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TECHNICAL EFFICIENCY ANALYSIS OF ORGANIC RICE PRODUCTION IN LEYTE, PHILIPPINES: A STOCHASTIC FRONTIER APPROACH

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This study investigates the technical efficiency of organic (uncertified) lowland irrigated rice farming in selected areas of Leyte Province. Technical efficiency indices were derived from a stochastic frontier production function analysis employing the maximum likelihood estimation. Organic (uncertified) rice farmers observed mean technical efficiency was high, with 92% for the dry season and 90% for the wet season, which is comparatively higher than the conventional practices findings available in the literature. Results showed that technical efficiency was significantly affected by farming experience, education, trainings attended, income from other sources, affiliation with organizations, technical services from the Department of Agriculture, and homemade sources of inputs. Results of the study suggest that farmers should apply optimal levels of organic inputs and continue water management to control weeds. For the government and non-government agencies to further promote the use of organic rice farming systems and intensive extension services is necessary. In addition, it is recommended that the government should create a policy and assistantship for organic farmers, especially small-scale farmers, in having their products certified at a lesser price or better a cost-free program. This will help farmers have a justified price for their products and will also further motivate other farmers to convert to organic farming.

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1. INTRODUCTION

Organic farming is the most environment-friendly way of farming, resulting in minimal to zero land degradation and fewer health problems (EPA, 2009). It is a system that avoids using any chemical or synthetic product. This type of farming system relies on crop rotation, green manure, use of natural fertilizers, and biological pest control, implying that this is a proactive ecology management strategy. The conventional method of rice farming compels the usage of chemical fertilizers, pesticides, herbicides, and other chemical products. Even though it is known for its high-yielding results, the conventional farming system is believed to have enhanced soil degradation, pollution, chemical residues in food, loss of biodiversity, and negative externalities to the farmers' health, not to mention the increase of the farmers' actual burden of high expenses (Mendoza 2002 and 2003). Organic agriculture technologies were developed to minimize such impacts. Since it refrains from using petroleum-based chemical inputs, this strategy leads to soil conditioning and fertilization with the help of microorganisms, prevents soil erosion, and simultaneously protects humans and animals from the side effects of chemicals and synthetic inputs (EPA, 2009). Thus, this farming system turns out to be a key to sustainable agriculture. There is also a continuous increase in demand for organic products in the marketplace (Declaro-Ruedas, 2019); however, there is a limited supply of organic products which cannot meet the market demand (Suwanmaneepong et al., 2020).

In the Philippines, organic rice farming is in its infancy stage. According to Philippine Development Assistance Program or PDAP (n.d.), only 0.35 percent of the total rice farming areas, or about 14,419 hectares in fifteen provinces are devoted to organic rice production. Approximately more than 82 thousand metric tons of organic rice are produced annually, with more than 36,592 farmer adopters (Doyo, 2003). The Bureau of Agricultural Statistics or BAS (2012), currently the Philippine Statistics Authority (PSA), reports that Eastern Visayas had a total of 984,017 metric tons of rice production in 2011, an increase of 2.06 percent from 2010. The region also had a farm area of 284,933 hectares, an expansion of 3.35 percent from 2010 (BAS, 2012). Specifically, Leyte accounts for 50 percent of the total rice production in Eastern Visayas and is the biggest rice-producing province, with about 347,000 tons produced in 2002 (Capuno, 2003).

Leyte was the 7th top rice-producing province in the Philippines (BAS, 2011). It intensified the campaign for the conversion of inorganic rice farms to organic ones (EVR News, 2011). However, in spite of the benefits derived from the technology and the campaign for an organic farming system by the Department of Agriculture (DA) with the support of some non-government organizations (NGOs) and other agricultural training centers and schools, the conventional way of farming system is still practiced by the majority of rice farmers. This hinders the ultimate goal of sustainability and the long-term benefits that can be obtained from the organic farming system. Hence, this study aims to assess the technical efficiency of farmer adopters of organic rice-irrigated farming in selected areas in the Province of Leyte. Conducting an analysis of the technical efficiency of farmer adopters of organic rice farming system will not only fill the gap in the existing literature, provide benchmark statistics to facilitate comparisons of efficiency, but also help policymakers in introducing the optimized usage of inputs factors (Benedetti et al., 2019) and allocations of training, extension services, subsidies, or technical services (Branca et al., 2021). These would help in the adaptation and sustainability of the organic farming system.

