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The effects of public funding on agricultural performance and environmental degradation in Ghana: Case studies of three arboriculture value chains (Cocoa, Cashew and Mango)

The effects of Public Funding on Agricultural Performance and Environmental Degradation in Ghana: Case studies of Three Arboriculture Value Chains (Cocoa, Cashew and Mango)

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Abstract

This paper examines the effects of public funding devoted to agriculture on the performance of the agriculture sector and on the environmental degradation in Ghana over the period 1996-2019. The paper particularly focuses on three tree crops value chains, namely cashew, cocoa and mango sub-sectors. The agriculture performance is measured by the value added. The environmental degradation is measured by the greenhouse emissions from agriculture. The empirical methodology is based on a multivariate econometric approach, in particular a VAR model in a form of error correction that considers the long-term relationships (cointegration) between variables. The results from the impulse-response functions indicate that public financing significantly improves agricultural performance but with mixed impacts on environmental quality. It helps improve agricultural performance by increasing agricultural value added and agricultural productivity. However, this support tends to have a negative impact in terms of CO2 emissions in Ghana. The policy implications suggest that the increase in support to the agricultural sector is highly commendable and should be strengthened for the three trees crops, but policymakers should consider the potential negative impact of the financing on carbon dioxide emissions. To this end, while for mango a few non-financial measures seem necessary, for cocoa and cashew, substantial non-financial resources are required to make these crops more climate or environmentally sensitive, through incentives and awareness. This means encouraging use of innovative tools on farms, including climate smart agriculture methods to make these crops less degrading for the quality of the environment in Ghana.

Keywords: Public Funding; Tree crops value chains; Environmental degradation; Ghana; VAR models.

JEL-Classification: Q14; Q18 ; Q56

1. Introduction

The importance agricultural sector lies on its capacity to contribute to rural development, social stabilization, environmental sustainability and cushioning economic shocks in Ghana (Ministry of Food and Agriculture [MoFA], 2021). It is a major employer of the economically active population and a critical source of revenue for the economy. Agricultural commodities account for over 30% of export earnings, serving as a source of foreign exchange, and a major source of inputs to the manufacturing industry. In 2020, the agricultural export value is estimated at USD 3.0 billion, an increase of 172.7% over 2005- 2020 (Table 1). This increase is well above the average increase of 160.6% in the other four countries (Cote d'Ivoire, Kenya, Nigeria, Senegal) over the same period. Ghana also appears to be performing well in terms of the average agricultural growth - 4.7% in 2019- compared to other countries, particularly Nigeria where the agricultural GDP grows very slowly by 0.2% in 2019. However, the long-stand progress does not appear to be sufficient, as the target set up by the Ghanaian government is higher, especially to meet targets related to the Comprehensive Africa Agriculture Development Program (CAADP).

Given the economic difficulties often caused by instable commodity prices, particularly cocoa, the government of Ghana has embarked on a process of diversifying the agricultural sector outcomes with a new focus on exports through intensification of production [1]. Through this, it seeks to improve agricultural productions as well as the incomes of rural farmers through the provision of certified improved seedlings, extension services, business support and regulatory mechanisms (AGRA, 2021). In addition to cocoa, MoFA has identified eleven commodity value chains such as cashew, citrus, coffee, coconut, cotton, mango, oil palm, rubber, shea, dawadawa kola which are found in most of the country's farming systems (MoFA, 2012; MoFA, 2020). Seven of these tree crops value chains – cashew, rubber, oil palm, coconut, mango, coffee and shea – have been selected for further government attention and support to drive the Ghana decentralization and industrialization agenda through the One District One Factory Initiative (AGRA, 2021; Asante, 2021; MoFA, 2020).

Strengthening the competitiveness of these tree crops by facilitating public financing and leveraging private investments is also a response to the external instability of the Ghanaian currency (Cedi), the need for resources to finance development, and the need for continued improvement in the living conditions of many farm households. However, it is clear that private financing for the agricultural sector is slow to take over from public financing. Public funding dedicated to agriculture was USD 549.3 million in 2020 (up from USD 121.2 million in 2000) (ReSAKSS, 2021), while loans from private financial institutions to the agricultural sector were USD 272.1 million in 2020, from USD 276.0 million in 2012 (FAOSTAT, access September 2022)[2]. The increase in public spending in the agricultural sector is also taking place in a context of climate change where dedicated resources must imperatively consider issues related to the sustainability of agricultural production systems and the environment.

[1] The Ghana government has launched the Tree Crop Policy in 2012 to promote the sustainable development of the tree crop (TC) sub-sector based on six major strategic objectives (i) support increased production and productivity; (ii) promote investment and increase processing capacities; (iii) improve marketing through VC development; (iv) promote sustainable practices for environmental protection; (v) support research and development; (vi) improve coordination and management of the Policy (MoFA, 2012).

[2] https://www.fao.org/faostat/en/#data/IC.

