ISSN: 18158129 E-ISSN: 18151027
Volume 17, Issue 09, September, 2021

Attitude, Profitability and Technical Efficiency of Smallholder Rice Farming in Bogia District of Madang Province, Papua New Guinea

Peter Manus[1], Dolores Kamang[2]

Department of Agriculture, Papua New Guinea University of Technology, Private Mail Bag, LAE, MP 411[1,2]

Corresponding Author: 1*

ABSTRACT— Rice production for family food security is an innovation. In this instance, external support services are provided when farmers integrate rice into their food production systems. The extent to which rice is successfully integrated would enhance farmer attitude, profit, and production efficiency. Therefore, this study aimed to examine whether farmers possessed favorable attitudes toward rice production, made profits and were technically efficient in growing rice. Additionally, the technical inefficiency effects of selected farm-specific socioeconomic factors on technical efficiency were evaluated. Three approaches, Likert scaling, cost accounting, and stochastic frontier production function, were applied to analyze the input-output and attitude data collected. The results indicate that while smallholder farmers possessed favorable attitudes toward local rice farming, production was economically unprofitable and technically inefficient. Low cash cost farm investment and the high cost of labor-dependent production have caused production economically unprofitable. However, area and cash costs attributed increased and significant productivity effects on output milled rice. Additionally, cultivated areas and tools provided were the most critical farm-specific factors influencing technical efficiency in smallholder rice production. Thus, given the food security aspect, a farm expansion program with external support services and farmer training programs would improve rice farmers' farm investments and technical efficiency in Bogia District.

KEYWORDS: rice, smallholder farmers, farmer attitude, profitability, technical efficiency

1. INTRODUCTION

Rice is a household staple in Papua New Guinea (PNG) [29]. However, 98% of the total rice consumed in the country is imported [13], [7], [29]. Given that PNG has suitable climatic conditions for rice production, successive governments have pushed rice to be produced locally considering the rising import costs [13], [7]. In this rice self-sufficiency stance, successive governments promoted several production modalities to drive local rice production [13]. They were [1] smallholder-based production, [2] nucleus and out-grower production system, [3] joint venture commercial production between local and foreign investors, and more recently, [4] large-scale mechanized irrigated production was proposed. Production modality [2], which incorporates smallholder farmers as out-growers to produce and supply a privately owned central plant, is being tried to some extent. However, nothing has been taken off in production associated with production modalities [3], [4]. Despite these efforts, local production remains low at 2%, which is an insignificant contribution to the total rice consumption in the country. Thus, rice has become a political crop with largely unknown economic impacts on society. The smallholder-based production modality intends to integrate rice production into the food production systems of farmers in the country to enhance family food security and contribute to local production. However, the extent to which it is successfully integrated depends on three interconnected aspects, among others. First, if rice is to be produced as a cash grain crop, smallholder production must be profitable. Second, making support services such as extension, transport, milling, and product markets readily accessible to farmers is critical. Finally, rice is a new crop, and the nature of its adoption into existing food production systems depends on farmers' attitudes toward rice production. Given the externally provided support services, farm-level production is influenced by production technology and factor productivity [27], [4]. Suitable rice seeds sourced locally and from IRRI are distributed to farmers when and where they are needed. The IRRI rice varieties were released to farmers only after their yield and taste performances were evaluated and their suitability for smallholder production was determined. Provided that the seeds distributed are suitable under smallholder production conditions, the farmers' technical efficiency is improved through factor productivity.

