affect on crop production, but are not included in the regression model due to the unavailability of data.

β_0 is the constant term, β_1, β_2, β_3, β_4, β_5 are the coefficients of the independent variables. The key independent in the model variables are social protection and GHG emissions; the hypotheses are stated in such a way that; $\beta_1<0$, while $\beta_2>0$; this implies that their coefficients should be negative for GHG emissions and positive for social protection, meaning that; an increase in GHG emissions reduces crop production in West Africa, this is through lowering of crop yields as a result of the damage caused by the emissions, while effective and efficient social protection programmes and policies such as crop insurance, insurance against theft and losses due to flood, pests and disesases, and so on are expected to increase crop production in the ECOWAS sub-region.

This study engaged panel data of 14 ECOWAS countries as listed above (see section 3.1). Panel data helps in controlling unobserved issues which accounts for individual heterogeneity (Torres-Reyna, 2007). With the panel data, the study employed the fixed, random effects and pooled ordinary least squares (POLS) in the analysis. The fixed effect was employed to eliminate the effect of time-invariant characteristics so as to assess the net effect of social protection and GHG emissions on crop production in the ECOWAS sub-region. This is because those time-invariant characteristics are unique to the individual and should not be correlated with other individual characteristics (Torres-Reyna, 2007). While the random effect was employed because the variation across entities is assumed to be random and uncorrelated with variables which are exogenously determined in the regression model. The POLS was employed in order to acertain the relationship between crop production, social protection and greehouse gas emissions. In order to be able to decide which out of fixed or random effects to use, the Hausman test was conducted; where the null hypothesis was stated. The result of the Hausman test supports the use of the random effects. It basically tests whether the unique errors (u_i) are correlated with the regressors, the null hypothesis states that they are not (Green, 2008; Osuma et al., 2018).

4. RESULTS

The results obtained from the analyses are presented in this section of the study. The study employed two approaches; the empirical approach and the econometric approach. The empirical approach engaged the use of figures to describe the nature of and effects of GHG emissions and social protection on crop production, while the econometric approach employed the random effects, fixed and POLS in estimating the regression model specified in previous section, (as presented in Tables 1 and 3).

4.1. Empirical Results

Social protection has widely been defined as policies and programmes which are made up of a set of benefits given by households, especially farmers who are more vulnerable with the aim of ameliorating risks and shocks associated with farming resulting from the reduction of farm yields or loss as a result of flood, and so on (African Platform for Social Protection - APSP, 2012; Osabohien and Osuagwu, 2017). Though, concerted efforts has been made by ECOWAS member countries in developing social protection programmes notably Sierra Leone, Nigeria and Ghana where the governments have taken leadership in integrating social protection to their agricultural activities, but these programmes have not lived up to expectation. Social protection is rated on a scale of 1-6 (1 = low to 6 = high). 1 applies to a situation where the system is weakly protected, while 6 represens a condition where the system is highly protected, and the range of 3 and 4 can be said to be partial social protection. From the empirical results obtained (Table 1); it is observed that ECOWAS countries have weak and partial social protection especially, Togo for the period of 2014 to 2016. The average social protection for the period 2000 to 2016 is presented in Figure 2, while average percentage per individual countries is presented in Figure 3.

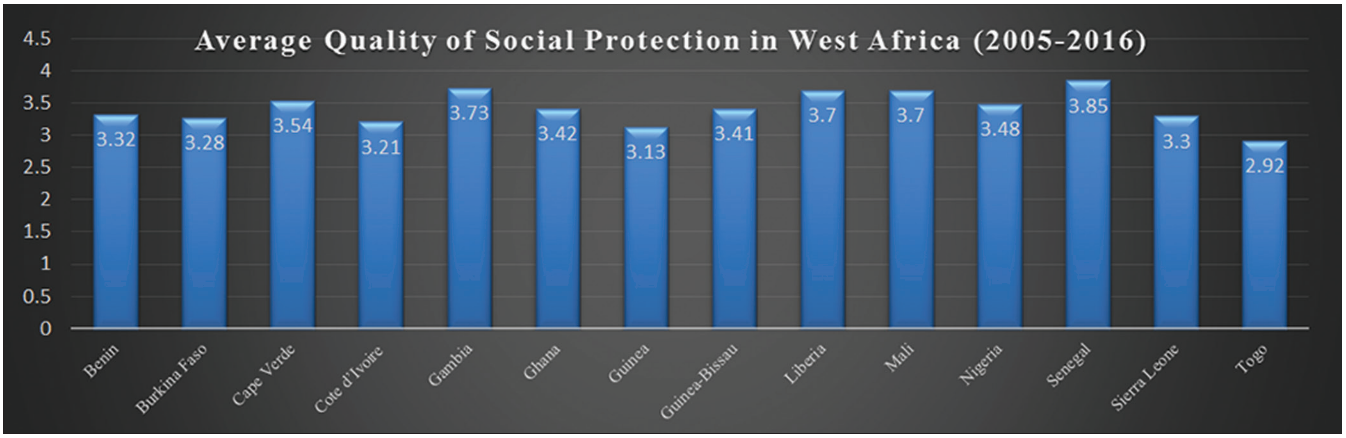
As previously defined, social protection policies and regulations are targeted to reduce the risk of becoming poor, assist those who are poor to better manage further risks, and ensure a minimal level of welfare to all people. The greatest proportion of the poor in ECOWAS are rural farmers who depends on agricultural yields for survival and often times, agricultural yields are lowered due to risks and loss of crop and other agricultural related products as a result

