TECHNICAL EFFICIENCY ANALYSIS OF INTEGRATED UPLAND RICE FARMS IN SELECTED MUNICIPALITIES OF CARAGA REGION, PHILIPPINES: AN APPLICATION OF STOCHASTIC FRONTIER ANALYSIS

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Abstract

This study was conducted to evaluate the determinants of technical efficiency of integrated upland rice farms in selected municipalities of Caraga Region, Philippines. A survey questionnaire was administered to 239 respondents from four municipalities of Caraga Region. Data were analyzed using Herfindahl Index (HI) and multi-input multi-output stochastic input distance functions. Results have shown that majority of integrated upland rice farms belong to 0.76 to 1.0 range which means that upland rice farmers were closest to complete specialization of the farms with a combination of upland rice and vegetables such as eggplants, string beans and squash. Furthermore, results on technical efficiency showed that years in upland farming, cropping per year, contact with extension agents, sex, tribe, land tenure, membership in an organization, and access to extension agents reduced technical inefficiency of integrated upland rice farms. It was found out the HI has no significant effect on the level of technical efficiency of upland rice. Thus, it is recommended that the government should extend credit policy, offering low interests for capital loans to upland rice farmers, intensify promotion of crop diversification, and provide effective extension services such as trainings and seminars conducted by government and non-government agencies that include research-based technology for upland rice farming.

Keywords: *Herfindahl Index, technical efficiency, stochastic input distance function, integrated upland rice*

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1.0 Introduction

In Caraga Region, upland rice is typically grown in sloping agricultural areas integrated with other crops such as coconuts *(Cocos nucifera* L.*)*, industrial crops such as falcata *(Falcataria moluccana)* or crop rotation systems such as vegetables and characteristically grown in accompaniment with livestock and poultry animals (Okonji *et al.,* 2007). Upland rice varieties are primarily the staple in combination with other root crops and tuber crops such as camote *(Ipomoea batatas)*, cassava *(Manihot esculenta)* and arrowroot *(Maranta arundinacea)* in sloping far-flung rural communities in the region. Upland rice cultivation is more intended for home consumption than for commercialization. Farmers producing these crops usually are poor due to small areas allocated for cultivation, little management intervention on the part of these farmers and diminutive government intervention and support in upland rice cultivation, promotion and marketing. Moreover, problems of low rice production in upland rice farming system were due to (i) the inefficient use of production factors and (ii) limited ability of farmers to manage the production factors (Budiono & Adinurani, 2017).

Caraga Region is rice deficit, its total annual palay production of 400,000 metric tons is not enough to support the region's 2.4 million population. With a per capita consumption of 128 kg/person/year, rice sufficiency level of Caraga Region is only 86 percent (DA-Caraga Region Rice Roadmap 2011-2016). However, no specific data from the Department of Agriculture-Rice Division on annual upland rice production in Caraga Region can be found in literature or at concerned government agency such as Philippine Statistics Authority. In the farmers' field, an average of 1,350 kg ha-1 of palay is obtained (MAO-DA Trento, 2019). This data shows the big potential for farming upland rice in order to increase productivity.

Farm productivity and efficiency are one of the important areas in developing countries (Hazarika & Subramanian, 1999). Efficiency is an important factor in the attainment of high productivity especially in an economy where resources are scarce and opportunities for new technologies are lacking. Research that focus on efficiency in integrated upland rice farms is needed to examine the potentials offered by the integrated upland rice industry through enriched productivity and profitability. Measuring the technical efficiency of the integrated upland rice farming sector is important to both household and policy makers in order to understand how far the output of integrated upland rice farms can be expected to increase by simply increasing the level of efficiency without absorbing other resources. Consequently, the researcher is motivated to conduct this study that focus on resource productivity and technical efficiency to help farmers of integrated upland rice farms to comprehend if production is efficient or not.

There are limited studies available that clearly evaluate the impact of crop diversification on technical efficiency (Binam *et al.,* 2005; Ogundari, 2013; Ojo *et al.,* 2014; Mango *et al.,* 2015; Zhang *et al.*, 2016; Mzyece, 2018; Lakner *et al.*, 2018). Thus, this study attempted to evaluate the technical efficiency analysis of integrated upland rice farms in selected municipalities in Caraga Region, Philippines. Specifically, it analyzed the effect of crop diversification on the level of technical efficiency, identified and evaluated the impact of socio-economic factors. This study provide useful information for producers, government and integrated upland rice producers and stakeholders that will be helpful in designing interventions for increased upland rice productivity.