Table 1: Some general characteristics of agriculture in selected countries (2004-2019)

Country	Rural Population (% of Total population)		Employment in agriculture (% of total employment)		Employment in agriculture by sex (2019)		Gross agricultural value added (% GDP)		Annual Growth of agricultural value added % (2015 prices)		Agricultural Export Value (US$ billion)		Gross Domestic Product per capita (Value US$ per capita, 2015 prices)	
	2005	2020	2005	2019	Female	Male	2005	2020	2005	2019	2005	2020	2005	2020
Ghana	52.7	42.7	55.0	29.8	22.1	36.4	37.5	19.3	4.1	4.7	1.1	3.0	1130.5	1940.7
Cote d'Ivoire	54.8	48.3	50.0	40.2	31.0	46.6	16.1	21.4	3.4	4.6	3.0	8.3	1639.0	2310.6
Kenya	78.3	72.0	61.1	54.3	59.3	49.6	24.2	23.0	6.9	3.6	1.6	3.6	1045.9	1475.2
Nigeria	60.9	48.0	45.0	35.0	23.6	44.5	26.1	24.1	7.1	0.2	0.7	1.5	1948.0	2396.0
Senegal	58.3	51.9	42.3	30.1	24.8	33.7	15.2	17.0	11.0	4.2	0.2	0.8	1133.7	1356.4
Average	**61.0**	**52.6**	**50.7**	**37.9**	**32.2**	**42.2**	**23.8**	**21.0**	**6.5**	**3.5**	**1.3**	**3.4**	**1379.4**	**1895.8**

Source: Authors, from World Bank Development Indicators and FAOSTAT database

Although agriculture is the most sensitive and vulnerable sector to climate change, it is also one of the main contributors to greenhouse gas emissions (IPCC, 2007). Moreover, improving agricultural performance and maintaining the quality of the environmental quality are fundamental achievements expected. In this study, we seek to examine the impact of public finance to the agricultural sector on agricultural performance (agricultural value-added and agricultural yield – agricultural value-added hectare) and agriculture Co2 emissions by focusing on the case of three tree crops, namely cocoa, cashew and mango. Since analysis of the effect of public funding on both agricultural value-added and the environment is scarce in the literature, we ask whether public financing, by contributing to improved performance in the three sectors mentioned, does not have a negative impact on the environment in terms of CO2 emissions in Ghana. The finding of this analysis can be useful in terms of public policy to what extent public funding dedicated to the agri-sector can be moderated or improved to reduce its impact on the environment.

Using panel data over the period 2000-2019, we consider a multivariate econometric model, more precisely a VAR (2) in a form of error correction that considers long-term relationships (cointegration) between variables to examine the link between public funding, agricultural performance, and environmental degradation. This perspective relies on economic policy theory which considers how changes in government spending on the agricultural sector can stimulate the performance of the targeted value chains while taking care of the environmental issues. To this end, we use impulse-response analysis of the shock to public financing dedicated to agriculture on all the impact variables of interest over time. Hence, this study contributes to the existing literature as one of the rare studies that examines the effect of public financing on the agricultural value-added and carbon dioxide emissions at the same time. Previous studies have been more focused on the effect of agriculture on the environment without considering the level of investment, particularly public financing, and without providing strong evidence on the nature of their relationship.

The rest of the paper is structured as follow. Section 2 attempts to examine previous studies related to the nexus public financing and agricultural performance and CO2 emissions based on the literature review. Section 3 is about the stylized facts in Ghana. Section 4 presents the methodology section. Section 5 displays the findings, while section 6 concludes the study and recommends appropriate policies.

2. Literature review

Increasing financing for agricultural production particularly could influence CO2 emissions through the intensive use of chemical fertilizers which can play an important role in increasing agricultural production. In several countries, public investment is partly used to subsidize fertilizers to push farmers to use them intensively, that can then exacerbate greenhouse gas emissions. But there is no evidence that increased financing for agriculture leads to environmental degradation. In the literature relating agricultural productivity to environment, two main hypotheses exist (Alhassan, 2021). The first presented by Borlaug (2007) assumes that agricultural productivity is associated with income growth that leads to demand for cleaner environment, goods and services, and the ability of government to enforce environmental regulations. The second is called Jevon paradox cited by several authors. It assumes that agricultural productivity is likely to increase agriculture's profitability, which encourages the expansion of cultivated land, causing deforestation and environmental degradation (Ceddia et al., 2013; Villori, 2019).

Various empirical studies have been conducted to investigate the two hypotheses. Alhassan (2021) has recently studied the relationship between agricultural total factor productivity and pollution (carbon dioxide emissions) in 38 Sub-Saharan African (SSA) countries over the period 1981–2016. The finding shows a U-shaped linkage between productivity and environmental deterioration. It suggests that agricultural productivity primarily reduces carbon dioxide emissions up to a certain point, beyond which higher agricultural productivity increases carbon dioxide emissions. In contrast, Degife and Mauser (2017) noted the need to integrate socio-environmental and economic aspects into the objectives of agricultural investments to support sustainable development in a country. They found that large-scale commercial farm investments have negative impacts in terms of environmental devastation such as deforestation, biodiversity depletion, and wetlands drained in the Gambella Region in Ethiopia. This reflection is in line with Adomako and Ampadu (2015) who undertook a review of the agricultural practices such as deforestation, slash-and-burn agriculture, negative soil nutrients balance, increased dependence on agro-chemicals for both crop and animal production on environmental sustainability in Ghana. They noted that in addition to the soil degradation, water, air and biodiversity, these practices also contribute to high carbon-emissions to the atmosphere, thereby facilitating climate change.

