ISSN: 18158129 E-ISSN: 18151027
Volume 17, Issue 10, October, 2021

Attitude, Profitability and Resource use efficiency of Smallholder Rice Farmers in Sumkar District of Madang Province, Papua New Guinea

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ABSTRACT— Making externally provided support services more accessible to smallholder rice farmers would improve farmer attitude, profits and production efficiency. In this study, the attitude, profitability, and resource use efficiency of smallholder rice farmers in the Sumkar District of Madang Province, Papua New Guinea, were investigated. Cross-sectional input-output data collected from 16 farmers were analyzed using Likert scaling to estimate attitude scores, cost accounting to compute costs of production and returns, and a Cobb-Douglas production function to estimate output elasticities and resource use efficiency indices of inputs used. The results indicated that smallholder farmers had favorable attitudes toward rice production, which was economically profitable. However, production was dependent on family labor, which accounted for 75% of the total cost of production. The cash costs incurred for transport accounted for the balance in the cost of production. The elasticity coefficient of land was positive, significant ($P<0.01$), and greater than 1, indicating an increased productivity effect of land on output milled rice. The elasticity of family labor was negative but significant ($P<0.10$), indicating a decline in the productivity of this input. The computed resource use efficiency indices indicated that land was over utilized, while labor and transport were underutilized in smallholder rice cultivation. Overall, farmers faced decreasing returns to scale. The management option to improve smallholder farmers' income, family food security, local production, and reduce rice imports is to improve the efficiency of resource use, access to agricultural extension, rice milling, transport, and marketing services. As the sample size was small, further studies are required.

KEYWORDS: attitude, profitability, resource use efficiency, smallholder, food security

1. INTRODUCTION

During the past 46 years since the attainment of political independence in 1975, rice consumption in Papua New Guinea (PNG) has steadily grown. The increase in consumption has been influenced by population growth, internal migration in search of better economic and educational opportunities, and rapid growth in urbanization. Although anecdotal evidence suggests that rice was brought into the country by earlier missionaries in the 18th century, rice consumption has not been matched by local production [25] since 1975. Of the total rice consumption in PNG, 98% of the total supply for consumption is imported. PNG is; thus, rice import dependent and local production only meet 2% of the total supply per annum [25]. Given the rising import bill and suitable climate, successive governments have in the past 20 years pushed for local rice production [25], [5], [8]. Several production modalities have been developed, ranging from smallholder production to commercial mechanized production [8]. Despite these policy stances, local rice production has stagnated [25]. The push to produce rice locally is to reduce rice imports in increments that match local production until PNG is self-sufficient [8]. While the stagnation may arguably be adduced to a lack of strong support from the government, much of that drawback may be due to our lack of understanding of the economically feasible production modality that can support policy stances. Several studies have indicated that

PNG has no comparative advantage in commercial rice production [13], [15], [14]. It has been argued that PNG is not only a high cost producer, but also a high cost service provider [14], [5]. The latter elements erode the comparative gains obtained at the farm level [14], as production is shifted for processing and distribution. The implication of this finding is that production and consumption must be localized to production areas. [19] indicate that localized production and consumption production systems are economically profitable. However, of all the production modalities pushed, the smallholder-based production and consumption modality may arguably be an economically feasible choice and needs to be encouraged. Several provinces have trailed local rice production through smallholder mandates with support from the national government. In these provinces, farmers were supported by providing them with rice seeds, farms tools, rice mills at central locations accessible to farmers, extension services and farmer training. Madang Province was one of these provinces. However, these trials have not been evaluated to share lessons learned and strategize the way forward, both at the production and support levels.

