RESOURCE EFFICIENCY AND PRODUCTIVITY OF GREEN MICRO, SMALL AND MEDIUM SIZE ENTERPRISES IN RURAL NIGERIA

Denis Nfor Yuni[1,3]
Nkechinyere R Uwajumogu[1]
Nataniel E.Urama[2,3]
Chukwunenye Ferguson Emekaraonye[2]

[1]*Department of Economics and Development Studies, Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State, Nigeria*
[2]*Department of Economics, University of Nigeria Nsukka, Enugu State, Nigeria*
[3]*African Heritage Institution, Enugu State, Nigeria*

ABSTRACT

Climate change poses a threat to natural resources and increases the vulnerability of rural livelihoods. This has raised an urgent need to focus on efficient and sustainable utilization of natural resources. This study examine s the relationship between resource efficiency and productivity in rural Nigeria. Using General Household Survey data, the study employed Data Envelope Analysis, multiple regressions, propensity score matching model and descriptive analysis to examine resource efficiency in selected agro-firms. The study found that 47.63% of the firms were efficient. Furthermore, land-area and capital were significant determinants of the efficiency of green agro-based firms and efficiency significantly and positively influenced labour and capital productivity of rural agriculture. The study recommends increased sensitization of farmers and agricultural entrepreneurs to increase their awareness of existing opportunities for increased resource efficiency and availability of advanced technology, hybrid seeds and innovative ways that are predominant in the agricultural sector, in order to improve efficiency.

JEL classification: D2, Q5, Q1, L2

1. Introduction

In the past two decades, the world's attention has been drawn to the problem of climate change, with increased concern for developing countries such as Nigeria. Many developing countries' economies are largely based on weather-sensitive agricultural production systems and as such, are vulnerable to climate change (Dinar et al, 2006). Indeed, there is growing consensus in literature that the effects of climate change will be more pronounced in developing countries, especially on their agro-based micro, small and medium enterprises (MSMEs), because they may lack the funds and skills required to adequately mitigate or adapt to the effects of climate change.

Micro, small and medium enterprises play an important role in every economy, both in developed and developing countries. They contribute significantly to job creation, poverty reduction and increase gross domestic product (GDP). Such enterprises have been instrumental to the economic growth of many developed countries contributing over 55% to GDP and over 65% to total employment. For example, in 2013, their contribution to GDP stood at 60% in China, 57% in Germany, 55.3% in Japan and 50% in Korea (Frimpong, 2013). It is important to note that the performance of MSMEs in developed countries has continued to be quite impressive despite the threats posed by climate change. This perhaps could be attributed to the fact that in these countries, there have been intense campaigns aimed at promoting green MSMEs in order to buffer the sector against the effects of climate change. In contrast, African countries still record poor MSME performance. Although Ousmane (2012) ascribed the poor performance to challenges such as limited access to finance and modern technologies, lack of adequate skills and lack of information or knowledge that can trigger and sustain growth, it is also possible that the low performance of MSMEs in most African countries is, in part, because they have not fully embraced or promoted green MSMEs.

The role of MSMEs as engines of economic development is gaining prominence and African governments appear to be increasingly paying attention to this sector. More recently, the Nigerian government's investment policy shifted from an excessive focus on large-scale industries as the major drivers of economic growth, to small and medium enterprises (Osotimehin et al., 2012). The shift was as a result of the recognition of the latent potency of MSMEs to mobilize local resources, grow output and drive the needed exports. However,

despite the shift in government policy and increasing involvement of NGOs, Nigerian MSMEs have not performed creditably well, especially in terms of their contribution to GDP. While Basil (2005), put the MSMEs sector's contribution to the manufacturing sector at 10-15%, Eniola (2014) noted that the sector's contribution to the country's GDP was just below 5%.

Notwithstanding their performance, there is no doubt that MSMEs have great potential to contribute to the reduction of absolute and extreme poverty in rural areas through job creation. It is possible that entrepreneurship through MSMEs could be one of the most important vehicles for improving the quality of life of individuals, families and communities and for sustaining a healthy economy and environment in rural areas. Rural MSMEs provide this opportunity due to the abundant and relatively cheap resources available in such areas. Nigeria, in this regard, with its abundant arable land and mineral resources which are critical to spurring growth, has great potential to develop its MSMEs sector. However, most rural MSMEs in Nigeria are characterized by low productivity while many are said to be struggling for survival.

As the rural agro-based MSMEs are slowly contending with their constraints, climate change is also imposing additional demands, requiring them to take a green pathway. The essence is to ensure that while entrepreneurs strive to grow their output, they should also be in position to prevent costly environmental degradation and inefficient use of natural resources. This is very critical as climate change increasingly impacts on the global economy. The implication is that Nigerian rural agriculture-based MSMEs now need to adapt to or mitigate climate change, even when they have not fully tackled other challenges. This presents another set of challenges to the entrepreneurs who may require new skills and other adjustments to adapt to climate change.

Efficiency and increased productivity are the major indicators for measuring the performance of MSMEs and their contribution to the growth of the economy. While developed countries are utilising available technologies and skills to boost the productivity and efficiency of their MSMEs, developing countries, Nigeria inclusive, are still deficient in this regard. Specifically, in Nigeria, low productivity and inefficiency have been the major challenges facing rural agro-based MSMEs, and this has also militated against their efficient performance over the years. No doubt, rural agro-based MSMEs are very essential to the country's growth strategy and could significantly drive the economy, but they

need to be strengthened by enhancing their efficiency and productivity so that they can effectively assume a vantage position and play this needed role.

