The Nexus Between Environmental Quality and Agricultural Sector Performance: Evidence from Cameroon

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Abstract: There is the growing belief that uncontrolled agricultural activities greatly reduce the quality of the environment wherein they are carried out, and in turn, this environmental degradation negatively affects agricultural sector performance as a whole. It is on the strength of this assertion that this paper examines the relationships between environmental quality (carbon dioxide emission) and agricultural sector performance (ASP) in Cameroon using the Vector Autoregressive modelling approach. Specifically, the paper attempts to determine whether environmental quality affects ASP or there is a reverse causation. Using time series data obtained from the 2018 version of the World Development Indicators from 1981 to 2016, the study reveals a negative and significant effect of the first lag of ASP on its current value while the first lag of environmental quality equally has a negative and significant influence on its current value in Cameroon over the study period. Further, there is a negative and significant effect of ASP on environmental degradation. The granger causality test shows that there is a bidirectional relationship between environmental quality and ASP in Cameroon. Finally agricultural labour negatively and significantly affects environmental degradation in Cameroon. From the findings of this study, it is recommended that the government should put in place policies that will promote agricultural produce transformation as well as preservation strategies. Also, farmers should practice farm fragmentation so as to reduce the chances of all the crops ripening at the same time. Afforestation policies should be fully implemented and agricultural development, extension and value chain strategies should be put in place. Restrictions and sanctions should be placed on initiators of bush fire and poor farming practices such as shifting cultivation and bush fallowing methods should be discouraged in favour of intensive farming through sensitization by agricultural extension services.

Keywords: Environmental Quality, Agricultural Sector Performance, Vector Autoregressive Model, Cameroon

1. Introduction

Environmental quality and agriculture, since the early 1970s, has been at the centre of world debate when the global community became aware of excessive exploitation of the environment in favor of agricultural activities [1]. This has led to several international summits on environment such as the Conference on Environment and Sustainable Development, which was aimed at examining the sustainable use of environment and implementation of strategies therefrom, to reduce poverty through agriculture. This is anchored on the belief that agriculture greatly contributes to the supply of raw materials to other sectors, especially the industrial sector, which in turn contributes about 60% of raw materials at the global scale [2].

In another sphere, this sector is the foundation of livelihoods for an estimated 86 percent of world's rural population, an undisputable source of job provision for smallholders as well as constitutes an instrument of poverty reduction [3]. If the environment is not sustainably used, there is a possibility of future decline in food production from 1.5% per annum in the next three decades, to 0.9% per annum by 2050 [4]. Empirical evidence shows that it is partly explained by climatic and environmental variations [5].

Further, most of the environmental problems are attributed to insufficient land and water. Worldwide estimates suggest that land accounts for 38% of agriculture, 66% of water withdrawals and 85% of water consumption [6]. In Sub Saharan Africa (SSA), about 64% of the population live in rural areas and majority of African households depend on agriculture and environment which are the major sources of livelihood [7]. From the foregoing accounts, there is a possible link between agricultural activities and the environment as the latter is a key input into the agricultural sector whilst the former greatly affect the environment [8]. The Organization for Economic Cooperation and Development (OECD) reports that public subsidies for agricultural protection and agrochemical inputs exacerbate environmental pressures through the intensive use of chemicals, the extension of farm land into sensitive areas, and the over exploitation of land, all of which greatly increase the environmental impacts of agricultural activities [9]. Pesticides are a major source of pollution of the environment as they kill beneficial insects, pollinators and fauna. They further cause health problems to farmers especially by increasing endocrine disruption, neurological and reproductive problems, which collectively have a negative effect on agricultural output [10].

Moreover, agriculture provides a range of environmental and ecosystem services which are essential to Green Growth. Direct greenhouse gas emissions from agriculture account for about 10% -12% of the total environmental pollution [11]. Estimates suggest that increasing the removal of atmospheric CO_2 through carbon sequestration in the soil and vegetation sinks, will increase the potential of agriculture to offset up to 20% of global fossil fuel emissions [12]. Green Growth cannot be realized without adequate supplies of food and other agricultural commodities to nourish growing populations. World population is expected to grow to 2.3 billion people by 2050, with a bulk of this increase occurring in developing countries [13]. The incidence of undernourishment is projected to fall from 17% of the population of developing countries at present to 11% in 2020 due to poverty reduction measures put in place by governments [14].

Green growth approaches improve the internalization of environmental externalities in agricultural production which in turn increases the economic returns to farmers through more efficient input use and resource management [11]. Although environmental measures may slow agricultural output in the short-term, eco-efficiency gains should yield long-term economic benefits. Ecologically-sound land management measures improve soil quality, nutrient content and moisture holding capacity of the soil [15]. For example, efforts to increase carbon sequestration in soil organic matter have yielded substantial benefits in many areas in terms of agricultural output and farm productivity [8].

Investing in the environment can lead to new sources of economic growth in agricultural production (organic products, renewable energy) and services (eco-tourism, resource conservation) which collectively contribute to green jobs creation and increases in farm incomes [16]. Certification and eco-labelling of products based on organic and ecological production processes can add substantially to marketing premiums from environmental and health conscious consumers. Organic price premiums are estimated at 20% - 40% in OECD markets depending on the food product [12]. Agricultural biodiversity generates significant option values in conserving genetic resources that can be the basis for the development of new crop varieties and animal breeds. Eco-tourism on farms and in rural areas is a profitable emerging industry in many OECD countries, just like production of biomass energy which is raising farm incomes and revitalizing rural communities.