While transferring new technology and support services to farmers remains a promising strategy for increasing factor productivity, adopting new technology depends on farmers' attitudes toward rice production. However, farmers have tested food production systems passed on for many generations. Therefore, if rice must be integrated into these systems, it must be as good as existing or better food security and family income activities. In this case, the extent of formation of their views in fulfilling these family goals in the given production environment plays an essential role in popularizing smallholder rice production and needs to be evaluated. The economic analysis of rice production and its impact on producers and the broader society in PNG is limited. [18] indicates that the comparative advantages gained at the farm level are often lost during processing and marketing. Such losses are also experienced in the export tree crop sector. These losses are caused by the high-cost non-traded goods such as transport, power, telecommunications, and unskilled labor used in processing and marketing [16], [17]. Given these findings, developing a smallholder-based rice industry could be a helpful strategy for localized production and consumption. Thus, [21] suggested that localized production and consumption would improve food security. However, further works are required to establish the economic feasibility of localized production and consumption. Additionally, the productive efficiencies of smallholder rice production have never been studied. Of the many provinces where rice was introduced, Madang was one province where rice has been integrated into the farmers' production systems in the past decade. In this study, an inquiry into the productive performance of smallholder rice production in the Bogia District of Madang Province will be made. The objectives of the paper were to evaluate the levels of (i) farmers' attitudes toward rice farming, (ii) farm profits made, (iii) technical efficiency, and (iv) the extent to which the technical inefficiency effects of selected farm-specific socioeconomic factors influenced technical efficiency. The information generated from this study is considered essential to farmers and rice development officers in formulating strategies to improve smallholder rice production for food security and local production in Madang Province.

2. METHODOLOGY AND DATA

2.1 Study Location

The study was conducted in the Bogia District of Madang Province. Bogia is the administrative center of the Bogia district. The district is located northwest of Madang Town, the administrative center of Madang Province. The geographical location of the district is $4^0 16' 0''$ South and $122^0 58' 0''$ East. The district has three local level governments (LLGs): Almami, Iabu, and Yawar, with more than 75,000 people. It has a total area of 3,978 Km^2. Moreover, it receives adequate rainfall all year round.

2.2 Sampling and sample size

Multistage purposive sampling was used to select the study sample. Madang Province has seven districts, of which Bogia District was purposively selected in the first stage. In the second stage, Almami and Yawar LLGs were purposively selected because rice was grown in some villages in these LLGs. Rice is a new crop, and its cultivation is not expected in all the villages of these LLGs. In the Almami LLG, rice was only found to be grown in Apengan village by four farmers, while in Yawar LLG, rice was grown in several villages: Goinban (one farmer), Seven (one farmer), Giri (one farmer), War'kum (one farmer), Dimuk (one farmer), Kumung (two farmers), Buliwar (three farmers), Bogan (three farmers), Jerkin (seven farmers), Akurai (six farmers), and Birak (two farmers). In the third stage, farmers growing rice in the indicated villages were selected, making our study sample of 33 farmers.

2.3 Data

The data sets collected were on inputs, outputs, and the relative prices of these inputs and outputs. These data were used to evaluate farm profitability, factor productivity, and technical efficiency levels of farmers. Additionally, farm-specific socioeconomic information of the farmers was collected to evaluate the influence of these factors on technical efficiency. As another interest of the study was to determine the attitude levels of farmers, data on farmer attitudes were also collected. The study's input-output and farm-specific socioeconomic data were collected through interviews using a survey questionnaire as an interview instrument. On the other hand, the data for attitude was collected through interviews using a set of attitude statements (see the section below for details) as interview instruments.

2.4 Analytical techniques

The collected data were analyzed using three analytical techniques. They were Likert attitude scaling, cost accounting, and regression techniques. The cost accounting technique was used to compute the costs of production, income, and profitability. Regression analysis was conducted to determine the factor productivity and technical efficiency of smallholder rice farming. Descriptive statistics used in these assessments were the mean, minimum, and maximum values, percentages, and standard deviations.

2.4.1 Likert Scale

A farme’s attitude toward rice production was measured using a 5-point Likert scale [20]. The attitude measurement scores were generated using eight attitude statements (four positives and four negatives). The statements were based on farmers' beliefs, knowledge, and actions on rice production. When read to, the farmers responded to each positive statement with an attitude score of strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1). For the negative statements, the scoring was reversed as follows: strongly disagree (5), disagree (4), neutral (3), agree (2), and strongly agree (1). The sum of all attitude statement responses provided the total attitude score for a farmer. Thus, the possible attitude scores for this farmer could vary between zero (no attitude) and 40 (highly favorable attitude). The mid-point 20 is the neutral attitude score, where the farmer has neither a favorable nor an unfavorable attitude. In their attitude studies, [10], [14], [31], [32] followed similar attitude measurements procedures.