In view of this, this study examines efficiency and productivity gaps of agro-based MSMEs in rural Nigeria in three important ways. First, the study evaluates the proportion of efficient green agro-based firms in rural Nigeria. Second, the study investigates the determinants of the efficiency of green firms in rural Nigeria. Lastly, the study ascertains how efficiency for agro-based green firms contributes to improved labour and capital productivity in Nigeria.

The following shall therefore constitute the null hypotheses of the study as informed by the research objectives stated above:

Ho1: Factors that determine firm efficiency of agro-based MSMEs in rural Nigeria are not significant.

Ho2: Firm efficiency does not significantly affect labour and capital productivity in Nigeria.

2. Review of Literature

2.1 Concept of green MSMEs

Green MSMEs adopt green processes and/or produce green goods using green production inputs (Zafar, 2016). These green processes, otherwise known as climate smart practices for agro-based firms, refer to climate change adaptation and mitigation practices required to survive climate change. Mitigation addresses the root causes by reducing greenhouse gas emissions, while adaptation seeks to lower the risks posed by the consequences of climatic changes. Some of the adaptation schemes as practiced by some of the agro-based firms include: using drought-tolerant seeds, irrigation, building canals for flood prone areas, early planting, agro-forestry, and the use of climate-friendly farming types, amongst others. Examples of mitigation practices include switching to low-carbon energy equipment and transportation options and renewable energy sources, and expanding forests in the form of agro-forestry to remove greater amounts of carbon dioxide from the atmosphere. Therefore, agro-based firms that were practicing any of these adaptation and mitigation practices were considered and referred to as green MSMEs.

2.2 Resource efficiency and green MSMEs

Every economy, firm or individual is faced with the problem of scarcity of productive resources amidst unlimited burgeoning needs. Productive resources include both natural and man-made resources. There are different categories of productive resources which differ from place to place and across activities or sectors of production. This study, however, focuses on resources that contribute to production in agro-based green MSMEs which include: capital, labour, land area and socioeconomic characteristics of the entrepreneur. The consequence of using productive resources without consideration of the future has led to many problems witnessed in the world today, such as climate change, civil wars, hunger, poverty, etc. In this regard, there is a need to revisit how to use resources efficiently. The concept of efficiency is one major microeconomic concept which is pursued by all economic systems.

This study conceptualizes efficiency to be technical efficiency, which is concerned with the best combination of factors of production to produce a certain level of goods and services. Further, it is concerned with using the minimum combination of factors of production to manufacture a given output level. The concept of efficiency often reiterates the need to use scarce resources in the most optimal mix to achieve maximum output, that is, minimizing waste and maximizing output or utility. Mankiw (2001) captured the concept succinctly as the characteristics of a society getting the maximum from its scarce resources with the aim of getting a larger pie (GDP) from the resources it has. Further, the concept can be seen as a feature of resource allocation to maximize the total surplus received by members of the society (Mankiw, 2001). On the other hand, inefficiency, as defined by Gumbau-Albert and Maudos (2002), is the variance between the actual values of production and the highest potential values of production, given the technology used. Therefore, an efficient firm has little or no difference between the actual and potential output levels.

Green MSMEs, in the context of this study, refer to agro-based firms that practice adaptation and mitigation schemes as required to survive climate change. Efficiency was estimated only for firms which practice adaptation or mitigation strategies; referred to as green MSMEs.

2.3 Resource efficiency versus labour and capital productivity

Resource use efficiency correlates positively with competition which leads to innovations that create jobs and sustainable economic growth (Rademaekers et

al., 2011). The jobs so created are called green jobs, which, according to UNEP (2015), are jobs in agriculture, manufacturing, research and development, administrative and service activities that impact greatly on preservation and restoration of the quality of the environment. It was estimated that in 2012, the number of people working in eco-industries globally was about 3.4 million with average annual growth of 2.72% between 2000 and 2008 (Rademaekers et al., 2011). Adoption of and investments in resource efficiency and energy-saving techniques are capable of lowering costs for MSMEs and low-income earners. They also increase the opportunities for locals to get better paid jobs. These can have positive multiplier effects on the whole economy. For instance, energy-saving techniques such as solar-powered fish dryers can reduce utility bills, which increases household and MSMEs savings that can be channelled to other productive investments like education.

Another way resource efficiency creates jobs is by presenting opportunities for the invention, manufacture, installation and maintenance of equipment necessary to conserve resources. Most often, these are done locally. Inter alia, these green jobs are available to not so educated and skilled persons unlike jobs in fossil fuel and energy sectors. In all, resource efficiency, although painful at first, is beneficial to all in the long run. Increased competitiveness of firms as a result of the drive to use resources more efficiently makes firms adopt practices that improve labour and capital productivity. The relationship between resource efficiency and competition in general (labour and capital productivity in particular) is couched in the Porter hypothesis. Proposed by Michael Porter in 1991, this hypothesis opines that tough but flexible environmental regulations that force firms to adopt practices that conserve resources and minimize waste can increase social welfare as well as net private benefits of the regulated firms (Porter, 1991).

Resource Efficiency in the Agriculture Sector

In the light of climate change, disruptions in ecological systems and greenhouse gas emissions, resource efficiency is defined as actions put in place to reduce production of pollutants in the course of producing a given level of output. On the other hand, it can also mean processing productive inputs (material, water or land) in the most efficient manner so as to get maximum output from the few resources used. One major indicator of resource efficiency is resource

productivity measured by the ratio of GDP to domestic material consumption and/or climate change adaptation or mitigation. According to Jansen (2013), resource efficiency involves ways of producing more using less resources, especially natural resources, as well as reducing the effect of using one resource on another resource.