2. METHODOLOGY

Theoretical Framework

Technical efficiency implies that farmers are doing the best job of combining resources to make goods without wasting these material inputs (Tipi et al., 2009). Figure 1, adopted from Aquino (2011), displays the graphical presentation of measuring technical efficiency in organic rice farming. The Y2 curve represents the production frontier that shows the best production result by the organic rice farmers when all inputs are used efficiently. In contrast, the Y1 represents the technically inefficient results if organic rice farmers obtain lower output at given levels of input.

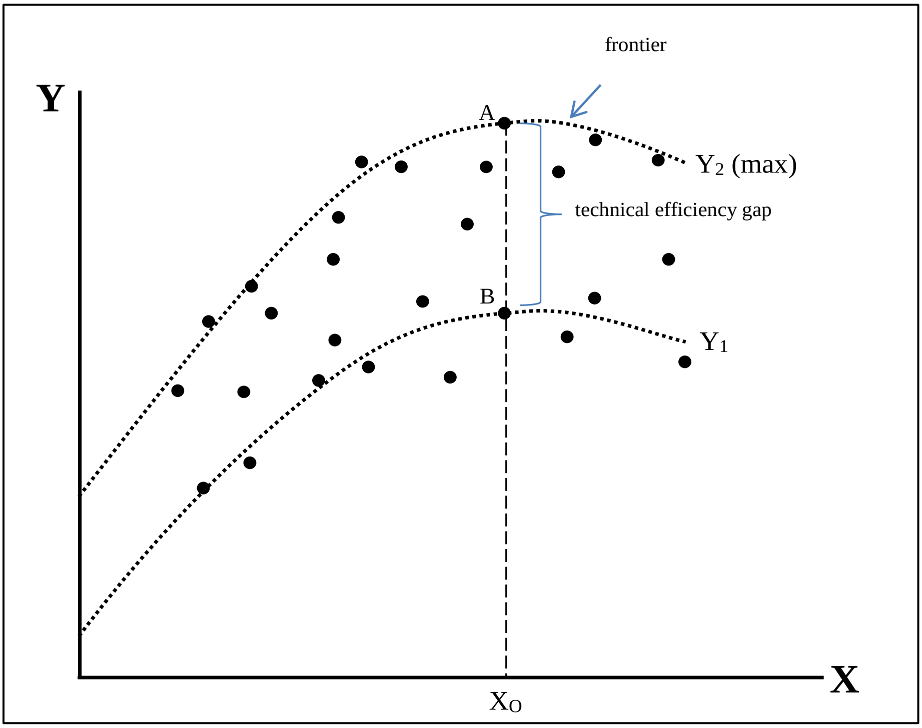

Figure 1. Graphical presentation of technical efficiency measures of organic rice farming system adopted from Aquino (2011).

Technical efficiency (TE) is measured as the ratio of the farm's actual observed output (Y) for a given level of inputs. The farm's specific stochastic production frontier representing the maximum possible frontier (Y_2) could be thus presented:

$$Y_i = f\,(X_i, \beta)\, e^{E_i} \tag{1}$$

wherein:

$$E_i = V_i - U_i \tag{2}$$

$$U_i = Z_i\delta + W_i \tag{3}$$

where:

Y_i = yield of organic (uncertified) rice (kg) per hectare of i-th farm
X_i = vector of inputs used to produce Y_i
B = vector of unknown parameters to be estimated
V_i = independent and identically distributed $N(0,\sigma_v^2)$ random errors

U_i = independent and identically distributed non-negative truncations (at zero) of $N(Z_i\delta, \sigma^2)$ distribution
Z_i = (1 x m) vector of farm specific inefficiency variables
δ = (m x 1) vector of unknown coefficients of the farm specific inefficiency variables
W_i = truncation of $N(0, \sigma^2)$

The composite error term (E_i) of equation 2 defines V_i as the two-sided, normally distributed, random error that captures statistical noises, measurement errors, and exogenous shocks beyond the control of the farms, and U_i as the one-sided efficiency component with a half-normal distribution, in other words, as the departure from their own frontiers due to inefficiency.

Equation 3 shows the inefficiency effects model, which relates U_i with a set of explanatory variables, Z_i, which causes the inefficiency (Aquino, 2011). By maximizing equations 1 and 3 log-likelihood functions, the coefficients of the various regression parameters of the model can be obtained (Battese and Coelli, 1993).

