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Addressing Sustainability Strategies and Agricultural Productivity: Farmers Based Evidence in Tubah Sub-Division North West Region, Cameroon

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Abstract

Agriculture has become the backbone of most developing countries in the world, especially Tubah Sub-Division North West region, Cameroon. Following the COVID-19 pandemic and socio-political crisis that hit Cameroon's economy, there has been a steady increase in food insecurity, which has paved the way for farmers to adopt some sustainable strategies to boost agricultural productivity. Therefore, in trying to find models for survival and the pursuit of growth, farmers adopted some traditional farming methods and the use of local input as a means of sustainability. This study specifically seeks to analyze the effect of sustainability strategies on agricultural productivity in Tubah subdivision North West Region, Cameroon. The data was elicited via a survey questionnaire administered to 202 participating farmers selected from the different farmer organizations in the Tubah sub-division. Using cluster-sampling approach, proximity villages were grouped into four clusters of villages, and stratified sampling was used to select farmers to participate in the study. The objective of the study was achieved using OLS and quantile regression estimation techniques. The result showed evidence that the sustainability strategies implemented by the farmers decreased agricultural productivity in the 25th quantile, and at the 50th and 75th quantile, agricultural productivity still declined. This decline is because of unsustainable agricultural strategies like the use of slash and burn, the use of chemical fertilizers, inadequate capital, low level of education, inadequate farming experience, inadequate income, inadequate farm size, and the type of technology used for farming. Based on the findings, this study recommends that the government should organize training programs and seminars, subsidize farm inputs, grant agricultural loans to farmers, and initiate and support mechanized agriculture to boost agricultural productivity.

Keywords

Agricultural Productivity, Sustainability Strategies, Quantile Regression

1. Introduction

Agriculture is the main employment sector for the poor, employing 76.3% of the extreme and 60.7% of the moderate poor [1]. Most of this group tends to be subsistence or semi-subsistence oriented and faces significant barriers to entering higher value agricultural activities. The agrarian population in Cameroon is essentially small-scale peasant farmers and their family members, who make up about 70% of the agricultural population. In the face of an increasing population and settlement, the use of farm inputs that are not environmentally sustainable, and wide-scale agricultural and forestland use changes, food crop production trends seem to be uncertain or rather stagnant as studies report that projected/expected needed crop production is often actual production [2]. Argued that, between 1975 and 2005, there were 20 years during which actual cereal production in Cameroon was persistently below projected/expected needed cereal production level. Epule *et al.* (2012) verified the vulnerability of experiencing food shortages along gender and poverty lines. Many past studies have argued that, as in most sub-Saharan African countries, Cameroon is currently experiencing declines or stagnation in food production at the national scale, which could be attributed to its socio-economic characteristics [2]. Agricultural adaptation requires consideration of both human and physiographic challenges that are responsible in specific contexts [3] to verify the role of land management practices and the socio-cultural properties of small-scale farmers in establishing differences in crop yields. Access to food is a basic need for human beings; however, many poor people do not have physical and economic access to sufficient, safe, and nutritious food [4]. There are many factors that account for this condition of food security, such as loss of job, lower level of education and employment, lack of access to land, single-parent families, unstable income level, and having a poor family head. All these factors lead to poverty, and the fundamental outcome is inadequate access to food [5].

In Cameroon, agriculture remains the backbone of the economy, employing up to 70% of the labor force and generating about 42% of gross domestic product (GDP) and 30% of export earnings [6]. Agriculture also provided 22.7% of value added in 2014, and an estimated 36.6% of the population is employed in agriculture [7]. Cameroon has great agricultural potential due to its geographic location, which provides an ideal climate for growing cash crops and food crops [8]. Despite this potential, the country continues to spend heavily on food imports. In 2011, the Treasury Department estimated that the government spent nearly FCFA 500 billion (about US$1 billion) on importing foodstuffs such as flour, rice, millet, sorghum, and fish. Therefore, the government needs to address the problems of the agricultural growth sector as it contributes enormously to poverty reduction

[9]. The lack of farmer contributions to agricultural production in Cameroon, as in most developing countries, has prompted farmers to seek different options to ensure household food security and maximize farm income. Therefore, in trying to find models for survival and the pursuit of growth, farmers draw their resources from all available places through both formal and informal systems [10]. One way for farmers to increase agricultural production and improve their welfare is to pool and pool their resources to work together as members of Farmer Organizations (FO). FO is defined as "a collective unit of farmers from a village or several neighboring villages, united towards common goals related to economic or social benefits related to agricultural activity" [11].