Kukreja and Meredith (2011) highlighted the potentials that exist in organic farming as a way of securing and ensuring sustainable food security with minimal resource use. This is made possible through sustainable farming practices that will guarantee sustainable nutrient management, energy use and water efficiency for generations to come. Such farming practices include crop rotation, grass-clover leys, cover cropping, alley farming, agro-forestry, animal manure, mixed farming, and use of organic (instead of inorganic or synthetic) fertilizers and pesticides. Agricultural activities such as high use of inputs and high stocking densities (intensification), plantation farming (specialization), overuse of inorganic fertilizers and pesticides, land abandonment, invasive alien species and overgrazing of farmlands contribute to loss of biodiversity (Kukreja & Meredith, 2011). Loss of biodiversity has adverse effect on clean air, water and soil; nutrient recycling; and pollination. Organic farming is capable of reversing this trend through crop rotation, leaving buffer strips, non use of synthetic pesticides, and using breeds adapted to the area (Kukreja & Meredith, 2011). Organic farming also has the potential of improving water quality and management via organic fertilizers; planting crops of different varieties with varying root forms; crop rotation, preservation of cash and cover crops, etc.

Evidence has shown that agriculture is the main sector that experiences the impact of GHG emissions through: changes in rainfall distribution, prolonged and more frequent droughts, new pests and diseases or an increase in existing ones, increased risk of heat stress in livestock, etc. In this regard, there is a need to reduce GHG emission, often called mitigation, as well as minimize the impact of these changes, called adaptation (Government of UK, 2012). To achieve the goals of mitigation and adaptation, some researchers have advocated for the use of biological energy (bioenergy) as an alternative to fossil fuel and the use of plants, instead of synthetic raw materials in manufacturing (Government of UK, 2012). An example given is the use of bioethanol and biodiesel instead of petroleum products and generation of heat and electricity from biomass.

2.5 Empirical literature

There abounds much empirical evidence on the determinants of efficiency in Nigeria's agro-based enterprises. Most works identified agricultural inputs as the determinants of efficiency. For instance, Yusuf, Williams and Abubakar (2015) measured technical efficiency and its determinants of cowpea production in Niger State, Nigeria. Their study used the stochastic frontier model in the 2013 season to show that quantities of seed, herbicide and pesticide used were significant determinants of cowpea production efficiency in Niger State. Similarly, Zalkuwi et al. (2010) examined the economic efficiency of maize production and its determinants in Ganye Local Government in Adamawa State, Nigeria and found the determinants to be fertilizer, herbicides, seeds and hired labour. This is also in agreement with the results of Obike, Idu and Aigbokie (2016) who examined labour productivity and resource efficiency among smallholder cocoa farmers in Abia State, Nigeria and found that planting materials, fertilizer use and capital were significant determinants of output among cocoa farmers. Adopting inferential statistics and loglinear regression analysis, the study included level of education, experience and planting materials among the factors influencing labour productivity among cocoa farmers in the study area. Furthermore, Amaechina and Eboh (2017) employed the Cobb Douglass production function to investigate resource use efficiency in rice production in the Lower Anambra Irrigation Project, Nigeria. The study identified seed, land and fertilizer as the major factors affecting rice yield even though gross margin analysis of the study showed that rice production is profitable in the area.

Some studies have recognized diverse impacts of various indicators on different types of efficiency. For Nandi et al. (2011), age and education positively relate to technical efficiency, but Kehinde and Awoyemi (2009), using the stochastic frontier approach to analyse economic efficiency in saw-wood production of Southwest Nigeria, found that managerial type, capital base and capacity utilization significantly improved efficiency levels of saw millers. In the same vein, Adewuyi, Agbonlahor and Oke (2013) analysed the determinants of technical efficiency of farmers in the production of cassava in Ogun State, Nigeria and found that farm size, agrochemicals, family labour, hired labour and quantity of fertilizer used were the significant factors affecting cassava production in the study area.

The relationship between labour/capital productivity and efficiency is often investigated from the standpoint of labour/capital productivity affecting efficiency and there exists huge empirical evidence to assert this. Nevertheless, this study examines the effect of efficiency on capital and labour productivity. With the assumption that competitiveness is a goal of resource efficiency, Flachenecker (2015) empirically examined this theory using panel data for 28 EU members as well as Norway, Switzerland and Turkey between 2004 and 2009. Using simple correlation, the study found a positive relationship between resource efficiency and competitiveness. However, using a 2-step system GMM (GMM-SYS), the study found a negative correlation between the two, though insignificant impact of resource efficiency on competitiveness. Similarly, Deelchand and Padgett (2009) analysed the relationship between risk, capital and efficiency in Japanese cooperative banks. They used the two-stage least squares with fixed effects estimation procedure to show that risk, capital and inefficiency are simultaneously determined. Furthermore, Margaritis and Psillaki (2007) examined the relationship between firm efficiency and capital structure using quantile regression analysis. Their results show that the reverse causality effect of efficiency on leverage is positive at low to mid-leverage levels and negative at high leverage ratios. The empirical literature shows that only a few works exist that examine the relationship between efficiency and productivity for labour and capital in Nigeria. It is this research gap, as well as economic and environmental implications that motivated this study.

2.6 Research gap

A review of existing literature suggests that a number of empirical studies have been carried out in the area of firm efficiency and productivity. The literature also reveals that most of the studies have dwelt on the determinants and relationship between labour/capital productivity and efficiency (Yusuf, Williams and Abubakar, 2015; Zalkuwi et al, 2010; Obike, Idu and Aigbokie, 2016; Amaechina and Eboh, 2017; Flachenecker, 2015; Deelchand and Padgett, 2009; Margaritis and Psillaki, 2007). However, none of the studies considered measuring firm efficiency in agriculture, especially in the rural sector of Nigeria with a view to ascertaining firms that are firm efficient and those that are not, before delving into determinants and relationship. This is one of the gaps the

study identified and in a bid to fill this gap, the study found that 47.63% of the firms were efficient while 52.37% were not.