At the farm level, farmers' attitudes toward rice farming, production technology, and the productive performance of the farmers are important attributes for increasing local rice production. While farmers may understand the significance of rice production for family food security and need to save foreign exchange and believe that this was important, their attitudes may lie dormant. This could happen when their beliefs could not be converted into strong actions toward rice production. Strong feelings require strong actions and actions that require strong support. The support relevant to smallholder rice production is a strong rice extension program with training, setting up and providing easily accessible rice milling services, transport and transport infrastructure, production technology, required rice farming hand tools, and markets where needed. Given that rice production is a new idea, farmers require holistic support to create a strong environment in which they feel at ease in making production and sales decisions. With suitable rice varieties provided with external support services, productive performance is the ability of the farmer to produce rice at technically and allocative efficient levels. With a given input set, technical efficiency is the ability of the farmer to produce rice at the maximum possible level allowable by the production technology available to them. This implies that farmers must produce frontier output that is technologically feasible. Studies on technical efficiency of rice [17], vegetables [21], cucumber [1] and cow-calf performance [28] using stochastic frontier analysis (SFA) and data envelopment analysis (DEA) [18] indicate that farmers are often found to be technically inefficient. In the SFA, inefficiency arises because farmers produce less than the frontier output. This means that resources were used at levels less than required and must be increased. An alternative approach is to maintain the current level of production by reducing the inputs used. In most situations, the farmer tries to maintain production at a given level of output, so it is preferable to reduce inputs. Although the technical efficiency analysis indicates the presence of resource use inefficiency through the shortfall in technical efficiency, this shortfall does not indicate the source of inefficiency among the input set.

In DEA technical efficiency analysis, technical inefficiency arises due to either misallocation of inputs, inappropriate scale of operation, or both. Although technical inefficiency may be due to resource use inefficiency, it is not possible to isolate the source of inefficiency among the inputs used. However, in DEA cost efficiency analysis, farmers are often identified as allocative inefficient, and when this happens, input ratios are often constructed residually and the level of efficiency of an input among the input set can be identified. Except for the DEA cost efficiency analysis, the inefficiency needs to be further decomposed to identify exactly which inputs in the input set are efficiently used and which were not. Resource use efficiency, also known as allocative efficiency or price efficiency indicates the farmers' ability to equate the value of marginal product (VMP) to the value of marginal factor cost (VMFC). This implies that farmers ought to generate an additional return from the last unit of input used to cover the added cost of using the last unit of input. Essentially, this is an optimality of input use, where costs ought to be covered from income generated at the optimal level of resource use. Given the production technology, input-output set, and relative prices, resource use efficiency analysis is conducted using either parametric production function analysis or nonparametric DEA analysis. In the former technique, the VMP and VMFC calculations are performed residually once the production function is estimated, while the latter allocative efficiency is computed as a system using linear programming. A production function approach was used in this study. The findings of studies examining allocative efficiency have been mixed. Research by [10], [22], [23], [2], [12] indicated that farmers faced increasing returns to scale where some of the inputs were used more than required while others were used less than required. In studies by [4], [3], [9], farmers faced increasing returns to scale with inputs used underutilized. [7], [20], [26], on the other hand, indicated decreasing returns to scale where inputs were both over-and underutilized, while [24] indicated that inputs were used less than required. Although over-utilization and under-utilization in input use may exist within a production system, the returns to scale index indicates the direction production should take. Such changes in the scale of operations and resource use would improve allocative efficiency and farm profitability. While much work has been done to date in other rice-growing countries, no studies have been conducted on how well smallholder rice farmers in PNG use their inputs, make profits, and access externally provided supported services in rice production. In this study, attitude, resource use efficiency, and farm profitability of rice farmers in the Sumkar district of Madang Province were evaluated. This topic was considered of importance to extension officers and rice development partners in providing them with the necessary information to plan for improving local rice production for food security.

2. Methodology and Data

2.1 Sample and Data

The study was conducted in Sumkar District. The district is located northeast of Madang, the capital of Madang Province. Rice, which was recently introduced, is a new grain crop that makes its way into the farming systems practiced by the people of Sumkar. A multistage purposive sampling procedure was used to select the study sample. Since the Sumkar District has two local level governments (LLG) areas – Sumgilbar and Karkar–in the first stage, Sumgilbar was selected because Karkar LLG was located on an island and difficult to reach. In the Sumgilbar LLG area, rice was recently introduced to farmers in the Bunu and Baskin villages. In the second stage, these villages were chosen. In these villages, 16 farmers were observed to grow rice. Therefore, they were selected for this study.

