EFFECT OF MANAGEMENT FACTOR ON STOCHASTIC FRONTIER PRODUCTION OF ORGANIC RICE FARMING IN INDONESIA

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ABSTRACT: *The main problem in this study is the effect of management factor on stochastic frontier production of organic rice farming that emphasized production efficiency. The aim of this research was to analyze the role of managerial ability of farmers in organic rice farming production. This study was conducted on 216 organic rice farmers as a sample during two planting seasons with purposive sampling method. The sample was consisted of two farmer groups, i.e. Pangudi Bogo and Pangudi Raharjo in Dlingo Village, Mojosongo District, Boyolali Regency, Central Java Province, Indonesia. This research used stochastic frontier production function approach with cross section data and estimated with maximum likelihood estimation. The result showed that average value of production efficiency is 0.5928 and the most dominant variable in determining the technical inefficiency of organic rice farming was variable of farming system management.*

KEYWORDS: Management, Organic rice farming, Production, Stochastic frontier, Indonesia

INTRODUCTION

Indonesian is a country with large population. Large population has implications on the provision of food, especially rice, because rice is a very important commodity as a staple food. Policy conducted by the Indonesia government in 1970s in efforts to meet the basic needs of food was through the green revolution. Green revolution is the process of more agricultural transformation from traditional to use of modern inputs together with the complementary technology [1]. The green revolution was initially able to bring Indonesia to be self-sufficient in rice in 1984. However, after 1984, it did not increase rice production significantly. In fact, the green revolution caused negative impacts on the environment, especially in soil fertility and soil’s ability to produce food with adequate quality and quantity [2]

There are three main impacts caused by human activities that among the environmental problems existing, i.e.: 1) effects of the use of production inputs on the production of agriculture and the environment; 2) effects of the farming system on the emission of greenhouse gases; 3) effects of industrial activities and urban expansion in agricultural land. The use of the means of production inputs in modern agriculture, such as fertilizer and chemical pesticides has big impacts on the degradation of environmental quality in agriculture. Modern agriculture which was rolled out as green revolution has strong correlation with the environmental issues [3].

Organic farming turns to be important because it indirectly might be alternative long-term solutions to the problem of rice production through natural recycling system to increase the productivity of the soil. Organic farming is sustainable agriculture. The sustainability framework for agriculture and food production consist of a trilogy of equally important and mutually interacting and reinforcing objectives for social, economic and environmental sustainability [4]. Organic farming is an option in agricultural production that enables Asian smallholders to attain household food

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security and modest income while regenerating the land, regaining biodiversity and supplying quality food to local communities. One of the basic principles of soil fertility development is through the management of organic matter. Management of organic matter is then applied in organic farming [5].

Organic rice farming system is a farming system that is environment-friendly. Food and Agriculture Organization (FAO) described that organic agriculture is designed to improve biological activity in the soil, maintain long-term soil fertility, promote the healthy use of the soil, water, and air as well as minimize all forms of pollution that may result from agricultural practices [6]. The advantage of organic rice farming apart from the better environment's health is the result produced. The rice produced becomes healthy food since it is free from residue of chemical fertilizers and pesticides. Organic agriculture provides agricultural products which are free from chemical substance residue in order to improve public health [7].

Organic farming system is agricultural business combining natural factors of production, labor, and capital. A balance between income and expenses is necessary in farming system. The fundamental problem in organic rice farming system is on the efficiency. Organic rice farming system is expected to be efficient so as the organic rice production can be increased to achieve the farmers' welfare. Therefore, it can be concluded that organic farming makes an important contribution to human health through the food produced, the health of economy through the income of farmers, and the health of the planet through its environment-friendly activities [2].

LITERATURE REVIEW

Studies on stochastic frontier

The study of economic efficiency was originally viewed on the Cobb-Douglas production function. Cobb-Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs. Sometimes the term has a more restricted meaning, requiring that the function display constant returns to scale [8] .