2.4.2 Cost accounting

Cost accounting procedure was used to calculate the costs and returns as

$$GM = \sum TR - \sum TVC \quad (1)$$
$$BCR = \sum TR / \sum TVC \quad (2)$$
$$NRPMDL = GM + IVL / MDL \quad (3)$$

where GM denotes gross margin, $\sum$ denotes the summation operator, TR denotes total revenue, TVC denotes total variable costs, BCR denotes the undiscounted benefit-cost ratio, NRPMDL represents net return per man-day of labor, IVL denotes the imputed value of family labor, and MDL represents total man-days of labor. A man-day is eight hours of work by an adult worker. For children under 18, 8 hours is considered half of the adult work in 8 hours. As farmers used simple farm tools in multiple production activities, it was not possible to apportion a fixed cost for rice cultivation. Thus, it was omitted from the income cost analysis.

2.4.3 Regression Analysis

Based on the pivotal work of [2], [22] and the recently applied work of [28], [1], [23], a Cobb-Douglass stochastic production function was estimated to determine the productive performance of rice farmers' inputs. For the i-th farmer, it is specified as:

$$LnY_i = \beta_0 + \beta_1 Ln(Land)_i + \beta_2 Ln(labor)_i + \beta_3 Ln(transport\ cost)_i + V_i - U_i \quad (4)$$

where Ln denotes the natural logarithm, land represents the area of land cultivated with rice and is measured in square meters (SQMs), labor represents the amount of family labor provided to rice production and is measured in man-days[1], transport cost represents the cost of transporting dried paddy from homestead to the milling site, V_i denotes the random error that accounts for the influences of factors beyond the control of the farmers, and U_i denotes the non-negative random error that accounts for the technical inefficiencies of rice farmers. The technical inefficiency effects of the selected farm-specific factors of the i-th farmer were estimated as

$$\mu_i = \delta_0 + \delta_1(Age)_i + \delta_2(Education)_i + \delta_3(Experience)_i + \delta_4(Family\ size)_i + \delta_5(Transport)_i + \delta_6(Area)_i + \delta_7(Extension)_i + E_i \quad (5)$$

where μ_i is the technical efficiency score of the i-th farmer, age denotes total lifespan of farmer since birth (years), education represents the years of schooling to obtain a formal education, experience denotes the number of years the farmer is involved in rice farming, family size is the number of persons in the farming family, transport represents the cost of transporting paddy to the milling sites in PNG Kina, the area is the area of land cultivated with rice in meters squared, extension denotes the frequency of extension contacts with extension officers, E is the error term of the equation. Technical inefficiency varies inversely with technical efficiency. A negative coefficient for a variable in equation (7) would suggest a positive technical efficiency effect and a positive otherwise. The parameters βs and δs for the variables specified in equations (6) and (7) are unknown parameters to be estimated.

The variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma^2$ [5] and the technical efficiency score for the i-th farmer as $TE_i = \exp(-U_i)$ [6] were estimated together with these parameter values. As simultaneous estimation of equations (4) and (5) gives efficient parameter estimates, they were estimated by the FRONTIER 4.1 computer program designed by [11], [12].

3. RESULTS AND DISCUSSION

3.1 Attitude toward rice production

Table 1 presents the attitude scores of the rice farmers. The attitude scores varied from 25 to 36, with an average score of 29.72. These scores indicate that rice farmers have a positive attitude toward rice production. Although rice farming is small-scale, farmers' positive attitudes are helpful and should be harnessed to sustain increased production. One way to improve farmer attitudes is to improve production efficiency and farm profits. Another is to provide support services, extension, training, transport, and milling easily accessible to farmers.