The sample data required for the study were farm input-output data and relative prices for these inputs and outputs for the 2018 production period. These data, collected between January and March 2019, used a structured questionnaire as an interview instrument.

2.2 Estimation methods

The study used three analytical approaches to analyze rice farm data: Likert scale, cost accounting and multiple regression methods. The Likert scale was used to compute farmer attitude scores. The cost accounting approach was used to compute the costs of production, income, and net returns of rice cultivation. The multiple regression approach was used to estimate factor productivity and resource use efficiency in rice production. These approaches are defined as follows:

2.2.1 Likert scaling

A 5-point Likert scale [16] was used to obtain the attitude scores of sample farmers from eight prepared attitude statements, four of which were positive statements and the other four were negative statements. Each farmer was expected to provide responses from five possible responses for each statement. For the positive statements, the possible responses and the assigned attitude scores were: strongly agreed = 5, agreed = 4, no opinion = 3, disagreed = 2, and strongly disagreed = 1. For the negative statements, the attitude scoring was reversed with strongly agreed = 1, agreed = 2, no opinion = 3, disagreed = 4, and strongly disagreed = 5. To obtain an attitude score from each farmer, the farmer was read to an attitude statement together with five possible response sets. The farmer was expected to select from each statement only one response, and the score for each response the farmer selected was recorded. The sum of all response scores for all statements indicates the overall attitude score for a farmer. The possible attitude score for a farmer could range from zero with no attitude to 40, with a highly favorable attitude. The mid-point attitude score was 20, indicating that the farmer had neither a favorable nor an unfavorable attitude. [11], [6], [27] used similar Likert scale procedures in their studies to determine farmer attitudes.

2.2.2 Cost accounting

Costs of rice production were specified as:

$$TC = VC + FC \tag{1}$$

where TC denotes total cost of production, VC represents variable costs, and FC denotes fixed costs. Farmers used simple implements to cultivate rice, but these tools were used, besides rice, in other activities, such as food production. Given the multiple uses of tools, it was difficult to apportion a precise depreciation value against each production activity undertaken. In this case, the fixed costs were omitted from the cost and return analysis. VC was defined as:

$$VC = EC + IC \tag{2}$$

where EC denotes the values of explicit or cash costs for the inputs used, and IC denotes the values of implicit or non-cash costs for inputs used. Family labor, a non-cash input, is the single most important input used in rice farming [19]. As no explicit monetary value for labor was available, family labor was imputed at PNG K3.50, the rural minimum wage rate for unskilled workers employed in rural economic industries. Explicit costs comprise the costs of transporting paddy rice from the homestead to the milling site and the cost of rice milling services provided.

Income from rice production was defined as:

$$GI = Y.P_y \tag{3}$$

where GI denotes gross income, Y denotes the total production of milled rice, and Py represents the price of a kilogram of paddy and/or milled rice.

With no fixed cost factored in, the profit margin of rice production was defined by computing the gross margins (GM) of the farmers as

$$GM = GI - VC \tag{4}$$

Given equations (2) and (3), an undiscounted benefit-cost ratio (BCR) is computed as

$$BCR = GI/VC \tag{5}$$

From equations (2) and (4), the return per man-day of labor (RMDL) is computed as

$$RMDL = (GM + IC)/MDs \qquad (6)$$

where IC represents the imputed value of family labor, and MDs denotes the total man-days of labor used in rice cultivation.

2.2.3 Multiple regression analysis

To assess factor productivity and resource use efficiency, a Cobb-Douglass production function for the Sumkar rice farmers was estimated. For the i-th farmer, it is specified as

$$Ln\,Y_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \cup \qquad (7)$$

where, Ln denotes natural logarithm, Y_i denotes total production of milled rice for the *i*th farmer (*i* = 1,…,16), X_1, X_2, and X_3 denote cultivated area in squared meters, man-days of family labor, and cost of transportation, respectively, and $\cup$ is the error term representing the unexplained component of total variation in the production of output milled rice. The βs are regression coefficients to be estimated, and β_0 is the y-intercept. The regression coefficients of the linearized model given in equation (7) directly measure the elasticities of production for the factor inputs used. Labor in hours of work was converted to man-day equivalents. A man-day of work is defined as the amount of work done in rice production activities in eight hours. Children's labor was half of the adult work done in 8 hours. Farmers produce rice less than a hectare. Land was thus converted to a square meter.

