Volume 9, Issue 9, September– 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24SEP906

Farm Mechanization Innovation Capacity and Rice Productivity: Evidence from Small Scale Rice Farmers in Kwara State, Nigeria

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Abstract:- Rice is a staple diet eaten by more than fifty percent of households in the whole world. There is a deficit currently in the demand- supply production of rice when carefully observed and this is traceable to the use of crude implements and traditional methods of farming. It is to this effect that this study addresses farm mechanization innovation and rice productivity using small scale rice farmers in Kwara State, Nigeria. A total of 261 rice farmers were used for this study out of which only 78 rice farmers adopted the farm mechanization innovation while 183 rice farmers did not. The focus group discussion (FGD) employed revealed that majority of the rice farmers do not have capacity for farm mechanization, hence the low adoption of the innovation. The FGD revealed that 65.90percent of the rice farmers had medium innovation capacity, 28.74percent had low innovation capacity and 5.36percent had high innovation capacity. Employing the Propensity Score Matching (PSM) method to evaluate the impact of farm mechanization on the productivity of rice farming households in Kwara State, Nigeria; the rice farmers that adopted the use of farm mechanization have a higher productivity of 12.68 kg/m^2 as against the rice farmers who do not adopt the use of farm mechanization in their farming activities with their own productivity standing at 6.31kg/m^2. This outcome implies that farm mechanization has a positive impact on the productivity of the farmers. It is therefore recommended that quality extension services be put in place in the study area on the benefits of adopting farm mechanization. Also, the government should provide machineries for lease to the rice farmers so as to boost their productivity.

Keywords:- *Farm Mechanization, Innovation Capacity, Focus Group Discussion (FGD), Productivity and Rice Farmers.*

I. INTRODUCTION

More than fifty percent of households worldwide eat rice (*Oryza sativa*) as a staple diet (Akinniran and Faleye, 2020). Rice as a prominent grain largely imported by Nigeria (leading importer in sub-Saharan Africa) produces about 2 million metric tons of milled rice annually while importing close to 3 million metric tons, according to a 2020 report from the Food and Agriculture Organization (FAO) (Toba *et al.*, 2022). Relevant agencies have been urged to increase crop productivity along the value chain in order to avert the imminent threat if this trend continues. Even at this, food insecurity is a major challenge faced by rice farmers in Nigeria today. There is persistent rise in the price of goods and services; unfortunately the farming sector is not spared. Farmers no longer get a commensurate reward for their hard labour in addition to the unanticipated shocks and unpredicted natural problems involved in rice farming. This particularly makes the farmers look elsewhere for income generation (Afodu *et al;* 2019). Critically diving into the current demand for rice, the demand-supply gap in rice production can be traced to the use of crude implements and the employment of traditional methods of farming. Pests, diseases, government bureaucracy, effect of weeds and climate change among others are also constraints encountered in the production process. As it is today in Nigeria, rice farming and production is still characterized by several challenges like low education level of the farmers, absence and inadequacy of extension services and the problem of land fragmentation. Rain is the only source of irrigation to the farms, fertilizer is used, farming operations are done by hand, and better seed varieties are not used, and all these challenges necessitate mechanizing agricultural production processes.

According to Rahman and Lawal (2003), Owombo *et al*. (2012), agricultural mechanization is described as the application of engineering technology into the field of agriculture, in order to improve agricultural output, as well as deliberate conscious departure from the peasant and

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24SEP906

subsistence agriculture into a commercial agriculture. This as a process involves developing and managing machineries for production in the field, control of water, handling material including post-harvest operations.

Innovation capacity as described by Szeto in 2000 involves a continuous improvement in the capabilities and resources of firms in order to discover opportunities that will lead to engagement in new product development. Hence, innovation capacity can be said to mean the farmers' adoption of new farm machinery. Farmers' innovation capacity is an all important characteristic of a farmer needed in adopting a new machinery to maintain his farm in an efficiently and cost-effectively.

The ideal effort to increase production by the rice farmers is to adopt and utilize mechanization. Adoption is therefore defined as the choice to maximally utilize an invention in form of technological advancement as the most effective decision to carry out. The farmers must put in a lot of mental work before they can determine whether or not to employ the invention. The farmer however is not sure if the technology will be profitable. Rogers (1969) argued that an individual farmer will go through an adoption process that includes awareness, interest evaluation, testing, and adoption before embracing new technologies. He asserts that an invention needs to be financially successful, socially acceptable, and visibly demonstrated by technology in order for farmers to embrace it. The necessity of farm mechanization adoption has forced agricultural research in the majority of nations to focus all of its attention and resources on engineering research in operations to minimize labor intensities, drudgery, and the intrinsic unwholesome handling that is prevalent with traditional manual operations (Davies, 2006). As a result, this study investigates the farm mechanization innovation capacity and rice productivity of small scale rice farmers in Kwara State, Nigeria. This goal was achieved by describing the characteristics of small scale rice farmers in Kwara State, determining the innovation capacity of the rice farmers and finally assessing the impact of Farm Mechanization on productivity of Rice farmers in Kwara State, Nigeria.