Table 1: Attitude of smallholder farmers to rice production

Category of attitude	Frequency (# of farmers)	Percent	Mean	Standard Deviation
Highly favorable (34-36)	3	9		
Favorable (25-33)	30	91	29.72	2.86
Not favorable (0-20)	0	0		

3.2 Profitability of rice production

The costs and returns calculated for small-scale rice production are presented in Table 2. The results show that family labor accounts for 94% of the total cost of milled rice production. Therefore, it is the most critical input for small-scale rice production. The cash costs incurred for transport and milling services constitute the remaining 6% of the total costs. Thus, the composition of the cost of production suggests that rice production depends entirely on family labor with no cash cost investments at the farm level. Because farmers operate on a small scale, a rice production system with no cash cost inputs is expected. However, farmers have access to good agricultural extension, road transport systems, and rice mills beyond the farm level, essential for rice production and milling.

Table 2: Costs, income, gross margins, and net returns of smallholder rice production

Item	Paddy (K3.50/kg)	Milled (K4.00/kg)	Milled (K4.50/kg)	Milled (K5.00/kg)
Income				
▪ Paddy	738.92	-	-	-
▪ Milled	-	633.36	712.53	791.70
Total income	738.92	633.36	712.53	791.70
Expenses				
▪ Labor	1717.54	1717.54	1717.54	1717.54
▪ Transport		23.50	23.50	23.50
▪ Milling		79.17	79.17	79.17
Total cash costs	-	102.67	102.67	102.67
Total implicit costs	1717.54	1717.54	1717.54	1717.54
Total costs	1717.54	1820.21	1820.21	1820.21
Implicit costs as % of total cost	100%	94.36%	94.36%	94.36%
Gross Margins				
Gross margin (cash cost based)	738.92	530.69	609.86	689.03
Gross margin (total cost based)	-978.62	-1186.85	-1107.68	-1028.51
Benefit-cost ratio (BCR)				
BCR (Cash cost based)	0	6.16	6.94	7.71
BCR (Total cost based)	0.43	0.35	0.39	0.43
Returns per man-day of labor				
Net return per man-day	26.39	18.95	21.78	24.61

The net return per mand-day of labor is less than the minimum wage rate of K28.

Farm profitability was evaluated using gross margins. The results (Table 2) indicate that small-scale rice production is financially profitable but economically unprofitable. Compared to the undiscounted financial benefit-cost ratio, the economic benefit-cost ratio was also less than one. The net returns per man-day of labor for paddy and milled rice were positive but lower than the rural minimum wage rate of K28 per man-day.

Given the low economic returns, the smallholder rice farmers could shift resources from rice to cultivating profitable cash crops. However, rice has been introduced into smallholder food production systems to promote family food security. In this case, production-enhancing innovations such as better yielding rice varieties, inorganic (urea and NPK) and organic (such as chicken manure) fertilizers, and labor-saving innovations such as using herbicides to control weeds should be introduced. Thus, cash cost investments in these areas are necessary to increase economic returns on rice farming.

3.3 Factor productivity

The computed elasticity estimates for the variables in the stochastic frontier and the coefficients for the farm-specific factors in the inefficiency effects model are given in Table 3. The coefficients have the expected signs and sizes. The results indicate that the elasticity coefficients of the area and cash costs are positive and statistically significant (P<0.01). However, the elasticity of labor was positive but not significant. These results indicate that the area was the most productive input at the production level and contributed significantly to the output of milled rice. If the cultivated area were increased by 100%, the output would increase by 36%. Although not significant, labor made a marginal positive productivity contribution to the output of milled rice. Beyond the farm gate, the cash costs incurred for transport and milling services were equally productive. This result suggests that as the cost for obtaining these services increased by 100%, the output would increase by 45%, indicating a significant productivity effect on output milled rice. As the access to service inputs impacts farm production, they should be readily accessible to farmers at affordable prices. Transport and milling services are thus considered essential inputs for popularizing small-scale rice production. Moreover, since the area has increased productivity on milled rice, a farm expansion program may benefit farmers.