The scope of existing empirical studies in Nigeria is limited to states and regions (Niger State, Adamawa State, Abia State, Anambra State, Ogun State and Southwest Nigeria). This study therefore makes a significant departure from existing studies by focusing on Nigeria as a whole. Moreover, most of the studies relied on primary data collected by their enumerators. The challenge with this kind of data is that in most cases, either the enumerators were not properly trained on data collection or the sample size is too small for any meaningful inference. This study therefore utilized the Nigerian General Household Survey (GHS) panel data with as high as 2,022 rural-based MSMEs constituting the sampling frame for the study.

Also, the appropriateness of methodology for studies of this kind is as important as the credibility of data sources. This study tried to improve over the existing study by adopting methods that have been carefully avoided by many previous studies because of their complexity and rigour (Data Envelope Analysis methodology, propensity score matching model, etc.). Ascertaining that the methods were most appropriate to address the hypotheses of this study, they were painstakingly utilized to ensure results robustness.

3. Methodology and Data

3.1 Determinants of resource use efficiency

To examine the proportion of green MSMEs that are efficient in rural Nigeria, the study employed the Data Envelope Analysis (DEA) technique. This approach was used to ascertain the technical resource efficiency of agriculture- based firms in rural Nigeria. In the DEA methodology, first developed by Charnes, Cooper and Rhodes (1978), efficiency is defined as a ratio of weighted sum of outputs to a weighted sum of inputs, where the weights structure is calculated by means of mathematical programming, and constant returns to scale are assumed, though it has been developed further by several other researchers. Resource efficiency, in this context, goes beyond the general inputs and outputs of firms to include smart climate indicators. The inputs to be considered include: land area (*lar*), number of workers (*now*), quantity harvested (*qhv*), capital (*cap*), value of inputs (insecticides and pesticides – *voi*), and the use of adaptation practices (*adp*). On the other hand, quantity sold (*qus*), value of sales (*vos*) and

value of finished stocks (*vfs*) were employed as the outputs. This study will therefore ascertain resource efficiency from an environmentally-friendly perspective as it considers adaptation practices as one of the inputs of the efficiency model.

The efficiency model could therefore be represented as:

$$TE\ (u, v) = \sum_{r=1}^{n}(u_r y_{r0}) / \sum_{r=1}^{n}(v_r x_{r0}) \quad (1)$$

Therefore, using the various inputs and outputs stated above, equation (1) develops into:

$$TE\ (u, v) = \frac{u_1(lar) + u_2(now) + u_3(qhv) + u_4(cap) + u_5(voi) + u_6(adp)}{v_1(qus) + v_2(vos) + v_3(vfs)} \quad (2)$$

where: *TE* represents relative technical efficiency, u_r and v_r are weights given to outputs and inputs respectively, while *y* and *x* represent the variables for output and input respectively.

To ascertain the second objective, which is to investigate the determinants of resource use efficiency in agriculture in rural Nigeria, the logit model was used. The DEA results were used to classify the agro-based firms into efficient and inefficient DMUs, wherein a technical efficiency score of 1 was considered efficient and zero if less than 1. It therefore constitutes a dummy variable representing whether the firm is efficient or not. The determinants of efficiency to be tested as suggested by empirical and theoretical literature are land area covered (*lac*), capital (*cap*), number of workers (*now*), experience of head of enterprise (*experience*) and educational level of head of enterprise (*edu*). While the dummy variable for efficiency is the dependent variable.

Considering that P_i as the probability of an MSME *i* being efficient and the factors that determine efficiency of an MSME as a vector *X*, the probability model is:

$$Prob(Y_i = 1|X_i) = F(X_i), \text{ for efficient DMUs} \quad (3)$$

$$Prob(Y_i = 0|X_i) = 1 - F(X_i), \text{ for non-efficient DMUs} \quad (4)$$

The logistic distribution function is therefore given as:

$$F(X_i) = \frac{1}{1+e^{-z_i}} = \frac{e^{z_i}}{1+e^{z_i}} \quad (5)$$

$$1 - F(X_i) = \frac{1}{1+e^{z_i}} \quad (6)$$

where :

$$Z_i = \beta_0 + \beta_1 lac + \beta_2 cap + \beta_3 now + \beta_4 exp + \beta_5 edu + \varepsilon \quad (7)$$

and equations (5) and (6) are the probabilities that a firm is efficient and not efficient respectively.

From equations (5) and (6), the odds ratio can be gotten and presented as:

$$\frac{F(X_i)}{1-F(X_i)} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} \quad (8)$$

Then the natural log of equation (7) is:

$$L_i = \ln\left(\frac{F(X_i)}{1-F(X_i)}\right) \quad (9)$$

The odds ratio of the logit estimation will be used for interpretation due to the fact that it is less complex/ambiguous than the log of odds ratio. Hence the estimation will show us those significant factors that increase the odds of a firm being efficient in Nigeria.

3.2 Effect of resource efficiency on labour and capital productivity

To ascertain the third objective, which examines how resource efficiency in agriculture contributes to improvement in labour and capital productivity, the study employed the efficiency scores from the DEA technique, the Propensity Score Matching (PSM) model and the multivariate regression model. The efficiency scores which were categorized into two groups as stated above will constitute the treatment and control groups while labour and capital productivity are proxied with output/labour and output/capital respectively.

The PSM is widely used in impact analysis due to the fact that it provides estimates of treatment effects that are less biased than those obtained from conventional multivariate models and its unique tool of matching participants to one or more nonparticipants on propensity score. The key strength of the propensity score matching method is that it matches or pairs individuals that are identical in the treatment grouping with every other aspect except their efficiency status with those of the counterfactual and then calculating the impact of the intervention as the difference in mean outcomes between the groups. The PSM does this by reducing the matching problem to a single dimension which is the propensity score and then individual units can be compared on the basis of their propensity scores alone.