Empirical Model for Technical Efficiency Analysis

The measurement of farmers' technical efficiency in rice production was estimated using a linear inefficiency effects model of the stochastic production frontier model designed by Battese and Coelli (1995).

The linear regression model was:

$$\ln yield = \beta_0 + \beta_1 \ln SAMT + \beta_2 \ln IMOA + \beta_3 \ln FPJA + \beta_4 \ln FFJA + \beta_5 \ln FAAA + \beta_6 \ln LABSA + \beta_7 \ln OHNA + \beta_8 \ln MANLABOR + \beta_9 \ln MACLABOR + \beta_{10} SVARIETY + \beta_{11} WT + \beta_{12} SEASN + (V_i - U_i) \quad (4)$$

where:

$$U_i = \delta_0 + \delta_1 FEXPYRS + \delta_2 EDAYRS + \delta_3 TRAININGS + \delta_5 DIST + \delta_6 HINCOME + \delta_7 AFFI + \lambda_1 EXSERVC + \lambda_2 SOI \quad (5)$$

The definitions of the above variables are as follows:

Y_i	=	yield of organic (uncertified) paddy rice (kg/ha)
SAMT	=	amount of seeds used (kg/ha)

IMOA	=	amount of indigenous microorganisms (IMO) applied (li/ha)
FPJA	=	amount of fermented plant juice (FPJ) applied (li/ha)
FFJA	=	amount of fermented fruit juice (FFJ) applied (li/ha)
FAAA	=	amount of either fish amino acid (FAA) or kuhol amino acid (KAA) applied (li/ha)
LABSA	=	amount of lactic acid bacteria serum (LABS) applied (li/ha)
OHNA	=	amount of oriental herbal nutrient (OHN) applied (li/ha)
MANLABOR	=	man labor employed (man days per ha)
MACLABOR	=	machine labor employed (days per ha)
SVARIETY	=	variety dummy; 1 if certified seeds, 0 otherwise
WT	=	water management dummy; 1 if applied, 0 otherwise
SEASN	=	cropping season dummy; 1 if dry season, 0 otherwise
FEXPYRS	=	farming experience (years)
EDAYRS	=	educational attainment (years)
TRAININGS	=	number of training attended related to rice farming
DIST	=	distance of farm from the nearest agency selling organic inputs (km)
HINCOME	=	Household Income from other sources (in pesos)
AFFI	=	number of farming-related organizational affiliation
EXSERVC	=	technical services dummy; 1 if DA, 0 otherwise
SOI	=	source of organic inputs dummy; 1 if homemade, 0 otherwise
B_i	=	regression coefficients
l_n	=	natural logarithm

Sampling Procedure and Data Collection

The respondent population included all the rice farmers practicing organic (uncertified) irrigated farming in the selected areas of the Province of Leyte in Region VIII (Figure 2). The lists of the farmers were obtained from the DA and NGOs. Stratified random sampling was used to choose the respondents for the survey. A total of 110 farmers served as sample respondents: 25 from Alang Alang, 24 from Calubian, 28 from Pastrana, 18 from Sta Fe, and 15 from the City of Ormoc. During the interview, it was discovered that these farmer-respondents did not avail of the "organic rice certification" due to its high cost from the third party that is accredited by the government. They are still, however, included in the lists given by the DA and NGOs because they follow the organic rice farming system. The difference between uncertified organic rice products from the certified ones is having no verification from the said third party, no certification, and are sold at a price similar to non-organic rice. For a farm to be certified organic, it had to be inspected by the said accredited third party to verify that the requirements of that certifying body are adhered to. Still, these farmer-respondents prefer to continue this farming system because of the benefits.

Primary data were collected through a survey using a pre-tested interview schedule. The interview schedule was developed in English but verbally translated into Cebuano or Waray during the interview. The data gathered for the study included demographic characteristics of the farmers, farm characteristics, production and management practices, labor inputs, material inputs, farm yield, sources of income, cropping mechanisms used, and problems encountered concerning rice production.