2.0 Methodology

Study Area and Sampling Design

The study was conducted in four municipalities of Caraga Region namely: Sibagat, Agusan del Norte, Trento, Agusan del Sur, Socorro, Surigao del Norte, and Tandag, Surigao del Sur. Selection of these municipalities was based on the recommendation of the Department of Agriculture Regional Field Unit XIII-Rice Section. Proportionate random sampling was employed using the Slovin's formula.

Table 1. Distribution of respondents per municipality in Caraga Region, Philippines

Municipality and Province	Population	Sample size (e=95%)
Trento, Agusan del Sur	305	123
Sibagat, Agusan del Norte	50	20
Tandag, Surigao del Sur	110	44
Socorro, Surigao del Norte	130	52
Total	N=595	n=239

The sample frame was therefore obtained by alphabetically arranging the names of all upland rice producers. Then, systematic

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random sampling was applied to constitute the sample. As such, the sampling interval was 595/239=2.49≈2. Hence, each second farmer was selected to be interviewed.

Data Collection and Analysis

Primary and secondary data were used for the study. Primary data was gathered using pre-tested questionnaire from upland rice-based farmers in the 4 municipalities of the region. A pre-tested structured questionnaire was used to collect data from farmers regarding socio-economic characteristics, farm information, farmers' land information, input used information, production and off-farm income, institution and social inclusions. Secondary data such as publications, reports and varied agricultural surveys were sourced from various stakeholders in the agriculture sector and particularly in the rice sector. These data such as volume of production, hectarage, population and etc were gathered from the Department of Agriculture-Regional Field Unit XIII, the Philippine Statistics Office (PSA), and the Caraga Region Rice Roadmap 2011-2016.

Empirical Model of Crop Diversification

Herfindahl index (HI) was used to examine the existence of economies of crop diversification among upland rice-based farming and the impact of crop diversification on technical efficiency in selected municipalities in Caraga Region. A detailed description of the Herfindahl index as used in the present study is described below (following the model espoused by several authors (Ojo *et al.,* 20014; Bhat and Salam, 2014; Baba and Abdlai, 2021).

$$H_D = \sum_{j=1}^{J} \left(\frac{Y_j}{\sum_{j=1}^{J} Y_j} \right)^2 0 \leq H_D \leq 1$$

Where:

Yj = area/revenue share occupied by the jth crop in total area/total revenue Y.

J = total number of crops, that is, when maximum diversification occurs.

The index ranges from zero, reflecting complete diversification (i.e., an infinite number of crops in equal proportion), to one, reflecting complete specialization (i.e., just one crop). It can be shown that this index attains a minimum value equal to 1/J.

Empirical Model of Stochastic Input Distance Function Approach

A multi-input-multi-output stochastic input distance function was used to identify the factors that significantly affect the farmers‟ efficiency level of integrated upland rice farms in Caraga Region, Philippines. The model was initially based on a Cobb-Douglas functional form so as to conserve degrees of freedom. However, in order to allow for diversification in economies, it is necessary to allow the frontier to be more flexible than the Cobb-Douglas in the output variables. To achieve this end, a partial translog function is created by adding the second-order terms to the Cobb-Douglas model (for the three output variables). Prior to estimation, the means of the log variables were adjusted to zero so that the coefficients of the first-order terms may be interpreted as elasticities, evaluated at the sample means. Following Coelli and Perelman (1996), the (partial) translog input distance function was used in this analysis and defined as:

$$lnD_i = \alpha lnY_1 + \alpha lnY_2 + \alpha lnY_n + \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \ldots + \beta_5 lnX_5 + \frac{1}{2}\beta_{13} ln(X_1)^2 + \ldots + \frac{1}{2}\beta_{24} ln(X_2)^2 + \omega_1 D_1 + \pi H_1 + v_i - u_i$$

where;

ln = Natural logarithm

D_i = Total value of all crops (pesos)

Y_1 = Total value of upland land (kg)

Y_2 = Total value of other crops (kg)

Y_3 = Total value of falcata (cu. m)

X_1 = Total land owned to upland rice and other crops (ha)

X_2 = Man Labor (MD)

X_3 = Man-animal labor (MAD)

X_4 = Seed (kg)

X_5 = Fertilizer (kg)