Every day, agriculture produces an average of 23.7 million tons of food, provides livelihoods for 2.5 billion people, and is the largest source of income and jobs for poor and rural households. In developing countries, agriculture accounts for 29% of GDP and 65% of jobs [12]). In addition, there has been an increase in food insecurity, which has been a major problem for farmers' livelihood in Tubah-sub-division. The prolonged COVID-19 pandemic has delayed the transportation of seeds and fertilizers and thus slowed down the global agricultural process. This affected the productivity of major food crops such as wheat, rice, and vegetables, because agricultural inputs could not be distributed promptly [10]. According to the recent results of the Cadre Harmonisé (2023), 10.6% of people are facing acute food insecurity in Cameroon, which represents 2,940,807 persons [13]. In addition, the mid-year update for the 2023 Global Report against food crises reveals that 22% and 10% of the population are respectively, in phases 2 and 3 of acute food insecurity in 2023. This represents a significant increase in food insecurity, given that in 2022, only 11% of the population was in phase 2, and 10% in 2021 [14].

Moreover, Low agricultural output has been observed by farmers in Tubah Sub-Division as some of the farmers had to implement some traditional farming methods with the use of local farming inputs such as manure, compost, and traditional seeds such as sorghum, asparagus due to increasing prices and shortages in suppliers of farm inputs which resulted to low agricultural productivity. According to the World Bank (2023), agricultural productivity dropped from 4.02% in 2022 to 2.2% in 2023 [7]. This was due to an increase in farm prices, and shortage of supplies of farm inputs such as fertilizer, pesticides, seeds, weaned animals, and feed coupled with the socio-economic crises in Tubah sub-division during COVID-19 pandemic. Many of these farmers, who belong to organizations like the Bambui farmers cooperatives, whose main farming activities are to cultivate cash crops, do not have access to pesticides and seeds. This is often accompanied by poor farming methods as slash and burn, which greatly reduces the productivity of farm produce in the long-run, hence reducing output. Farm inputs such as chemical fertilizers and insecticides, which could help farmers, improve yields are difficult to acquire by most farmers as their prices continue to increase because of shortages, and flight restrictions impose this increase in prices. In Cameroon, a fall in consumption combined with interruptions to production disrupted global supply chains affecting agricultural industries across Cameroon [15]. The COVID-19 pandemic outbreak in Mezam has caused a lot of businesses to shut down, leading to a monumental disruption of trade and commerce in many agricultural sectors. Farmers and retailers face many short-term challenges relating to workforce, health and safety, cash flow, supply chain, consumer demand, sales, and marketing. Many markets, especially, no longer exist because of these shortages and price increases. As a major effect of COVID-19, the global food prices have linearly increased since February 2020. According to the FAO Food Price Index (FFPI), the international price of food commodities reached the highest level of 97.19 points in September [12]. The value increased by 5% since last year and was the highest between September and February. Similarly, a significant rise was seen in the price index of cereals and vegetable oils for four consecutive months. This was mainly due to the greater shelf life of food commodities [12].

Purpose of the Study

The Main Objective of the Study is to:

❖ Analyze the effect of sustainability strategies on agricultural productivity in Tubah sub-division North West Region, Cameroon.

The Main Research Question is to:

❖ What is the effect of sustainability strategies on agricultural productivity in Tubah sub-division North West Region, Cameroon?

2. Literature Review

2.1. Conceptual Review of Sustainability Strategies

Sustainability strategies are plans and actions taken by farmers to improve and increase agricultural productivity [16]. These strategies aim to balance economic, social, and environmental considerations to ensure a sustainable future. Sustainability strategies refer to the ability of farmers to meet the needs of the present without compromising the ability of future generations to meet their own needs [17]. It involves the responsible management of resources, adoption of environmentally friendly practices, and the maintenance of the economic viability of farming operations. By embracing sustainability, farmers aim to strike a balance between agricultural production, environmental preservation, and social well-being. Sustainable agriculture is the ability of a farm to produce unlimited amounts of food without seriously or irreparably damaging the health of the ecosystem. The two key issues are biophysical (the long-term effects of different practices on soil properties and processes critical to crop productivity) and socio-economic (farmers' long-term ability to procure and manage resources such as labor [17]. Farmers employ a range of sustainability strategies to minimize their environmental impact while maximizing productivity. These strategies encompass various aspects of farming, including soil management, water conservation, pest and disease control, nutrient management, biodiversity conservation, energy efficiency, waste management, and social responsibility [18]. Farmers practice conservation tillage, crop rotation, and cover cropping to maintain soil health and fertility. They adopt irrigation efficiency techniques, rainwater harvesting, and drip irrigation systems to conserve water resources. Integrated Pest Management (IPM), biological control methods, and crop rotation for pest control are employed to minimize the use of pesticides. Precision fertilization, nutrient cycling, composting, and the use of organic fertilizers ensure efficient nutrient management. Biodiversity conservation efforts include creating wildlife habitats, planting native species, conserving pollinators, and preserving natural areas. Energy efficiency is achieved through the use of renewable energy sources, energy-efficient equipment, and energy-saving practices. Waste management strategies involve recycling and composting farm waste, proper disposal of hazardous materials, reduction of packaging waste, and implementation of waste reduction strategies. Lastly, social responsibility is demonstrated through fair labor practices, community engagement initiatives, support for local economies, and education and outreach programs. These strategies collectively form the foundation of farmers' sustainability practices [19]. Sustainable agriculture encompasses the three main goals of environmental health, economic viability, and social and economic equity. Various philosophies, policies and practices have contributed to the achievement of these goals.