2.2.4 Resource use efficiency

Using the elasticity coefficients estimated in equation (7) together with the prices of inputs and output prices, the resource use efficiency indices were computed. The i-th farmer is resource use efficient whenever the following profit maximization condition holds:

$$VMP = VMFC \qquad (8)$$

where VMP denotes the value of the marginal product for input, X_i, and VMFC represent the value marginal factor cost for input, X_i. The VMP for the i-th farmer is computed as

$$VMP = EP(\frac{\bar{Y}}{\bar{X}})P_y \qquad (9)$$

where EP is the elasticity coefficient for input, X_i, $\bar{Y}$ and $\bar{X}$ are the values of output Y_i and input X_i, evaluated at their geometric means. The VMFC for the i-th farmer is computed as

$$VMFC = EP(\frac{\bar{Y}}{\bar{X}})P_x \qquad (10)$$

where P_x is the price of the input X_i. The resource use efficiency index (EI) for input X_i is computed as

$$EI = VMP/MFC \qquad (11)$$

An EI equal to 1 indicates that the *i*-th farmer is allocatively efficient in the use of input X_i. An EI > 1 or EI < 1 indicates that the i-th farmer is allocative inefficient. In the case where EI > 1, input X_i is used more than the optimal level required, in the case where EI < 1, input X_i is used less than the optimal required. In the former case, the quantities of input X_i used must be reduced, whereas in the latter, the level of its usage must be increased.

3. Results and Discussion

3.1 Summary statistics

Table 1: Summary values for output and inputs of smallholder rice farmers

Variable	Measurement Unit	Mean	Minimum	Maximum	Standard Deviation
Dependent					
Output	Kilograms	104.06	7.50	300.00	88.13
Independent					
Land	Squared meters	1487.75	100.00	3500	1240.78
Family labor	Man-days	54.34	25.25	92.50	19.66
Transport	PNG Kina	11.25	2.00	37.00	9.86

Summary statistics for the variables defined by Equation (7) are presented in Table 1. Most farmers cultivated rice plots of less than 1 ha, and because of this produced less than 1 ton of milled rice. As equation (7) was estimated in logged-linear form, areas cultivated and milled rice obtained were converted to meters squared (MSQ) and kilograms, respectively. Cultivated areas ranged from 100 MSQ to 3500 MSQ with a mean of 1488 MSQ while milled rice produced varied between 7.5 kg and 300 kg with an average of 104.06 kg. Family labor used in rice cultivation varied between 25 and 93 man-days, with a mean of 54 man-days. The cost for transporting dried paddy to the milling site was measured in PNG Kina and it varied between K2.00 and K37.00 with a mean of K11.25.

3.2 Attitude

Table 2 gives the attitude scores of the rice farmers. The results indicate that farmers have a favorable attitude toward rice production. As rice has recently been introduced, farmers are aware of the need to produce rice to insulate family food security. To popularize rice production in the area, continued support to farmers in extension services, rice milling services, transport, and marketing are required and must be provided. Thus, the results reflect the effort put in by the Madang provincial government through its rice extension program in creating an appropriate impact on farmers' attitudes toward local rice production, and this level of support must be continued.