Cobb-Douglas production function was developed with stochastic frontier approach. This approach as it appears in the current literature was originally developed by [9]. Many varieties of the stochastic frontier model have appeared in the literature. A major survey that presents an extensive catalog of these formulations was initiated by [10]; [11]; [12]. After the Cobb-Douglas production function, there are only few research projects about the technical efficiency of organic rice farming with stochastic frontier production approach documented compared to conventional rice farming. Previous researchers analyzed technical efficiency with conventional rice farming such as done by [13-21] and with organic rice farming such as done by [22-26].

In rice research studies, both organic and conventional which are related to production cost (allocative efficiency) and profit (profit efficiency) that use the stochastic frontier approach are still very limited when compared to rice production (technical efficiency) with the stochastic frontier approach. Several previous organic and conventional rice farming researchers with stochastic frontier production cost function approach such as those done by [27-31]. Several previous organic and conventional rice farming researchers with stochastic frontier profit function approach such as those done by [32-37].

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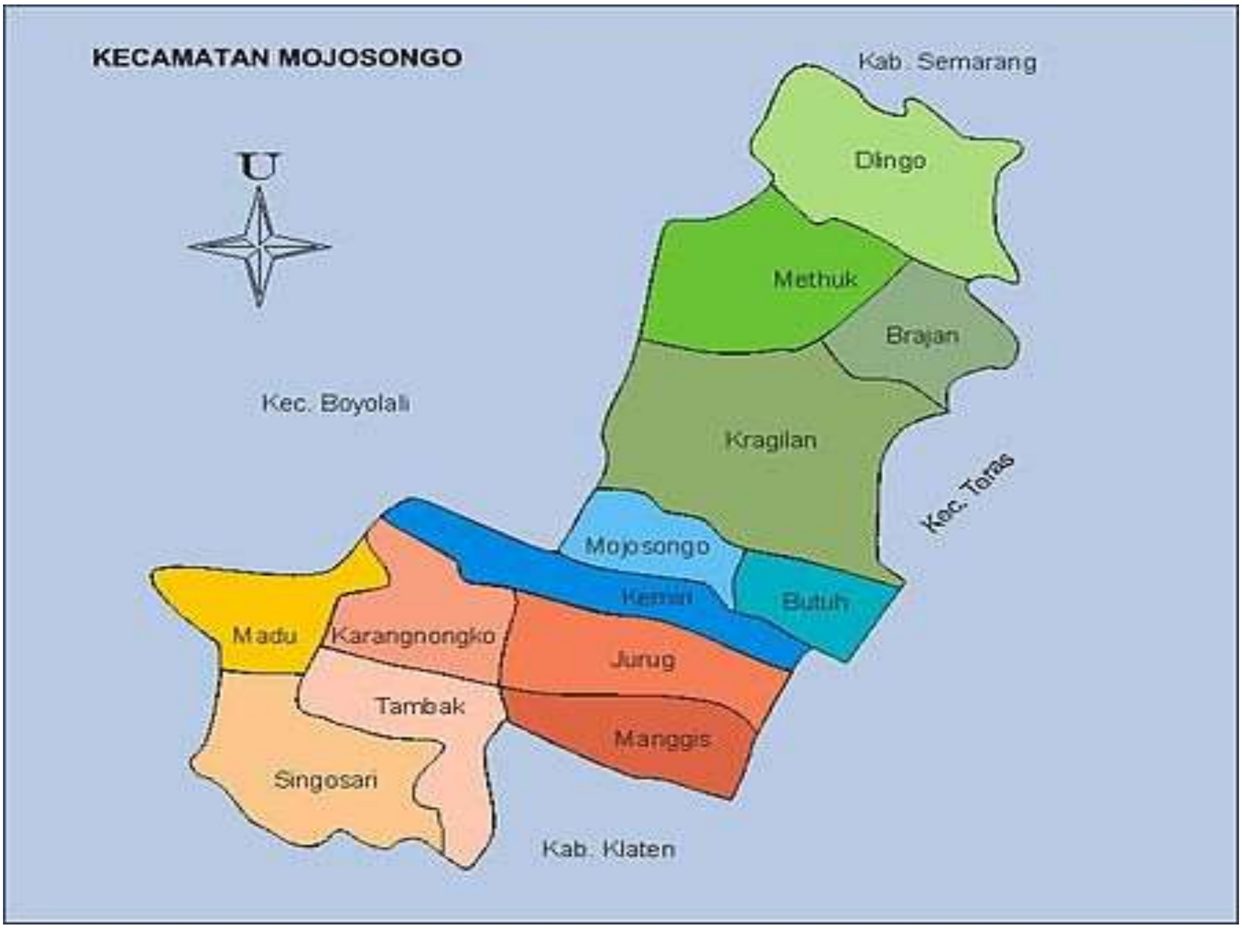