D_1 = Dummy variable for Seed type (0=inbreed, 1=otherwise)

v_i = Random error (white noise)

u_i = Non-negative random variable called inefficiency effects

To determine the socio-economic factors that influence the technical efficiency level of farmers in integrated upland rice farms, this was determined by the specification of an inefficiency model, which involves regression of the inefficiency component of (U2i) to the farm social-economic characteristics. It is empirically specified as follows:

$$U^2_i = \gamma_0 + \gamma_1 Z_1 + \gamma_2 Z_2 + \gamma_3 Z_3 + \gamma_4 Z_4 + \gamma_5 Z_5 + \gamma_6 Z_6 + \gamma_7 Z_7 + \gamma_8 Z_8 + \gamma_9 Z_9 + \gamma_{10} Z_{10} + \gamma_{11} Z_{11} + \gamma_{12} Z_{12} + \theta_1 D_1 + \theta_2 D_2 + \theta_3 D_3 + \theta_4 D_4 + \theta_5 D_5 + \theta_6 D_6 + \theta_7 D_7 + \Gamma_1 H_D$$

Z_1 = Age of farmer

Z_2 = Years in formal school (no.)

Z_3 = Household size (no)

Z_4 = Family members working in the farm (no)

Z_5 = Years in upland rice farming (no)

Z_6 = Years in farming (no)

Z_7 = Occupational Activity (no)

Z_8 = Other crops grown (no)

Z_9 = Cropping per year (no)

Z_{10} = Seminars/trainings attended (no)

Z_{11} = Contact to extension agents (no)

Z_{12} = Distance of farm to the nearest market (km)

D_1 = Dummy variable for sex of the farmer (0= male, 1= other wise)

D_2 = Dummy variable for marital status (0= married, 1= other wise)

D_3 = Dummy variable for tribe of the farmer (0= IP, 1= otherwise)

D_4 = Dummy variable for land tenure (0= owned, 1= otherwise)

D_5 = Dummy variable for soil analysis (0= yes, 1= otherwise)

D_6 = Dummy variable for membership in organization (0= member of an organization, 1= otherwise)

D_7 = Dummy variable for access to extension agents (0= beneficiary of any government program, 1= otherwise)

$\Gamma_1 H_D$= Herfindahl Index (crop diversification index)

$\gamma 0$ = Inefficiency parameters to be estimated

The significance level is determined by the probability values generated from the analysis. Critical values to determine the level of significance of each parameter in the analysis are derived from the *t* distribution table. Critical values for 1% and 5% levels of significance are 2.639 and 1.990, respectively. Given the functional and distributional assumption of maximum likelihood estimate (MLE) for all parameters of the input distance function, this was estimated using the computer program, FRONTIER 4.1 (Coelli, 1996).

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3.0 Results and Discussion

The extent of crop diversification economically among integrated upland rice farms is depicted in Table 2. Herfindahl index, which ranges from zero for complete diversification to one for complete specialization of farms. Based on the proportional mix of crops in land use, the Herfindahl index was determined for each individual farm in the dataset.

Table 2. Extent of economies of crop diversification among integrated upland rice farms in selected municipalities in Caraga Region, Philippines.

Range	Number (N)	Percentage (%)
0.00 - 0.25	44	18.41
0.26 - 0.50	15	6.28
0.51 - 0.75	28	11.71
0.76 - 1.0	152	63.60
Total	239	100.0

Results revealed that the majority of the integrated upland rice farms (63.60%) belong to the 0.76 to 1.0 range, which means that integrated upland rice farms are closest to complete specialization. On the other hand, 18.41% of integrated upland rice farmers practiced complete diversification (0.00 - 0.25 range). This result is in consonance with that of Nguyen (2014), who said that the average Herfindahl index is 0.75 for Vietnam, which is slightly higher than the estimated average of 0.70 for Afghanistan (corresponding to a mean CDi of 0.30). Whereas, Rahman (2009) reported an average Herfindahl index of 0.60 for Bangladesh. Likewise, Ogundari (2013) said that a Herfindahl index of 0.46 was noted in Nigeria, and Manjunatha et al. (2013) reported 0.55 in India. Thus, this means that farmers of integrated upland rice have a choice either to adopt crop diversification or crop specialization as long as they can maximize the use of their resources and earn a higher income.