Table 3: Regression coefficients for the variables in the stochastic frontier for rice farming

Variable	Parameter	Coefficient	Standard Error	T-Test
Stochastic frontier				
Constant	β_0	0.113	0.277	0.408
Area	β_1	0.363	0.063	5.761***
Labor	β_2	0.097	0.072	1.347
Cash costs	β_3	0.453	0.095	4.768***
Technical inefficiency effects				
Constant	δ_0	0.476	0.385	1.236
Gender	δ_1	-0.011	0.105	-0.105
Age	δ_2	-0.003	0.024	-0.125
Education	δ_3	-0.015	0.029	-0.517
Experience	δ_4	-0.012	0.041	-0.293
Family size	δ_5	0.007	0.019	0.368
Training	δ_6	-0.067	0.116	-0.578
Extension	δ_7	-0.124	0.180	-0.688
Area	δ_8	-1.014	0.494	-2.053*
Attitude	δ_9	-0.010	0.110	-0.091
Tractor	δ_{10}	0.372	0.528	0.705
Tools	δ_{11}	-0.389	0.185	-2.103*
Variance parameters				
Sigma squared	σ^2	0.020	0.005	3.982
Gama	γ	0.991	0.039	25.410
Log-likelihood function		27.528		
LT. Test for one-sided-error		20.516		

3.4 Technical inefficiency Effects

Except for family size and tractor services (Table 3), the coefficients of all the farm-specific factors were negative. For area and tools, the coefficients were statistically significant (P<0.10). Family size and tractor, although positive, were not statistically significant. The negative coefficients were expected for gender, age, education, experience, training, extension, area, attitude, and tools. These findings indicate that male farmers, older, more educated, more experienced, received training and extension, had favorable attitudes, and received farming tools were technically efficient. Rice production is an intensive and physically demanding activity. Hence, male farmers are technically more efficient than female farmers. The negative coefficient of age indicates that older farmers are technically more efficient than young farmers. This result was expected because older farmers have families and were more concerned about rice farming for family food security. Rice is rapidly becoming a household staple [29]. Additionally, rice is expensive to buy on the food shelves. Given these reasons, older farmers are more prepared to grow rice by accepting new technology and production methods. Education helps farmers update and assimilate new rice production information through reading and communication. As experience complements education, an extended period of experience puts the farmer in good stead to undertake rice production. In this case, our finding is that farmers with more education and experience are technically more efficient than farmers who are less educated and have less experience was expected. However, the results of previous studies yielded mixed findings. Education level can lower [26] or increase [3], [30], [23], [28] technical efficiency. The former situation arises when farms have less education than secondary schooling [3]. On the other hand, experience increases technical efficiency [3], [26] and lowers efficiency with less experience [30]. Thus, adequate education and experience are essential for smallholder rice production.

Often, education and experience are inadequate for farming, and where this is the case, providing farmer training backed with extension services is necessary. Our findings show that farmers who received training and extension visits were technically more efficient than farmers who did not receive these services. This result was expected because the sample farmers grew rice with regular advice provided to them by model farmers who grew rice among them. Thus, while working with model farmers may help farmers who lack training and extension visits, it is critical to provide these services to all farmers. These findings agree with the findings of [23], [3]. As part of the strategy to popularize rice production, farmers are provided free rice seeds and farming tool kits with rice mills established at locations accessible to all farmers. The negative coefficient for tools indicates that farmers who received farming tool kits were technically more efficient than those who did not. While this is a one-off service, it increases productivity on milled rice and may be provided to all farmers. The negative coefficient for area suggests that farmers who grew large rice areas were technically more efficient than farmers who grew rice using smaller areas. As the cultivation area determines the production level, this result was expected and is in line with the results found in [1], [8]. Given that other required inputs were available, the increase in the planted area caused an increased productivity effect on the output milled rice. The negative coefficient for attitude indicates that farmers who have a positive attitude toward rice production are technically more efficient than farmers who have a less favorable attitude. Rice, introduced to farmers, was to attain family food security, increase local production, and save foreign exchange by reducing rice imports. Essentially, farmers must be motivated to grow rice to fulfill the national stance for local rice production. At the same time, farmers must be supported with the essential support services (extension, training, seeds, tools, transport, and milling services) required. Thus, a strong positive relationship between attitude and support services should be maintained to push rice self-sufficiency.

The positive coefficients for family size and tractor indicate that farmers with large families and hired tractor services are technically less efficient. As rice production is labor-intensive, the technically inefficient production result associated with larger families was not in line with [26]. This inefficiency may suggest the presence of disguised unemployment within farming family households [25]. The technically less efficient production result associated with tractor services was expected, as this service is not fully provided to rice farmers. Therefore, farmers who require this service may miss scheduled operations when engaged in their regular activities.