Specifically, some empirical studies have been undertaken in Ghana. Using WDI data between for the period, 1971-2008, Kwakwa et al. (2014) employed the Johansen cointegrating test to find positive and significant impacts for agricultural and industrial growth but significant negative effects for the square of industrial and agricultural growth on environmental degradation. This result is convergent with the Environmental Kuznets Curve (EKC) hypothesis for the agricultural and industrial sectors in Ghana. It also suggests that there is a difference between the short-term effect and the long-term effect. More recently, Owusu and Asumadu-Sarkodie (2017) have used the impulse-response function based on autoregressive distributed lag method following a time series data from 1960 to 2015 to examine the causal effect between agricultural production and carbon dioxide emissions in Ghana. They found a relationship between copra production, corn production, green coffee production, milled rice production, millet production, palm kernel production and sorghum production and carbon dioxide emissions particularly for short-run relationship. Their result suggests that a 1% increase in copra and green coffee production would increase carbon dioxide emissions by 0.22% and 0.03%, a 1% increase in millet and sorghum

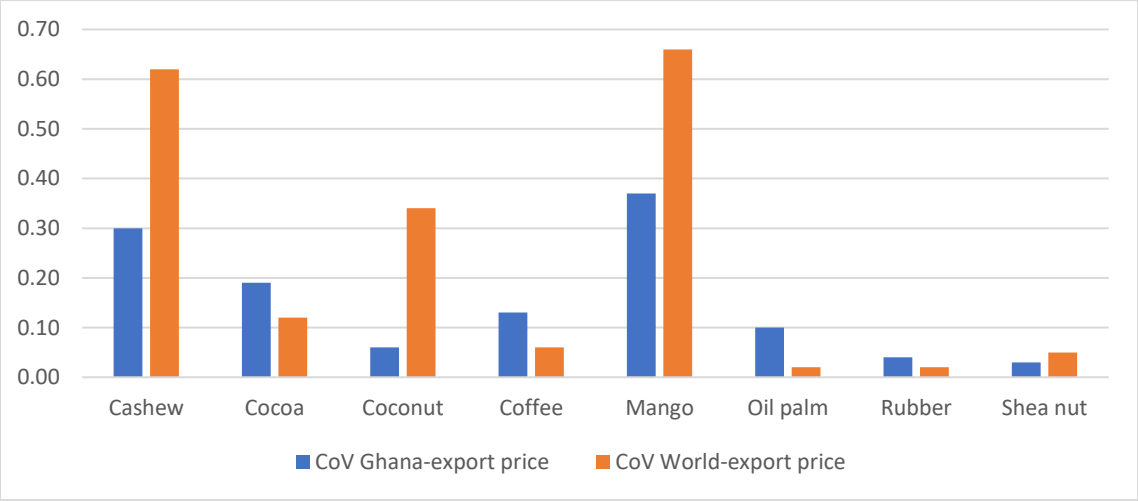
production would decrease carbon dioxide emissions by 0.13% and 0.11% in the short run, while shocks in maize production cause a 31% of change in carbon dioxide emissions.

These studies tend to support the general hypothesis of increased environmental degradation due to agricultural production although it appears important to differentiate short-term and long-term effects as well as to consider the nature of the crops. The brief review above also provides two key insights. First, analyzed studies generally focus on seasonal food crops rather than perennial crops to examine the nexus agricultural production and environmental degradation, often from a food security perspective. It is commonly accepted that agricultural practices leading to increased dependence on agro-chemicals rely more on crop and animal production. This does not mean that perennial crops do not use agro-chemicals. Second, studies do not explicitly consider or identify public financing/investment as the key explanatory variable in investigating the link between agricultural production and environmental degradation. It seems to be implicitly assumed that this public financing even private finance play a role, but by facilitating farmers access to fertilizers to conduct their farming operations. Our interest stems from this gap in the literature to explicitly examine the potential effect of public financing devoted to the agricultural sector on the agricultural performance – agriculture value-added – and carbon dioxide emissions for three perennial crops such as cashew, cocoa and mango in Ghana.

3. Recent development of the targeted agricultural sub-sectors and climate issues in Ghana

The tree crop sector is a sustainable financial provider for the Ghanaian economy, government, and all players involved in these value chains. Until 2010, the Ghanaian government paid more attention to the cocoa sector[3], spending more to reinforce the sector but neglecting other tree crop value chains even with high economic potential (Diao et al., 2019). With continuous volatility in the external value of the country currency, regard is turning to other crops with more potential.