The assessment of sustainability strategies in agriculture involves the consideration of several environmental variables that impact the sustainability of agricultural practices. These variables include soil erosion, water quality, biodiversity, and climate change, which are affected by factors such as land use, soil type, conservation practices, and agricultural technologies. For instance, soil erosion can be reduced through the adoption of conservation tillage and cover cropping, while water quality can be improved through the use of integrated pest management practices. Socio-economic variables are also crucial in assessing the sustainability of agricultural practices. These variables comprise farm income, food security, rural employment, and social equity, which are influenced by factors such as crop yields, market prices, production costs, and access to credit and markets. For example, farm income can be improved through the adoption of high-value crops and value-added products, while food security can be enhanced through the promotion of home gardens and community-supported agriculture programs. Institutional and technological variables also play a significant role in determining the sustainability of agricultural practices. Institutional variables include policy and regulatory frameworks, institutional capacity, market access, and community participation, which shape the adoption and implementation of sustainable agriculture practices. Technological variables comprise agricultural technology, irrigation systems, soil conservation techniques, and organic amendments, which can improve the efficiency and sustainability of agricultural practices. For instance, the use of precision agriculture and biotechnology can improve crop yields and reduce the environmental impact of agricultural practices (**Figure 1**).

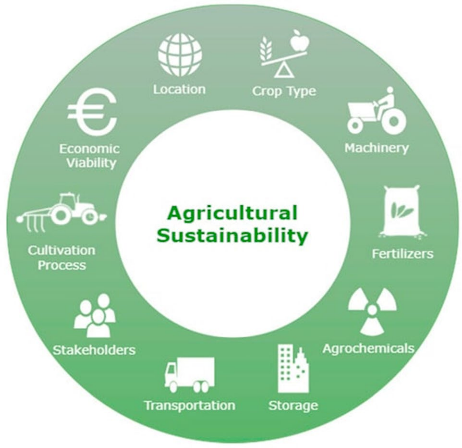

Figure 1. Variables involved in sustainability strategies assessment. Source: Adopted by [18].

Practices that can cause long-term damage to soil include excessive tillage (leading to erosion) and irrigation without adequate drainage (leading to accumulation of salt in the soil). Long-term experiments provide some of the best data on how various practices affect soil properties essential to sustainability [20]. It is for these arguments that this study seeks to analyze the effect of sustainability strategy on agricultural productivity in Tubah sub-division, the North West region of Cameroon. This paper is divided into five sections: introduction, literature review, methodology, results, and conclusions.

2.2. Review Empirical Literature on the Link between Sustainability Strategies and Agricultural Productivity

Apata (2021) examined the impact of government spending sustainable strategy on agricultural productivity in key agroecological regions of Nigeria (1981-2018). Agricultural productivity returns were analyzed using public financial data from the agricultural and non-agricultural sectors across the country [21]. Government spending on agricultural growth drivers such as education, agricultural access roads and health facilities and their impact on agricultural productivity were also examined. The data were analyzed in three steps using descriptive statistics and simultaneous equations. The results of the descriptive statistical analysis showed that the ratio of government spending on agriculture to total government spending was 4 on average 0.013. All of these variables were significant at the 1% level. These results suggest that a 1% increase in funding for education, farm access roads, and health facilities would increase agricultural productivity per capita by 0.043. Thus, the results gave an estimated cost-effectiveness ratio of 4.3:1. As a result, government spending on education, farm access roads, and health facilities by 4.3% would increase agricultural productivity by 1%. However, the edge effects and the assessed yields are different for the four agroecological regions. Thus, harmonization coupled with high-quality public spending on access to health care, education and access roads to agriculture would increase agricultural productivity.