Table 3: Panel summary statisitcs of variables

Variable	Mean±SD	Minimum	Maximum
Crop production	111.011±25.61803	42.21	201.65
Greenhouse gas emissions	8335.863±25385.67	−85.27789	106068
Social protection	3.5155±0.4960	2.04	4.4300
Arable land	17.8615±12.7795	0.3783	48.7221
Fertiliser consumption	7.6279±7.4317	0.0004	50.2393
Labour	51.6784±19.0037	1.1000	85.400
Capital	3.1509±1.2410	−38.5330	8.5710

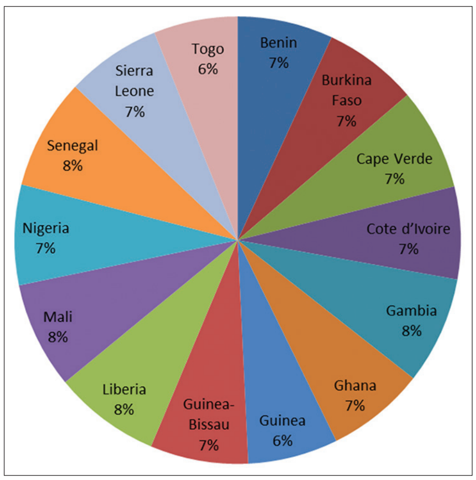
Source: Authors’ computation using Stata 13, 2018

Figure 2: Average Quality of Social Protection in West Africa (2005-2016)



Source: Authors' Compilation, 2018

Figure 3: Average percentage score of Social Protection for individual ECOWAS



Source: Authors' Compilation, 2018

of the damage caused by GHG emissions, floods, erosions, pests and diseases and so on. Social protection policies are required to mitigate the effects of these hazardous shocks and risks associated with farming. Figure 2 presents the average score of the quality of social protection in ECOWAS, while Figure 3 presents the average percentage score of individual countries for same region and range. For the rating: Benin 3.32, Burkina Faso 3.28, Cape Verde 3.52, Cote d'Ivoire 3.21, Gambia 3.73, Ghana 3.71, Guinea 3.13, Guinea Bissau 3.41, Liberia and Mali 3.70. Nigeria 3.48, Senegal 3.85, Sierra Leone 3.30 and Togo 2.92. As observed from Figure 2, ECOWAS countries are partially and weakly protected, especially Togo with a score of 2.92. Social protection for farmers in form of insurance agaisnt risks and losses, in-kind or cash support to purchase farm implements will invariably enhance agricultural production which will in turn reduce povery among rural households in ECOWAS who solely depend on agriculture as means of livelihood.

Figure 3 presents the average percentage score in terms of policies and institutional framework in ECOWAS countries. Basically, all the ECOWAS countries have similar scores: Guinea and Togo with the lowest (6%), followed by Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Ghana, Guinea Bissau, Nigeria, and Sierra Leon are the second (7%), while Gambia, Liberia, Mali and Senegal are the highest (8%). Generally, ECOWAS countries are weak in terms of agricultural social protection.

4.2. Econometric Results

This sub-section of the study presents the result obtained from the econometric analysis. The starting point of this result presentation is the summary statistics of the variables as shown in Table 3. The summary statistics presents the mean, standard deviation, minimum and maximum values of the variables and number of observations. The means present the average values of the variables, the minimum and the maximum present the range of the data. The variables used in the analysis are; crop production as the dependent variable, GHG emissions and social protection are the key independent variables; other independent variables include; arable land available to farmers, fertiliser consumption. Also included as explanatory variables are labour and capital (used as variable inputs) respectively. The results in Table 3 revealed that the mean value of crop production is 111.011 while the minimum and maximum values are 42.21, 201.65 respectively. Mean value of GHG emissions is 8335.863 while the minimum and the maximum values are −85.27789 and 106068 respectively. The mean value of social protection is 3.5155 and the minimum and maximum values are 2.04 and 4.43 respectively. Arable land has a mean value of 17.8615, and the minimum and maximum values ranges from 0.3783 to 48.7221 respectively. The variable inputs (labour and capital) have mean values of 51.6784 and 3.1509 respectively, with minimum and maximum values of 1.1 and 85.4 (labour), −38.5330 and 8.5710 (capital).

