

**AGRICULTURAL INNOVATION AND RICE COMMERCIALISATION:
EVIDENCE FROM THE MOUNT MBAPIT RURAL RICE
DEVELOPMENT PROJECT, NOUN DIVISION, CAMEROON**

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DOI: <https://doi.org/10.51193/IJAER.2026.12303>

Received: 23 Mar. 2026 / Accepted: 03 Apr. 2026 / Published: 09 May 2026

ABSTRACT

Despite Cameroon's potential for rice self-sufficiency, smallholder farmers often face low productivity and limited market participation due to a lack of modern technological adoption. The Mount Mbapit Rural Rice Development Project was established to address these constraints by promoting agricultural innovations and enhancing rural livelihoods through value-chain development. This study evaluates the impact of agricultural innovations specifically improved seed varieties, mechanization, irrigation, and modern processing techniques on the level of rice commercialization among smallholders in the Noun Division. Using a cross-sectional survey design, primary data was collected from a representative sample of 290 smallholder rice farmers. Descriptive statistics were used to profile farmer characteristics and a multinomial logit regression model to identify the determinants of market participation and the intensity of commercialization. Preliminary evidence suggests that the adoption of innovations significantly increases both yields and the proportion of rice sold to the market. Key drivers of commercialization include agricultural innovation, membership in cooperatives, access to market information, off farm income, farm size, price and distance from the market. However, high input costs, irrigation and inadequate road infrastructure remain barriers to full market integration. The study confirms that agricultural innovation is a critical driver for transforming subsistence rice farming into a commercially viable enterprise in the study area. The study recommends that policy should aim at subsidizing modern

inputs and encouraging farmers membership into cooperative so as to maximize their impact on local economic growth and food security.

Keywords: Agricultural Innovation, Rice Commercialisation, Smallholder Farmers, Mount Mbapit Project, Noun Division, Cameroon.

1. INTRODUCTION

Agricultural innovation and commercialisation play a dominant and strategic role in the growth and development of most developing nations of the world. Most importantly, the role of the agricultural sector as a source of employment and enhancing food security cannot be overemphasised. In Sub-Saharan Africa (SSA), Asia and the Pacific, the agriculture-dependent population is between 60-70%, while in Latin America and some high-income economies, the proportions are estimated to be around 14.5% and 2% respectively [50, 46]. Therefore, the agricultural sector is vital for bringing about economic growth and development, overcoming poverty and enhancing food security. However, the aforementioned potentials of the agricultural sector could only be achieved through an increase in productivity of farmers as emphasised in the 2008 World Development Report. Thus, boosting agricultural productivity and enhancing commercialisation has been an issue of paramount importance to development institutions across the globe. To achieve this, the use of technological improvement has played a key role [26].

Based on the success stories emanating from the Green Revolution in Asia, efforts to improve agricultural productivity have been directed towards the adoption of improved agricultural innovations. It is believed that improved agricultural technology adoption, such as using improved seed varieties, fertiliser, pesticides, and traction/mechanisation, could inspire the change over from the presently low productivity, peasant, and subsistence farming to commercial farming to generate surpluses for export [6]. Improved agricultural innovation has the potential to deepen the market share of agricultural output through which the smallholder farmers' resource use and output diversification decisions could be guided increasingly by their objective of profit maximisation. This will lead to emphasis on the importance of purchased inputs thereby boosting the growth of specialised commercial farming units in developing countries [36].

In Cameroon, the production of rice has transitioned from a localized food security crop to a strategic commodity within its national agenda for import substitution and economic emergence. Despite having vast ecological potential, the country remains heavily dependent on foreign imports to meet a domestic demand exceeding 700,000 tons annually [41]. In response, the Government of Cameroon launched the Mount Mbapit Rural Rice Development Project in the Noun Division in 2006 to transform traditional subsistence farming into a modern, market-oriented enterprise [11]. This study examines the nexus between agricultural innovation and rice commercialization,

providing critical evidence on how technological advancements drive smallholder integration into the national market.

Agricultural innovation, encompassing improved seed varieties, traction/mechanization, irrigation, and fertilizer, is widely recognized as the primary engine for rural transformation. Recent empirical evidence suggests that the adoption of such innovations can increase rice productivity by over 24% and farmer income by up to 50% [31]. However, productivity gains do not automatically translate into commercial success. In the Noun Division, smallholders often grapple with high transaction costs, inadequate storage facilities, and fragmented market linkages that stifle their ability to compete with high-quality imported brands [15]. The Mount Mbapit project serves as a crucial intervention, providing the infrastructure and institutional support necessary to bridge the gap between farm-gate production and urban consumption.

Commercialization in the context of this study refers to the transition where farmers produce primarily for the market rather than for household consumption. While national strategies such as the National Development Strategy 2020-2030 (SND30) aim to achieve rice self-sufficiency, the intensity of commercialization among smallholders remains uneven [28]. Current data from late 2025 indicate that while paddy production is rising, the "quality gap" in local milling often prevents Cameroonian rice from capturing the premium urban market [44]. Therefore, understanding the determinants of market participation ranging from access to credit and cooperative membership to the use of mechanized harvesters is essential for evaluating the success of rural development initiatives [4].

By analyzing a sample of 290 smallholder farmers, this research addresses a critical gap in the literature regarding the specific impact of the Mount Mbapit project's localized interventions. While previous studies have focused on larger parastatals like SEMRY or UNVDA, there is a paucity of data on how targeted rural projects in the Noun Division influence the commercial behavior of individual farmers. This study seeks to determine the extent to which agricultural innovations have fostered a market-oriented mindset, ultimately contributing to the broader goal of reducing Cameroon's trade deficit and enhancing the livelihoods of rural producers.

2. LITERATURE REVIEW

2.1 Determinants of Commercialisation

[19] carried out a study on agricultural commercialisation in coffee growing areas of Ethiopia. The objectives were to assess the determinants of the likelihood and extent of market participation among smallholders in major coffee growing areas in Ethiopia. They applied the logit and OLS regression methods on survey data. The logit model was applied to categorical dependent variable data while OLS regression was applied to continuous sales data for the dependent variable. Results

of the study showed that socio-economic variables such as total farm size, household size and education level of the farmer were found to have no effect on the degree of commercialisation among sampled households. The study recommended that market risks in both the food and coffee market should be address by increasing research and policy attention. We borrow from these authors and use the multinomial logit model to investigate the contribution of agricultural innovation on commercialisation in the Mount Mbapit Project.

[38] conducted a study to determine the factors that influence fish farmers to participate in the marketing of their produce in the Niger Delta Region of Nigeria. Using a sample of 120 fish farmers and employing a Tobit and logit regression model, they reported that farm size, household size, distant to the nearest marketing channel, price of the commodity and sex of the fish farmer/marketer significantly influence market participation. These authors used the Tobit and logistic model to determine only the factors that influence market participation; we will go further to investigate the factors that influence commercialisation and the influence of commercialisation on production.