Figure 1: Coefficient of variation of some cash crops and prices in Ghana, 2000–2020

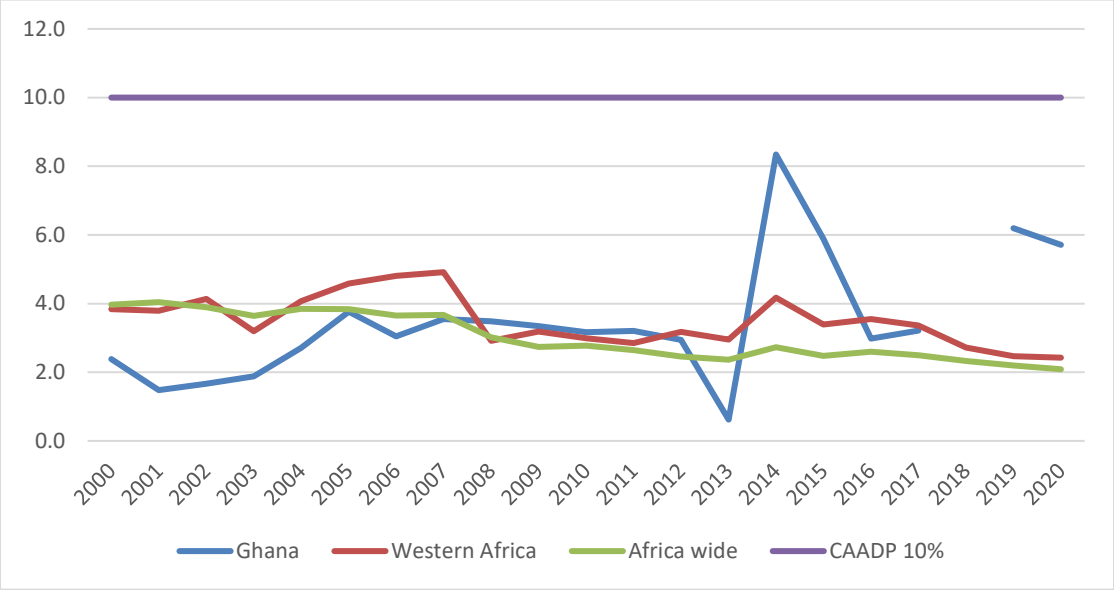


Source: Authors calculation based on FAOSTAT database (Accessed September 2022)

[3] Cocoa is Ghana's second largest exporting commodities in terms of total foreign exchange earnings, after mineral exports. It employs 800,000 farm families and generates about USD 2 billion.

Among these crops, cashew, cocoa and mango, appear to offer opportunities to make more revenues and foreign exchanges. Ghana appears to be influential in cashew and cocoa values chains as the average prices the country receives in the world markets for these commodities are higher than the average world prices on the same international markets. For non-traditional markets, such as the mango, Ghana appears to be more competitive. Ghana mango export price seems to be well above the average world price, although the quantity of mango exported is limited. Moreover, Ghana's cashew and mango export are quite reactive to market signals (price changes) (Figure 1). Respectively, 62% percent and 66% of the variance in exported quantity of cashew and mango are explained by the variance in average world price for these respective commodities. The current challenge is to provide more resources to enhance the production of these tree crops. The Ghanaian government's financial efforts in the agricultural sector have been significant over the last two decades. The trend has been upward since 2000. Overall, government agriculture expenditure has quadrupled from USD 121.2 million in 2000 to USD 549.3 million in 2020, based on constant 2015 USD prices (ReSAKSS, 2021). Although this volume of funding is increasing, the amount of public funding and the share of government spending dedicated to the agricultural sector experienced two main series of decline, in 2013 and in 2016 due to the macroeconomic challenges – cocoa prices falling by about one-third in 2012 and gold prices by more than a third in 2013– by the country, affecting the national budget and the economy in general (Younger, 2016; Diao et al., 2019).

Figure 2. Government agricultural spending (% of total expenditure) in Ghana, 2000-2020



Source: Authors based on ReSAKSS Tracking Indicators (Accessed September 2022)

The share of public spending which stands at 5.7% in 2020 from 2.4% in 1990, is higher than the average of share of West Africa (2.4%) and Africa (2.1%), but well below the CAADP budget allocation commitment of 10% (Figure 2). This is encouraging as the poorest performance was achieved prior to CAADP in Africa. Agricultural sector financing in Ghana is generally oriented towards specific value chains, particularly the cocoa sector, which accounts for the lion's share, and modestly in cashew, palm oil and rubber, which are considered more structured and/or

organized. There is thus room for increased public spending on agriculture in favor of the cashew or mango sectors.

Compared to annual crops, perennial crops increase the soil organic carbon and carbon dioxide (CO_2) storage and reduce carbon emissions to the atmosphere, which helps to mitigate the global warming (Kumar, 2018). Ofori-Frimpong et al. (2010) demonstrated that, regardless of shading conditions, net soil carbon gains are higher on farms with lower cocoa plant density. The results suggested that cocoa planted at low plant density under shade stores more carbon per unit area of soil than an equivalent area of cocoa planted at high density without shade. The conclusion is that cocoa farming could be an effective means to mitigate carbon dioxide emissions in cocoa growing countries. For the cashew sector, Adjei and Alomu (2020) conducted a study to analyze the dual role of cashew production as a tool for adaptation and GHG mitigation in the face of climate change and variability in the forest/savannah agro-ecological transitional zone in Ghana to examine. According to this study, the presence of cashew farming has enhanced mitigation strategies such as reduced tillage, ecosystem preservation, reduced "slash and burn" farming method. Crops produced using no-tillage systems sequestered more carbon than crops established using conservation or conventional tillage practices. These no-till practices slow the decomposition of crop residues and thus reduce emissions and sequester more carbon in the soil. With respect to mango tree crop, the study by Tom-Dery et al. (2015) has determined the amount of carbon sequestered by a mango plantation as well as soil productivity in terms of soil nutrients and other physical properties under mango plantations in Northern Ghana. The study concluded that mango agroecosystems sequester substantial amounts of carbon in addition to providing economic gains, although they contribute little to soil nutrients improvement.