Muindi *et al.*'s (2016) study was to determine the impact of the Agricultural Sector Development Strategy (ASDS) on agricultural productivity in Kenya, with a focus on Tana River County. The specific objectives of the study are to assess the impact of climate change responses on agricultural productivity and the impact of agribusiness on agricultural productivity. Assessing the impact of agricultural extension services on agricultural productivity and examining the impact of access to agricultural credit on agricultural productivity. The study will provide managers and decision makers in agriculture and possibly other sectors with an overview of the impact of agricultural sector development strategies on agricultural productivity, general strategic planning in the public sector and possible solutions. It will also help the Tana River County Sector to find out if there are any concrete results from the implementation of the County's Agricultural Sector Development Strategy. Farmers in Tana River County and beyond are likely to benefit from the study as it can identify gaps in the industry and help fill them or prompt government action. It will also be a useful reference for any researcher who wishes to conduct research related to this study, to help them generate new ideas or develop problems that may not have been addressed in these studies. The study examines the resource-based approach and systems theory and shows how they relate to these studies. A descriptive survey design was used in this study as it is an efficient method of data collection and covers a large and small population survey. His target was sixty-eight (68) agricultural engineers in Tana River County. The census was taken because the population was small. The study used open and closed questionnaires in the drop-and-drop procedure to collect data. To increase validity, a pilot study was conducted in which the questionnaires were randomly distributed to seven (7) selected respondents in the Tana River sub-district, representing 10% of all respondents. It was further refined by making the necessary corrections to the questionnaire based on the results of the pilot study. In this study, instruments were tested for reliability using Cronbach's Alpha, with a value of 0.7 and higher being considered acceptable. Quantitative and qualitative data were analyzed using descriptive statistics and inference and presented in tables and graphs. A multiple regression model was used to determine the influence of the independent variable on the dependent variable. The study concluded that climate change response, agribusiness, farm extension services and access to farm finance have a positive and significant impact on farm productivity. Based on the research, the study recommends that Tana River County implement agricultural extension services by providing enough labor force in the county to regularly build capacity to improve agricultural productivity in the county [22].

3. Material and Methods

The data used in this study were obtained from the survey questionnaire administered to the sample of 202 farmers belonging to FO's, which comprises common initiative groups and cooperatives. A stratified random sampling method was used to select only participating farmers who belong to a farmer organization. This method was chosen to avoid bias estimates and the problem of simultaneity. The targeted population of the study was divided into strata (Table 1). Firstly, out of the seven Divisions, Mezam Division was chosen because it has the highest number of farmer organisations, which are divided into two: CIGs and cooperatives. These two groups were later categorized into registered farmer organisations and unregistered farmer producer organisations to select individual participating farmers to represent each strata.

Table 1. Distribution of selected Farmers in Tubah sub-division.

FOs	Registered FOs		Unregistered FOs		Total
Villages	CIGs	Cooperatives	CIGs	Cooperatives	
Bambui	42	5	13	18	78
Bambili	23	2	13	4	42
Kedjom Ketinguh	20	2	12	8	42
Kedjom Keku	19	1	14	6	40
Total	104	10	52	36	**202**

Source: ACEFA Mezam Division, 2023.

It is important to note that it is not possible to study the entire population as a result of time constraints and limited resources available for the effective handling of the study. Therefore, only a portion of the population is studied. The opinions and views sampled (a part of population on which the study is focused) from participating farmers in each farmer of the organizations. To ensure the determination of accurate sample size, a sample size of 202 farmers selected from the different farmers organizations.

Model Specification

Objective three assess the effect of sustainability strategies on agricultural productivity in Tubah Sub-Division Northwest Region Cameroon

Olayide *et al.* (2015) analyzed the policy correlations between agricultural production and sustainable development of agricultural production in Ghana and Nigeria. Emphasizes the influence of political systems and international development programs as correlates of agricultural production and sustainable agricultural production outcomes. This objective follows the argument of reasoning of [23]. Table 2 summarises the indicators of Sustainability Strategies.

Table 2. Indicators of sustainability strategies.

Item	Indicator
Diversification of crops and cultural practices to enhance the economic stability of the farm	S001_1
The use of organic fertilizer was implemented	S002_1
Increase use of traditional seeds to boost productivity	S003_1
Usage of local farming tools, manure, compost and traditional seeds	S004_1
Recycling crop waste and livestock or human manure	S005_1

Continued

Slash and burn farming was implemented due to shortages of farm inputs	S006_1
Cultivation of a sequence of crops on the same land (crop rotation)	S007_1
Concurrent cultivation of more than one crop species on the same field (Intercropping)	S008_1
Cultivation of crops that are grown to cover the ground for reducing soil erosion and nutrient loss (Cover cropping)	S009_1
Increased in the prices of farm products due to shortages in farm inputs	S010_1
Farmers develop buffer stock to sell at higher prices in times of shortages	S011_1

Source: Computed by Author (2023).

The dependent variable is agricultural productivity, while the independent variable is sustainable strategies and other covariates.

The model is specified as follows.

$$\begin{aligned} APq = \vartheta_0 + \alpha_1 SS + \alpha_2 AGP + \alpha_3 farm_e xp + + \alpha_4 INC + \alpha_5 PEDU \\ + \alpha_6 SEDU + \alpha_7 TEDU + \alpha_8 Female + \alpha_9 Married + \alpha_{10} Member + \varepsilon_1 \end{aligned} \quad (1)$$

Equation (1) shows the relationship between sustainability Strategies (*SS*) and agricultural productivity (*AP*). The parameter α_1 measures the contribution of sustainable strategies on agriculture productivity at different quantile (*q*). The magnitude can either be positive or negative. AGP stands for the various age groups and its effect on agriculture productivity at different quantile is captured by the coefficient α_2. The associated covariate uses as control exogenous variables are summarized on Table 3.