[32] studied the market participation of smallholder farmers in the upper west region in Ghana. The objective was to assess the level of market participation by smallholder maize and groundnuts farmers in the region. A multi-stage random sampling procedure was employed to select 400 farmers from four agricultural districts in the region. The household commercialisation index was used to assess the level of market participation and the double hurdle model to estimate both the factors influencing market participation and intensity of participation. The results indicated that farmer characteristics (such as age, gender, education, household size); private assets variables (such as farm size, output experience); public assets variables (such as credit, extension contact and price) and market information significantly influence the probability and intensity of market participation in the region. The study recommended creation of rural finance schemes to address credit needs of farmers as well as create a service to make market information delivery effective. However, the study in Ghana was silent on the effect of commercialisation on production and therefore no empirical basis to argue for or against the promotion of commercialisation.

[39] carried out a study on market participation decision of smallholder farmers and its determinants in Bangladesh. The objective of the study was to sort out the most important factors that influence smallholder farmers' decision to participate in the output market to sell their produce in Bangladesh. Data was collected from 100 smallholder farmers of Durgapur Upazila under Rajshahi District. A Probit regression model was employed to analyse the data. They reported that farm size, household labour, income from livestock and farm income might be the main factors that affect the smallholder farmers' decision to participate in the output market. Contrary to the expectation, they found that market information does not have any significant impact on the farmers' decision towards commercialisation. The study recommends development of market

infrastructure and provision of marketing incentives to smallholder farmers. While this study analysed the determinants of market participation, it did not address the effect of agricultural innovation on market participation.

[12] conducted a study on the Trends and Determinants of Coffee Commercialisation among Smallholder Farmers in Southwest Ethiopia: Jimma Zone Coffee Potential Districts. They had as objectives to assess coffee commercialisation trends and factors that encourage and discourage coffee commercialisation level as transforming the subsistence-oriented production system into a market-oriented production system as best option to increase the smallholder farmer's income and reduce rural poverty. Primary data was collected from 156 households in three coffee potential districts. Descriptive statistics and the Tobit model were used and the results showed that distance to main market and cooperatives, transport cost and land allocated for other crops affects level of coffee commercialisation negatively and significantly. However, total land holding of the household head, coffee price and volume of coffee produced affects level of commercialisation positively and significantly. The study recommended support towards developing institutional sectors like marketing cooperatives and improving physical access to market places could yield positive results towards coffee commercialisation by smallholder coffee producers.

[1] conducted a study on the determinants of commercialisation and its impact on the welfare of smallholder rice farmers. This study had as objectives to assess the factors that affect smallholder rice farmers' participation in the market. In addition, it also examines the effect of commercialisation on the welfare of smallholder farmers. They collected data from 249 smallholder farmers. The Heckman two-stage method was used to obtain the desired objectives. The results of the study indicate that gender of the household head, age, household size, vocational training, and the farmer being land lord and farm size were major determinants of market participation. They recommended that participation in market can be increased by providing subsidized prices for their production, cold storage houses and vocational training. While this study analysed determinants of market participation adequately by controlling for sample selection in the second stage of estimation, it could have been more informative if it had a larger sample.

[10] carried out a study on agricultural technology adoption, commercialisation and small holders in rural Nigeria. This study has as objective to assess the determinants of intensity of adoption of Improved Rice Varieties (IRVs) and the effect of market participation on farmers in Nigeria using the Tobit and Heckman two-stage models, respectively. The sample consists of cross-sectional data of 600 rice farmers selected randomly from three notable rice producing States in Nigeria. They employed the tobit and the Heckman two-stage model and found that gender of household head, access to improved seed, years of formal education, and average rice yield were those variables that are positive and statistically significant in increasing the probability that a farmer would participate in the market. The study recommended that programmes to improve extension contact,

increased access to credit, raising educational background are the factors to be promoted in order to increase market participation. Though this study was very informative on the determinants of market participation, it did not explain the effect of agricultural innovation on market participation.

[16] carried out a succinct study on the socio-economic analysis of the banana-plantain marketing system in western region of Cameroon. The study had as objectives to highlight the functioning of the various banana- marketing systems and their economic viability in west region of Cameroon. Using a sample of 167 stakeholders involving 33 producers, 50 collectors, 25 wholesalers, 44 retailers and 15 transporters and employing descriptive statistics they found that market information is one of the major factors influencing banana-plantain commercialisation in the west region. The study recommended that the actors involve should negotiate market contracts with the aim of reducing the loss linked to the banana market.

[18] studied the determinants of sorghum crop commercialisation, the case of Southwest Ethiopia. The study aimed at identifying the determinants of sorghum producers' commercialisation in Kaffa, Sheka, and Bench Sheka zones Southwest Ethiopia. Using data from a sample of 543 farmers, they employed descriptive statistics and the Tobit model to analyse the data. The results indicated that sex of the household head, educational level of household head, land under sorghum production, non/off farm income, sorghum quantity produced, credit amount received were found to influence significantly the degree of commercialisation. They recommended supporting female-headed households through different policy initiatives and interventions that can improve their market participation, strengthening supportive institutions such as credit access and extension contacts would motivate farm households to improve market participation. Though this study was very informative in determining the factors that influence commercialisation, it failed to indicate the effect of innovation on commercialisation.

[42] conducted a study titled "Determinants of Rice Commercialization among Smallholder Farmers" to identify factors hindering commercialization in Tanzania. Utilizing multiple regression analysis and the Household Commercialization Index (HCI), the researchers found that gender, education level, and family size were significant determinants. Crucially, they noted that market distance and bank loan use were pivotal in enabling a high degree of market participation, with the HCI reaching over 95% by 2023.

[17] explored "Determinants of Rice Production and Market Supply" in Ethiopia. Their objective was to investigate the factors affecting market supply and the constraints facing production. Using a multiple linear regression model on a sample of 119 households, the study revealed that total farm size, credit use, and the total quantity of rice produced were the most significant positive drivers of the volume supplied to the market.

[45] assessed the "Determinants of Commercialization and its Impact on Welfare" for smallholder farmers. The objective was to understand what drives market participation and how it affects overall household well-being. By applying the Heckman two-stage model to data from 249 farmers, they found that age, household size, and vocational training significantly determined participation. Their results also showed that higher rice output and off-farm income were essential for improving farmer welfare.

[1] assessed the determinants of market participation and its impact on the welfare of rice farmers in Pakistan. Using the Heckman Two-Stage Approach on a sample of 249 farmers, the study first determined that vocational training and land ownership were key predictors of the decision to enter the market. The second stage of the analysis proved that commercialization had a profound positive impact on household welfare, specifically through increased income and improved dietary diversity.

[25] examined the factors influencing rice commercialization among smallholder farmers in Wembere Basin in Tanzania. The primary objective was to identify the socio-economic and institutional drivers that affect both the decision to participate in the market and the extent of that participation. Utilizing a sample of 352 households and applying Multiple Regression Analysis, the researcher found a remarkably high commercialization index of 94.8%. The results indicated that access to bank loans, the use of improved seed varieties, higher educational attainment, and male gender were significant positive determinants. Conversely, market distance and large family sizes which increase home consumption were found to be significant barriers to commercial entry.