Based on this review, the underlying and inferable hypothesis is that public financing will have a positive impact on agricultural value added and agricultural productivity as well as reducing the impact on carbon dioxide emissions associated with the production of the three tree crops.

4. Empirical Methodology and Data

4.1 Empirical methodology

With a macroeconomic perspective, we investigate the effect of public funding dedicated to the agriculture on the performance of the agriculture sector (Agriculture value added) and the environmental degradation (agriculture CO2 Emissions) regarding cocoa, cashew and mango sub-sectors in Ghana. Our empirical methodology is based on a multivariate econometric model, specifically a VAR (2) under an error correction form which accounts for the long-term (cointegrating) relations among the variables. The VAR models are particularly useful for modeling the dynamic behavior of a vector of variables that are linearly dependent and for studying the impact of economic shocks as well as their transmission channels.

We consider, a vector $Y_t = [Y_{1,t} \quad Y_{2,t} \quad Y_{3,t} \quad Y_{4,t}]'$ of 4 variables including the financing to agriculture $Y_{1,t}$, the log of agriculture performance $Y_{2,t}$ (agriculture value added), the log of GHG Co2 emissions $Y_{3,t}$, and the temperature change $Y_{4,t}$. The VAR(2) representation is

$$\boldsymbol{Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \varepsilon_t} \quad (\mathbf{1})$$

Where A_0 is a 4×1 vector of parameters, A_1 and A_2 are 4×4 matrices of parameters, and ε_t is a 4×1 vector of disturbances. ε_t is assumed to have mean 0, has covariance matrix Σ, and is i.i.d. normal over time. The VAR (2) model can be rewritten in VEC(1) form as:

$$\Delta Y_t = B_0 + B_1 \Delta Y_{t-1} + \Pi Y_{t-1} + \varepsilon_t \quad (2)$$

where $B_0 = A_0$, $B_1 = -A_2$ and $\Pi = \mathrm{A}_1 + A_2 - I$. The matrix Π can be written in the form $\Pi = \alpha\beta'$ where r is the rank of Π and α et β are both matrices of dimension (N, r). The vector α is the speed of convergence towards the long-term equilibrium and β is a matrix whose column vectors consist of the coefficients of the cointegration relations that may exist between the elements of the vector Y_t. If there is no cointegration among variables Y_t, a simple VAR (1) on variables in first difference is estimated. Before the estimation, the Johansen cointegration rank test is used to investigate the number of cointegration relationships in the vector of interest.

For the robustness check, we will use an autoregressive distributed lag (ARDL) model as an alternative error correction model to account for the long-term relationships (cointegration) between public financing and the other variables of interest.

4.2 Data source and descriptive statistics

We use panel data collected over the period 1996-2019 for Ghana. We examine the effect of public and private financing dedicated to the agriculture on the performance of the agriculture sector (Agriculture value added and agricultural productivity) and on the environmental degradation (Agriculture CO2 Emissions, Temperature changes) over the period 1996-2019. First, it examines the effects of government spending on both the agriculture sector performance and the environmental issues. The agriculture performance is measured by two indicators including the growth rate of the agriculture value added and the agriculture productivity (Agriculture value added per hectare of agricultural land). The environmental degradation is measured by the greenhouse gas (GHG) emissions (in terms of CO2 equivalent) from agriculture and annual temperature change (we would like to use Annual change in forest area but series available are not enough).

These data are from different sources including FAOSTAT database and ReSAKSS database. Appendix Table A1 presents the data description and sources. Table 2 and Table A2 (in annex) present summary statistics of the various variables of interest.

Table 2: Summary Statistics, 1996-2019

Variable	Count	Mean	SD	Min	Max
Government agriculture expenditure. 2010 USD, million	24	245,99	182,19	65,25	788,56
Credit to Agriculture, related. 2010 USD, million	23	215,85	83,32	90,35	344,21
Agriculture, value added. 2010 USD, million	24	8152,92	1425,7	5800	10150
Agriculture value added per hectare of agr. land. 2010 USD	24	563,54	83,58	425	687
Cocoa value added. Constant USD	24	564334,46	174336,22	277173	833091
Cashew value added. Constant USD	24	8629,38	6965,7	367	25098
Mango value added. Constant USD	24	9088,04	8687,84	680	21487
Greenhouse gas emission from agriculture (CO2eq)	24	8767,15	1003,55	7307,54	10503,21
Temperature change	24	0,95	0,27	0,48	1,41

Source: Author calculation Based on FAOSTAT and RESAKSS data

5. Empirical Results

5.1 Correlation analysis

We first examine the simple linear (Pearson) correlations, in one hand, between the financing dedicated to agriculture and performances of agriculture sector, and in other hand between the financing dedicated to agriculture and environmental degradation indicators. Table 1 reports these correlation coefficients with significance tests at the usual 10-5-1%level.