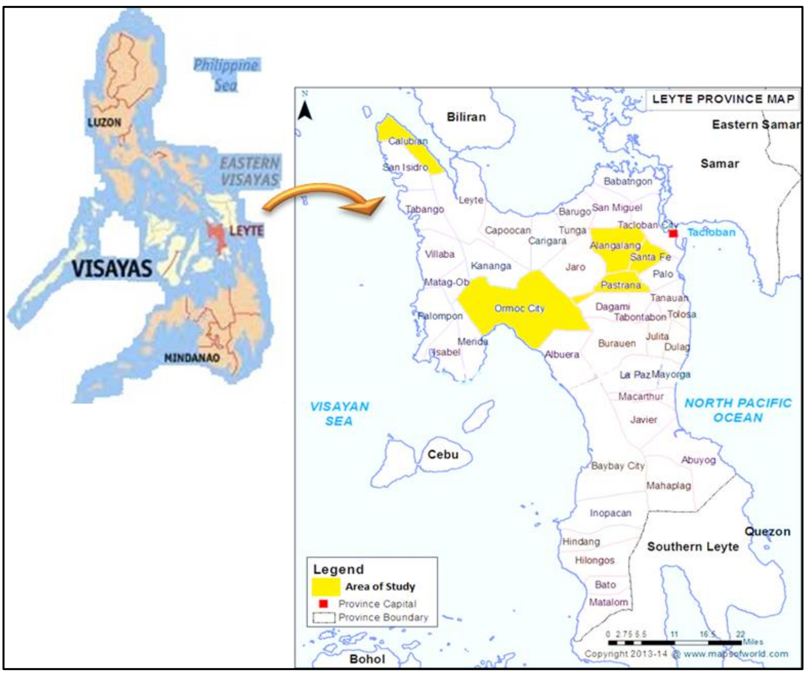

Figure 2. Map of Leyte showing the study areas
(Source: Maps of the World, 2012)

Data Analysis

Descriptive analysis was used to summarize the data, including the computation of mean, totals, ranges, variances, standard errors, and percentages (Argyrous, 2011). Regression analysis was conducted to predict the relationship between yield and production inputs. Meanwhile, technical efficiency and production function analyses were examined using Frontier 4.1 software (Coelli, 1996). Several regression diagnostic tests were conducted to test the validity of the results.

3. RESULTS AND DISCUSSION

Socio-Demographic Characteristics of Farmers

The farmer-respondents, on average, were in their early fifties and spent about eight years in school (Table 1). A little over half (51%) were females, and the majority were married (88%), with an average of two (2) household members who helped on the rice farm. All respondents had other income sources, mostly from other crops grown, livestock and poultry production. The farmer-respondents spent long years in agricultural production with an average experience of 24 years, of which about four years were lately spent on organic rice farming. The majority of the respondents (75%) were owner-operators.

Most of the farmer-respondents (86%) did not avail of credit, implying that the other sources of income helped raise funds for rice production. Almost all organic rice farmer-respondents (89%) were affiliated with organizations associated with organic rice farming. Most of these organizations were NGOs such as Magsasaka at Siyentipiko para sa Pag-unlad ng Agrikultura (MASIPAG), Rural Development Institute (RDI), and Saint Benedict Farmers' Institution on Sustainable Agriculture (SBFISA) and some were associated with cooperatives established and assisted by the DA. All organic rice farmer respondents' farm topographies were irrigated lowland with an average area of 1.05 ha. From the rice farm, the farmer-respondents would take an average of 6.99 km distance to the nearest agricultural suppliers.

The technical services the NGOs and DA technicians gave were training and seminars related to organic rice farming practices and organic input (fertilizer, pesticides, and weedicides) making. They also provide information, education, and communication (IEC) materials such as leaflets, brochures, and booklets related to organic rice farming approaches. NGOs (76%) are noted to be aggressive in the coverage and influence of farmers on the organic farming system. On average, the respondents attended two seminars/training related to organic rice production (Table 1).

Table 1. Socio-demographic characteristics of organic rice farmer-respondents in selected areas in Leyte, 2013.

Demographics	N	Mean	Min	Max
Age (years)	110	52.72	19.00	88.00
Male (1 for male, 0 for female)	110	0.49	0.00	1.00
Married (1 for married, 0 otherwise)	110	0.88	0.00	1.00
Household members in farm operation (quantity)	110	2.00	1.00	5.00
Formal schooling (years)	110	8.00	1.00	14.00
Other sources of income (1 has, 0 otherwise)	110	110.00	0.00	1.00
Rice farming experience (years)	110	23.93	1.00	60.00
Organic rice farming experience (years)	110	4.75	1.00	10.00
Owner-operator (1 owner-operator, 0 otherwise)	110	0.75	0.00	1.00
Did not avail credit (1 did not avail, 0 otherwise)	110	0.86	0.00	1.00
Affiliation with organization (1 affiliated, 0 not)	110	0.89	0.00	1.00
Farm Area (ha)	110	1.05	0.25	4.24
Distance of farm from nearest inputs supply (km)	110	6.99	2.00	14.00
Technical services (1 from DA, 0 otherwise)	110	0.24	0.00	1.00
Number of Seminars attended	110	2.00	1.00	4.00