2.2 The Effect of Agricultural Innovation on Rice Commercialisation

[31] examined the effects of adopting technological innovations on rice value chain actors in Cameroon with the objective of determining how modern tools impact income and market engagement. Utilizing a multi-actor sample across the West Region and applying multiple regression analysis, the results revealed that 62% of adopted innovations significantly boosted commercial returns. A key finding was that "soft" innovations, such as mobile banking and digital market information systems, were more effective at reducing transaction costs than traditional mechanical tools alone, thereby facilitating higher volumes of market sales. A notable strength of this study is its identification of the "innovation-commercialization" link through digital financial inclusion.

[5] investigated the determinants of technology adoption and its subsequent impact on market participation among 117 small-scale rice farmers. Using a double-hurdle regression model, they found that the adoption of improved seed varieties and chemical fertilizers increased the Household Commercialization Index (HCI) by approximately 95% among adopters. However, they concluded that the effect of innovation on commercialization is heavily mediated by education

and farm size, as larger, more educated households were better equipped to leverage these innovations for market surplus. This study is significant for quantifying the specific threshold at which innovation leads to market entry.

[15] assessed the impact of seed and irrigation innovations on productivity and market supply using a sample of 721 farms in the Sudano-Saharan zone. Employing an Endogenous Switching Regression (ESR) model to account for selection bias, the results demonstrated that innovation adopters achieved a yield surplus of 646.44 kg/ha over non-adopters. This surplus was the primary driver for commercialization, as it provided the necessary volume to justify transportation costs to urban centers. The study proves that without the productivity "shock" provided by innovation, smallholders remain trapped in subsistence cycles regardless of market availability.

[41] analyzed the performance of rice producers under national import-substitution strategies using regional survey data from major production basins. Their descriptive and trend analysis showed that while paddy production grew by 4.5% annually due to better seeds, local commercialization was hindered by a "quality gap." They found that without innovation in post-harvest processing (milling and bagging), local rice could not compete with imported brands in urban markets. This highlights that for innovation to drive commercialization; it must extend beyond the field into the processing stage.

[44] evaluated the impact of state-subsidized mechanization on rice output and commercialization rates in the Noun Division. Monitoring data from thousands of smallholders indicated that the provision of combine harvesters and tractors reduced post-harvest losses by 15%, directly increasing the volume of "market-ready" paddy. The assessment concluded that mechanized innovation is the most effective way to scale commercialization, as it allows farmers to meet the bulk requirements of modern processing plants like the one in Ntabah. The advantage of this report is its use of real-time 2026 data to validate the success of the Piisah import-substitution plan.

[2] explored the digital transformation of the sector in their study, "Commercial Platforms Revolutionizing Rice Farming," which aimed to evaluate the impact of e-commerce on rice value chains. Using a value chain analysis, they found that digital platforms enabled over 50,000 farmers to bypass traditional middlemen. This innovation reduced transaction costs by 40% and resulted in a 30% increase in total revenue for the participating households.

[42] investigated the "Determinants of Rice Commercialization Among Smallholder Farmers," focusing on identifying the factors that drive market participation. By applying multiple regression analysis and the Household Commercialization Index (HCI), the study revealed that the adoption of improved seed varieties and access to formal credit were critical. Their results showed that these innovations helped farmers reach a commercialization level of nearly 95% during the 2023–2024 season.

[9] analyzed the "Adoption of Improved Rice Technologies" with the objective of assessing how integrated technology packages influence productivity. Using a Multivariate Probit (MVP) model to analyze 594 households, the researchers discovered that farmers who adopted a combination of innovations such as row planting, certified seeds, and precise fertilizer application doubled their yields. This led to a significant increase in surplus sales income compared to those using traditional methods.

[37] examined the "Impact of Uptake of Selected Agricultural Technologies" to understand their effect on income distribution among rice farmers. Employing Propensity Score Matching (PSM), the study found that the uptake of improved seeds and fertilizers increased net revenue per acre by 153.54%. The results demonstrated that these innovations not only boosted the volume of rice sold but also had a positive equalizing effect on rural household income.

[43] looked at the technological frontier in "Smart Farming for Sustainable Rice Production," aiming to determine the role of the Internet of Things (IoT) in crop health. Through a correlational quantitative design involving IoT sensors and deep learning models, they found that precision monitoring reduced input waste. This efficiency allowed farmers to produce a higher volume of high-quality, marketable surplus, which commanded better prices in competitive markets.

[7] evaluated how the adoption of agricultural technologies, such as improved rice varieties and fertilizer application, affects income distribution and commercial potential. Utilizing a survey of 917 farmers and an Endogenous Switching Regression model, the research found that technology adoption significantly boosts net revenue. Specifically, farmers who adopted these innovations saw a revenue increase of over 150% compared to non-adopters. The study concluded that innovation not only facilitates commercialization by increasing yield but also narrows the income inequality gap among rural producers.

3. MATERIALS AND METHODS

3.1 The study area

This study was carried out in the Mount Mbapit Rural Development Project (MMRDP) area in the Noun Division, West Region of Cameroon. It is located at latitude 5.45⁰ N and latitude 10.55⁰E. The Project was created in 2006 with the mission to ameliorate the living standards of the rural population and to develop value chain in agricultural production [8]. Most of the families in the area are crop farmers with rice as one of their major crops in their farming system. Rice production in the area is characterised by small-scale farmers with farm sizes of less than 1.5hectares [40]. The total land area for the Division is estimated at 7,687 square kilometres by MINADER, 2006 as cited by [28]. According to the Central Bureau for Census and Population Studies in 2005, the total population for Koutaba and Bangourain Sub divisions are 30,877 and 49,171 respectively

while the total surface area for rice cultivation for the sub divisions is 455.38 hectares of which net sown area is 391.49 hectares [30]. The major traditional crops cultivated include maize, rice, cassava, groundnut, yams, tomatoes, okro and sweet potatoes. The sub divisions are characterised by a single rainy season which starts in March and ends in November. The dry season starts in November and ends in March. The mean annual temperatures stand at 22⁰C with minimum in November and ends in March. The mean annual temperatures stand at 22⁰C with minimum in September and maximum 29⁰C in March. The mean annual rainfall stands at 1500mm [40]. The topography of the area is made up of flat land as well as hills. The soils are dark and suitable for rice production.