Table 3: Pairwise Correlations

Variables	Public financing to agriculture
Agriculture value added	0.672**
Agriculture productivity	0.654**
Cocoa value added	0.672**
Cashew value added	0.677**
Mango value added	0.596**
Agriculture Co2 emissions	0.552*
Temperature change	0.454*

NB: The symbol *, **, and *** stands for significance at 10%, 5%, and 1%.
Source: Author calculation Based on FAOSTAT and RESAKSS data

The correlation table indicates that there is a significant (at 5% level) and positive correlation between public financing dedicated to agriculture and agriculture performance indicators (Agriculture value added and agriculture productivity), as expected. At the same time, there is a positive and weakly significant correlation between public financing and temperature change as well as Co2 emissions caused by agriculture activities. Moreover, there is a positive and weakly significant correlation between public financing dedicated to agriculture and value added in cocoa, cashew, and mango value chains.

5.2 Estimation results

To estimate the model (1), we first determine the integration order of each of the variable of invest by conducting unit root tests, in particular the Augmented Dickey Fuller (ADF) and Phillips-Perron tests. The null hypothesis of both tests is that the variable is non-stationary. The results indicate that all our variables are non-stationary and integrated at order 1, i.e. I(1). The second step is to test if there exists a long run relationship among variables. We examine the dynamic marginal effects (the Impulse Response functions) of shocks to public financing dedicated to agriculture on the performance of each of the sub-sector in agriculture (cocoa, cashew and mango) of agriculture and on Co2 emissions and temperature changes.

5.2.1. Impact of public financing to agriculture on agricultural value-added and productivity

Tables 4 below shows the impacts (up to 5 years ahead) of a 10% initial increase in government agriculture expenditure on performance in agriculture sector and on environmental degradation indicators over the period 2000-2019. As indicated in Table 4, a 10% increase in public financing is associated to 0.42% increase agriculture value added (Step 0) and the effect over 5 years ahead is between 0.25% and 0.43%. A 10% initial increase in government agriculture expenditure leads to increase in temperature change of 0.009 to 0.024 degree Celsius. While the effect on CO2 emissions is sometimes positive sometimes negative (the effect in terms of relative change of CO2 emission is between -0.09% and 0.04%).

Table 4: Impulse response functions of a 10% increase in public financing to Agriculture

Step	Effect on agriculture value added			
	Public financing	**Agriculture value added**	**Agriculture CO2 Emissions**	**Temperature changes**
0	10.00	0.42	-0.09	0.009
1	0.07	0.31	0.18	0.025
2	1.85	0.25	-0.07	0.024
3	4.53	0.43	0.00	0.020
4	3.47	0.48	-0.04	0.020
5	3.00	0.43	0.04	0.024

The shock is normalized to have a 10% increase in financing upon the impact.
Source: Author calculation Based on FAOSTAT and RESAKSS data

5.2.2. Impact of public financing to Agriculture on cocoa, cashew and mango value-added

We now conduct the same type of analysis on the value added in each of the tree crops value chains. The results indicate that the impacts of public financing dedicated to agriculture on the performance of Cocoa, Cashew, and Mango are positive over the 5 years ahead. As indicated in Table 5, a 10% increase in public financing is associated with 0.97% increase in cashew value added (Step 0) and the effect over 5 years ahead is between 2.07% and 4.02%. The effect on CO2 emissions is sometimes positive sometimes negative. This means a negative impact (decline) of 0.08% in cashew CO2 emissions in step 0 and an increase ranging from 0.37% (step 1) to 0.24% (step 5). The 10% initial increase in government agricultural expenditure leads to an increase in temperature changes of 0.013 to 0.029 degree Celsius due to activities in the cashew subsector.

With respect to cocoa, a 10% increase in government agricultural expenditures is associated with 0.57% increase in cocoa value added (step 0), which reaches 0.81% (step 4) and 0.60 (step 5). The impact on carbon dioxide emissions varies between a decline of 0.10% (step 0) and an increase of 0.29% (step 1) and 0.12% (step 5). The effects on temperature changes appear positive over 5 years (5 steps).

Table 5: Impulse response functions of a 10% increase in public financing to Agriculture

	Effect on cashew value-added				Effect on cocoa value-added				Effect on mango value-added			
Step	Public financing	Cashew value added	Agriculture CO2 Emissions	Temperature changes	Public financing	Cocoa value added	Agriculture CO2 Emissions	Temperature changes	Public financing	Mango value added	Agriculture CO2 Emissions	Temperature changes
0	10.00	0.97	-0.08	0.013	10.00	0.57	-0.10	0.014	10.00	0.30	-0.22	0.004
1	-0.76	2.07	0.37	0.029	-0.84	0.34	0.29	0.031	-0.48	0.63	-0.05	0.019
2	0.87	4.02	0.08	0.023	1.91	0.48	0.02	0.026	-0.12	0.13	-0.27	0.020
3	5.20	3.41	0.27	0.017	6.13	0.62	0.15	0.021	4.47	0.27	-0.03	0.017
4	4.26	2.87	0.17	0.015	2.89	0.81	0.10	0.022	2.15	0.22	-0.12	0.014
5	1.92	2.95	0.24	0.022	2.22	0.60	0.12	0.026	1.11	0.31	-0.11	0.016

Source: Author calculation Based on FAOSTAT and RESAKSS data

A 10% growth in public spending on agriculture implies an increase in mango value added from 0.30% (step 1), 0.63% (step 2), to 0.31% (step 5). However, its effects are negative in terms of carbon dioxide emissions and moderate on temperature changes over the 5 years. This result is consistent with Tom-Dery et al. (2015) who show that mango agroecosystems sequester substantial amounts of carbon in addition to providing economic gains in Northern Ghana.