Production and Management Practices in Organic Rice Farming

All farmer-respondents defined organic rice farming as the absence of chemical (synthetic or inorganic) use in environmental and health-friendly farming. They further mentioned that the over-application of organic inputs such as organic fertilizer is safe aside from being affordable compared to inorganic inputs. Thus, most of the respondents applied more than the recommended amount required by the DA or NGOs in their production practices. Unfortunately, all farmer-respondents did not avail of having their products be certified organic rice due to its high cost. However, they continued practicing the organic rice farming system due to its benefits.

Farmer-respondents used either certified or non-certified seeds. Certified seed users claimed that such seeds were high-yielding and had a high germination rate and response to fertilizers with resistance to pests and diseases. Besides, these were insured by DA. However, non-certified seed users attributed their preferences to the high cost of certified seeds; hence, they kept seeds from their previous harvest. They also expressed their preference for variety rotation after two or three cropping seasons. They added that they used non-certified seeds due to the unavailability of certified seeds in their location.

Most respondents acquired certified seeds from DA (69%), while the rest were purchased via the nearest agricultural suppliers and intermediaries in the area. Most (59%) of the non-certified seed users obtained the seeds from NGOs, while the rest were purchased from fellow farmers and intermediaries, and a few obtained these from their previous harvest.

All respondents practiced the conventional wet bed method on their seedbed preparation with no seed treatments. Following the organic rice farming standards set by MASIPAG, some farmers soaked the seedlings within 24 hours with fermented plant juice (FPJ) before sowing the seeds on the seedbed. On the other hand, the Philippine National Standard for Organic Agriculture (PNSOA) required certified organic seeds; however, if these were unavailable, untreated conventional seeds were permitted.

In inland preparation, almost all (92%) of the farmer-respondents used mechanical methods with the help of water buffaloes or "carabaos" for leveling or flattening the farm. More than half of the respondents did not apply any organic input during land preparation. However, the rest of the respondents sprayed IMO before plowing and after leveling the rice field, as prescribed by the technicians. IMO, a foliar fertilizer and a weedicide that reduces weeds' growth are considered good soil conditioners. All farmer-respondents practiced the manual transplanting method.

The majority of the respondents (93%) did weed control to avoid weed competition for nutrients. About 44 percent of total farmer-respondents used organic weedicides; a homemade IMO formulation was sprayed in the rice field before transplanting as recommended. Almost 31 percent used water management in controlling weeds. Water is one control measure to minimize weeds; many weeds cannot germinate or grow under flooded conditions.

Several days before transplanting, the farmer-respondents submerged the rice field with water for an average of 2.5 cm deep. This complies with IRRI's requirement of maintaining a 2 to 5 cm water level in the field to minimize weed emergence and lower weed pressure. Moreover, fields were continuously added with sufficient water from the transplanting time to cover the soil completely, an advantage to farmers with an irrigated rice field. Good land leveling is critical to avoid high spots where weeds can regrow.

All farmer-respondents applied organic fertilizers. One-third of them preferred making their own fertilizer, while the rest preferred buying from NGOs, DA, fellow farmers, and merchants. More than half of the respondents applied Fermented Plant Juice or FPJ (63%) and Fermented Fruit Juice or FFJ (61%). FPJ enhances plant growth and photosynthesis, thus helping maintain vigor in rice plants and resistance against pests. FFJ is a good source of potassium which speeds up plants' absorption and results in sweeter-tasting fruits, thus helping maintain rice plant vigor. Almost half (45%) of the respondents applied Fermented Amino Acid (FAA), a good nitrogen source that served as a growth hormone. On the other hand, some of the respondents used Vermicast (7%). Vermicast brings back to life degraded fields and acts as a soil conditioner. On average, respondents applied organic fertilizer more than twice since they had the advantage of having more homemade organic fertilizer.