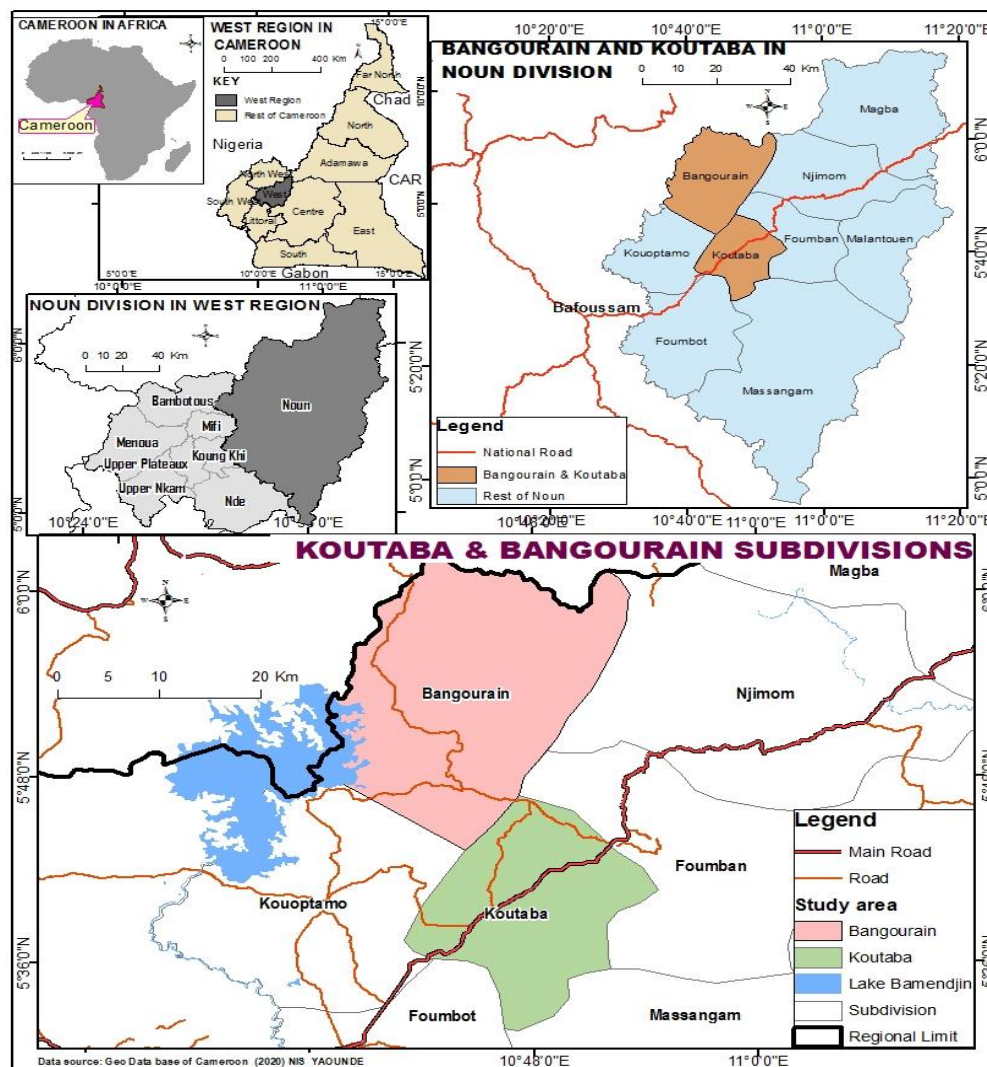


Figure 3.1: Map of Africa, Cameroon, West Region and Noun Division Showing the Study Areas.

Source: Geo Data base of Cameroon, NIS Yaounde [34]

3.2 Population, Sampling and Sampling Size

3.2.1 Population of the Study

The target population for this study comprises all registered smallholder rice farmers within the Noun Division of the West Region, Cameroon, specifically those operating under the framework of the Mount Mbatit Rural Rice Development Project. According to project records, there is a total of 1,138 registered rice farmers across the primary production hubs.

3.2.2 Sampling Technique and Sample Size

A multistage sampling technique was employed to select a representative subset of respondents, ensuring the collection of manageable data while minimizing sampling error. In the first stage, two major rice-producing communities that is, Tchoupa (Bangourain Sub-division) and Ngoundouop (Koutaba Sub-division) were purposively selected. These areas were chosen because they represent the core zones of rice production and commercialization activities within the Mount Mbatit project area. In the second stage, the sample size was determined using the Yamane (1967) formula for a finite population. Out of the 1,138 registered farmers, a required sample of 296 rice farmers was identified. To ensure fair representation, a Probability Proportional to Size (PPS) sampling technique was applied across the two locations, resulting in the selection of 180 farmers from Ngoundouop and 116 farmers from Tchoupa. In the third stage, a simple random sampling technique was utilized to select individual respondents from the registers, giving every farmer an equal chance of being included in the study. Following the data collection phase, 6 questionnaires were rejected due to significant missing data or inconsistencies. Consequently, the final study was based on a realized sample of 290 smallholder rice farmers.

Table 1: Sample Distribution Across Villages

Total number of households in Koutaba and Bangourain sub divisions	Rice producing households in the study area	Sample villages in the sub divisions	Total number of households in each village	Rice producing households in each village	The proportion of sample households	Sample households in each village
		Tchoupa	5000	421	37%	110
		Ngoundouop	3000	717	63%	186

80,877	1138	Total	8000	1,138	100%	296
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Source: Authors’ analysis from literature (2025)

The sample size for this research is calculated using Yamane formula for determining the minimum sample size from a given population. Accordingly, the required sample size at 95% confidence level with degree of variability of 0.05 level of precision equal to 5% were used to obtained the sample size required. The calculation formula for Yamane is presented as follows:

$$n = \frac{N}{1+N(e)^2} \dots\dots\dots(1)$$

Where: n= sample size required, N=number of people in the population, e=allowable error (%)

Substituting the numbers in the formula: $n = \frac{1138}{1+1138(0.05)^2} \quad n = 295.968790637 \approx 296$

3.2.3 Data Collection Instrument

The study was conducted based on both primary and secondary data sources. A cross-sectional household survey was conducted to gather primary data from smallholder rice producers in the study area. The primary data were collected by preparing a semi-structured questionnaire and with the help of enumerators after giving necessary training. The questionnaire was pre-tested and amended by conducting a pilot survey on 20 farm households in another village in the study area since households have more or less similar socioeconomic characteristics to the others.

3.2.4 Informed Consent

The enumerators sought informed consent for this study from the participants before the interviews. They clearly explained their roles and responsibilities to the participants during data collection, providing a comprehensive overview of the study’s objectives. The enumerators informed the participants that their participation was entirely voluntary and that they could withdraw from the study at any time without any penalties or negative consequences. They verbally obtained consent and meticulously documented it to adhere to ethical standards. We also assured the participants that their responses would remain confidential and anonymous throughout the study

3.3 Analytical Techniques

3.3.1. Descriptive Statistics

Before estimating the model, the data was checked for outliers, missing data, incorrectly entered variables that will affect the quality of results from the analysis. Both quantitative and qualitative methods were used in analysing the data gathered from the surveys. Quantitative analysis included

the use of descriptive statistics and inferential statistics. Descriptive statistics such as measures of frequency (counts, frequencies, percentages) were used to put the message across.

3.3.2. Econometric model

Inferential statistics (principally regression analyses) using the multinomial logit model was employed to explore the relationships among the variables. The results of both the descriptive and inferential analyses were displayed on tables. Rice commercialisation was measured in categorical terms as 0 for subsistence, 1 for semi-commercialised and 2 for commercialised. Rice production or yield was measured as the annual quantity of rice produced in kilograms or tonnes.