Table 3. Description of variables.

Variable	Code	Description
Dependent variable	---	--
Agriculture productivity	Nor sa	Continuous
Exogenous variables	---	--
Age group (1 = Age less than 20 years, 0 otherwise)	Age l20	Binary
Age group (1 = Age 20 years to less than 30 years, 0 otherwise)	Age 20 l30	Binary
Age group (1 = Age 30 years to less than 40 years, 0 otherwise)	Age 30 l40	Binary
Age group (1 = Age 40 years to less than 50 years, 0 otherwise)	Age 40 l50	Binary
Age group (1 = Age 50 years to less than 60 years, 0 otherwise)	Age 50 l60	Binary
Age group (1 = Age 60 years and above, 0 otherwise)	Age a60	Binary
Gender (1 = female, 0 otherwise)	Female	Binary
Marital status (1 = married, 0 otherwise)	Married	Binary
Education (1 = primary education, 0 otherwise)	Pedu	Binary
Education (1 = secondary education, 0 otherwise)	Sedu	Binary
Education (1 = primary education, 0 otherwise)	Tedu	Binary
Farm experience (1 = 1 to less than 3 years, 0 otherwise)	Farm exp1 l3 years	Binary

Continued

Farm experience (1 = 3 to less than 6 years, 0 otherwise)	Farm exp3 l6 years	Binary
Farm experience (1 = 6 to less than 9 years, 0 otherwise)	Farm exp6 l9 years	Binary
Farm experience (1 = 9 years and above, 0 otherwise)	Farm exp a9 years	Binary
Types of farmers organizations		
Membership (1 = belong if member of CIG, 0 otherwise)	CIG's	Binary
Membership (1 = belong if member of farmers'cooperative, 0 otherwise)	Cooperative	Binary
Membership (1 = belong if member of farmers association, 0 otherwise)	Association	Binary
Income groups (In thousands francs CFA)		
Income (1 = if income group is between 100 to 200 francs)	inc 100 200 frs	Binary
Income (1 = if income group is 201 to 400 francs)	inc 201 400 frs	Binary
Income (1 = if income group is 401 to 600 francs)	inc 401 600 frs	Binary
Income (1 = income group is 601 1000 francs)	inc 601 1000 frs	Binary

Source: Computed by Author (2023).

4. Results and Discussion

Drivers of Agricultural Productivity

	Frequency	%
	Farm hectares	
<1 hectare	182	91.9
1 - 3	10	5.1
4 - 7	6	3.0
Total	198	100.0
	Income levels of the farmers	
100,000 - 200,000	105	53
201,000 - 400,000	60	30.4
401,000 - 600,000	25	12.6
601,000 - 1,000,000	5	2.5
>1,000,000	3	1.5
Total	198	100.0
	Type of technology used	
Capital intensive	18	9.09
Labour intensive	136	68.6
Both labour and capital	44	22.2
Total	198	100.0
	Major crop cultivated	
Cash crop	167	84.3
Food crop	31	15.7
Total	**198**	100.0

The majority of the farmers had farm size of less than one hectare of land. Obinyan (2000) described the implication of small farm sizes for rural farmers, thus leading to low income and low capital investment [24]. With respect to the income of the farmers, 53% of the farmers earn an annual income of 100,000 FRS - 200,000 FRS and between 201,000 FRS - 400,000 FRS respectively. This translates to average of 12,500 FRS and 25,042 FRS monthly income respectively. Cash crop is the major food production. This accounts for 84.3% of the responses

Table 4 shows a summary of descriptive statistics for socio-economic characteristics of farmers, the observations, mean, standard deviation, maximum, and minimum values. The total distributed questionnaires were 202; among this number, only 198 were returned while 4 questionnaires were missing, giving a response rate 98.02 percent. All the socio-economic characteristics of farmer's organizations were treated as binary, that is, taking the value of 1, 0 otherwise.

Table 4. Descriptive Statistics of socio-economic drivers of farmers in Tubah-Sub Division.

Variable	Obs	Mean	Std. Dev.	Min	Max
Gender					
Male	198	0.455	0.499	0	1
Female	198	0.545	0.499	0	1
Age groups					
Age l20	198	0.066	0.248	0	1
Age 20 l30	198	0.293	0.456	0	1
Age 30 l40	198	0.323	0.469	0	1
Age 40 l50	198	0.202	0.403	0	1
Age 50 l60	198	0.096	0.295	0	1
Age a60	198	0.02	0.141	0	1
Marital status					
Married	198	0.652	0.478	0	1
Unmarried	198	0.348	0.478	0	1
Educational qualification					
Noedu	198	0.131	0.339	0	1
Pedu	198	0.338	0.474	0	1
Sedu	198	0.222	0.417	0	1
Tedu	198	0.308	0.463	0	1
Longevity in farming					
Farm exp1 l3 years	198	0.222	0.417	0	1
Farm exp3 l6 years	198	0.247	0.433	0	1
Farm exp6 l9 years	198	0.126	0.333	0	1
Farm exp a9 years	198	0.404	0.492	0	1

Continued

Types of Farmers organizations					
CIG's	198	0.631	0.484	0	1
Cooperative	198	0.258	0.438	0	1
Association	198	0.111	0.315	0	1
Income groups (In thousands francs CFA)					
inc 100 200 frs	198	0.535	0.5	0	1
inc 201 400 frs	198	0.318	0.467	0	1
inc 401 600 frs	198	0.096	0.295	0	1
inc 601 1000 frs	198	0.051	0.22	0	1

Source: Computed by Author (2023).