Overall, we can notice that the effect of an increase in government agricultural expenditures on cashew value added is higher compared to the two other tree crops. It is followed by cocoa sector and mango. On the other hand, mango appears to be the most climate-friendly crop compared to cocoa and cashew respectively. The results tend to suggest that public financing is associated with a growth in agricultural value added that leads to an improved environment for the mango sector while showing a mixed or even negative effect on climate degradation over the five years for cocoa and cashew tree crops. This echoes Jevon's paradox suggesting that agricultural productivity is likely to increase agriculture's profitability, which then encourages the expansion of cropland, causing deforestation and environmental degradation (Ceddia et al., 2013; Villori, 2019). As well, our result partly confirms those of Alhassan (2021) concerning the U-shaped linkage between productivity and environmental deterioration. He indicated that agricultural productivity primarily reduces carbon dioxide emissions up to a certain point, beyond which higher agricultural productivity increases carbon dioxide emissions.

5.3. Robustness analysis: The ARDL as an alternative econometrics model

For robustness check, we use the autoregressive distributed lag (ARDL) model as an alternative error correction model which accounts for the long-term (cointegrating) relations among two variables. It is employed to model the relationship between variables in a single-equation time series setup (instead of multi-equations set up as in VECM). The ARDL model has the advantage to be suitable for small data and a mixture of series that are I(0) or I(1). Let's consider the ARDL(p,q)

$$\Delta \boldsymbol{Y_t} = \boldsymbol{c_0} + \boldsymbol{\alpha}(\boldsymbol{Y_{t-1}} - \boldsymbol{\theta X_{t-1}}) + \sum_{\boldsymbol{i=1}}^{\boldsymbol{p}} \boldsymbol{\phi_i} \Delta \boldsymbol{Y_{t-i}} + \sum_{\boldsymbol{j=0}}^{\boldsymbol{q}} \boldsymbol{\psi_j} \Delta \boldsymbol{X_{t-j}} + + \boldsymbol{\varepsilon_t}$$

X_t is the financing dedicated to agriculture and Y_t is each of the impact variables: the agriculture performance (agriculture value added), the GHG Co2 emissions, and the temperature change. To examine the long-run effect of government expenditure dedicated to agriculture on each of the impact variables, we look at the parameter θ and associated p values for each impact (dependent) variable.

As per the results, the long run coefficient of public expenditure is positive and significant (p-value>0.1). That means government financing has a long run positive effect on agricultural performance. For example, a 1% increase in public expenditure on agriculture leads in the long run to 0.05% increase in agricultural value added as well as in agriculture productivity. However, this implies a statistically non-significant long-run increase of 0.062% in agricultural greenhouse gas emissions and a statistically non-significant decline of 0.002% in temperature change.

For the three tree crops value chains, a 1% increase in public financing translates to a long run increase of 0.147% in cocoa value added, and a non-significant positive increase of 0.221% in cashew nuts value added and a non-significant decline of 0.117% in mango value added.

Table 6: Impact of public financing dedicated to agriculture in Ghana over 1996-2019

		Y = Log(Agricultural, value added (constant 2010 USD, million))	Y = Log(Agricultural value added per hectare of agricultural land (constant 2010 USD))	Y = Log(Cocoa value added. Constant USD)	Y = Log(Cashew value added. Constant USD)	Y = Log(Mango value added. Constant USD)	Y = Log(Greenhouse gas emission from agriculture (CO2eq)"	Y = Log(Temperature change"
ADJ								
	L.Y	-0.733***	-0.743***	-0.693***	-0.131	-0.404***	-0.675**	-0.828***
		(0.168)	(0.177)	(0.176)	(0.174)	(0.102)	(0.253)	(0.260)
LR								
	X	**0.054***	**0.046***	**0.147****	**0.221**	**-0.117**	**0.062**	**-0.002**
		(0.025)	(0.025)	(0.069)	(0.740)	(0.479)	(0.076)	(0.130)
	Z1	**0.334***	**0.146**	**-0.401**	**-0.782**	**1.322**	**0.147**	**-0.552**
		(0.170)	(0.147)	(0.439)	(4.281)	(1.760)	(0.248)	(0.671)
	Z2	**0.133*****	**0.112*****	**0.293*****	**0.845**	**1.955*****	**0.072**	**0.168**
		(0.027)	(0.025)	(0.061)	(0.663)	(0.384)	(0.058)	(0.108)
SR								
	LD.Y	0.585**	0.682***	0.269		0.300*		
		(0.196)	(0.180)	(0.172)		(0.161)		
	D.X					-0.207	-0.058	
						(0.136)	(0.034)	
	D.Z1	-0.372***	-0.311**			-1.911**		
		(0.110)	(0.107)			(0.762)		
	LD.Z1	-0.175						
		(0.124)						
	D.Z2	-0.068**	-0.062**			-0.945***	-0.135**	
		(0.024)	(0.023)			(0.236)	(0.046)	
	LD.Z2					-0.791***	-0.078*	
						(0.199)	(0.042)	
	_cons	6.148***	4.315***	8.125***	0.828	1.861**	5.802**	0.466
		(1.396)	(1.021)	(2.066)	(0.972)	(0.841)	(2.231)	(0.455)