Table 3 shows the multiple cropping combinations of integrated upland rice farming. It was observed that most of the farmers cultivated more than one cropping enterprise within a year. Results showed that majority in upland rice farming (38.49%) preferred to have upland rice and vegetable combinations while 18.83% of upland rice farmers preferred to combine upland rice and corn. Other farmers preferred to combine upland rice and industrial crops such as banana and abaca which consists of 7.53% while other farmers preferred to have more than two combinations. The result is supported by Tobgay (2005) and De and Chattopadhyay (2010) who stated that the farmers preferred to have two cropping combinations which is millet + sorghum combination, although it was noted that the composition of the mixtures depend largely on rainfall. In addition, farmers would also try to cultivate as many crops as possible on a given piece of land. They often choose crops which could meet their food requirements, and also meet their minimum cash requirements for the maintenance of their daily lives. Jamagani and Bivan (2013) revealed that the most frequent mixtures in upland farming were: maize + sorghum; maize + pepper + sweet potato; maize + cowpea +sorghum; yam + sorghum + rice; and millet + cowpea + groundnut. The study of Jha *et al.* (2009) confirmed that agricultural diversification at the farm level is supposed to increase the farm income. However, the utility of diversification as risk management practices still remains.

Table 4 presents the results of maximum likelihood estimates (MLE) of the parameters of the multi-output multi-input stochastic frontier model. Out of nine (9) explanatory variables include in the model, six (6) variables came out significant at the one (1) and five (5) percent probability level with signs consistent with a priori expectations. These are total value of upland rice, total value of other crops, total value of falcata total land owned to upland rice and other crops, man labor, and organic/inorganic fertilizer were significant (P<0.001) which means that increasing the usage for these variables would result to the significant increase in integrated upland rice farms output productivity. However, the three (3) variables which came out not significant include man-animal labor, seed and seed type. Other factors were held constant. This implies that man animal labor and seed type does not significantly lead to increase in integrated upland rice farms output productivity.

Table 3. Multiple cropping combination of integrated upland rice farms in selected municipalities of Caraga Region, Philippines.

Type of Combination	Number (N)	Percentage (%)
Upland Rice + Vegetables	92	38.49
Upland Rice + Corn	45	18.83
Upland Rice + Industrial Crops	18	7.53
Upland Rice + Vegetables + Coconut	11	4.60
Upland Rice + Coconut + Industrial Crops	9	3. 77
Upland Rice + Corn + Vegetables + Industrial Crops	8	3.35
Upland Rice + Corn + Industrial Crops	8	3.35
Upland Rice + Corn + Vegetables	6	2.51
Upland Rice + Corn + Vegetables + Industrial Crops	6	2.51
Upland Rice + Vegetables + Industrial Crops	6	2.51
Upland Rice + Corn + Coconut + Industrial Crops	5	2.09
Upland Rice + Coconut	4	1.67
Upland Rice + Corn + Root Crops	3	1.26
Upland Rice + Vegetables + Falcata	3	1.26
Upland Rice + Corn + Industrial Crops + Falcata	2	0.84
Upland Rice + Corn + Coconut + Falcata	2	0.84
Upland + Industrial Crops + Falcata	1	0.42
Upland +Root Crops + Coconut + Industrial Crops	1	0.42
Upland Rice + Corn + Root Crops + Industrial Crops + Falcata	1	0.42
Upland Rice + Corn + Vegetables + Root Crops + Industrial Crops	1	0.42
Upland Rice + Corn + Vegetables + Root Crops + Industrial Crops	1	0.42
Upland Rice + Coconut + Industrial Crops	1	0.42
Upland Rice + Corn + Coconut	1	0.42
Upland Rice + Corn + Root Crops + Industrial Crops	1	0.42
Upland Rice + Root Crops	1	0.42
Upland Rice + Vegetables + Coconut + Industrial Crops	1	0.42
Upland Rice + Vegetables + Coconut + Industrial Crops + Falcata	1	0.42
Total	239	100.00

Note: Vegetables = Eggplant (*Solanum melongena* L.), String Beans (*Phaseolus vulgaris*), and Squash (*Cucurbita maxima* L.)
Industrial Crops = Banana *(Musa acuminata and balbisiana*) and Abaca (*Musa textilis*)
Rootcrops = Cassava (*Manihot esculenta*) Karlang (*Xanthosoma sagittifolium*), and Camote (*Ipomoea batatas*)

The total value of upland rice, total value of other crops and total value of falcata to rice was significant (p < 0.001) and had the highest coefficient of 0.589 for the total value of upland rice while the coefficient of 0.026 for total value of other crops and the coefficient of 0.071 for the total value of falcata. This implies that increases in upland rice, other crops such as corn, vegetables, banana and abaca production by 10% tend to increase the distance to the frontier by about 58%, 3% and 7%, respectively, ceteris paribus. This result indicates the relatively higher capacity of upland

Table 4. Maximum likelihood estimates of the stochastic frontier production function of integrated upland rice farms in selected municipalities in Caraga Region, Philippines.