According to Heinrich et al. (2010), the impact of a treatment for an individual i, denoted δi, is defined as the difference between the potential outcome in case of treatment and the potential outcome in the absence of treatment. This could be represented as:

$$\delta i = Y_{1i} - Y_{0i} \tag{10}$$

In an attempt to measure the mean impact of resource efficiency on labour and capital productivity, the average impact across all individuals in the population is calculated. This is referred to as the average treatment effect (ATE) and represented as:

$$ATE = E(\delta) = (Y_{1i} - Y_{0i}) \tag{11}$$

where $E(\delta)$ implies average or expected value, Y represents labour or capital productivity, and *Eff* symbolises efficiency.

However, this study measures the mean impact of resource efficiency on labour and capital productivity for efficient firms. This is estimated with the aid of the average treatment effect on the treated (ATT) denoted as:

$$ATE = E(Y_{1i} - Y_{0i} \mid Eff = 1) \tag{12}$$

It is noteworthy that these parameters are not observable since they depend on counterfactual outcomes. Therefore, based on the fact that the average of a difference is the difference of the averages, the ATT can be rewritten as:

$$ATE = E(Y_1 | \ Eff = 1) - E(Y_0 | \ Eff = 1) \quad (13)$$

The second term, is the average outcome that the treated individuals would have obtained in the absence of treatment, which is not observed.

The propensity score model has two basic assumptions that must be verified; the conditional independence assumption (CIA) and the overlap or common support condition. Although there might not be a direct test to CIA, it is expected that a well-specified model that includes all relevant variables reduces the chances of invalidating the CIA. On the other hand, this study addresses the common support condition automatically through the software by restricting estimation only on individuals that lie on the common support zone.

The multivariate regression model is used to complement the propensity score model in assessing the impact analysis of resource efficiency on labour and capital productivity. Labour productivity is estimated as a function of capital, land area covered, education, efficiency status, quantity harvested and experience of the household head as informed by empirical and theoretical literature. On the other hand, capital productivity is a function of education, experience of the household head, credit access, efficiency, land area covered and climate change adaptation, again as informed by literature.

3.3 Data description and suitability

The data available for this study is the Nigerian general household survey panel data (GHS, 2013). From the GHS, 2022 rural-based MSMEs constituted the sampling frame. However, considering the study's focus on green MSMEs, only 1460 rural-based enterprises which were identified as green were included in the sample. The selected enterprises constituted 72.21% of the sampling frame. This, therefore, constituted the focus sample for the estimation.

The data comprised information on socio-economic characteristics: education, labour and labour options, credit and savings, financial capability, assets, farm and non-farm enterprise and income generating activities, food security, agricultural output, cost of transportation, energy, size of land, harvest labour, agricultural production, agricultural capital, extension services, animal holdings, animal cost, and other agricultural income, amongst other information that are sufficient to address the research questions of the study.

The Central Bank of Nigeria's (2005) classification of the various strata of small-scale enterprises is used in this study. In this classification, micro and small-scale industry is defined as an industry with a labour size of not more than 100 workers or a total cost of not more than ₦50 million, including working capital but excluding cost of land. A medium-scale industry is an industry with a labour size of between 101-300 workers or a total cost of over ₦50 million but not more than ₦200 million, including working capital but excluding cost of land. This study is therefore confined to these boundaries as it is interested in SMEs.

Levels of disaggregation: The above-listed community-level variables can be classified and disaggregated to levels of analysis as follows: 6 geographical zones, 37 states and 774 local government areas, urban and rural areas or community-levels. The study employed Stata 13 econometric software package for the analysis.

4. Results and Interpretation

4.1 Socioeconomic Characteristics of the SMEs

This section highlights the major variables and the relationships between the variables studied. In this regard, certain summary statistics are discussed for clarity and better understanding as presented in table 1. The variables related to the agro-firms considered in the table include size of land owned by the firm, capital, value of inputs and sales, number of workers employed by the firm, and experience of proprietors.

Table 1. Summary Statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
Land Area (sq. km)	950.3354	1,920.27	50	10,000
Capital (₦)	61,630.34	187,034.7	1,100	3,666,000
Value of Inputs (insecticides, pesticides) (₦)	17,655.55	57,969.8	500	1,000,000
Value of Sales (₦)	79,647.17	244,583.8	5,000	5,251,500
Number of Workers	2.985163	3.145298	1	50
Experience of Firm Heads (Years)	22.21167	15.88232	1	59

Source: Authors' computation from GHS data.

The summary statistics in table 1 show that that the size of land owned by the firms ranged from 50 to 10,000 square kilometres (sq. km), with an average of 950.3354sq km. However, the high standard deviation of 1,920.27 shows the inequality in size of land owned by the agro-firms considered in this study. In the same light, capital had an even higher standard deviation, again, showing the wide gap between the agro-firms which is reflected in the lower and upper bounds of 1,100 and ₦3,666,000 respectively. The high inequality in capital reflects the income inequality that exists in the Nigerian economy that needs to be redressed. The mean capital is given as ₦61,630.34 suggesting that a greater proportion of the firms are skewed to the lower bound. The value of inputs ranged between ₦500 and ₦1,000,000 which should largely correspond to the size of land owned by a firm, capital and type of crops cultivated. The average value of inputs was ₦17,655.55 while the standard deviation was ₦57,969.8. The value of sales was similar in characteristics to the behaviour of capital though slightly higher. Its average was ₦79,655.55, with a standard deviation of 244,583.8 and a maximum of ₦5,251,500. The number of workers ranged between 1 and 50 with an average of about 3 workers. The years of experience of the agro-firms' proprietors ranged between 1 and 59 years, with an average of about 22 years, though with a high standard deviation of about 15.88232. Their educational distribution is illustrated in figure 1.