II. LITERATURE REVIEW

Mechanization is described as the act of changing from working at a large scale, mainly by hand or with animals to the use of machines (Mabayoje, 2017). Agricultural mechanization is the application of implements, tools, and machines usually powered by man, animal, and engines as inputs for agricultural production (Clarke and Simalenga, 1997). In 2008, Verma opined that agricultural mechanization is the use of various power sources and improved farm tools and equipment, reducing the labour of human beings and draught animals, enhancing the cropping intensity, clarity, and timely efficiency in utilization of different crop inputs bringing a reduction in the losses and wastages at different stages of crop production. Olaoye and Rotimi (2010) on the other hand reiterated that attainable levels of land productivity, labor productivity, farming profitability, sustainability, the environment, and the living standard for those involved in agriculture are all directly and significantly impacted by the quantity, wise selection, and subsequent appropriate use of mechanized inputs in agriculture. Several types of innovative farm machinery has been unveiled, yet the adoption by the generality of farmers is still unexpected possibly because they lack adequate knowledge about the machines and the likely benefits of using them. In lieu of this, innovation capacity is lacking on the part of the farmers although they have been recognized as one of the key sources of innovation. Several studies on agricultural innovations have considered farmers continuously as adopters of externally driven innovations (World Bank, 2011; Hayami and Ruttan, 1985). Farmers are now recognized as experimenters and innovators rather than merely as consumers of newly developed technology. There are even suggestions that some of the technologies created by scientists were inspired by local farmers' concepts and methods. (Roling, 2009; Chambers *et al.*, 1989; Rhoades, 1989).

Dauda *et al.* (2010) noted that tractor power has been a competitive alternative to animal draught in recent years. These farm tractors were first introduced in Nigeria in the 1950s through a farm settlement scheme in the country's western region, and later throughout the nation. The authors further opined that the reason for the underutilization of farm tractors in Nigeria is that they are only used sparingly during the seasons, and there is a lack of managerial and technical expertise in handling, operating, and maintaining the farm machines (Manuwa, 1996, Oni, 2004, Usman and Umar, 2003).

Generally speaking, not less than two pathways of farm mechanization related innovation have been observed in developing countries, Nigeria inclusive. The current method of mechanization which is characterized with using large machineries which are appropriate for lands that are flat, and alternative mechanization that representing machines that are smaller, locally manufactured or family owned animal traction, and hand tools useful for labour reduction on hilly farms (Biggs and Justice, 2015). Notwithstanding the recent increase in literature on agricultural innovation systems as a result of limitations of the transfer of technology approach of agricultural innovation, not so many of the farmers get to know innovations that are agricultural mechanization related (Baudron *et al.* 2015, Mottaleb *et al.* 2016). Eastwood *et al.* (2019) outlined that most applications of responsible innovation studies were done in the Europe and North America and even at that, a very few and limited study is available in agricultural innovation, most especially in developing area contexts, Nigeria inclusive.

Critically examining Rogers Innovation Diffussion Theory (Rogers, 1969), he observed that before the adoption of a new technology by any farmer; an adoption process will be followed like awareness, interest evaluation, trial and adoption. He further reiterated that for an innovation to be acceptable to the farmers; it must be profitable economically, acceptable socially and visible technologically. The attention of most countries' National

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Agricultural Research has been drawn to the urgent need on adoption of farm mechanization which is believed to be committed with uppermost interest and resource to engineering research in operations to minimize the drudgery, reduce labour intensities, unsanitary and intrinsic unwholesome handling that are involved in the traditional manual operations (Davies, 2006).

➢ *Theoretical Framework*

This study employed the Propensity Score Matching (PSM) method to analyze the impact of adopting farm mechanization on the productivity of rice farmers in Kwara State, Nigeria. This method is another way of estimating the impact of a treatment on a particular subject. The PSM method is usually employed in evaluating the impact of an intervention but not able to collect experimental data on the division of observations into two groups, namely the group that received treatment and the group that was not given treatment, that is standing as the control (Li, 2012). For this study, the treatment group are the rice farming households that use farm mechanization, that is agricultural machines in the rice production activities while the control group are the rice farmers that did not use agricultural machines for their rice farming activities.