Observations	21	21	21	21	21	21	21
R-square	0.63	0.60	0.45	-0.20	0.50	0.46	0.29
AIC	-66.71	-66.11	-26.34	1.74	11.42	-46.03	4.39
BIC	-57.31	-57.75	-20.07	6.96	21.87	-37.67	9.61
P-value of F for I(0) variables	0.02	0.03	0.02	0.98	0.05	0.28	0.11
P-value of t for I(0) variables	0.00	0.01	0.01	0.77	0.01	0.08	0.04
P-value of F for I(1) variables	0.05	0.08	0.06	1.00	0.14	0.52	0.26
P-value of t for I(1) variables	0.03	0.04	0.05	0.90	0.05	0.27	0.15
P-value for no-autocorr test at order 1	0.69	0.71	0.61	0.62	0.96	0.98	0.86
P-value for no-autocorr test at order 2	0.30	0.51	0.76	0.73	0.61	0.85	0.86
P-value for no-autocorr test at order 3	0.35	0.41	0.87	0.86	0.73	0.86	0.90

Notes: *** (**) (*) denotes significance at the 1 (5) (10) percent level.

6. Conclusion and policy implications

This paper examined the effects of public funding dedicated to agriculture on agricultural performance and environmental degradation in Ghana over the period 2000-2019, both at the national level and at the level of the three tree crops, namely cashew, cocoa and mango sub-sectors. The empirical methodology initially used is based on a multivariate econometric approach, in particular a VAR model in a form of error correction that considers the long-term relationships, using impulse-response functions. Then, the autoregressive distributed lag (ARDL) model was mobilized to perform the robustness analysis.

The results from the impulse-response functions indicate that public financing significantly improves agricultural performance for all the three crops (cashew, cocoa and mango) but with mixed impacts on environmental quality. It helps improve agricultural performance by increasing agricultural value added and agricultural productivity. However, this support tends to have a negative impact in terms of increasing CO2 emissions particularly for cocoa and cashew while mango emerges as the most climate-friendly crop.

The policy implications suggest that the increase in support to the agricultural sector is highly commendable and should be strengthened for the three trees crops, but policymakers should consider the potential negative impact of the financing on carbon dioxide emissions. To this end, while for mango a few non-financial measures seem necessary, for cocoa and cashew, substantial non-financial resources are required to make these crops more climate or environmentally sensitive, through incentives and awareness. This means encouraging use of innovative tools on farms, including climate smart agriculture methods to make these crops less degrading for the quality of the environment in Ghana.

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Appendix

Table A.1. Data description and source

Indicators	Variable description	Source
Financing dedicated to agriculture	Government agriculture expenditure (constant 2010 USD, million)	RESAKSS
	Credit to Agriculture, Forestry and Fishing (constant 2010 USD, million)	FAOSTAT
Indicators of agriculture performance	Agriculture, value added (constant 2010 USD, million)	RESAKSS
	Agriculture value added per hectare of agricultural land (constant 2010 USD)	RESAKSS
	Cocoa value added. Constant USD	FAOSTAT
	Cashew value added. Constant USD	FAOSTAT
	Mango value added. Constant USD	FAOSTAT
Indicators of Environmental degradation	Greenhouse gas emission from agriculture (CO2eq)	FAOSTAT
	Temperature change	FAOSTAT

Table A.2. Summary Statistics, growth rate (%) averaged over 1996-2019

Variable	Count	Mean	SD	Min	Max
Annual growth rate: Government agriculture expenditure. 2010 USD	23	55,36	233,15	-80,32	1108,56
Annual growth rate: Credit to Agriculture, Forestry and Fishing. 2010 USD	22	7,28	16,73	-6,16	66,58
Annual growth rate: Agriculture, value added. 2010 USD	23	2,45	6,76	-17,84	17,56
Annual growth rate: Agriculture value added per hectare of agricultural land. 2010 USD	23	1,98	6,78	-18,27	16,73
Annual growth rate: Cocoa value added, Constant USD	23	4,43	17,93	-19,98	48,29
Annual growth rate: Cashew value added, Constant USD	23	30,98	84,13	-32,02	400,27
Annual growth rate: Mango value added, Constant USD	23	28,23	96,14	-17,97	458,92
Annual growth rate: Greenhouse gas emission from agriculture (CO2eq)	23	1,81	9,39	-13,48	25,08

Source: Author calculation Based on FAOSTAT and RESAKSS data