Figure 1. Map of Boyolali Regency with Mojosongo District indicated

THEORETICAL FRAMEWORK

The concept approach that used in this research is the approach to the concept of efficiency proposed by [38]; [39] mentioning that efficiency is classified into three classes namely technical efficiency, allocative efficiency, and economic efficiency. However, this research was limited to technical efficiency. Technical efficiency shows the ability of farming system to obtain maximum output from certain number of inputs. This suggests that the efficiency of production is a relative measure of farmers' ability in using inputs to produce certain number of output at certain level of technology.

Production function is a functional relationship which shows the number of maximum inputs that can be produced by using two inputs or more [40]. If so, then a production function theoretically must show the number of the most possible output produced from certain number or combination of inputs. In other words, production function describes the outermost production levels that can be produced by the use of certain inputs called frontier. Frontier function of production is a production function which illustrates the maximum output that can be achieved from any level of input use. If a farming system is at a point in frontier function of production, it means that the farming system is technically efficient [41]. To analyze the effects of institutional and managerial ability of farmers in organic rice farming system on the production of organic rice, stochastic frontier of production approach is used.

Stochastic frontier function is an extension of the original deterministic models to measure the unpredictable effects (stochastic frontier) in the production limits [9]; [13]; [41]; [42]. In his

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production function, random error (v_i) is added into non-negative random variable (u_i), as stated in the following equation:

$$Y = \alpha_0 + \alpha_i X_i + \ldots + \alpha_k X_k + (v_i - u_i),\ i = 1,\ldots,N \qquad (1)$$

where:

Y = organic rice production in natural logarithm (ln)
X_i = number of inputs used in production process in natural logarithm (ln)
α_0 = constant
α_{i-k} = estimated parameter
v_i = error factors caused by factors beyond the farmers' control
u_i = error factors caused by factors under the farmers' control

Random error (vi) is useful to calculate the size of errors and other random factors such as weather, and others together with the effects of the combination of input variables that are undefined in the production function. Random error (vi) variables are independent random variables and normally distributed (independent identically-distributed) with zero mean and constant varians. u_i variable is assumed as i exponential or half-normal random variables u_i variable serves to capture the effects of technical inefficiency.

DATA AND METHODOLOGY

Determination of research site

The study was conducted in Dlingo Village, Mojosongo District, Boyolali Regency, Central Java Province, Indonesia (Figure 1). Boyolali Regency was chosen as a research area because there are still many farmers who do organic rice farming. The reasons for the study were conducted in the area were: (i) both groups are located in the same area, (ii) they have the same water source from soil water irrigation, (iii) they are separated from other farmer' groups, and (iv) they can carry out three planting seasons in a year.

Sample of farmers

Total population of organic rice farmers with ICS (Internal Control System) and National certified in seven villages (Catur, Jatisari, Dlingo, Metuk, Andong, Wates, and Glonggong) and five districts (Andong, Simo, Mojosongo, Sambi, and Nagasari) in Boyolali Regency as many as 521 people. From the population of the farmers, the sample (organic rice farmer with national certified) was taken by the purposive sampling method as many as 216 people.