Using Propensity Score Matching (PSM) in impact evaluation reduces bias when it comes to observational researches. Comparisons are strengthened by the use of PSM as it also enhances causal inferences by reducing the impact of confounding factors and selective biases (Li and Xue, 2024). The inability of PSM to measure the possible outcomes of the treatment group and the control group simultaneously, allowing for the observation of only one of the two, is a fundamental and frequent issue that arises when applying PSM. To this effect, the Average Treatment Effect on the Treated (ATT) approach which is an estimation model that allows observing the average value of the impact of the use of mechanization is employed (Feryanto and Rosiana, 2021). ATT is used to approximate the average value of the potential outcomes of rice farming households that use machinery in their farming activities (Khandker *et al*, 2010; Rosenbau and Rubin, 1983). The ATT model can be written as:

$$ATT = E(Yi(1) \mid Di = 1) - E(Yi(0) \mid Di = 0) \ldots\ldots \text{Equation 1}$$

From Equation (1) above, Average Treatment Effect on the Treated (ATT) is explained as the impact estimated from the outcome variable which is the farm income calculated from the yield of rice farming households using farm mechanization, described as E[Y1i|Di=1] less rice farming households that did not use farm mechanization : E[Y0i|Di=0].

Nearest Neighbor Matching (NNM) was employed to perform the matching. This method involves pairing members of the participant group with a control group that has the same probability value. For the treatment in this method, all units affected by treatment have a partner, and then the difference between the results of the treatment group and the control group is estimated. The main objective in NNM is to reduce the absolute difference in the estimated propensity score between the treatment group and the control group.

III. MATERIALS AND METHOD

➢ *Data and Sampling*

The study was conducted in Patigi and Edu Local Government Area of Kwara State, which are the largest rice producing communities of Kwara State. Primary data was obtained through well structured questionnaires. This instrument was subjected to content validity for critical review by experts in the field of Agricultural Economics. Multi stage sampling technique was employed for this study. At the first stage, Kwara State was chosen purposively. The second stage involves the purposive selection of two local governments out of sixteen local governments in the state where rice is largely produced. At the third stage, random sampling technique was used to pick three districts from each of the two local governments that were selected. Random sampling technique was employed at the fourth stage to select six (6) wards from each of the six districts totalling thirty six (36) wards, after which eight (8) respondents were randomly chosen from the farmers list made available by Rice Growers Association at the final stage. A total of 288 respondents were selected for the study and the questionnaires were administered by well trained enumerators deployed for the data collection. Only 261 questionnaires were eventually used for the analysis.

IV. RESULTS AND DISCUSSIONS

➢ *Characteristics of Rice Farming Households in Kwara State, Nigeria*

According to Table 1, the characteristics of rice farming households are either pooled or based on households that have used mechanization in their farming activities, that is the treatment group and households that have not used mechanization, the control group. A total of 261 respondents were used, 78 rice farmers adopted the farm mechanization innovation while 183 rice farmers did not. The PSM model targets comparing if there are significant differences in the use of farm mechanization and none use. It is therefore important to form treatment and control groups. From the findings of this research, the average age of rice farmers in Kwara State is 49 years for the pooled, 50 years for rice farmers that employ farm mechanization, that is the treatment group and 42 years for rice farmers who do not use farm mechanization (the control group). This is in support of a study carried out by Feryanto and Rosiana in 2021 on the use of mobile phones for marketing and its impact on farmers' welfare. It was discovered that farmers who do not adopt the new innovation of using mobile phones to market their products are mainly young people. For sex of the rice farmers, both treatment and control groups were dominated by male farmers. This shows that household decisions are primarily made by men as supported by Kurniawan (2021) in his work titled “The dilemma of agricultural mechanization and the marginalization of women farm workers in rural areas”. The level of education from the findings of this research reveals

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24SEP906

that the average number of years spent in school in the treatment group is higher than the average education in the control group. The average years of formal education for rice farmers using farm mechanization is 12 years, while the average length of formal education for those that did not adopt farm mechanization is only 7years. This is supported by Sims and Kienzle (2016) and Takeshima *et al*. (2016) when they opined that education level is one of the major factors that influence farmers decision to accept innovations and new technologies in their farming activities. The average yield of rice in the treatment group was 10300kg, which was lower than the average yield of rice for the control group put at 8150kg. The productivity of rice farmers on the average in the treatment group, that is those that adopted farm mechanization are higher than those that did not adopt the innovation of farm mechanization in the control group. The average productivity of the treatment group was 12.68 kg/m^2 and that of the control group was valued at 6.31 kg/m^2.