The study adopted the Multinomial Logit Model to investigate the determinants of commercialisation drive of rice farmers. The multinomial Logit Model is used when the dependent variable has multiple unordered nominal categories [8]. The farmers’ decision to produce is divided into three categories: subsistence, semi-commercial, and commercial. These dependent variables are categorical rather than ordinal, and they conform to the assumption of Independence of Irrelevant Alternatives (IIA). We assumed that the relative odds of choosing one category over another are unaffected by other categories, the log odds are linear in parameters, and there is no perfect multicollinearity. Therefore, following Amemiya [8], we established the Multinomial Logistic Model. Thus, rice farm household will produce only for subsistence, semi-commercial or commercial if doing so will maximise his/her utility. The requirement for an *i*th rice farmer to choose any package, *j*, over any alternative package *m* is that $\pi_{ij} > \pi_{im}$, for all $m \neq j$. Following recent studies [12,21], the expected benefit π_{ij}^* that a farmer derives from selecting package *j* is a latent variable determined by household and farm-specific characteristics and can be specified as;

$$\pi_{ij}^* = X_i \alpha_j + \varphi_{ij} \dots \dots \dots (2)$$

Where X_i is observed covariates and φ_{ij} is the error term capturing unobserved characteristics. Therefore, the Multinomial Logit Model to investigate the determinants of commercialisation is defined as;

$$\log \frac{P_r(y=k|X)}{P_r(y=K|X)} = \alpha_0^k + \alpha_1^{(k)} x_1 + \alpha_2^{(k)} x_2 \dots + \alpha_p^{(k)} X_p \dots \dots \dots (3)$$

For $k=1, \dots, k-1$. According to this model, the ratio of any two group membership probabilities is a log linear function of x , since we have

$$\log \frac{P_r(y=j|X)}{P_r(y=K|X)} = (\alpha_0^{(j)} - \alpha_0^{(k)}) + (\alpha_1^{(j)} - \alpha_1^{(k)}) \dots \dots \dots (4)$$

For any *j* and *k*, including the baseline category *k* if we take $\alpha_i^{(k)} = 0$ for $i=0, 1, \dots, p$, a convenient choice to ensure that the model is identifiable. This can be solved explicitly by;

$$P_r(y = k|X) = \frac{\exp(\alpha_0^{(k)} + \alpha_1^{(k)}x_1 + \dots + \alpha_p^{(k)}x_p)}{\sum_{j=1}^K \exp(\alpha_0^{(j)} + \alpha_1^{(j)}x_1 + \dots + \alpha_p^{(j)}x_p)} \dots\dots\dots (5)$$

Where, $P_r(y = k|X)$ are the categories of commercialisation which are subsistence, semi-commercial and commercial, α is the vector of parameters and X_i is a vector of all explanatory variables which include farmers’ characteristics. These factors include gender, household size, membership into farmers’ cooperative, off-farm income, farm size, distance from the market and market information, price and media.

Thus, the empirical model to be estimated to measure the effect of agricultural innovation (AGIN) on commercialisation is specified as follows:

$$P_r(y = K|X) = \alpha_0 + \alpha_1AGIN_1 + \alpha_2GEND_2 + \alpha_3HHS_3 + \alpha_4MEMSHIP_4 + \alpha_5OFFINC_5 + \alpha_6FSIZE_6 + \alpha_7MKTINFO_7 + \alpha_8DMKT_8 + \alpha_9PRICE_9 + \alpha_{10}MEDIA_{10} + \varepsilon_i \dots\dots\dots (6)$$

Where α_0 is the constant term, $\alpha_1 \dots \alpha_{10}$ are a set of explanatory variables which includes AGIN indicates agricultural innovation and captures improved seeds, chemical fertilizers, row planting and traction. The hypothesized variables used in the model are summarized in Table 2.

Table 2: Summary of the Variables used in the Econometric Model

Variables	Variable Code	Type of variable	Specification of variable	Expected sign	Empirical studies
Agricultural innovation	AGIN	Dummy	1 If the farmer adopted innovations and 0 otherwise	+	Fofiri and Kounaghe (2023); Motto (2025)
Gender of household head	GEND	Dummy	1 if male and 0 otherwise	+	Ruhul <i>et al.</i> , (2025)
Household Size	HHS	Continuous	Number of household members in the adult equivalent	+/-	Ullah <i>et al.</i> , (2025); Abdullah <i>et al.</i> , (2025)
Member in cooperative	MEMCOOP	Dummy	1 if a household is involved in farmers’ cooperatives and 0 otherwise	+	Arouna <i>et al.</i> , (2023); Diro <i>et al.</i> , (2016)

Off farm income	OFFINC	Continuous	1 if the farmer has off-farm income and 0 otherwise	+	Gebre <i>et al.</i> , (2021); Gibreel and Bauer (2007)
Farm Size	FFSIZE	Continuous	The quantity of land own by the household for rice production	+/-	Motto (2025); Aman <i>et al.</i> , (2013)
Market information	Mkinfo	Dummy	1 if a household has access to market information and 0 otherwise	+	Musah <i>et al.</i> , (2013); Fongang <i>et al.</i> , (2019)
Distance from the market	DMKT	Continuous	Distance from the farm to the market Centre measured in kilometers	+/-	Aman <i>et al.</i> , (2013)
Price	PRICE	Continuous	if the price is low, equal to market price or above	+	Musah <i>et al.</i> , (2013)
Media	Media	Dummy	1 if a household has access to media and 0 otherwise	+	Maina <i>et al.</i> , (2024)

Source: Authors' Analysis from Literature (2026)

4. PRESENTATION OF RESULTS

4.1 Descriptive statistics

The socio-economic and institutional characteristics of rice producers for some selected variables used in this study are presented in Table 3 and Table 4 and discussed according to their influence on agricultural innovation and commercialisation of rice production. They include age, gender, marital status, education level, household size, farm size, membership in cooperative, access to credit, off-farm income, and off-farm activities. These aspects pose an important element because household heads and their decisions are more likely to be influenced by household socio-demographic, economic and institutional characteristics since most of the household activities are coordinated and led by household heads [24].