3.5 Technical efficiency

The predicted technical efficiencies of the rice farmers varied between 0.504 and 0.994, with an average of 0.773 and a standard deviation of 0.136. These results indicate that technical inefficiency was present in the farming operations of rice farmers by 23%. This result suggests that farmers could reduce the factor inputs used by 23% and still produce them at the current output level.

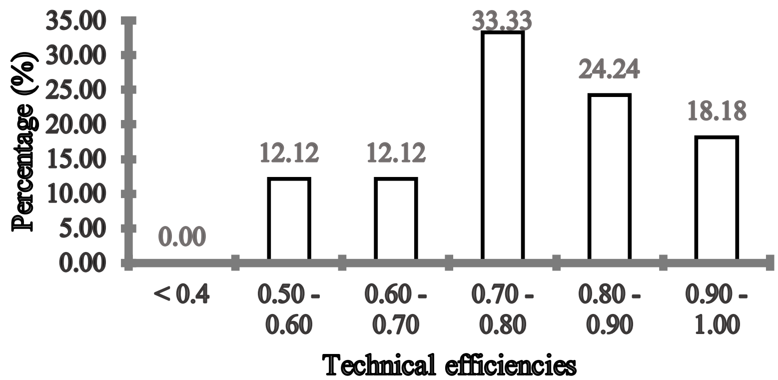

Figure 1: Frequency distribution of the predicted technical efficiencies of smallholder rice

Figure 1 shows the distribution of the predicted technical efficiency of the rice farmers. The efficiency distribution is skewed toward 1.00, from 0.500, with 76% of the farmers having efficiency scores between 0.700 and 0.994. Of these farmers, about 33% have efficiency distributions between 0.70 and 0.80, while 42% have efficiency scores greater than 0.80. Thus, although technical inefficiency prevailed everywhere, these farmers were operating closer to the efficient frontier. However, it was noted that the gamma (γ) value of 0.991 (Table 3) was closer to 1 and statistically significant ($P<0.01$). In addition, it was observed that only a few farm-specific attributes were significant. Therefore, the highly significant gamma value indicates that the cumulative technical inefficiency effect on the technical efficiency of all the farm-specific factors analyzed was significant. Essentially, 99% of the total variability in technical efficiency in rice production was contributed by the farm-specific factors analyzed. Much of the inefficiencies were associated with knowledge and management information gaps, which training farmers could reduce.

4. CONCLUSION

Local rice production is to replace rice imports. Smallholder rice farmers play an essential role in producing rice for family food security and increasing local production. However, the sustainability of smallholder production to fulfill these objectives depends on farmers' attitudes toward rice farming, the capacity to make profits through factor productivity, and the ability to access external support services when needed. Although farmers have favorable attitudes toward rice farming, smallholder rice production is not economically profitable or technically inefficient in this study. Economic profitability is unattainable due to low cash cost farm investment and high labor-intensive cost of production. Therefore, it is helpful to shift resources out of rice and use them in the alternative, more profitable enterprises. However, rice has been introduced to farmers to support family food security. If this goal was to be pursued, the low cash cost farm investment and technical inefficiency faced in the production operations were to be addressed: first, by introducing labor-saving and production-enhancing innovations to improve farm profitability and factor productivity, and second, technical inefficiencies associated with farmers who were young, less educated, had less experience, received less training and extension visits, smaller areas cultivated, had less favorable attitudes, and received no farm tools were to be addressed by instituting an appropriate training program to reduce the inherent production and management information gaps of these farmers. Additionally, as cultivated areas significantly influenced output milled rice, a farm expansion program with cash cost investments backed by the training program, agricultural extension and support services (transport, milling, tools, and markets) would strengthen farmers' attitudes, family food security, and improve local rice production.

5. ACKNOWLEDGEMENT

The authors thank the Trukai Industries for providing funding support through the Department of Agriculture, Papua New Guinea University of Technology, for Ms. Dolores Kamang to collect farm-level data for the study.

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