Two-thirds of the respondents (67%) applied organic pesticides [Oriental Herbal Nutrients (OHN)] to control pests from damaging their crops. OHN serves as an insecticide and fungicide and, at the same time, provides more vigor and vitality to rice plants. The rest did not apply pesticides because no pest infestation was observed and to lessen costs. In addition, there were respondents (18%) who used Lactic Acid Bacteria Serum or LABS. LABS prevents the growth of harmful or pathogenic bacteria.

All farmer-respondents applied the manual method in harvesting. Aside from family members, all respondents hired labor to help them in rice farming with different remuneration systems. Transplanting, harvesting, and threshing had the highest labor requirements among the production activities of the organic (uncertified) rice farmer-respondents, similar findings from the study of the Techno Gabay Program (TGP) on palay farms in selected municipalities in Leyte by Gabunada et. al. (2011). The Sun-dry method was used for drying. In disposing of, more than half of them (62%) preferred to sell their farm produce un-milled, while some (38%) of the farmer-respondents preferred to sell it after milling due to its higher price.

Material Inputs of the Organic Sample Rice Farm

Material inputs of the organic rice farmer-respondents are shown in Table 2. More than 67 kilograms of seeds were used by respondents using the certified type of seeds: this is lesser in quantity compared to the non-certified type of seeds used due to its higher germination rate. Compared to the required amount by the MASIPAG (30 kg/ha) and the findings of the study of Gabunada (2011) on TGP (58 kg/ha), seed quantity is too high due to the average close planting distance and the greater number of seedlings planted per hill. Farmers believed that the greater seeds planted per hill with close planting distance reap a higher harvest that leads to favorable income.

Table 2. Material inputs in organic rice production of farmer-respondents in selected areas in Leyte, two cropping seasons, 2013

Material Inputs	Cropping Season (Quantity/ha)		Average (per hectare)
	Dry	Wet	
Seeds			
Certified (kg/ha)	64.43	70.20	67.31
Non-certified (kg/ha)	78.21	83.93	81.07
Indigenous microorganism (IMO) (liters/ha)	11.30	11.49	11.39
Organic Fertilization (liters/ha*)*			
Fermented plant juice (FPJ)	2.91	2.86	2.88
Fermented fruit juice (FFJ)	2.59	2.65	2.62
Fermented amino acid (FAA)	2.37	2.40	2.38
Worm fertilizer (Vermicast)*	2.40	2.42	2.41
Organic Pest Control (liters/ha)			
Oriental herbal nutrients (OHN)	2.01	2.03	2.02
Lactic acid bacteria serum (LABS)	1.58	1.43	1.51

**kg/ha*

The preparation of the various homemade organic inputs was all based on the standards provided by the NGOs and DA. The farmers followed the recommended materials and method of preparation needed. IMO application per hectare before and after land preparation utilized an average of 11 liters. This was done by spraying the IMO mixture at 8 tbsp/liter concentrate two times before plowing and the same amount re-sprayed after leveling as recommended by the Agricultural Trainings Institute (ATI) and DA. IMO was applied every 7 to 10 days on newly planted seedlings until maturity for rice at the rate of 2 tbsp/liter. On average, more than 2 liters each of FPJ, FFJ, FAA, and 2 kgs of Vermicast per hectare were applied for fertilization. FPJ and FFJ at a rate of 2 tbsp/liter per hectare were sprayed early in the morning (4:00 am-6:00 am) or in the afternoon (5:00 pm until sunset), for the microorganisms are active during this time period. FAA was sprayed seven days after transplanting up to the panicle initiation stage at the rate of 2 tbsp/liter. On average, 2 liters of OHN for pest control and more than 1 liter of LABS for pathogenic bacteria control were applied per hectare. OHN mixture of 2 tbsp/liter was sprayed on the leaves or soil at both ends of the day when microorganisms are most active. The application was dependent on the degree of pest infestation; however, it is recommended by the DA and NGO to apply twice a week if the field is in critical condition. For LABS, 2tbsp/gal of water is sprayed to plant leaves to fortify phyllo-sphere microbes to prevent harmful bacteria.