Table 3: Descriptive Statistics of Socio-Demographic Variables

Age in years	Freq.	Percent	Cum.
20-30	33	11.38	11.38
31-40	93	32.07	43.45
41-50	88	30.34	73.79
51 and above	76	26.21	100.00
Gender			
Male	156	53.79	53.79
Female	134	46.21	100.00
Marital status			
Married	247	85.17	85.17
Single	11	3.79	88.97
Widowed	16	5.52	94.48
Divorced	16	5.52	100.00
Education level			
Primary	176	60.69	60.69
Secondary	104	35.86	96.55
University	10	3.45	100.00
Household size			
1-5 members	71	24.48	24.48
6-10 members	140	48.27	72.75
11-15 members	79	27.25	100.00
Farm size in hectares			
0.5 to 1	249	85.86	85.86
1.1 to 1.5	23	7.93	93.79
1.6 and above	18	6.21	100.00

Source: Authors' computation from field survey (2025)

Regarding the age characteristics of the respondents, Table 3 shows details about the age groups of the respondents for purposes of understanding their ages and possibly the experience they possess in rice farming. From the description, it is evident that majority of the respondents are in the age bracket of between 31- 40 years and 41-50, followed by 51+ and 20-30 in the orders 32.07%, 30.34%, 26.21% and 11.38% respectively. This indicates that majority of the rice farmers are at the most productive age of their life and this could positively influence agricultural innovation and consequently high volume of rice production and hence, market participation *ceteris paribus*. Descriptive statistics further shows that majority of the youths perceived

agriculture as being difficult and assumed to be meant for the ageing rural population while others claimed it is not profitable [34].

The study examines and describes the gender details of the rice farmers in Table 3. The results statistics revealed that out of 290 respondents, 53.79% were males and 46.21% were females. This was necessary for the study to get a balanced view of the rice farmers. While causality cannot be implied from these descriptive results, these gender differences might be attributed to the fact that rice farming is an energy demanding activity as well as the fact that male headed households have better access to land compared to their female counterparts. This is consistent with the findings of [35] who found that rice farming is a male dominated enterprise in Anambra and Ebonyi states in Nigeria. Further, it could also be attributed to an extent that the study area is a Moslem dominated community in which most women stay home.

Concerning the level of education of the respondents, Table 3 depicts the situation. The results revealed that 176 respondents from the total sample of 290 retained had primary level of education making 60.69% while 104 of them had reached the Secondary level scoring 35.86%. Only 3.45% of the respondents had attended higher education. This means that the higher the level of education the lesser the time put in agriculture. People who have attained higher level of education prefer white collar jobs than agriculture. These results imply that the rice farmers in the study area are not very enlightened and do not easily appreciate value addition as a necessity to improve on the quality of rice as well as increase their income from rice production. This also implies that the rice farmers will not be more receptive to information from extension agents and other means on the adoption of best practices for improved yield and harvesting techniques that would harness the quality of rice.

As regards the household size of the respondents, the results showed that 48.27% of the rice farmers had households' size of 6-10 members, while 27.75% had household sizes of 11-15 persons and 24.48% of the households had 1-5 members in the household. The mean household size is found to be 7 persons. Higher number of members of the household contributes to family labour. Thus, the burden of hiring labour for all activities in rice production, from land preparation to harvesting contributes significantly to labour cost. Hence, extra family labour leads to a reduction in cost of production, as well as efficiency in production, as some labour activities can be shared among the family members.

The distribution of rice farmers according to farm size is shown on Table 3. The statistics revealed that the mean farm size was 0.86 hectares with 85.86% of the rice farmers having farm holdings of 0.5-1 hectares, 7.93% had 1.1-1.5 hectares while 6.21% had 1.6 hectares and above. The size of the farm holdings confirm that these rice farmers are smallholders and produce on small scale. Since land is a primary factor in agricultural production, these descriptive results means that those

households with bigger farms might be having a higher probability of commercialisation compared to those with small farms.

Table 4: Descriptive Statistics of Economic and Institutional Variables

Membership coop.	Freq	percent	Cum
No	176	60.69	60.69
Yes	114	39.31	100.00
Access to credit.			
No	252	86.90	86.90
Yes	38	13.10	100.00
Place of sale			
Farm gate	18	6.25	6.25
Village mkt	119	41.32	47.57
Town mkt	24	8.33	55.90
Farmer association	127	44.10	100.00
Extension contact			
Yes	45	15.51	15.51
No	245	84.49	100.00
Market information			
Yes	135	46.55	46.55
No	155	53.45	100.00

Source: Authors' computation from field survey (2025)

Table 4 present membership into farmers' cooperative. This variable in this study was considered an important factor and hypothesized to have a significant influence on commercialisation. Membership into farmers' association could enable us assess the level to which farmers are expose to information on rice production and equally how they can easily carry out group marketing. Table 4 shows that membership in farmers' cooperative was below average as only 39.31% of the farmers were members in cooperative while 60.69% were not cooperative members. This implies that the rice farmers are not very much in unity and hardly benefit from assistance that come through cooperatives such as accessing funding from financial institutions both government and private institutions.

As concerns access to credit, Table 4 shows that farmers in the study area appear to be challenged in respect to access to credit. The results depict that access to production credit was very low as only 13.10% of farmers had access to credit while 86.90% never had. This implies that the rice farmers suffer a lot of financial constraint which make it difficult for them to obtain farm inputs. This could be one of the reasons which accounts for the low output and thus commercialisation.

Regarding the place of rice sales, the results in Table 4 reveals that 4.10% of the rice farmers sell their produce in the cooperative, 41.32% in the village market, while 8.33% sell in the town market and 6.25% sell at the farm gate. Majority of the farmers sell at the farmers' association given that they buy at a higher price than in the local market. The paddy rice is sold in the local market at 125frs/kg, while the cooperative buys at 130frs/kg. This finding shows that though the farmers are smallholders, they are also interested in commercialisation.

Further, Table 4 depicts the distribution of rice farmers according to access to extension contact. The farmers in the study area appears to be challenged in relation to extension services due to absence of these services. The results showed that 15.15% of the farmers had contact with extension agents while 84.49% never had. This implies that most farmers never had contact with the extension agent and this affected their innovation activities and thus commercialisation. This is because extension services accelerate the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt innovation technologies [22].

Finally, Table 4 shows the distribution of rice farmers according to access to market information. The results indicates that 46.55% had access to market information while 53.45% does not have. This could account for the low commercialisation in the study area.

4.2 Determinants of Rice Commercialisation

To ascertain the effect of agricultural innovation (AGIN) on rice commercialisation in the study area, we used agricultural innovation as an explanatory variable in the equation of the determinants of rice commercialisation. The Multinomial logit model was estimated in this study using the Maximum Likelihood Method (MLM) using SPSS version 15. The regression results of the effect of agricultural innovation on rice commercialisation are presented in Table 4.