Cameroon's economy is mainly agrarian making the environment and agriculture to be the main driving forces of its economic growth and development [17]. The sector experiences growth of about 5.6% of Cameroon's GDP in 2018 [18], 70% of its labour force, 60% of its export earnings and total annual value of agricultural output greater than $4 billion [19]. Cameroon's Gross Domestic Product (GDP) was reported to be 19,421CFAF billion in 2017 and 21,263CFAF billion in 2018, with agriculture accounting for agriculture (44.8 percent), industry (17.3 percent) and services (37.9 percent) [18]. The government of Cameroon lays emphasis on agriculture and environmental protection as one of her top development priorities. This is highlighted in the in the country's agricultural and environmental policies rigorously implemented by the Ministry of Agriculture and Rural Development. Yet agriculture is widely seen as underperforming, and the environment keeps deteriorating with most of those involved in it living in abject poverty [20].

Government policies on agriculture in Cameroon have improved over the decades and the sector has witnessed a steady and increasing contribution to the country's GDP and further makes a significant contribution to other allied sectors. Environmental quality in Cameroon, unlike in many other Sub-Saharan African countries, is deteriorating due to continuous pollution which affects the performance of the agricultural sector [15]. Great fluctuations in rainfall in Cameroon cause diverse impacts ranging from occurrence of drought to other devastating effects, which greatly affect agricultural outputs [21, 22].

Taking into consideration the Vision 2035 that outlines the goals and priorities for Cameroon becoming an emerging economy, the environment and agricultural sectors are singled out as key contributors to the growth and emergence of the Cameroon economy through increase agricultural productivity [23]. The achievement of this Vision requires acceleration of the implementation of policies and techniques of agricultural production. Empirical evidence suggests a declining trend in productivity in the agricultural sector in Cameroon and a rising environmental degradation especially after the oil boom of 1987 [24]. This has greatly affected almost all agricultural related farming activities in crop and livestock, industrial sector and service sectors. A case in point is the drastic decline in output of key speculations like crops like coffee, rubber, palm oil, cocoa, and bananas [25].

Literature on the nexus between environmental quality and agricultural sector performance, both theoretical and conceptual, provides a wide array of the bi-directional causal effects in the two facets as one affects the other. However, issues like land for agriculture, agricultural raw materials as well as government policies on agriculture greatly influence the performance of the agricultural sector in Cameroon. Few studies that have attempted to investigate the effects of environmental quality on agricultural sector performance in Cameroon. Results singles out the inability of government policies directed towards protecting the environment thereby achieving greater agricultural sector growth in Cameroon as a major problem. Moreover, increasing environmental degradation, falling agricultural output and increasing poverty levels especially in rural areas, are exacerbating the not too enviable results in this sector. The overall poor performance of the agricultural sector is a major problem which has triggered the interest to investigate the nexus between environmental quality and agricultural sector performance in Cameroon.

On account of the above views, the objective of this paper is to investigate empirically whether environmental quality affects agricultural sector performance in Cameroon or there is reverse causality. The remainder of the paper is structured in four sections. After the introduction, section 2 which is both theoretical and empirical, focuses on literature relating environmental quality and agricultural sector performance. Section 3 follows with the analytical methodology, Section 4 dwells on findings and discussions of results, and lastly, section 5 provides conclusions and policy recommendations.

2. Literature Review

The theoretical nexus between environment and agriculture can be explained with the aid of the Ricardian model. The model is based on the production function, which observes the responses of crops and farmers to varying climates. The observations of farm performances in various agro-climatic regions are exploited [27]. The Ricardian model measures the long term variations in profitability and performance variations in relation to local environmental and climatic conditions while controlling other factors such as socio economic variables on agricultural performance. This model used in this paper because has been applied in other studies to evaluate the effect of climate change and environmental quality upon a specific agricultural output variable [26, 27].

Further, the Environmental Kuznets Curve is another theoretical foundation to explain agricultural growth performance and environmental quality [28-30]. The model brings out an indirect link between environment and economic growth over time in an inverted U-shaped nature [31]. This shows that environment greatly affects agricultural growth through productivity of output [32-34]. This nexus is explained by pollution levels which depend on Gross Domestic Product (GDP) composition, itself linked to development level (ECK hypothesis). The hypothesis designates the nexus between declining environmental quality and income as an inverted-U, that is, in the course of economic growth and development, environmental quality initially worsens but ultimately improves with improvement in income levels [35, 36] as shown on figure 1 below.
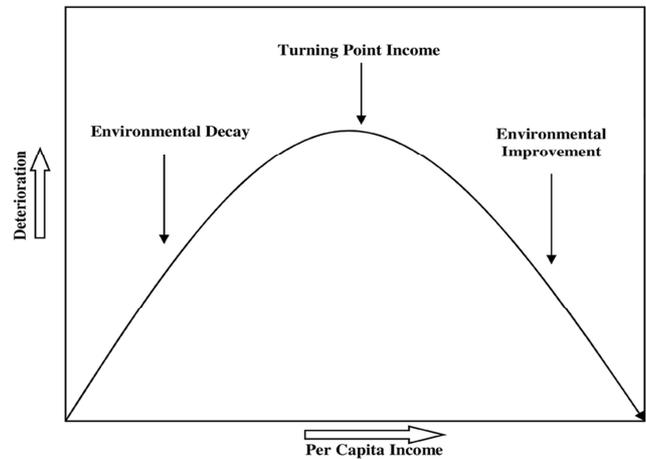
Source: Adopted from Torras and Boyce [36].