Variables	Parameter	Coefficient	Standard Error	T-Ratio
Constant	β_0	6.598***	0.341	19.352
Total Value of upland Land	β_1	0.589***	0.045	13.063
Total Value of Other Crops	β_2	0.026***	0.005	5.121
Total Value of Falcata	β_3	0.071***	0.009	8.349
Total Land Owned to uplands rice & other crops	β_4	0.229***	0.054	4.279
Man Labor	β_5	0.149***	0.039	3.794
Man Animal Labor	β_6	-0.001	0.007	-0.0161
Seed	β_7	0.055	0.038	1.445
Organic Fertilizer/ Inorganic	β_8	0.011**	0.005	2.273
Seed type	D_1	0.282	0.315	0.894

Source: Estimated by FRONTIER 4.1c (, ** and *** is significant at 10%,5% and 1% respectively)*

rice production over other crops to enhance the efficiency level of smallholder farmers. Total land owned to upland rice and other crops significantly (p<0.01) influenced efficiency. This implies that upland rice farmers cultivated other crops in order to improve efficiency. This result is in line with Binam *et al.* (2005), who mentioned that intercropping groundnuts and maize improves efficiency. However, the result of Ho *et al.* (n.d) contradicts the estimated coefficients of coffee production and rice production, which are β_1= -0.400 and β_2= -0.291, respectively. This indicates that increases in coffee and rice production by 10% tend to decrease the distance to the frontier by about 4% and 3% respectively, ceteris paribus with the negative sign of the coefficient.

The amount of manpower used is positive and significant at 1%. This indicates that the amount of labor used in integrated upland rice production will increase by 0.149%. This result implies that the quantity of human labor has a positive effect on the productivity of integrated upland rice crops. This is due to the fact that upland rice farming is labor intensive, and there is a possibility of increase in wages which would crowd out low income earners from the labor market thus rendering them less effective in production. Thus, modern technologies can reduce labor demands and improve efficiency. This result conforms to Jude (n.d), and Balogbog and Gomez (2020), who said that the coefficient of labor is positive and significant.

Meanwhile, fertilizer used (organic or inorganic) is positive and significant at the 5% level. This indicates that a one percent increase in the quantity of fertilizer will bring about a 0.011% increase in yield. This finding is consistent with the results of Ho *et al.* (n.d.); Ahmadzai (2017); Ogundari (2013); and Mariano *et al.* (2010), who said that the quantity of fertilizer used is positive and significant.

Table 5 shows the results of maximum likelihood estimates (MLE) of the technical inefficiency model of integrated upland rice farms in selected municipalities in Caraga Region, Philippines. Out of twenty (20) explanatory variables included in the model, 11 came out significant at the one (1), five (5), and ten (10) percent probability levels, respectively. These are household size, years in upland rice farming, years in farming, other crops grown, cropping per year, contact with extension agents, access to extension agents, sex, tribe, land tenure, and membership in organizations. On the other hand, the nine (9) variables which came out not significant include age, years in formal school, family members working on the farm, occupational activity, number of seminars/trainings

Table 5. Maximum likelihood estimates of the inefficiency model of integrated upland rice farms in selected municipalities of Caraga Region, Philippines.

Variables	Coefficient	Standard Error	T-Ratio
Constant	1.996**	0.711	2.808
Age	-0.006	0.008	-0.792
Years in formal school	0.018	0.023	0.809
Household size	0.120*	0.070	1.698
Family members working in the farm	-0.089	0.075	-1.192
Years in upland rice farming	-0.061***	0.012	-5.064
Years in farming	0.027**	0.014	2.011
Occupational Activity	-0.265	0.277	-0.959
Other crops grown	0.203***	0.050	4.039
Cropping per year	-0.800**	0.320	-2.496
Seminars/trainings attended	-0.018	0.018	-1.012
Contact to extension agents	-0.251***	0.033	-7.698
Access to extension agents	-0.652**	0.263	-2.477
Distance of farm to the nearest market	-0.031	0.079	-0.396
Sex	-0.609***	0.218	-2.792
Marital Status	-0.393	0.579	-0.679
Tribe	-0.853***	0.253	-3.365
Land tenure	-1.717***	0.396	-4.338
Soil analysis	-0.398	0.354	-1.123
Membership in organization	-0.741***	0.093	-7.975
Herfindahl Index	0.006	0.050	0.0113
Sigma-squared	0.709***	0.109	6.504
Gamma	0.853***	0.041	20.925
Log likelihood	-124.78		