Table 5: Multinomial logit Results of the Influence of Agricultural Innovation on Rice Commercialisation Drive

VARIABLES	Pr(motive=consume) logits	Pr(motive=sell/consume) logits	Pr(motive=sell) logits	Pr(motive=consume) rrr	Pr(motive=sell/consume) rrr	Pr(motive=sell) rrr
AGIN		1.285*** (0.282)	1.630*** (0.289)		3.615*** (1.021)	5.102*** (1.472)
GEND		-0.797 (0.506)	-0.989* (0.528)		0.451 (0.228)	0.372* (0.196)
HHSIZE		-0.109 (0.0822)	-0.0364 (0.108)		0.897 (0.0738)	0.964 (0.104)
MEMCOOP		2.831*** (0.263)	2.980*** (0.431)		8.124*** (4.376)	8.893*** (4.744)
OFFINC: base 50000-100000						
100000-150000		-0.0501 (0.482)	-0.0560 (0.553)		0.951 (0.459)	0.946 (0.523)
150000 and above		-0.555 (2.306)	3.070* (1.802)		0.574 (1.323)	21.55* (0.960)
FSIZE: base 0.5 to 1 ha						
1.1 to 1.5 ha		2.114*** (0.557)	35.351*** (1.867)		8.281*** (4.614)	354,219*** (378,582)
1.6 ha or above		3.252*** (0.618)	36.056*** (1.797)		25.851*** (15.990)	383,614*** (427,712)
MKTINFO		0.891*** (0.397)	1.127*** (0.494)		2.434*** (0.967)	3.086*** (1.525)
DMKT		-0.0594 (0.0657)	-0.0179 (0.0628)		0.942 (0.0619)	0.982 (0.0617)
PRICE		1.657* (0.945)	2.177** (1.029)		5.241* (4.952)	8.817** (9.076)
MEDIA		-2.269 (0.834)	1.936 (1.043)		0.103 (0.0863)	0.144 (0.150)
CONTANT		4.062** (1.705)	1.981 (1.855)		58.10** (99.09)	7.250 (13.45)
Mean dependent var	1.049		SD dependent var	0.702		
Pseudo r-squared	0.230		Number of obs	290		
Chi-square	868.398		Prob > chi2	0.000		
Akaike crit. (AIC)	525.951		Bayesian crit. (BIC)	650.492		

Robust standard errors in parentheses *** p<.01, ** p<.05, * p<.1

Source: Authors' computation from field survey (2025)

The overall significance and fitness of the model was checked from the chi² value. To test for robustness, the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity was used. Accordingly, Prob>chi2=0.0000 indicated that the independent variable reliably predicts the dependent variable.

To check for multicollinearity, we used the variance inflation factor (vif). Multicollinearity can occur in multinomial regression when the correlation increases among the independent variables and the standard errors of the logit parameters will become inflated. If the variance inflation factor of a certain variable is greater than 10 or its tolerance greater than 0.1, then the variable is worrisome. If the mean vif is less than 2.5, then the problem of multicollinearity is absent or negligible. Multicollinearity does not change the estimates of the parameters, only their reliability. We checked the asymptotic correlation matrix which is a matrix of parameters estimates correlation. In this matrix we found that the correlation coefficients were less than 0.1. This means that we do not have any problem of multicollinearity among the explanatory variables that are used in this model.

The model summary output has a block of coefficients and a block of standard errors. Each of these blocks has one column of values corresponding to a model equation. Focusing on the block of coefficients, we can look at the first column comparing motive for rice production = household consumption to our baseline. This column for producing for household consumption is empty because it is considered as the referent group. Motive for production = semi-commercialisation and the second column comparing motive for production = commercialisation to our baseline production for household consumption. The results indicated that agricultural innovation (AGIN) significantly explain rice commercialisation at $p < 0.01$ level of significance.

The results in Table 5 further shows that excluding the constant term, seven out of ten explanatory variables were found to be statistically significant at 1%, 5% and 10% in explaining commercialisation. These are innovation, gender, membership in farmers' cooperative, off-farm income, farm size, market information and price. Variables such as household size, distance from the market and the media which were expected to influence rice commercialisation drive among rice farmers and were included in the model, were found to be insignificant regarding their influence on rice commercialisation.

The innovation status of the householder variable was significant at $p < 0.01$ for all the factors that influence rice farmers commercialisation. A one-unit increase in the variable innovation is associated with the decrease in the relative risk ratio (log odds) of producing for household consumption versus producing for partial commercialisation in the amount of 3.615. Also, a one-unit increase in the innovation variable is associated with the increase in the log odds of producing for commercialisation versus producing for household consumption in the amount of 5.102.

The gender (GEND) of the household head has positive and statistically significant coefficients at $p < 0.10$. This finding implies that being a female farmer reduces the probability of choosing to produce entirely for commercialisation over subsistence. This is seen as it has a relative risk factor

of 0.372. The results further revealed that being a male farmer increases the probability of choosing commercial over subsistence.

The coefficient of membership in to farmers' cooperative (Memcoop) was found to be significant at $p < 0.01$ and positive as one of the factors that influence rice commercialisation. The results showed that the probability of a farmer to produce for partial commercialisation was 2.831 higher than producing for home consumption when the farmer is a member in a cooperative. The results also revealed that the probability of producing for full commercialisation over subsistence increases when the farmer is a member of a cooperative. This is seen as it has the relative risk ratio of 8.893.

Off-farm income (Offinc) was also significant at $p < 0.10$ among the factors that influence rice commercialisation. A unit change in income is associated with an increase in the relative risk ratio of producing for full commercialisation in respect to producing for subsistence by an amount of 3.070 when the farmer falls within the income bracket of 150,000frs and above. It increases the relative risk of producing for full commercialisation in respect to producing for subsistence by an amount of 21.55.

Farm size (Fsize) is one of the factors militating rice commercialisation and significant at $p < 0.01$ for producing for partial commercialisation and producing for full commercialisation respectively. A unit increase in farm size is associated with a decrease in the relative risk of producing for household consumption versus producing for partial commercialisation by an amount of 8.281 when the farm size is between 1.1-1.5ha. The results further indicated that a unit increase in farm size is associated with an increase in the relative risk of producing for full commercialisation against producing for subsistence by an amount of 354.219. The result shows that greater farm sizes have a positive effect on commercialisation drive. However, it remains conclusive that farmers with farm sizes between 1.1-1.5 and 1.6ha and above are more likely to commercialise their produce as compared to those with farm sizes below 0.5-1ha.

Farmers with access to market information (Mktinfo) are more likely to produce for partial commercialisation or full commercialisation than farmers without access to market information. This variable is significant at $p < 0.01$. The results show that the probability of a farmer producing for partial commercialisation in respect to producing for household consumption was 0.819 higher when the farmer has access to information. The results equally indicated that the probability of producing for full commercialisation over subsistence increases when the farmer has market information by an amount of 1.127. This is in line with the apriori expectation and suggests that farmers lacking market information had a low probability of commercialisation.

The coefficient of price is significant in determining rice commercialisation at $p < 0.10$ and $p < 0.05$ for semi-commercialisation and full commercialisation respectively. The results showed that a

unit increase in price increases the probability of producing for semi-commercialisation over producing for subsistence by 1.657. Moreover, a unit increase in price increases the probability of full commercialisation over subsistence by an amount of 2.177.

5. DISCUSSION OF RESULTS

Looking at the estimated results of the determinants of commercialisation in Table 5, six of the variables were found to be significant. These include agricultural innovation, gender, membership in farmers' cooperative, off-farm income, farm size, price and market information.