Figure 1. Environmental Kuznets Curve.

The shape of the curve can be explained as follows: As GDP per capita rises, so does environmental degradation. However, beyond a certain point, increases in GDP per capita lead to reductions in environmental damage [37]. That is at low incomes, pollution abatement is undesirable as individuals are better off using their limited income to meet their basic consumption needs. Once a certain level of income is achieved, individuals begin considering the trade-off between environmental quality and consumption, and environmental damage increases at a lower rate; and after a certain point, spending on abatement dominates as individuals prefer improvements in environmental quality over further consumption, and environmental quality begins to improve alongside economic [38].

Empirical literature provides conflicting and varied views on the key determinants of agricultural sector growth performance over time. Some studies used major inputs into the agricultural sector such as fertilizer usage, labour, land availability for agriculture and agricultural credit [39]. Yet others are based on the macro and classical determinants of agricultural sector growth performance such as environmental quality, foreign direct investment, gross fixed capital formation, inflation, population and real exchange rate [40].

In a study examining the two-way relationship between agricultural growth and the quality of the environment in Cameroon. They linked agricultural income and the quality of the environment using the Environmental Kuznets Curve (EKC) approach and the Ricardian model. Their results indicated that there is a U-shaped relationship between agricultural growth and environmental quality proxy by carbon dioxide (CO_2) emission in Cameroon [26]. This shows that it is difficult to carry out agricultural production

without having a negative effect on the quality of the environment. They finally indicated that rising temperatures have a U-shaped impact on farm income. In a similar vein, environmental degradation negatively affects economic activity and reduces the ability of poor countries to reach developed ones economically and health is a channel through which environment impacts economic growth [41]. This shows that environmental quality could be considered as a constraint for economic convergence.

In another research estimating the co-integrating nexus between some macroeconomic aggregates and agricultural sector output in Pakistan, the findings show that external debt, foreign direct investment, foreign trade, gross fixed capital formation, gross national expenditures, inflation, population and real exchange rate have significant effect on agricultural sector output in Pakistan [42]. This indicates that the aforementioned variables are the major determinants of agricultural sector performance in Pakistan. A separate study saw that the key inputs into the agricultural sector such as environmental quality, fertilizers, human capital and credit to the agricultural sector have significant and positive role on agricultural sector performance growth in Pakistan [39].

Further, there is possible links between environmental quality and agricultural sector performance in Nigeria especially in rural areas where poverty levels are severe due to poor access to societal resources and widening gaps of inequalities across communities [42]. This compels rural people to over exploit their immediate environmental resources which are readily available for subsistence or mini commercial agriculture. They concluded that in most rural areas, agriculture is the main source of livelihood and environmental resources form the basic source. They observe that this dependence on the environment easily depletes resources when people are faced with poverty and high population density. When these resources become depleted the people are once again pushed into more poverty. They highlighted the impact of unsustainable agricultural practices on the environment and emphasized the importance of addressing the challenges of rural poverty in achieving effective sustainable development and management of environmental resources which agriculture rely on.

Similarly, studying the determinants of agricultural GDP growth in Nigeria using time series data on regression analysis of macro and micro economic variables. Results showed that 49% of the variation in GDP were explained by both the micro and macro variables. They concluded that agricultural labour, infrastructural development and total factor productivity were the major factors that contributed to GDP in Nigeria [43].

An examination of the relationship between environmental quality and economic growth in developing countries using Environmental Performance Index (EPI) and Auto Regressive Distributed Lag Model (ARDL) revealed co-integration among the variables when economic growth was modelled as a dependent variable. Trade openness showed a significant long run relationship with economic growth. The results further revealed a significant and positive impact of

environmental performance index and foreign direct investment on economic growth [44].

In examining the impact of emissions of SO2, NO2 and SPM in India from 1991-2003 using the Environmental Kuznets' Curve (EKC) applied to explore the relationship between economic development measured in terms of State Domestic Product (SDP) per capita and different air quality parameters for industrial and residential locations respectively. Using a methodology that focused on testing the EKC hypothesis at state level in India, using cross-section and time series data for 15 major states and fixed effect version of pooled data estimation technique. Findings revealed that several developmental factors contribute to change in emissions of these air quality parameters. These factors generally include the scale effect, composition effect and the pollution abatement effect. Finally, their findings revealed a directional inverted U-shaped EKC relationship for both industrial and residential locations, without being significant statistically. Basically, some developmental factors such as population density, urbanization and policy variables were significant with expected signs in explaining the relationship for most of the cases [45].

Based on the above theoretical and empirical evidences, this work sets out to examine the relationship that exists between environmental quality and agricultural sector growth performance in Cameroon.

3. Analytical Methodology

This paper makes use of time series data on agricultural sector performance and environmental quality, proxied respectively by annual growth rate of agriculture and by CO_2 emission in Cameroon from 1981 to 2016. The data used in this work are mainly from World Development Indicators [46] and Food and Agricultural Organization Statistical Data Base [47]. This study is based on sector specific analysis focused mainly on the agricultural sector growth performance and environmental quality. The choice of data and time frame is justified by the introduction of major economic reforms that affected the Cameroon economy in general and the agricultural sector in particular, among which are the oil boom, Structural Adjustment Program (1980s), devaluation era (1990s), the financial crisis (2008), Millennium Development Goals (2000s), and lastly, the ongoing Vision 2035 in Cameroon. To investigate the relationship between environmental quality and agricultural sector growth performance, we employed the neo-classical Cobb-Douglas production function with inputs that contribute to a given output, measured as input-output relations of the agricultural sector in Cameroon.