Technical Efficiency of the Organic Sample Rice Farm

Table 3 presents the distribution of technical efficiency indices of irrigated organic (uncertified) rice farms during dry and wet cropping seasons. The average level of technical efficiency is more than 92 percent for the dry cropping season, a little bit higher than the wet cropping season (90%). As compared to the conventional practices findings of Rola *et al.* (1993), Koirala *et al.* (2014), and Cañete and Temanel (2017), the said results are comparatively higher. The national irrigated rice farm findings of Rola *et al.* (1993) resulted in an average of 72 percent efficiency. The Metro Manila and Laguna rainfed rice farm findings of Koirala *et al.* (2014) showed an average of 54.8 percent efficiency. And the High Yielding Municipalities, Medium Yielding Municipalities, and Low Yielding Municipalities under irrigated and rainfed farms in Isabela, findings of Cañete and Temanel (2017) revealed an average technical efficiency of 87 percent, 79 percent, and 76 percent, respectively, for the irrigated rice farms, while 80 percent, 73 percent, and 72 percent for rainfed rice farm ecosystem. This shows that the organic rice farming system is less technically inefficient than the conventional way.

Table 3. Distribution of organic rice farms by the level of technical efficiency of the farmer-respondents in selected areas in Leyte, 2013.

Technical Efficiency Index	**Dry Season**		**Wet Season**	
	No.	**%**	**No.**	**%**
Below 0.70	2	1.82	2	1.82
0.71 – 0.80	6	5.45	20	20.00
0.81 – 0.90	9	8.18	17	15.45
Above 0.90	93	84.55	69	62.73
Total	110	100.00	110	100.00
Mean*	0.925		0.898	
Standard Deviation	0.122		0.137	
Coefficient of variation	13.23%		15.26%	
Range	0.1948 - 0.9973		0.1804 - 0.9969	

**The difference between dry and wet cropping season values is significant at α =0.01.*

The organic farmer-respondents are more efficient during the dry season and still have the potential to increase their efficiency up to 8 to 10 percent. Achieving the full potential leads to some additional output. The absolute level of variability in technical efficiency among farmer-respondents is more than 12 percent for both cropping seasons. Relative variability of technical efficiency measured through the coefficient of variation is very low for both dry (13%) and wet (15%) cropping seasons.

Factors Affecting Technical Efficiency of Organic Rice Farms

This study's stochastic frontier model of organic (uncertified) rice was estimated using Maximum Likelihood Estimation (MLE). MLE represents the "best practice" and shows the inefficiency effects model (Table 4).

It can be observed from MLE results those variables such as organic farming experience, household education, training attended, affiliation with organic organizations, household income from other sources, technical services from DA, and homemade organic inputs had negative and significant coefficients. This means that farmers with higher organic farming experience, having better-educated household members, attending more training, and having income from other sources (that can be used for capitalization for rice farming) tend to be less technically inefficient, *ceteris paribus*. This shows that farmers gain more knowledge, not only through the classroom but also through trials and errors and experiences, thus enhancing their efficiency in organic rice farming, similar to the findings of Capuno (2003), Lingard *et al.* (1983), and Moock (1981).

Similarly, members of organic farming-related organizations and those who produce homemade organic inputs showed to be less technically inefficient. These imply that organizations help develop the farmers' skills to be efficient enough to apply the organic farming system. Farmers who produce homemade organic inputs can use them as frequently as recommended, thus may result in an efficient farming system.

Acquisition of technical services from DA also helped farmers become less technically inefficient. Although NGOs are noted to be aggressive in the coverage and influence of farmers on the organic farming system, DA personnel, on the other hand, might have provided more effective technical assistance to farmers.

In addition, the farther the distance of farms from suppliers of organic inputs had a significant positive influence on the level of technical inefficiency, *ceteris paribus*. This implies that farmers tend to be less technically inefficient if the source of organic inputs is nearer or more accessible. Sources of organic inputs acquired by the farmer-respondents are from DA, NGOs, agricultural suppliers, and middlemen in their area.

Table 4. Maximum Likelihood Estimates of the parameters of the stochastic frontier production function and technical inefficiency effects model of the organic sample rice farm in selected areas in Leyte, 2013.