The finding suggest that agricultural innovation (AGIN) has a positive and significant coefficient. This means that innovation has a positive effect on market participation by rice farmers in the study area. Agricultural innovation such as improved seeds, plant spacing, chemical fertiliser and tractors improve yield and leads to surplus which is destined for the market. These results are in tandem with those of [31, 5, 41, 44, 42,9,7] who found that agricultural innovations such as improved or certified seeds, chemical fertilizers, row planting and tractors lead to increase productivity and thus market participation. [7] further concluded that innovation not only facilitate commercialisation by increasing yield but also narrow the income inequality gap among rural producers. This finding implies that to increase the market participation of rice farmers in the Mount Mbapit Rural Rice Development Project, agricultural innovation must be at the forefront. The finding thus satisfies the objective of the study which was to determine the effect of agricultural innovation on rice production.

The gender (GEND) of the household head has a positive and statistically significant coefficient. This suggest that households headed by males could influence market participation positively. This could be due to the fact that male headed households tend to have larger output than the female headed households as a result of their better access to productive inputs. [47] revealed that women rarely had similar access to assets and markets as men, which led to different level of participation in cash crop markets. [13] also concluded that the discriminatory tendencies towards women tend to weaken their negotiation talent and therefore making them less effective in agro-commodity trade. In addition, women also spend most of their time doing house work and allocate less time to other matters like market. This finding is similar to that of [1,18, 42, 25, 38, 32,10,]. However, this finding contradicts that of [38] in which they found a higher probability of fish commercialisation if the head of the household is female in the Niger Delta Region of Nigeria. This finding implies that in order to increase market participation, male headed households should be encouraged in the study area.

Household membership in cooperative (MEMCOOP) is an important determinant of commercialisation. It is regarded as a form of social capital. This variable was positive and significant in determining market participation. The results shows that farmers who are members

in farmers' cooperative are more likely to participate in the rice market than those that are not members. This is due to the fact that household membership farmers' cooperative increases access to information important to production and marketing decisions given that most farmer groups engage in group marketing. This finding is consistent with the findings of [23,12] who found that belonging to a farmers group significantly influenced the extent of farmers' participation in Banana and potato markets, respectively. This finding contradicts that of [3] who found that farmers who are not members of any organisation are more likely to participate in the market given that most farmers organisations are not market oriented.

Farmers with access to market information (MKTINFO) has a positive and statistically significant coefficient. This means that farmers with access to market information in the study area are more likely to produce for partial commercialisation than farmers without access to market information. The reason for this is that market information arrangements guarantee producers flow of insights on market requirements and opportunity sets that enable farmers to plan effectively on enterprise choices and efficient resource allocation. It also reduces the cost for searching for suitable prices [32]. This finding corroborates those of [32, 27, 16] who opined that market information has a positive effect on commercialisation. However, this finding is inconsistent with that of [39] in which market information has no significant impact on the farmers' decision towards commercialisation.

Off-farm income (OFFINC) is another factor that was positive and significant among the factors that influence rice commercialisation. The plausible reason for this finding may be that rice producing households invest their off-farm incomes in rice production which boost production volume and sales. This finding is in line with that of [20] who reported that output commercialisation positively correlates with off-farm income of the producer. Equally, [27,18] also found that non-farm income significantly influences the degree of commercialisation. However, this contradicts [38] who posited that non-farm income earned negatively and significantly affected the potato farmer's level of participation in the crop market as a result of the possibility of distraction away from farming. This finding implies that off farm income can enable farmers to acquire farm inputs that will enable them to produce beyond subsistence level.

Farm size (FSIZE) is one of the factors militating rice commercialisation and is statistically significant. The plausible reason for this could be that those farmers with large farm sizes of produce beyond subsistence level leaving the surplus to be absorbed by the market. These finding tie with those of [9, 38, 32, 39, 1, 42, 17, 27] who found that farm size was significant in affecting extent of market participation. However, these finding averse that of [19] who found that farm size has no effect on the degree of commercialisation. This implies that increasing rice farmers farm sizes through easy access to farm land will increase their market participation.

Unit price (PRICE) of rice had a positive and significant coefficient. This is because price influences the tendency of households to supply more rice to the market. This finding confirms the assertion from economic theory that output price is an incentive for farm households to supply more produce for sale. This result confirms the findings by [32, 12] that output price is significant as it is an incentive for sellers to supply more maize in the market. This result is also consistent with the finding of [14] who found that price of cassava influences the level of cassava market participation decision of households in Africa. This implies that by increasing rice prices in the study area, this can boost market participation by rice farmers.

The variable distance from the market (DMKT) is found to have a positive and significant effect on commercialisation. This could be explained by the fact that there is significant improvement in the farm to market roads which makes distance from the farm to the market insignificant. These finding is consistent with those of [38, 12, 42]. However, this contradicts the findings of [25, 9], who found distance to the market to have a negative and significant effect on both the farmer's decision to participate and the extent of farmer participation in the market.

6. CONCLUSION AND RECOMMENDATION

This study provides evidence that agricultural innovation has a significant influence on rice commercialisation in the Mount Mbapit Rural Rice Development Project Noun Division. The results suggest that the adoption of improved seeds, chemical fertilizers, plant spacing and traction can be an effective strategy for enhancing rice commercialisation and improving the livelihoods of smallholder farmers. Policy makers and development practitioners should prioritize the promotion of these agricultural innovations by subsidizing the prices of improved seeds, chemical fertilizer and tractors, vocational training, institutional support by encouraging farmers cooperatives, and facilitating access to market information, reducing transaction costs as key strategies for enhancing agricultural commercialisation and improving the livelihood of smallholder farmers in the study area.

7. LIMITATIONS OF THE STUDY

The main source of data for the study is based on self-report by the rice farmers through the use of questionnaire. However, the low rate of literacy among the farmers was a limitation. As such, measurement errors from the collection of data due to missing values can cause the results to be bias.

The main limitation of this study stems from the absence of panel data to analyse rice production. This is because cross-sectional dataset used in this study is simply a snapshot of the reality for a given time period (that is data collected at one point in time) which does not allow the analyses of the dynamics and is further challenged by endogeneity problems. While we have tried to address

these issues by using robust estimation techniques, a more rigorous analysis will require the use of panel data to provide a better understanding of the dynamics and long-term effects of farmer innovation.

Geographically, the study was restricted to the Noun Division (specifically the Mount Mbapit area). Given that agricultural dynamics, soil fertility, and ethnic farming practices vary significantly across Cameroon, the findings may have limited generalizability to rice farmers in other agro-ecological zones.

Furthermore, another limitation was tied to the fact that farmers often adopt innovations piecemeal e.g., using improved seeds but not the recommended fertilizer. Measuring the "effect" of innovation can be complex because it is difficult to isolate which specific component of the "technological package" is responsible for the increase in commercialization.

DATA AVAILABILITY STATEMENT

The datasets generated during/analysed during the current study are not publicly available due to reasons of anonymity expressed by some respondents but are available from the corresponding author on reasonable request.

FUNDING STATEMENT

This study was not supported by any external funding agency. The authors have no funding sources to acknowledge.

ACKNOWLEDGEMENTS

We wish to express our heartfelt gratitude to the farmers and agricultural extension agents who participated in this study. Our sincere appreciation also goes to the administrative authorities that allowed this study to be conducted in Noun Division West Region of Cameroon.

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