Assuming a neo classical Cobb-Douglas production function with constant return to scale given thus:

$$Q=f(K, L) \qquad (1)$$

Where Q=output; K=capital utilized (Land and Machinery) and L=Labor input. The augmented Cobb-Douglass production function used to capture the objective of the study

which is to investigate the effect of environmental quality on agricultural sector growth performance is specified with environmental quality included in the model as thus:

$$ASP = f(ENQ, LAB, ALA, AMA) \qquad (2)$$

Where ASP Agricultural Sector Performance proxied by the annual growth rate of agriculture; ENQ is the environmental Quality which is proxied by quantity of Carbon dioxide emission (CO_2), LAB is the labour allocated to agriculture; ALA is the Agricultural land which is the total land allocated for agriculture; and lastly, AMA the

agricultural machinery captured as the total quantity of tractors used in agriculture over the aforementioned time.

This paper makes use of the VAR model to estimate the relationship between the variables. It is preferred over other approaches given its simplicity of estimation. Secondly when the variables are non-stationary at level but achieve stationarity after first difference, the VAR is appropriate to estimate the model over the VECM and other estimation techniques, especially when there is no cointegrating relationship among variables [48]. The VAR models used in this study are estimated as follows:

$$ASP_t = \alpha_0 + \alpha_1 ASP_{t-1} + \alpha_2 ENQ_{t-1} + \alpha_3 LAB_{t-1} + \alpha_4 ALA_{t-1} + \alpha_5 AMA_{t-1} + U_1 \qquad (3)$$

$$ENQ_t = \alpha_0 + \alpha_1 ENQ_{t-1} + \alpha_2 ASP_{t-1} + \alpha_3 LAB_{t-1} + \alpha_4 ALA_{t-1} + \alpha_5 AMA_{t-1} + U_2 \qquad (4)$$

$$LAB_t = \alpha_0 + \alpha_1 LAB_{t-1} + \alpha_2 ASP_{t-1} + \alpha_3 ENQ_{t-1} + \alpha_4 ALA_{t-1} + \alpha_5 AMA_{t-1} + U_3 \qquad (5)$$

$$ALA_t = \alpha_0 + \alpha_1 ALA_{t-1} + \alpha_2 ASP_{t-1} + \alpha_3 ENQ_{t-1} + \alpha_4 LAB_{t-1} + \alpha_5 AMA_{t-1} + U_4 \qquad (6)$$

$$AMA_t = \alpha_0 + \alpha_1 AMA_{t-1} + \alpha_2 ASP_{t-1} + \alpha_3 ENQ_{t-1} + \alpha_4 LAB_{t-1} + \alpha_5 ALA_{t-1} + U_5 \qquad (7)$$

Where ASP represent Agricultural Sector Performance, ENQ is environmental quality proxy by CO_2 emissions, LAB is agricultural labour input, ALA is the total land allocated for agriculture, and AMA is the agricultural machinery proxy by number of tractors used. The variables are not logged because they are measured in percentages. Considering that other factors apart from the ones mentioned can as well contribute in explaining variation in the dependent variable are held constant. It is capture using the white noise error terms in each equation ($U_1, U_2...U_5$) and t is time while t-1 is lag 1 of each variable. Finally, α_1, α_2, α_3, α_4, and α_5 are the coefficients to be estimated.

The a priori expectation are as follows;

$$\alpha_0 > 0, \ \alpha_1 > 0, \ \alpha_2 < 0, \ \alpha_3 > 0, \ \alpha_4 > 0 \ and \ \alpha_5 > 0$$

Agricultural sector Performance is measured using agricultural annual growth rate of agricultural value added. It measures agricultural productivity, output of the agricultural sector as well as the value of intermediate inputs. It comprises value added from hunting, fishing, and forestry, cultivation of crops and livestock production as indicated by world development indicator, 2018. The data on agricultural sector growth was also collected from World Development Indicators [46]. In another aspect, most significant environmental problems as pointed out from the literature are related to emission of Greenhouse gases of which Carbon dioxide (CO_2) is the dominant contributor. It is measured in Kg per tons. It was also collected from World Development Indicators [46].

Further, agricultural labour is the proportion of total labour allocated to agricultural production. It is measured in terms of number of man hours devoted to agriculture and according to the classical economists: labour is one of the fundamental inputs into the production system. The variable is obtained from World Development Indicators [46].

In addition, agricultural land is an input that influences agricultural production. It is measured in hectares of arable

land. And, agricultural machinery is the capital input used in agricultural production measured in terms of the number of tractors per year. All these variables are obtained from the world development indicators book [46].

According to the models in the VAR equations above, the model utilizes the Wald bound test statistic which has two critical values for testing cointegrating relationship among the determinants identified. In the first scenario, the lower bound critical values are assumed to show no cointegrating equations or relationships, hence the variables are not cointegrated I (0). Moreover, the upper bound critical values reject null hypothesis of no cointegrating equations and hence all variables are cointegrated of the order one (1). If the estimated Wald test (F - statistic) is greater than upper bound critical value, then the case of no cointegration is not rejected [49]. If the Wald statistic falls between upper and lower bound critical values, the results are accepted. To select the optimal lag length, we employ the Akaike Information Criterion (AIC) since it is optimal when using small sample size [50]. This is very crucial in VAR models because it aids in the explanation of the problem of over parameterization [50]. To estimate the equation, we use lag one (1) since the AIC confirmed one lag.