Variable	Coefficient		Standard Error
Frontier Production Function			
Constant	8.4454	***	0.0436
Seeds	-0.0011		0.0069
IMO	0.0095	***	0.0007
FPJ	0.0051	***	0.0008
FFJ	0.0042	***	0.0005
OHN	0.0037	***	0.0007
FAA	0.0010	*	0.0005
LABS	0.0049	***	0.0009
Man labor	0.0231		0.0122
Machine use	-0.0002		0.0006
Variety (dummy)	0.0012		0.0046
Water management (dummy)	0.0439	***	0.0101
Season (dummy)	0.0166	*	0.0072
Inefficiency Effects Model			
Constant	0.9849	**	0.3984
Farming experience	-0.1178	***	0.0278
Education	-0.0459	***	0.0082
Training	-0.3026	***	0.0531
Distance to supplier	0.0581	**	0.0238
Household income from other sources	-0.0001	***	0.0000
Affiliation (dummy)	-0.3588	***	0.0880
Technical Services (dummy)	-0.1016	*	0.0585
Source of Organic Input	-0.9548	***	0.1498
Variance Parameters			
Sigma-squared	0.0740	***	0.0041
Gamma	0.9827	***	0.0072
Log-Likelihood	359.5090		

Note: ****, **, * Significant at α = 0.01, 0.05, and 0.10, respectively.*

The variance parameter (gamma) shows a higher and more significant value, implying that technical inefficiency effects are likely to be highly significant in the analysis of organic farm yields. In fact, all variables of the model are highly significant. In addition, technical efficiency was found to correlate with yield, implying that the more technically efficient farmers become, the higher the yield they obtain. Meanwhile, the productivity of organic rice farming was positively and significantly affected by the application of IMO, FPJ, FFJ, OHN, LABS, and the usage of water management to control weeds. This implies that an increase of 100 percent of either input increases the yield by almost 1 percent, as shown in the coefficients shown in Table 4. The coefficients in regression analysis describe the mathematical relationship between each independent variable and the dependent variable. The coefficient value signifies how much the mean of the dependent variable changes given a one-unit shift in the independent variable while holding other variables in the model constant. This property of holding the other variables constant is crucial because it allows you to assess the effect of each variable in isolation from the others. Thus, specifically looking at a 100 percent increase of IMO input increases the yield by 0.95 percent.

Production Function Analysis of Organic Sample Rice Farms

Table 4 shows the results of the stochastic frontier production function for organic (uncertified) rice farmer-respondents. Among the variables, the amount of organic weedicide and soil conditioner (IMO), organic fertilizer (FPJ and FFJ), organic pesticides (OHN and LABSO), and usage of water management to control weeds are highly significant variables that influenced the production level of farmer-respondents.

In addition, material input (FAA) and cropping season (dry) are significant at the 0.10 level. This implies that organic rice farms' productivity increases with more inputs, as stated earlier. Yield was also significantly higher during the dry season due to longer day length, higher solar radiation, and optimum temperature resulting in higher photosynthetic activity of the plants. Solar radiation is essential for photosynthetic activity. As such, the level of solar radiation affects the growth, development, and yield of rice plants. In fact, FAO (1995) stated that rice yields are closely correlated to solar radiation during the reproductive and ripening phases of the rice plants. Another reason for the decrease in income during the wet season is due to unlikely rotten grains even before harvesting, mainly caused by heavy rains.

4. CONCLUSION

This study focuses on the technical efficiency of farmer-adapters of organic (uncertified) rice-irrigated farming. The stochastic production frontier model's linear inefficiency effects model in analyzing the farmers' technical efficiency was employed. This study has shown that farmers' average level of technical efficiency is more than 92 percent for the dry season and 90 percent for the wet season, which is comparatively higher than the conventional practices findings of Rola et al. (1993), Koirala et al. (2014), and Cañete and Temanel (2017). The technical efficiency of organic rice farming is significantly affected by education, training attended, affiliation with organizations, technical services from DA, homemade source of organic inputs, and the shorter distance of supplier of organic inputs. Therefore, policies that will enable the farmers to improve their education, access to training related to organic rice farming, affiliation with organizations, technical services from DA, capacity to create organic inputs, and close access to organic inputs be vigorously pursued. They are important for increasing the farmers' efficiency.

Moreover, it is recommended that organic rice farmers should apply optimal levels of organic inputs (IMO, FPJ, FFJ, OHN, LABS) and continue water management to control weeds. This is in order to produce better quality rice products and maintain the good soil condition necessary for a sustainable farming livelihood. Also, the government is suggested to create program plans to construct subsidiary centers (store outlets) where material inputs and molasses are accessible to local farmers. This would also create business opportunities for skillful farmers to display their homemade organic inputs. In addition, it is recommended that the government should create a policy and assistantship for organic farmers in having their products certified at a cost-free program. This will help farmers have a justified price for their products and will also further motivate other farmers to convert to organic farming.

5. CONFLICT OF INTEREST

The author declares no conflict of interest.

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