In examining the effect of GHG emissions on crop production, and the mitigating potential of social protection, the results obtained from the regression analysis is presented in Table 1. Based on pre-estimation test conducted (Hausman test), the random effect model is prefered to the fixed effects model, this implies that, unlike the fixed effects model, the variation across the various ECOWAS countries is randomly and uncorrelated with the explanatory variables included in the model. On the other hand, this means that differences across ECOWAS member countries influenced the level of crop production in different ways. From the results in Table 1, a 1% increase in the level of GHG emissions exerted a negavive effect on crop production. This means that a 1% increase in gas emissions reduces crop production by 0.13% (random effect and POLS).

It is observed, based on the result, that African countries, though, not as industrialized as other regions of the world, contribute significantly to the accumulation of GHG emissions. Social protection as a mitigating mechanism, was observed to be positively related to crop production, this means that increased social protection will invariably increase crop production by approximately 15.0 units, 18.8 units and 9.42 units respectively. Labour, capital and arable land were also found to be positively related to crop production. From the results, arable land, labour (proxied by agricultural employment) and capital are positively related to crop production. It implies that; a unit increase in hectares of arable land increase crop production by 17.82 units, agriculture employment by 13.83 units and capital 9.78 units. On the contrary, fertilizer consumption was found to be negatively related to crop production, this means that application of fertilizers contributes to GHG emissions thereby reducing crop production.

One of the prominent goals of sustainable development is to eradicate hunger and improve human well-being. Sustainable development encompasses the economic, social and environmental domains targeted towards preserving and maintaining growth in the economy through the concern on welfare as well as quality environment of the people. In order to achieve these goals, there is a need to improve productivity in the agricultural sector and also enhance good health and human well-being (Kijewska and Bluszcz, 2016). The findings of this study is similar to that of Vetter et al. (2017), they pointed out that globally agriculture is the foundation of GHG emissions due to the high demand for agricultural product as a result of the global increase in population. This resulted in the application of fertilizer to more than 50% of the crops grown worldwide in order to improve and sustain the output from the agricultural sector, this is validated in Table 1 as fertilizer consumption is negatively related to crop production. An atmospheric gas that absorbs and discharges ultraviolent heat like water vapour, CO_2, CH_4, N_2O and ozone is called GHG, (Verge et al., 2007).

In agriculture, CO_2 (majorly emitted from human activities in land use such as deforestation, cultivation and planting of crops (Verge et al., 2007); CH_4 (from flooded rice paddle, enteric fermentation) and N_2O (from manure usage in livestock production and application of fertilizer in crop production) are the main GHGs, (Yue et al., 2017; Kijewska and Bluszcz, 2016; Snyder et al., 2009). This accounts for about one-fifth of the radiation and one-third when change in land use are incorporated (Verge et al., 2007). The above conjecture provides the motivation to carry out this study.

5. CONCLUSION AND RECOMMENDATIONS

It is widely known that the agricultural sector is among the most hazardous sectors, this is due to hazards such as carbon emissions, flood, pests and diseases, climate change and weather variation, drought and so on. All these hazards lower the productivity of the sector. This study was motivated to examine the effect of GHG emissions on crop production in the ECOWAS sub-region, using social protecion as a mitigating factor through which the effects of GHG emissions can be absorbed. To the best knowledge of the authors, studies with respect to how social protection mitigates the effects of GHG emissions on crop production in ECOWAS has not been conducted (if there are such studies, just a few of them).Therefore; this study contibutes to existing knowledge and extant literature by probing into the rate at which effects of GHG emissions can be absorbed through effective and efficient social protection programmes.

Thus, based on the findings of this study, the following recommendations are made; first this study recommends that social protection programmes should be channeled to the agricultural sector, this can be in form of support for rural farmers which will increase agricultural value chain for greater sustainability. As the case of Nigeria, the government has taken steps towards the implementaton of programmes such asLinkage Assurance Crop Insurance Solutions; Linkage Assurance Farm All Risk lnsurance. The reason for this is because, the African agribusiness needs insurance to remain sustainable and achieve long term growth expectation, the Linkage Assurance Crop Insurance Solutions is to provide cover against unavoidable loss of crops or resulting directly from the insured perils, for example, GHG emissions, flood, drought, excessive rains, hailstorm, diseases and pest, with covers including Weather lndex Crop Insurance; Area Yield – lndex Crop lnsurance, and so on. The aftermath effect of this is that the output from crop production will increase. This can be replicated by the other ECOWAS member countries. Second, the governments of these ECOWAS countries should put in place measures that will help reduce, if not completely eradicate GHG emissions. When this is achieved, it will help increase the level of crop production. Lastly, this study also strongly recommends that the governments of the ECOWAS countries should provide land that can be used for agriculture, provide soft loans to farmers, so that the farmers will be able to purchase mechanized equipment and fertilizers that will help boost agricultural output. When this is put in place, more people, especiallly the youths will be encouraged to engage in and practice agriculture thereby providing more employment in the agricultural sector.

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