Based on the distribution of the respondents with respect to gender, on average, females have a mean of 54.5% and a standard deviation of 49.9%. Meanwhile, male has a mean of 45.5% and a standard deviation of 49.9%. This finding indicates that both female & male farmers were well represented. Balance of opinions is necessary to reduce opinion disparity bias in the study. It further shows that female farmers are more represented than their male counterparts in Tubah sub-division.

According to the age group distribution of respondents, respondents within the age group 30 to less than 40 years have the highest mean of 32.3% and a standard deviation of 46.9%, followed closely by those who are within the age group 20 to less than 30 years (that is, mean of 29.3% with a standard deviation of 45.6%). These age groups are the strongest age groups who can work for long hours on farms; they also have much time to do multi task, and are mostly graduates who can concentrates on farming without distractions from schools. Meanwhile the lowest mean of age group are those from 60 years above and those with less than 20 years with means of 2% and 6.6% respectively and standard deviations of 14.1% and 29.5% respectively, this is because those who are less than 20 years are into school like secondary and tertiary education while those above sixty years are already aging so they cannot work for long hours this called for the reasons why we have small percent of them in farming.

The results in Table 4. also indicated that out of the total population, the married persons have a mean of 65.2% while the mean for unmarried is 34.8%. This finding indicates some level of social cohesion. More so, it is relevant to know that marital status is a responsibility and stability at individual and community level. Married individuals may be more likely to have grown up in a family with a farming background and continue the tradition. They both have the same standard deviation which is 47.8%

As concerns educational qualification, primary education has the highest mean (33.8%) and a standard deviation of 47.4%, this was followed by tertiary education with a mean of 30.8% and a standard deviation of 46.3%. This implies that much time is tilted to education than farming; that is, people who are into studies give much time preference to education and lesser concentration on farming activities. Those with no education have the lowest mean, which is 13.1% and a standard deviation of 33.9%. This might be because of the inadequate technical skills needed in farming and also because they give more time to concentrate on farming activities than education, which is why the mean is small, and the variation is high.

In addition, Table 4 shows that farmers with farming experience of more than 9 years have the highest mean of 40.4% and a higher standard deviation of 49.2%, while those with 6 - 9 years of experience e and 3 years' experience have the smallest mean which is 12.6% and 22.2% respectively. The results of the descriptive statistics show evidence of threshold level of experience that farmers need to have for them to be more productive.

Further, the study examines three types of farmers' organizations, with regards to types of farmers organizations, the CIG's has the highest mean which constituted 63.1% and a standard deviation of 48.4%, averagely cooperative has 25.8% as mean and 43.8% as standard deviation while associative has the smallest mean of 11.1% and standard deviation of 31.5%. Farmers preferred to work with CIGs than other organizations.

Furthermore, the income group for this research ranges from 100,000 to 1,000,000 FCFA. The above table shows that people with income levels that range from 100,000 to 200,000 has the highest mean (53.5%) and standard deviation of 50% while those with income levels from 601,000 to 1,000,000 have the lowest mean of about 5.1% and the variation is 22%. Farmers with low income may have limited access to modern farming technologies, equipment, and inputs like fertilizers and pesticides. This restricts their ability to optimize crop yields and quality, leading to a wider variation in their production outcomes. Farmers with low incomes often have limited access to education and training programs that can help them improve their farming practices and management skills. As a result, they may struggle to adopt efficient and effective practices, leading to higher variability in their income and productivity.

According to the above Table 5, based on farm size, it shows that farmer's with less than 1 hectare of farm size have the highest mean and standard deviation of 49.5% and 50.1% while those with 8 hectares of farm size and above they have the lowest mean and standard deviation of 2% and 14.1%. Comparatively, it shows farmers with 1 hectare have much time and concentrations to their 1 hectare which results in good output with little or no variability in the output as the difference between the variations is 0.6. Meanwhile, there are high variations for those with 8 hectares, showing that there is less concentration in each hectare and that there may be bias. Since they mostly have one hectare of land, the farms mostly practice labour intensive farming with the highest mean (57.1%) and standard deviation (49.6%) than other methods.