Source: Estimated by FRONTIER 4.1c (, ** and *** is significant at 10%,5% and 1% respectively)*

attended, distance of farm to the nearest market, marital status, soil analysis and Herfindahl Index, and other factors held constant. The significant but negative coefficients, which can be interpreted as indicating that increasing the usage of these variables would reduce the inefficiency of integrated upland rice farms. The significant and positive coefficients would have the opposite effect. The sign on the coefficients in the inefficiency model is interpreted in the opposite direction, such that a negative sign means that the variable increases efficiency and a positive sign decreases technical efficiency (Cañete & Temanel, 2017).

According to Bethel *et al.* (2016), the sigma squared indicates the goodness of fit and correctness of the distributional form around the composite error term. Gamma (γ) is the variance ratio, explaining the total variation in output from the frontier level of output attributed to technical efficiency. The estimated value of γ (the ratio of the variance of output due to technical efficiency) is 0.853, indicating that about 85.3% of the difference between the observed and frontier output is primarily due to inefficiency factors that are under the control of upland rice-based and it is significant at one percent (p<0.001), which confirms the previous proposition that upland rice farmers in the study area were not producing along the frontier level. Gamma (γ) is bound between zero and one (Battese, 1992). Where it is zero, inefficiency effects do not exist in the model, and if it is one, inefficiency is significant and is not random. This implies that the observed inefficiencies are related to farmer practices. Results show that household size, years in upland rice farming, other crops grown, cropping per year, contact with extension agents, access to extension agents, sex, tribe, land tenure, and membership in organizations would reduce the technical inefficiency of integrated upland rice farms.

The frequency distribution of the technical efficiency of individual upland rice-based farms is shown in Table 6. The result shows that 54.39% of the respondents are in the efficiency level of 81-90 while 17.99% belong to the efficiency level of 71-80 and 9.21% of the respondents are in the efficiency level of 91-100. This implies that 81.59% of the integrated upland rice farms in the study areas are operating closer to the frontier. The average technical efficiency of the sample farms is 78.52, indicating the maximization of the input-output ratio in production. This signifies a 21.48% potential for integrated upland rice farms to increase their productivity. The foregoing also means that by being efficient, integrated upland rice farms in the study area can increase their productivity by 21.48% at the current level of technology and resources. This result conforms to the study of Balogbog and Gomez (2020) and Idiong (2007) revealed that the mean efficiency level of rice farmers living in Sarangani Province and Nigeria is 77%, which means that farmers are not fully technically efficient and there is a remaining 23% room for improving their efficiency. The respondent with the highest technical efficiency value of 95 was cultivating upland rice using proper cultural management practices, which are recommended by the Department of Agriculture. According to the respondent, he had enough capital invested in upland rice, labor, and fertilizer. On the other hand, the respondent had a low TE value of 23, which means he utilized no fertilizer input. Fertilizer is one of the most important inputs for upland rice farmers.

Table 6. Frequency distribution of technical efficiency scores of integrated upland rice farms in selected municipalities of Caraga Region, Philippines.

Efficiency Estimate	Number (N)	Percentage (%)
21-30	6	2.51
31-40	5	2.09
41-50	9	3.77
51-60	8	3.35
61-70	16	6.69
71-80	43	17.99
81-90	130	54.39
91-100	22	9.21
Mean	78.52	
Minimum Technical Efficiency	23	
Maximum Technical Efficiency	95	
Standard Deviation	15.55	

4.0 Conclusion

Based on the study's findings, it was concluded that integrated upland rice farmers could adopt complete specialization or crop diversification as long as they can maximize the use of their resources and earn a higher income. Years in upland rice farming, cropping per year, contact with extension agents, sex, tribe, land tenure, membership in the organization, and access to extension agents would also reduce the technical inefficiency of integrated upland rice farms. Hence, it is recommended that upland rice farmers focus on crop specialization one at a time to maximize resource allocation. However, crop diversification is still encouraged to increase income and maximize land utilization. Thus, the government should intensify the promotion of crop diversification. Effective extension services such as training and seminars conducted by government and non-government agencies should include research-based technologies on upland rice farming, especially on soil analysis and fertilizer application, pest and disease management, and control to improve upland rice production. Further, the government should include upland rice as one of the priority commodities in order for upland rice farming to be allocated with funds such as plant breeding research for upland rice improvement, specifically on production and pest and diseases.

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