Table 1 Descriptive Statistics of Rice Farmers in Kwara State

		Pooled Sample		**Farmers that adopted Farm Mechanisation (Treatment Group)**		**Farmers that did not adopt Farm Mechanisation (Control Group)**
Variable	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Age(Years)	49	12.28	50	12.25	42	11.49
Sex(Male=1,Female =0)	0.90	0.36	0.91	0.34	0.89	0.35
Education (Years)	10	5.45	12	5.36	7	5.42
Productivity(kg/m^2)	12.52	3.45	12.68	3.26	6.31	5.45
Sample Size		261		78		183

Source: Field Survey, 2024

- *Farmers Innovation Capacity in Adoption of Farm Mechanisation*

Farmers' innovation capacity is an important attribute of a farmer which signifies the ability of the said farmer to adopt a new machinery to keep his farm efficiently and cost-effectively. Therefore, the farmers' innovation capacity in adopting farm machinery was measured and revealed in Table 2 below. This was achieved through focus group discussion (FGD) sessions and the farmers responded to the questions asked.

Table 2 below revealed that 65.90percent of the rice farmers had medium innovation capacity, 28.74percent had low innovation capacity and 5.36percent had high innovation capacity. From this result, innovativeness and knowledge about farm mechanization among rice farmers in Kwara State is largely medium, hence, we conclude that they are able to adopt new machinery within the shortest time possible with the willingness to gather expertise on using machinery in the future. Most of the farmers had low to medium level of innovation capacity for adopting farm mechanisation. This outcome is in line by the findings of Wang and Pervaiz, 2004; Yam *et al.,* 2011 and Santamaria *et al.*, 2009.

Table 2 Distribution of the Rice Farmers based on their Innovation Capacity.

Category of Rice Farmers	**Number of Rice Farmers**	**Percentage**	**Mean**	**Standard Error**
Low Innovation Capacity (0- 25)	75	28.74		
Medium Innovation Capacity (26- 50)	172	65.90	82.64	10.85
High Innovation Capacity (51-75)	14	5.36		

Source: Field Survey, 2024

- *The Impact of Farm Mechanization on Productivity of Rice Farmers in Kwara State.*

Propensity Score Matching (PSM) method was used to evaluate the impact of farm mechanization on the productivity of rice farming households in Kwara State, Nigeria. The indicators estimated which are derived from the results of the PSM are used as indicators of the impact of treatment. For the purpose of this study, the impact of farm mechanization was calculated using the Nearest Neighbor Matching method. This method is usually used in the PSM method and it involves the pairing of the closest propensity value between the treatment group and the control group.

Table 3 below revealed that the farm mechanization operations carried out by the rice farmers showed a positive and statistically significant result at 1 percent on the observed outcome, which is productivity. For the rice farmers that adopted the use of farm mechanization, they have a higher productivity of 12.68 kg/m^2 as against the rice farmers who do not adopt the use of farm mechanization in their farming activities with their own productivity standing at 6.31kg/m^2. The average productivity difference between these two categories of rice farmers is 6.37 kg/m^2. This outcome is supported by Feryanto *et al.* (2022) where they reiterated that one of the important roles of farm mechanization is increase in agricultural productivity. This is also supported by Peng *et al.* (2022) when they opined that when machines are used for harvesting, the potential for loss of crop yields is reduced drastically which is a normal and usual occurrence with manual harvesting.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24SEP906

Table 3 The Impact of Farm Mechanization on Productivity of Rice Farmers in Kwara State, Nigeria.

Outcome	Sample	Treated	Controls	Difference	Standard Error	t-stat
Productivity (kg/m^2)	Unmatched	12.68	7.27	5.41	0.026	56.30
	ATT	12.68	6.31	6.37	0.052	18.23*

Source: Field Survey, 2024
* means significant at 1%

V. CONCLUSION AND RECOMMENDATION

This study evaluated the impact of farm mechanization on the productivity of rice farming households in Kwara State, Nigeria. Propensity Score Matching (PSM) method was employed to analyze the impact of adopting farm mechanization on the productivity of the rice farmers. This method serves as an alternative for the estimation of the impact of a treatment on a particular subject. The empirical findings from the study showed that the average age of rice farmers in Kwara State when pooled together is 49 years, 50 years for rice farmers that employ farm mechanization and 42 years for rice farmers who do not use farm mechanization. Majority of the farmers were males and those that adopted farm mechanization were more educated than those that did not use farm mechanization. Also, it was revealed that rice farmers that adopted the innovation of farm machinery use had higher yields than those that did not adopt. This study also revealed that 65.90percent of the rice farmers had medium innovation capacity, 28.74percent had low innovation capacity and 5.36percent had high innovation capacity; therefore majority of the farmers had low to medium level of innovation capacity for adoption of farm mechanisation. Furthermore, the rice farmers that adopted the use of farm mechanization have a higher productivity of 12.68 kg/m^2 as against the rice farmers who do not adopt the use of farm mechanization in their farming activities with their own productivity standing at 6.31kg/m^2. This outcome implies that farm mechanization has a positive impact on the productivity of the farmers.

It is therefore recommended that quality extension services be put in place in the study area on the benefits of adopting farm mechanization. Also, the government should provide machineries for lease to the rice farmers so as to boost their productivity.

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