With regards to major crops cultivated, food crop is the most cultivated crop with the highest mean (78.3%) and variation of 41.3%. This is because as compared to land fertility, the lands are non-fertile land with its own mean being 55.1%. That is why majority of the farmers mostly obtained quantity of fertilizers from 0 - 50 kgs for their land which constituted the highest mean 33.3% and the standard deviation was 47.3% as seen above. This was followed by 100 kgs of fertilizer with mean (32.3%) and standard deviation (46.9%).

Table 5. Descriptive Statistics of agricultural productivity.

Variable	Obs	Mean	Std. Dev.	Min	Max
Farm size					
fs L1hectare	198	0.495	0.501	0	1
fs1 L3hectare	198	0.389	0.489	0	1
fs3 L7hectare	198	0.096	0.295	0	1
fs A8hectare	198	0.02	0.141	0	1
Types of technology					
Capital intensive	198	0.146	0.354	0	1
Labour intensive	198	0.571	0.496	0	1
Mix intensive	198	0.283	0.452	0	1
Major crop cultivated					
Cash crop	198	0.217	0.413	0	1
Food crop	198	0.783	0.413	0	1
Fertility of the Land					
Fertile land	198	0.449	0.499	0	1
Not fertile land	198	0.551	0.499	0	1
Quantity of fertilizer					
Fertilizer 50 kg	198	0.333	0.473	0	1
Fertilizer 100 kg	198	0.323	0.469	0	1
Fertilizer 150 kg	198	0.101	0.302	0	1
Fertilizer 200 kg	198	0.091	0.288	0	1
Fertilizer 200 kg	198	0.152	0.359	0	1
Quantity of seedling					
Seedling 50 kg	198	0.409	0.493	0	1
Seedling 100 kg	198	0.273	0.446	0	1
Seedling 150 kg	198	0.116	0.321	0	1
Seedling 200 kg	198	0.086	0.281	0	1
Seedling 200 kg	198	0.116	0.321	0	1

Source: Computed by Author (2023).

Table 6 shows the OLS and Quantile regression result of variables in study; in the 25th quantile, sustainable strategies has led to a decrease in agricultural productivity. At the 50th and 75th quantile agricultural productivity, still declines. This quantile shows the different variations in their mean, despite the mean being the averages of the quantiles. However, these inverse relationships are statistically significant at 1% significant level. Therefore, we reject the null hypothesis and accept the alternative hypothesis, which states that there is a statistical relationship between sustainable strategies and agricultural productivity in Tubah sub-division.

Table 6. Result of the effect of sustainability strategies on agricultural productivity in Tubah Sub-division.

	OLS	(q25)	(q50)	(q75)
VARIABLES	Nor_sa	nor_sa	nor_sa	nor_sa
nor_sus_strategies	−0.117***	−0.0817***	−0.149***	−0.183***
	(0.0429)	(0.0249)	(0.0178)	(0.0176)
Female	0.0211	0.0260**	0.0349***	0.0184**
	(0.0225)	(0.0118)	(0.00843)	(0.00834)
age_l20	−0.0782	−0.00397	−0.0583*	−0.0346
	(0.0750)	(0.0456)	(0.0327)	(0.0323)
age_20_l30	−0.0446	0.0150	−0.0314	−0.0121
	(0.0614)	(0.0405)	(0.0291)	(0.0287)
age_30_l40	−0.0453	−0.0232	−0.0201	−0.0199
	(0.0582)	(0.0401)	(0.0288)	(0.0284)
age_40_l50	−0.0382	0.0359	0.0103	0.0194
	(0.0631)	(0.0401)	(0.0287)	(0.0284)
age_50_l60	−0.0482	−0.0285	−0.0284	0.00814
	(0.0691)	(0.0429)	(0.0308)	(0.0304)
Married	0.0298	−0.00463	−0.000874	0.00938
	(0.0257)	(0.0127)	(0.00908)	(0.00898)
Pedu	−0.00965	−0.0626***	−0.00613	0.0163
	(0.0390)	(0.0194)	(0.0139)	(0.0137)
Sedu	−0.0403	−0.0863***	−0.0150	0.0154
	(0.0413)	(0.0200)	(0.0143)	(0.0142)
Tedu	−0.0287	−0.0600***	−0.0432***	−0.00790
	(0.0409)	(0.0207)	(0.0149)	(0.0147)
farm_exp3_l6_years	0.0169	0.0368**	−0.0338***	0.0784***
	(0.0353)	(0.0173)	(0.0124)	(0.0123)
farm_exp6_l9_years	−0.00614	−0.00561	−0.0268*	−0.0179
	(0.0360)	(0.0214)	(0.0154)	(0.0152)
farm_exp_a9_years	−0.0763**	0.00101	−0.0596***	−0.0504***
	(0.0370)	(0.0189)	(0.0135)	(0.0134)
inc_201_400_frs	0.0362*	0.0468***	0.0260***	0.0218**
	(0.0212)	(0.0134)	(0.00959)	(0.00949)