Table 2: Attitude levels of rice farmers

Category	Frequency	Percent	Mean	Standard Deviation
Highly favorable	1	6	30.10	2.30
Favorable	15	94		
Unfavorable	0	0		

3.3 Cost composition

Table 3: Cost and gross margins of paddy and milled rice

Cost Item	Paddy rice (K3.00/kg) (Option 1)	Milled rice (K4.50/kg) (Option 2)	Milled rice (K5.00/kg) (Option 3)
Income			
Paddy rice	416.25	-	-
Mill rice		468.28	520.31

Total income	416.25	468.28	520.31
Variable costs			
Labor	190.20	190.20	190.20
Transport	-	11.25	11.25
Milling	-	52.03	52.03
Total variable cost (TVC)	190.20	253.48	253.48
Non-cash cost as % of cash cost	100	75.04	75.04
Gross margin	226.05	214.80	266.83
Benefit – cost ratio	2.18	1.84	2.05
Return per man-day of labor	7.66	7.45	8.41

@ indicates net returns for milled rice sales at K4.5 per kg. # indicates the net returns for milled rice sales at K5.00 per kg

Costs, income, and net returns from smallholder rice production are given in Table 3. The costs of production values indicate that family labor accounts for 75% of the total cost of milled rice production, and for paddy, it makes up the entire cost of production. The cost of family labor could be higher than indicated, as the value of labor time for taking harvested paddy to homestead was not included. Meanwhile, the costs of transporting paddy to the rice milling site and milling services accounted for the balance of the total production costs. Clearly, the cost structure of rice production indicates that paddy rice production is entirely dependent on family labor. In this low input-low output production system, the composition of costs of production at the farm level is unlikely to change, and family labor will continue to remain as the single most important input for smallholder rice production. In general, these results are supported by the findings of a previous study [19].

3.3 Income

Farmers have two options for selling rice: paddy and milled rice. Markets for these products are available in local areas where rice is produced. The gross margin values in Table 2 indicate that rice production is economically profitable with undiscounted benefit-cost ratio (BCR) greater than 1 and a net return per man-day of labor greater than the rural minimum wage rate of K3.50. However, these returns are likely to be lower if the missing value for labor time is used to carry paddy after field harvest. The extent of the impact of the missing labor cost on returns may not be significant, but needs to be investigated to understand the nature of the cost involved. Nevertheless, farmers could aim to achieve one of three objectives for producing rice: (i) for home consumption, (ii) for sale, and (iii) produce both for sale and home consumption. The first is a food security objective. The all production for consumption option suggests that the farmer has some form of income generated elsewhere and that rice production activities are supported by this source of income. This option is attainable if farmers are also producing other cash crops, such as cocoa. The second objective has a profit motive. In this case, production is all for sale. Table 2 indicates three sales options: option 1: sell in paddy form; option 2: sell if the market price for milled rice is K4.50 per kilogram; option 3: sell if the market price for milled rice is K5 per kilogram. Of these, option 3 was the most profitable. For farmers who have difficulty in meeting transport and milling costs, option 1 is equally profitable and suits them in this case. If the market price is reduced to K4.50 per kilogram of milled rice, the sample farmers sell their produce in paddy form, as sales option 2 is less profitable. All production for sales options is aimed at pooling income to meet externally imposed household demands, such as school fees for children, groceries, and other household needs.

The third objective is to apportion part of the production for home consumption and a part for sales. In this objective, food security and the continuation of rice production for sale are equally important. Once the paddy is milled, the farmer takes home the home consumption component of the milled rice and sells the balance. As rice production is locally popularized as, eat what you produce, farmers ought to follow options 1 or 3, whichever is feasible, and sales made must be enough to cover the cost of production.

3.4 Factor productivities

The estimated ordinary least squares (OLS) elasticity coefficients for the Cobb–Douglas production variables are presented in Table 4. The coefficient of multiple determination was estimated at 0.855, which indicates that 86% of the total variation in output milled rice produced was influenced by the size of cultivated areas, quantities of labor used, and amount of money spent in freighting paddy to the nearest rice mills. This result suggests that the farm data analyzed adequately captured the underlying influences of factor inputs used in rice production.