One of the fundamental assumptions when dealing with time series variables is that the variables are stationary. Stationarity means variable exhibits mean reversion over time. That is, it fluctuates around a constant long run mean and thus stabilizes over time [51]. The variables were tested for stationarity since the outcome of unit root testing is an important indicator in selecting the best estimation technique. This paper relies on Augmented Dickey-Fuller (ADF) unit root testing procedure. The significance of unit root testing is to avoid spurious regression and also to improve on the precisions of the forecast of the estimates. The test was conducted with drift or without drift depending on the graphical presentation of the variables over time. Further, Granger causality was also used to check the direction of

causality between environmental quality and agricultural sector performance before the VAR model was estimated.

4. Findings and Discussions

Considering that the VAR estimation technique and Granger causality test were conducted to examine if there exist a bi-directional relationship between agricultural sector growth performance and environmental quality in Cameroon.

Prior to the test, the statistical properties of the variables included in the model were examined. However, it should be noted that agricultural raw material and environmental quality proxy by greenhouse gas emission showed no particular trend and were very stochastic whereas agricultural performance and agricultural land depict upward trends with a less stochastic evolutions. A summary of the ADF tests is presented in table 1 below.

Table 1. *Summary of the Stationarity Test Using ADF test.*

Variables		Test statistics	Critical Value			Order of integration
			1%	5%	10%	
ASP	Level	-1.436	-3.577	-2.928	-2.599	I (1)
	First Diff	-9.554	-3.579	-2.929	-2.600	
ENQ	Level	-2.350	-3.577	-2.928	-2.599	I (1)
	First Diff	-8.994	-3.579	-2.929	-2.600	
LAB	Level	0.002	-3.577	-2.928	-2.599	I (1)
	First Diff	-7.836	-3.579	-2.929	-2.600	
ALA	Level	-2.218	-3.577	-2.928	-2.599	I (1)
	First Diff	-5.411	-3.579	-2.929	-2.600	
AMA	Level	-2.296	-3.577	-3.928	-2.599	I (1)
	First Diff	-6.038	-3.579	-3.929	-2.600	

Source: Authors, 2019.

From the ADF stationarity tests results, it can clearly be seen that all the variables were not stationary at their levels since their test statistics at level were all less negative that their critical counterparts. However, all achieved stationarity after first difference which implies that the variables are integrated of order 1. This allows us to test if there exist a long run equilibrium relationship among the variables using the Johansen co-integration method. Prior to the co-integration test it should be noted that the VAR lag order selection test indicates that the appropriate lag length for the co-integration and VAR is 1.

Table 2. *Johanson Test for Cointegration.*

Trend: constant Sample: 1981-2016					Number of Obs=36 Lags=1
Maximum Rank	parms	LL	eigenvalue	Trace statistics	5% Critical value
0	4	169.53455	.	40.8051*	47.21
1	11	183.61668	0.54267	12.6409	29.68
2	16	188.84307	0.25200	2.1881	15.41
3	19	189.91515	0.05782	0.0439	3.76
4	20	189.93712	0.00122		

Source: Authors, 2019.

The co-integration result presented in table 2 reveals that there is at most 0 (zero) rank of co-integrating equations in the model and thus the variables are not co-integrated. The absence of co-integration further validates VAR as the choice of the estimation technique over Vector Error Correction Model (VECM).

Table 3. *VAR Estimation Results.*

VARIABLES	(1)	(2)	(3)	(4)	(5)
	D_asp	D_enq	D_lab	D_ala	D_ama
LD. asp	-0.237*	19.21	-0.0120	-0.0102	0.00641
	(0.130)	(93.84)	(0.0179)	(0.00903)	(0.00390)
LD. enq	-0.000455**	-0.326**	-0.00005**	0.000008	-0.0000004
	(0.0002)	(0.141)	(0.00003)	(0.00001)	(0.000006)
LD. lab	-0.688	729.3	-0.0570	0.0397	-0.00942
	(1.002)	(725.1)	(0.138)	(0.0698)	(0.0302)
LD. ala	0.0867	-136.5	0.181	0.281**	0.149***
	(1.843)	(1,333)	(0.254)	(0.128)	(0.0555)
LD. ama	-1.972	4,354	0.499	0.623**	0.156

VARIABLES	(1)	(2)	(3)	(4)	(5)
	D_asp	D_enq	D_lab	D_ala	D_ama
	(4.423)	(3,199)	(0.610)	(0.308)	(0.133)
Constant	-0.411	248.6	-0.206***	0.0496**	0.00123
	(0.357)	(258.4)	(0.0493)	(0.0249)	(0.0108)
Observations	36	36	36	36	36

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Source: Authors, 2019.

Results in table 2 above indicate that there is a negative and significant relationship between the current value of agricultural sector performance and its first lag difference. This means that agricultural sector performance affects itself over time. This result particularly shows that a unit increase in the first lag difference of ASP will lead to -0.237 units fall in its current value and this effect is statistically significant at 10%. Further, there is a negative and significant relationship between environmental quality and the agricultural sector performance in the environmental quality equation. The coefficient of -0.000455 reveals a unit increase in CO_2 emission will lead to 0.000455 units fall in agricultural sector performance implying that the higher the environmental degradation, the lower the agricultural sector performance in Cameroon especially in the short run. This confirms with the Environmental Kuznets Curve (EKC) hypothesis which stipulates that higher C02 emission leads to worsening performance of the agricultural sector in Cameroon. These results are also in conformity with the findings of Domguia and Njangang [26] who examined the two-way relationship between agricultural growth and the quality of the environment in Cameroon by linking agricultural income and the quality of the environment using the Environmental Kuznets Curve (EKC) approach and the Ricardian model.