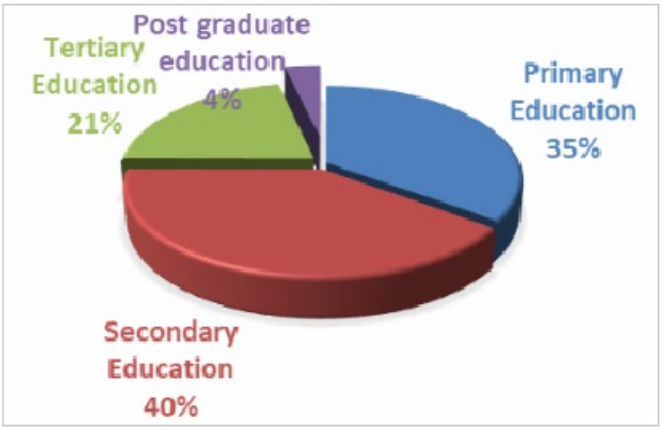

Figure 1. Education Level of Enterprise Head.
Source: Authors' computation from the GHS data.

The representation of the educational level of the sample (enterprise heads) in figure 1 shows that the majority (75%) did not have tertiary education, 35% had only primary education and 40% had secondary education. Thus 21% had tertiary education such as a university degree or its equivalent, and only 4% had post graduate education.

The study further analysed the distribution of access to credit and use of adaptation practices. The results are shown in figure 2.

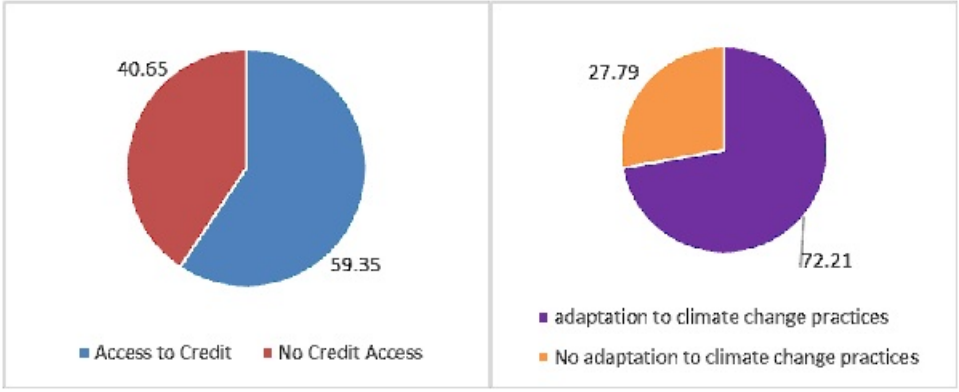

Figure 2. Distribution of Sample by Credit Access and Adaptation Practice (%).
Source: Authors' computation from the GHS data.

The distribution of the sample by credit access shows that 59.35% had access to credit as compared to 40.65% who did not. Credit access refers to both formal and informal mechanisms.

In terms of adoption of climate change adaptation measures, the results show that 72.21% of the sample were involved in climate change adaptation practices such as early planting, mixed cropping, and irrigation, while 27.79% of the sample were not. This is a representation of the reality as the firms must adapt to any changes in the climatic conditions in order to remain in business. However, much still needs to be done in terms of the variety of practices the firms need to be exposed to and involved in.

4.2 Resource-use efficiency for agriculture in rural Nigeria

The findings suggest that 47.63% of the firms are resource-use efficient while 52.37% are not. This implies that in using the inputs and outputs stated in the

section above, 47.63% of the firms had a Theta score of 1, while the rest were less than 1.

Now, considering the efficiency variable as a dummy, wherein the efficient firms are denoted 1 and 0 otherwise, the study further analysed the determinants of resource-use efficiency in the agriculture sector, using a logit regression. The results are shown in table 2.

Table 2. Determinants of Resource Use Efficiency

Variables	Log of Odds Ratio	Odds Ratio	z-value	p-value
Land area	-0.1137779	0.8924562	-6.25	0.0
Number of workers	-0.0197998	0.980395	-1.24	0.216
Capital	0.1432232	1.153987	2.51	0.012
Experience of enterprise head	0.0000924	1.000092	0.03	0.975
Education of enterprise head	-0.1302113	0.8779099	-1.17	0.24
Constant	-0.6640356		-1.69	0.092

Source: Authors' computation from GHS data.

The results show that the probability chi square is 0.0000, hence the overall model is significant though with a relatively low pseudo R square. The logit estimation shows that land area and capital are significant determinants of efficiency in the agricultural sector, whereas number of workers, experience of enterprise head and education of enterprise head are not. The absolute z value of 6.25 which is greater than 1.96 and the p-value of 0.000 which is less than 0.05 show that the land area of an agricultural firm significantly decreases the odds in favour of being efficient at the standard 5% significant level. In fact, a square kilometre increase in land area reduces the odds ratio that a firm is efficient by 0.8924562. This could be attributed to the fact that the larger the land area, the more expensive are the inputs which might not be sufficiently utilized to achieve the desired outcome, as is often the case in extensive farming. Moreover, such land area cultivation often practices mono cropping which is seldom the case in intensive farming or small-scale land use, where mixed farming is practiced.