The elasticities of production estimated indicated that the elasticity of cultivated land area was positive, significant ($P< 0.01$), and greater than 1, indicating increasing returns to scale of this input. This result suggests that a 10% increase in the cultivated area caused a significant productivity increase in output milled rice by 11.31%. The elasticity of the family was, although significant, negative. This result suggests a significant productivity decline of 7.99% as family labor increases by 10%. The elasticity of transport is negative, indicating that, although, non-significant causes a productivity decline of 1.1% when the input is increased by 10%. Although the areas cultivated have caused output to increase at increasing returns, the sum of the elasticities of production amounted to 0.214, indicating overall diminishing returns to scale in smallholder rice production. This finding is supported by the findings from studies by [7], [20], [26], [24]. Much of the fall in the returns to scale was caused by the productivity decline in the family labor used.

Table 4: OLS regression coefficients of the Cobb-Douglas production function

Variable	Parameter	Coefficients	Standard Error	T-Ratio
Constant	β_0	-0.1521	1.264	-0.1203
Area (M.SQ)	β_1	1.1318	0.1379	8.2073***
Labor (MDs)	β_2	-0.7998	0.3906	-2.0476*
Transport (Kina)	β_3	-0.1181	0.1734	-0.6811
Coef. Multiple Determination	$AdjR^2$	0.855		
Sum of elasticity of production	$\sum EP$	0.2139		
No of observations	N	16		
Degrees of freedom	DF	12		

The *** indicates coefficient significant at 1% level of significance

3.5 Resource use efficiency

The resource use efficiency indices (EI) computed for the factor inputs used in rice production are given in Table 5. The results indicate that the EI for the cultivated area is less than 1, indicating that farmers have cultivated an area larger than required.

Table 5: Resources allocation indices of Madang rice farmers

Input	GM	VMP	MFC	EI
Land (ha)	931.81	0.329	1.201	0.274
Labor (MDs)	51.13	4.59	3.57	1.285
Transport (Kina)	8.25	4.32	1.217	3.549
Output (kg)	66.04			

The EIs for labor and transport were greater than 1, which indicates that these inputs were used less than required, while land was overutilized. Both over-and under-resource use inefficiency findings agree with the findings of studies by [12], [7], [20], [26]. An important feature that needs to be understood by the rice-producing families in this study is the relationship between farm size and labor availability for successful rice cultivation. Cultivating a larger area without matching family labor available during the production period and/or matching the interests of the family members in rice production would have a constraining effect on production. Thus, labor availability is an effective bottleneck for family rice production. In our study, a downward adjustment in the area cultivated and an upward adjustment to family labor would lead to the optimal use of these inputs. The underutilization of transport costs implies that farmers were transporting less than the required amount of output paddy rice for milling. In this case, the transport cost tends toward its optimal use level as more paddy is produced and freighted for milling.

Given that the sample size was small, the results may be considered baseline information. As more farmers venture into rice cultivation, further work can be conducted to verify these findings.

4. Conclusion

In the rice import replacement stance, smallholder rice producers are important stakeholders contributing to increased industry production. In this strategy, production aims to improve family food security and reduce rice import costs. The sustainability of participation of this stakeholder in expanding rice farming is, however, dependent on supporting the production systems that are profitable. In this study, gross margin analysis indicated that smallholder rice production is economically profitable. Rice production, however, was found to be dependent on family labor, which accounts for 75% of the total cost of production. As paddy and milled rice produced were both profitable, farmers could sell paddy only when milling services were not accessible. Although there was a significant ($P<0.10$) decline in productivity of family labor, there was an increasing return to scale of land, indicating a significant ($P<0.01$) productivity increase in output milled rice. However, land was over-utilized. The management option, therefore, is to scale family labor, presently underutilized, upwards to make further productivity improvements to land. The continued presence of agricultural extension, access to rice mills, markets, and transport by rice farmers are necessary to support rice production for food security and to popularize rice as a profitable crop. The profitability performance observed is, however, location-specific and based on small sample data; therefore, further work to confirm this result in all rice-growing districts is required to strengthen support for sustainable local rice production in Madang Province.

Acknowledgements

The authors thank the Trukai Industries for funding support to Ms. Dolores Kamang for collecting the data required for this study.

Conflict of interest

There is no conflict of interest to declare

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