Also, environmental quality equally has a negative and significant influence on its lag with a coefficient of -0.326 at 5% level of significance. This means the higher the green house emission of last year, the lower the emission of the current year. This is because more people are becoming aware of climatic variations and there are many policies especially renewable energy policies, policies to reduce climatic variations especially agricultural practices that are environmentally friendly [52]. Furthermore, environmental quality has a negative and significant effect on agricultural labour. This means as environmental degradation increases, the number of labour going into agricultural activities falls. This is because of the fall in agricultural productivity caused by poor environmental quality and when this happens more labour will move to other sectors that are doing better than agriculture which is in agreement with the work of Blandford [53].

The coefficient of agricultural land is positive which reveal that there is positive relationship between agricultural land surface and agricultural performance in Cameroon. But this result was found to be statistically insignificant. However, the relationship between land and its first lag is also positive, and statistically significance at 5%. Meaning the value of

land in a year depends on land utilisation in the previous year. Furthermore, the agricultural land equally has a positive and significant relationship with agricultural machinery. That is an increase in the value of agricultural land will lead to an increase in agricultural machinery. This means as more land is allocated for agricultural, the demand for agricultural machinery increases. In addition, there is a negative but insignificant relationship between agricultural land and environmental quality. This is in disagreement with the works of Radoslava [54] who found a positive relationship between agricultural land-use and environmental quality due to human influence on land caused by population growth and increasing food requirements.

The coefficient of agricultural machinery in the agricultural sector performance equation is negative and insignificant. However, agricultural machinery proxy by number of tractors has a positive and significant relationship with agricultural land and its lag (t-1). This indicates that the more land allocated for agriculture, the higher the demand for more capital input in the form of machinery which is significant at 5% level of significance. This work is in conformity with the works of Zeng, Jin and Zhong [55] who concluded that agricultural machinery seriously affects the demand for agricultural land in China. The negative and insignificant effect of agricultural machinery on agricultural sector performance in Cameroon can possibly be due to the fact that most agricultural practices are peasantry and small holding in nature with little or no use of machineries and thus using a machine on small pieces of land may increase cost more than revenue.

The granger causality test indicates that environmental quality granger cause agricultural sector performance. This is evident by the fact that the Wald test of the coefficients of the lag of environmental quality in the agricultural performance equation accepts the null hypothesis since the probability value of chi^2 (0.019) is far less than the conventionally accepted level of significance 0.1 (10%). We can therefore conclude that the coefficient of the lag of environmental quality in the agricultural sector performance equation is not statistically equal to zero.

Further, there is reverse causality between agricultural sector performance and environmental quality. Evidence is the fact that the Wald test of the coefficient of the lag of agricultural sector performance in the environmental quality equation rejects the null hypothesis given a probability value of 0.002. This implies that the result is significant at 1%. We therefore conclude that agricultural sector performance

granger causes environmental quality. Finally, the coefficient of the first lag of agricultural sector performance in the environmental quality model is statistically different from zero.

It should further be noted that all the coefficients of the VAR are stable as the VAR satisfies the stability condition with all Eigen-values lying inside the unit circle. Also, no autocorrelation was recorded at lag 1 as revealed by the Lagrange multiplier autocorrelation.

5. Conclusion

The findings suggest that agricultural sector performance negatively affect itself over time. This can be justified by the cyclical fluctuations in the agricultural output and prices over time due to farmers' expectations (as captured in the Cobweb Theory). More so, agricultural sector performance negatively affect environmental quality (CO_2 emission) in Cameroon. This is due to the fact that achieving higher agricultural sector performance (more output) mostly lead to increase vegetation in the environment which release oxygen and absorb CO_2 thereby reducing the amount of CO_2 in the atmosphere and thus improving on the quality of the environment. Furthermore, the findings indicate that increase in agricultural labour reduces CO_2 emission (i.e. improves environmental quality). This is because agricultural labour constitute an input to agricultural production and increasing labour for agriculture mean increase in agricultural production and hence increase in CO_2 absorption.

6. Recommendations

From the findings of this study, it is recommended that the government should put in place policies that will promote agricultural produce transformation as well as preservation strategies such as establishing factories that can transform and preserve perishable farm produce so as to increase their lifespan thereby reducing the waste associated with agricultural production. Also, farmers should practice farm fragmentation so as to reduce the chances of all the crops ripening at the same time. Further, afforestation policies should be fully implemented and agricultural development, extension and value chain strategies should be put in place so as to improve on agricultural sector performance thereby reducing CO_2 emission and hence improve environmental quality. Also, restrictions and sanctions should be placed on initiators of bush fire and poor farming practices such as shifting cultivation and bush fallowing methods should be discouraged while intensive farming encouraged through sensitization by agricultural extension services. Finally, the government should encourage youths to undertake agricultural activities that are environmentally friendly by providing grants and loans with awards given to the best practitioners. This could also include providing adequate training to farmers on the best farming practices as well as environmental conservation strategies so as to maintain a good environmental quality for sustainable and inclusive growth in Cameroon.

References

[1]   Nwokoro, C. V., Chima, O. F. (2018) Evaluation of Impact of Unsustainable Agricultural Practices on Rural Poverty and Environmental Resources in Ogoni, Nigeria, International Journal of Education and Human Developments, Vol. 4, No. 4.