In the same light, increasing number of workers and reducing efficiency is an indicator of the use of non-qualified workers or the fact that some of the processes do not necessarily need manpower but machines. Capital, on the other

hand, is significant at 5% significant level, given its probability value of 0.012, which is less than 0.05. Therefore, a naira increase in capital significantly increases the odds ratio in favour of being efficient by 1.153581 or about 15.36%. This is expected a priori as a sufficient capital base will ensure that the enterprise is well-equipped with all the inputs needed to achieve the desired output, hence the higher the capital the higher the resource use efficiency.

The experience of the enterprise head is not a significant factor in increasing the odds in favour of a firm being efficient. This is explained by the fact that the probability value for experience of the enterprise head is 0.975 which is greater than 0.05 hence not significant at the standard 5% significant level. It is worth noting, however, that increasing experience increases the odds in favour of being efficient which are expected a priori though not significant. Further, the education level of the enterprise head is not a significant determinant of efficiency given that the probability value for education level of the enterprise head is 0.240, which is greater than 0.05 hence not significant at the standard 5% significant level. It is however surprising that the level of education of the enterprise head is not a significant determinant of efficiency though we note that this assertion is not significant.

This study therefore rejects the null hypotheses for the variables, land area and capital. It concludes that there exist significant factors that determine resource use efficiency of agriculture in rural Nigeria, which are land and capital. For the other variables which are number of workers, experience and education, the null hypotheses is not rejected and it is concluded that they are not significant determinants of firm efficiency.

4.3 Effect of resource efficiency of agro-firms on labour and capital productivity

This section is aimed at ascertaining the second research objective which investigates how resource use efficiency in agriculture can contribute to improved labour and capital productivity of agro-based firms in rural Nigeria. It employed multiple regression and the propensity score matching method. For the sake of the two areas of interest – labour and capital productivity, the section is alienated accordingly.

4.4 Effect of resource-use efficiency in agriculture on labour productivity

As explained in the methodology section, the study uses two tools to address the effect of resource use efficiency on labour productivity. The result of the multiple regression that was estimated with the ordinary least squares estimation technique is presented in table 3.

Table 3. Impact of Efficiency on Labour Productivity Using Multiple Regression

Variable	Coefficient	t-value	Probability t-value
Capital	8653.459	11.65	0
Land area	0.0245524	0.05	0.957
Education of enterprise head	1531.461	0.61	0.545
Dummy for efficiency	22882.45	6.90	0
Quantity harvested	148.5788	1.12	0.264

Source: Authors' computation from GHS data.

The estimation shows an F probability of 0.0000 which implies that the overall model is significant. Also, a multi-collinearity test using the variance inflation factor (VIF) and the results suggest that the mean VIF is 2.22 with none of the independent VIF being more than 4.2. Hence there exists no multicollinearity while heteroscedasticity was controlled for. The result, therefore, shows that capital and efficiency significantly influenced labour productivity while land area, education level of enterprise head and quantity harvested did not. The probability value for efficiency is 0.000 which is less than 0.05 and 0.01 hence significant at 5% and 1% significant level. In fact, the coefficient shows that efficient firms have a significantly higher labour productivity than non-efficient firms as expected. Therefore, labour productivity of efficient firms is, on the average, higher by 22,882.45 than non-efficient firms.

This study further used propensity score to test the effect on the treated only and the results are shown in table 4. First, the balancing property was estimated and was satisfied at the sixth block where the mean propensity score was not different for treated and controls in each block. After having ensured that the balancing property was satisfied, the study used 4 different matching methods: Nearest Neighbour (Random draw version), Nearest Neighbour (Equal weights version), Stratification Method, and Radius (0.5) to ensure that the estimations

did not depend crucially on the particular methodology chosen, thereby ensuring robust results.

Table 4. Treatment Effect of Firm Efficiency on Labour Productivity – PSM Results

Matching Method	ATT	Standard Error	t-value
Nearest Neighbour			
(Random draw version)	22620.792	3514.265	6.437
Nearest Neighbour			
(Equal weights version)	22619.119	3516.072	6.433
Stratification Method	23268.191	3415.710	6.812
Radius (0.5)	23846.501	3407.701	6.998

Source: Authors' computation from GHS data.

The propensity matching estimation shows that for all the matching methods used, the ATTs for each methods were similar while the t-value for all matching methods was higher than 1.96 and 2.54 (ranging between 6.433 and 6.998) hence significant at 5% and 1% significant levels respectively. The average treatment effect on the treated (ATT) equally ranged between 22,619.119 and 23,846.501. Hence, the average treatment effect of efficiency on labour productivity of efficient firms is significant and positive. Therefore, the null hypothesis that resource use efficiency does not significantly affect labour productivity in rural Nigeria is rejected.

Unlike t-tests and other statistical tests of hypothesis, the standardized difference is not influenced by sample size, therefore, standard difference can be used to compare balance in measured variables between treated and untreated subjects in the matched sample with that in the unmatched sample (Austin, 2009). At this point, a post-estimation test was done to measure the standardized difference between the treatment and control groups and the results show that the mean bias of the difference is 8.5, which is less than 10 hence valid. The study therefore rejects the null hypothesis that resource-use efficiency does not significantly affect labour productivity in Nigeria. It concludes that efficiency is a significant determinant of labour productivity in Nigeria

4.5 Effect of resource-use efficiency in agriculture on capital productivity

In the same way as in the above, the study used both multiple regression analysis and propensity score to investigate the effect of efficiency on labour productivity in Nigeria. The result of the multiple regression result is presented in table 5.

Table 5. Impact of Efficiency on Capital Productivity Using Multiple Regression

Variable	Coefficient	t-value	Probability t-value
Education of enterprise head	-7.38388	-4.24	0
Experience of enterprise head	.0869334	-1.54	0.123
Access to Credit	-3.456609	-1.33	0.183
Dummy for Efficiency	4.286754	2.39	0.017
Land area	-.0000413	-0.09	0.929
Dummy for Climate Adaptation Practices	13.85441	4.95	0

Source: Authors' computation from analysis of data.