Continued

inc_401_600_frs	−0.0315	−0.0905***	−0.0171	−6.88e−06
	(0.0339)	(0.0198)	(0.0142)	(0.0141)
inc_601_1000_frs	−0.0411	−0.174***	−0.0141	0.0204
	(0.0639)	(0.0276)	(0.0198)	(0.0196)
Association	−0.00894	−0.00876	−0.0194	0.0305**
	(0.0353)	(0.0200)	(0.0143)	(0.0142)
Cooperative	−0.0494	−0.113***	−0.00433	0.00906
	(0.0368)	(0.0148)	(0.0106)	(0.0105)
Constant	0.817***	0.725***	0.834***	0.844***
	(0.0864)	(0.0498)	(0.0357)	(0.0353)
Observations	198	198	198	198
R-Square /Pseudo R-Square	0.154	0.1110	0.0988	0.2695
VIF	3.59			
Ramsey Reset Test F (3, 172), Prob.	0.5033			
IM Test Prob	0.0515			
Pseudo R-Square	0.154	0.1110	0.0988	0.2695

Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6 also shows the results for gender; on average females, as compared to males, contribute more to agricultural productivity than males in the 25th, 50th and 75th quantile; but this female contribution was highly significant in the 50th quantile at 1%. This also explains the reason why we have more females in farm organizations than males, they are less occupied than males. Biologically, females are stronger than males, so they can work in an un-conducive environment for a long period than males. Therefore, we reject the null hypothesis and accept the alternative hypothesis, which states that there is a statistical relationship between females and agricultural productivity in Tubah sub-division.

Also, education has a negative association with agricultural productivity. So, Primary, secondary and tertiary education has decreased agricultural productivity in the 25th quantile and this result is statistically significant at 1% significant level. Meanwhile in the 50th quantile all these categories of education still reduce agricultural productivity, but only tertiary education was significant at 1%. However, at the 75th quantile, the Primary and secondary education increases agricultural productivity, though it is not significant, the tertiary education instead decreases agricultural productivity, as seen in the above table.

Moreover, based on farm experience, it shows that those with farm experience from 3 to less than 6 years increase agricultural productivity in the 25th quantile, though it reduces agricultural productivity in the 50th quantile, it later increments it at the 75th quantile. It shows that those with less experience concentrate much time on farming organizations to ensure that their output is better than those with much experience. This relationship was statistically significant at 1% level of significance in the 25th and 75th quantile while in the 50th quantile is at 5%. In addition, those with farm experience from 6 to less than 9 years lead to a decrease in agricultural productivity in all the quantiles, but it is only significant at 10% in the 50th quantile. On the other hand, farming experience from 9 years above produces a decline in agricultural productivity both in the 50th and 75th quantiles, which is significant at 1%, but it was positive in the 25th quantile.

However, those with a lower income level, from 201,000 to 400,000, have a positive relationship with agricultural productivity, which is significant at 1% in all the quantiles. While those with higher income from 401,000 and above decrease agricultural productivity. This result is evidence that those with low income have a higher marginal propensity to spend on agricultural productivity than those with higher income who have high MPS.

Furthermore, farm organizations such as the associative have a positive and significant effect on agricultural productivity at 5% in quantile 75th, while cooperatives have a negative and significant effect on agricultural productivity at 1% in quantile 25th. This implies that the mean of associative organizations in quantile 70 is better than the other quantile.

5. Conclusion

In conclusion, the study aims to analyze the effect of sustainability strategies on agricultural productivity. Taking a cursory look at all the variables entered in the model has a significant effect. Using the ordinary least square and quantile regression estimation technique, the result revealed that sustainability strategies implemented by farmers reduce agricultural productivity. However, some control variables exert a negative significant effect. All the negative relationships are due to unsustainable farming practices, inadequate capital, low level of education, low farming experience, inadequate income, inadequate farm size, and the type of technology used for farming by these farmers. Based on the findings, this study recommends that the government organize training programs to educate the farmers on sustainable farming practices and implement environmentally friendly policies to boost productivity.

Recommendations

Based on the analysis and findings of this study, the researcher therefore recommends that:

- ❖ Policies directed towards agricultural sustainability should be environmentally friendly because of their consequences on the livelihood of the farmers in terms of poor yield.
- ❖ Credit to farmers was identified to be inadequate. Providing adequate credit to the farmers is, therefore, imperative. This will help improve farmers' output. Increased output leads to increased income and increased capital investments

in the agricultural sector

- ❖ More agricultural infrastructure and training centers should be created to help improve farmers' experience because it has been identified as one of the major challenges faced by cooperative farmers in improving agricultural production.
- ❖ Agricultural financial institutions should be created. Providing adequate credit to the farmers is, therefore, imperative. This will help improve the farmers' output. Increased output leads to increased income and increased capital investments in the agricultural sector.

The state should grant agricultural loans to farmers initiate and support mechanized agriculture. This will help improve the productivity and efficiency of farmers in Tubah-sub-division.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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