[2]   FAO, (2017) Challenges and Opportunities for African Food prices, Climate change, Population Growth, and HIV and AIDS. Expert meeting on how to feed the World 2050. Food and Agricultural Organisation of the United Nations Economic and Social Development delivered by Hans P. & Mkhize B.

[3]   Arias, P., Hallam, D., Krivonos, E., & Morrison, J. (2013) Smallholder integration in changing food markets. Food and Agriculture Organization of the United Nations, Rome.

[4]   World Bank Prosperity Annual Report (2013) End extreme poverty, Environmental, Social and Economic Sustainability, Rome.

[5]   Hosam, E. A., Bayoumi, H., Paktko, I. (2010) Relationship between Environmental Impacts and Modern Agriculture, Obuda University e-Bulletin, Vol. 1, No. 1.

[6]   Food and Agricultural organization (FAO, 2017) Water pollution from agriculture: a global review, FAO and International Water Management Institute, Research program on water, land and ecosystems, Colombo.

[7]   World Energy Outlook (WEO, 2017) Global Energy Trends International Energy Agency, secure sustainable together, OECD.

[8]   Lichtenberg, Erik. (2000) Thoughts on modern Agricultural Technologies, Human Welfare, and the environment, Fifth Annual EPA STAR Graduate Fellows Conference Panel on "The Sorcerer's Apprentice, Global Impacts of Human Technological Development' 'Washington, DC.

[9]   Lingard, J. (2002) Agricultural Subsidies and Environmental Change. In Encyclopedia of Global Environmental Change, I. Douglas (ed). John Willey and Sons, Ltd., New Jersey, United States.

[10] Alavanja M C R, Samanic C, Dosemeci M, Lubin J, Lynch C F, Knott C, et al., (2004), Pesticides and lung cancer risk in the agricultural health study cohort. Am j epidemiol 160: 876-885.

[11] World Economic Outlook (WEO, 2017) Sharing the Growth, Equity and Development Report, Phnom Penh, World Bank for Cambodia Development Cooperation and Forum.

[12] Stevens, C. (2010) Agriculture and Green Growth, (2010g), Interim Report of the Green Growth Strategy, OECD, Implementing our Commitment for a Sustainable Future, Meeting of the OECD Council at Ministerial Level.

[13] World Bank (2007) Sharing the Growth: Equity and Development Report 2007, Phnom Penh, World Bank for the Cambodia Development Cooperation and Forum.

[14] FAOSTAT, (2016) Food and Agricultural Organization Statistical Database, Food and Agricultural Organization of the United Nations.

[15] Abia, W. Conallus, E. Shum, Richard N. Fomboh, Epole N. Ntungwe & Markjovert T. Ageh (2017) Agriculture in Cameroon: Proposed Strategies to Sustain Productivity. International Journal for Research in Agricultural Research.

[16] Tim Everett, Mallika Ishwaran, Gian Paolo Ansaloni and Alex Rubin (2010) Economic Growth and the Environment, Defra Evidence and Analysis Series Paper 2, Department for Environmental and Rural Affairs, Defra, United Kingdom.

[17] Ministry of Agriculture and Rural Development Cameroon (MINADER, 2017) Annual Report on the agricultural and environmental outlook and progress, Yaoundé, Cameroon.

[18] Ministry of Finance Cameroon (MINFI, 2019) Report on 2017 Finance Bill Report on the Nation's Economic, Social and Financial Situation and Prospects, Yaoundé, Cameroon.

[19] ZEF, FARA, and IRAD (2017) Country Dossier: Innovation for Sustainable Agricultural Growth in Cameroon. Program for Accompanying Research for Agricultural Innovation, Bonn, Accra and Yaoundé. hCenter for Development Research, Forum for Agricultural Research in Africa, and Institute des Recherché agricole pour le Development.

[20] World Bank (2017) World Bank Assistance to Agriculture in Sub-Saharan Africa: An IEG Review, Washington, DC.

[21] MINADER (2013) Innovation for Sustainable Agricultural Growth in Cameroon, Program of Accompanying Research for Agricultural Innovation (PARI), Cameroon.

[22] Ministry of Agriculture and Rural Development Cameroon (MINADER, 2018) Annual Report on the agricultural and environmental outlook and progress, Yaoundé, Cameroon.

[23] Ministry of Employment and Vocational Training, MINEPAT (2016) National Plan of Action for Youth Employment, Inter ministerial Framework, Yaoundé, Cameroon.

[24] Food and Agriculture Organization (FAO) (2010), "Payments for Environmental Services within the Context of the Green Economy," Background Report No. 3.

[25] National Institute of Statistics (NIS, 2015) the population of Cameroon: Reports of the presentation of the final results of the third general census of population and housing (RGPH): Central Bureau of census and populations, Ministry of Economy and Finance Yaoundé, Cameroon.

[26] Domguia, E. N, and Njangang, H. (2019) Agricultural Growth and Environmental Quality in Cameroon: Evidence from ARDL Bound Testing Approach, LAREFA, University of Dschang, Cameroon, MPRA Paper No. 91735.

[27] Mendelsohn, R., Nordhaus, W. D. and Shaw, D. (1994) The Impact of Global Warming on Agriculture: A Ricardian Analysis. American Economic Review, 1994, 84 (4), 753-771.

[28] Grossman, G. M. and Krueger, A. B. (1991), "Environmental impacts of a North American Free Trade Agreement", National Bureau of Economic Research Working Paper 3914, NBER, Cambridge, MA.