The results again show an F probability of 0.0000 which implies that the overall model is significant. And the multi-collinearity test using the variance inflation factor suggests that the mean VIF is 1.62, with none of the independent VIFs being more than 2.7, hence there exists no multicollinearity. Heteroscedasticity was automatically controlled for in the estimation using the robust command of Stata. Table 4 above shows that the education level of the enterprise head, efficiency and climate change adaptation practices are the significant determinants of capital productivity, while experience of enterprise head, access to credit and size of land owned are not. It is, however, surprising to note that access to credit, experience and level of education of enterprise head are negatively related with capital productivity. However, access to credit and experience of enterprise head are not significant.

It must be recalled that efficiency is a dummy wherein the base categories are the non-efficient firms. The probability value for the efficiency dummy, which is our point of focus is 0.017, which is less than 0.05 hence significant at 5% significant level. The coefficient infers that efficient firms have significantly higher capital productivity by 4.286754 than non-efficient firms as expected. The study further employed propensity score to test the treatment effect on the treated only and the results are shown in table 6.

Table 6. Treatment Effect of Firm Efficiency on Capital Productivity

Matching Method	ATT	Standard Error	t-value
Nearest Neighbour (Random draw version)	4.098	1.944	2.108
Nearest Neighbour (Equal weights version)	4.084	1.944	2.1
Stratification Method	4.342	1.938	2.24
Radius (0.5)	4.417	1.936	2.282

Source: Authors' computation from GHS data.

Having satisfied the balancing property as noted above, the study equally employed 4 matching methods. The results are shown in figure 3. The four methods clearly show that the average treatment effect of efficiency on the capital productivity of efficient firms is significant and positive. This complements the result of the multiple regression earlier discussed. The t-values for Nearest Neighbour (Random draw version), Nearest Neighbour (equal weights version), Stratification Method, and Radius (0.5) are 2.108, 2.100, 2.240 and 2.282 respectively, all greater than 1.96, hence significant at 5% significant level. The average treatment on the treated for all matching methods ranged between 4.084 and 4.417, hence validating the robustness of the results as they were similar.

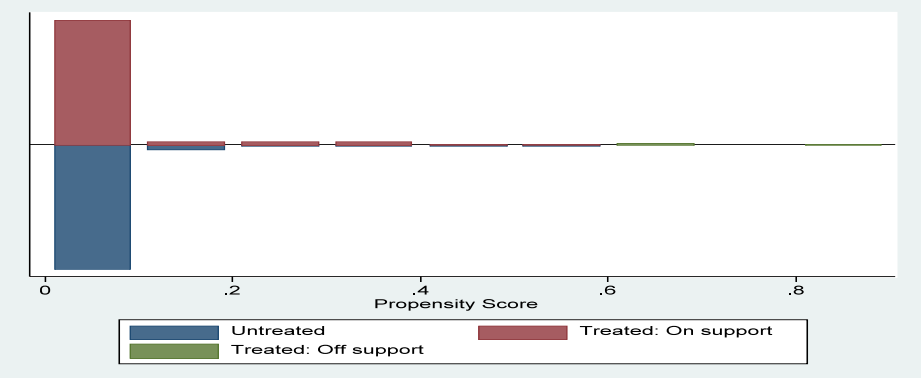

Figure 3. Propensity Score Graph for Common Support.
Source: Authors' computation from the GHS data.

The study, therefore, rejects the null hypotheses that resource use efficiency does not significantly affect capital productivity in Nigeria. It concludes that efficiency is a significant determinant of capital productivity in Nigeria

5. Conclusion and Recommendation

This study was motivated by the need to respond to threats posed by climate change in developing countries. In particular, the study has drawn attention to the notion of resource efficiency as one of such response strategies. In this vein, the study sought to measure resource use efficiency in the Nigerian agriculture sector, especially in the rural areas. In terms of specific objectives, the study examined the proportion of efficiency for green agro-based firms in rural Nigeria, ascertained the efficiency of green firms in rural Nigeria and lastly, it looked at how resource-use efficiency for agro-based green firms contributes to improved labour and capital productivity in Nigeria.

The results show that size of land owned by an agro-firm and capital are significant determinants of efficiency of green agro-based firms, whereas number of workers, the years of experience of the enterprise head and level of education of enterprise head are not. Furthermore, the study used multiple regression to show that efficiency significantly influences labour and capital productivity. The propensity score method also validated the multiple regression results showing, with different matching methods, that efficiency significantly and positively affects labour and capital productivity of rural agriculture in Nigeria.

From the results of the study, it is also clear that the level of awareness of opportunities for improving resource efficiency among the MSMEs is low. In this regard, the study recommends that more sensitization should be carried out in order to improve awareness of farmers and agricultural entrepreneurs of existing opportunities for improving resource efficiency. The MSMEs need to be aware of the advanced technologies, hybrid seeds, modern tools and innovative ways that are available within the agricultural sector. This can be done using all media channels, including social media.

Further, the fact that efficiency significantly improves capital and labour productivity only demonstrates the importance of being green and efficient. There is thus the need for the government and other actors involved in promoting growth of agro-based MSMEs to work towards programmes that will improve

farmers' access to infrastructure and services (e.g., energy services) with a bearing on resource efficiency. Lastly, there is the need for a comprehensive policy on agriculture-based MSMEs given that agriculture remains one of the most important routes to economic diversification, which is the most eminent goal of the current Nigerian government. Once developed, such a policy can be complimented by a robust framework on climate change adaptation and mitigation.

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