[29] Shafik, N. and Bandyopadhyay, S. (1992) "Economic growth and environmental quality: time series and cross-country evidence", Background Paper for the World Development Report, Vol. 1992, The World Bank, Washington DC.

[30] Selden, T. M. and Song, D. (1994), "Environmental quality and development: is there a Kuznets curve for air pollution?" Journal of Environmental Economics and Environmental Management, Vol. 27 No. 2, pp. 147-62.

[31] Grossman G. M. and A. B. Krueger, (1995), "Economic Growth and the Environment", The Quarterly, Journal of Economics, MIT Press, vol. 110 (2), pages 353-77.

[32] Mansour, M., Salama, H., Ali, F., Abou, H. (2005) Cell and Plant Response to NACL in Zea Mays Cultivars Differencing in Salt Tolerance, Journal of General Applied Plant Physiology, 31 (1-2), pp. 29-41.

[33] Yadav, N. (1997) Dynamic Optimization of Nitrogen use when Groundwater Contamination is internalized at the Standard in the long run. American Journal of Agricultural Economics, volume 79, issue 3, pp. 931-945.

[34] Hettige, H., Mani, M. and Wheeler, D. (1997) Industrial Pollution in Economic Development: Kuznets Revisited, Development Research Group, World Bank.

[35] Torras M, Boyee, K. (1998). Income, Inequality and Environmental quality. An international cross sectional analysis. In Proceedings of the 4th Biennial conference Economics, Boston University U.S.A.

[36] Levinson, P. (2001) Preferences, Technology, and the Environment: Understanding the Environmental Kuznets Curve Hypothesis, American Journal of Agricultural Economics, 88 (30), pp. 632-643.

[37] Panayotou, T. (2000), "Economic Growth and the Environment." CID Working Papers 56, Center for International Development at Harvard University.

[38] Economides G. and A. Philippopoulos, (2008) "Growth enhancing policy is the means to sustain the environment." Review of Economic Dynamics, Elsevier for the Society for Economic Dynamics, vol. 11 (1), 207-219.

[39] Ahmed, K. and Heng (2012) Determinants of agricultural productivity in Pakistan. International Research Journal of Finance and Economics, Vol. 95, pp. 1–11.

[40] Gilal, M., Ajmair, M. and Hussian, K. (2016) Determinants of agricultural sector growth in Pakistan, International Journal of Science and Engineering Research, vol. 7, issue 10, no 2229–5518.

[41] Alassane, Drabo (2011) Interrelationships between Health, Environment Quality and Economic Activity, What Consequences for Economic Convergence, halshs-00552995.

[42] Nwokoro, C. V. and Chima, O. F. (2017) Impact of Environmental Degradation on Agricultural Production and Poverty in Rural Nigeria, American International Journal of Contemporary Research, Vol. 7, No. 2.

[43] Udah, C., Nwachukwa, N. (2015) Determinants of Agricultural GDP Growth in Nigeria, International Journal of Agricultural Research and Review: ISSN-2360-7971, vol. 3 (3), pp. 184-190.

[44] Ali-Hossein and Abedi, Z. (2017) Relationship Between Environmental Quality and Economic Growth in Developing Countries (Based on Environmental Performance Index) Environmental Energy and Economic Research Journal, 1 (3), pp. 299-310.

[45] Geetilaxmi Mohapatra and A. K. Giri, (2009),"Economic development and environmental quality: an econometric study in India", Management of Environmental Quality: An International Journal, Vol. 20 Issue, 2 pp. 175-191.

[46] World Development Indicators, WDI (2018), World Bank Group, CD ROM on statistical Indicators on Economic Performance.

[47] FAOSTAT (2018) Production Crop Data for Food and Agricultural Organization of the United Nations, the State of Agricultural Commodity Markets, FAO, Commodities and Trade Division, Rome.

[48] Lutkepohl, H. (2000) Applied Time Series Econometrics, 4th Edition, European University Institute of Development Studies.

[49] Pesaran, M. and Shin, Y. (1999) An autoregressive distributed lag modeling approach to cointegration analysis, in Econometrics and Economic Theory in 20th century: The Rangnar Frisch Centennial Symposium, (Ed.) S. Storm Cambridge University Press, Cambridge, pp. 1-33.

[50] Taban, S. (2010) An Examination of the Government Spending and Economic Growth Nexus for Turkey using the Bond test Approach, International Research Journal of Finance and Economics, vol. 48: 187-196.

[51] Seiler, A. (2004) Trends and Spatial Patterns in Ungulate-vehicle collisions in Sweden-Wildlife Biology, vol. 10, pp. 301-313.

[52] Jayant, Sathaye and Andrea, Ketoff (1991) CO_2 Emissions from Major Developing Countries: Better Understanding the Role of Energy in the Long Term, The Energy Journal, International Association of Energy Economics, Vol. 12, No. 1, pp. 161-196.

[53] Blandford, David (2019) Agriculture and the Environment, Better policies to improve the environmental performance of the Agricultural sector, OECD.

[54] Radoslava, K. (2016) Agriculture and its Impact on Land-Use, Environmental, and Ecosystem Services, Open access peer-reviewed chapter, DOI: 10.5772/63719.

[55] Zeng, Y., Jin, Y. and Zhong, T. (2016) Investigating the Relationship Between Land and Labour Endowments and Agricultural Mechanization among Chinese Farmers, Selected paper Prepared for Presentation for the 2016 Agricultural and Applied Economics Association, Boston, MA.