Data analysis

In this research, data was analyzed with stochastic frontier production function (with cross section data) and then was estimated with Maximum Likelihood Estimation (MLE). MLE requires a particular assumption about the distribution of disturbance. There is a large class of disturbance distributions which may be specified which make the maximum likelihood frontier estimator regular and well behaved. The estimation of production function has been one of the more popular areas of applied econometrics [10]. Recent work in duality theory which has linked production and cost functions has made this topic even more attractive. Stochastic frontier production function is an original deterministic model to measure the unpredictable effects (stochastic frontier) in the production limits. Stochastic frontier production function is formulated as follows:

$$Y = \alpha_0 + \alpha_i X_i + \ldots + \alpha_k X_k + (v_i - u_i),\ i = 1,\ldots,N \qquad (2)$$

where:

Y = organic rice production in natural logarithm (ln)
X_i = number of inputs used in production process in natural logarithm (ln)
α_0 = constant
α_{i-k} = estimated parameter
v_i = error factors caused by factors beyond the farmers' control
u_i = error factors caused by factors under the farmers' control

Stochastic frontier production function was assumed to have the form of Cobb-Douglas production function that transformed into natural logarithm (ln) by including the effects of determinant factors of the level of technical inefficiency, so that stochastic frontier production function can be written as follows:

$$\ln Y = \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + \alpha_8 \ln X_8 + \alpha_9 \ln X_9 + \alpha_{10} D_1 + \alpha_{11} D_2 + \alpha_{12} D_3 + (v_i - u_i) \quad (3)$$

where:
Y = number of grain production of organic rice (kg/ha/planting season)
X_1 = area of land used by farmers (ha/planting season)
X_2 = number of organic rice seeds (kg/ha/planting season)
X_3 = amount of solid organic fertilizer (kg/ha/planting season)
X_4 = amount of liquid organic fertilizer (ltr/ha/planting season)
X_5 = amount of liquid organic pesticide (ltr/ha/planting season)
X_6 = amount of solid organic pesticide (kg/ha/planting season)
X_7 = wage of non-family labors (IDR/man days/planting season)
X_8 = wage of family labors (IDR/man days/planting season)
X_9 = tractor's rental fee (IDR/ha/planting season)
D_1 = dummy 1 (D_1 = 1; *mentik wangi* cultivar; D_1 = 0, other cultivars)
D_2 = dummy 2 (D_2 = 1; IR64 cultivar; D_2 = 0, other cultivars)
D_3 = dummy 3 (D_3 = 1; *pandan wangi* cultivar; D_3 = 0, other cultivars)
α_0 = constant
$\alpha_{1,..,12}$ = coefficient of regression on production factors
v_i = errors caused by factors beyond the farmers' control
u_i = errors caused by factors under the farmers' control

The effect of the factors determining the level of production inefficiency on organic rice farming system in Boyolali can be formulated as follows:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} \quad (4)$$

where:
U_i = production inefficiency
Z_1 = the farmer's age (years old)
Z_2 = formal education level of the farmer (years)
Z_3 = period of organic rice farming system (years)
Z_4 = number of family members (person)
Z_5 = frequency of participation in extension (times)
Z_6 = frequency of participation in training (times)
Z_7 = coaching or courses about organic rice farming (score)
Z_8 = the role of farmers groups and counselors (score)
Z_9 = the role of institutions (score)
Z_{10} = farming system management (score)
δ_0 = constant
$\delta_{1,..,10}$ = coefficient of regression on determinant factors of technical inefficiency

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Hypothesis

Testing a hypothesis on the variables that influence the production inefficiency can be formulated as follows:

$H_0: \delta_i = 0$: If $t_{count} < t_{table}$, then H_0 was accepted (H_1 rejected). It means that the variables did not influence the production inefficiency of organic rice farming in Boyolali, Central Java, Indonesia.

$H_1: \delta_i \neq 0$: If $t_{count} > t_{table}$, then H_0 was rejected (H_1 accepted). It means that the variables influenced the production inefficiency of organic rice farming in Boyolali, Central Java, Indonesia.

RESULTS AND DISCUSSION

The influence factors on stochastic frontier production function

From the result of the research, the production of organic rice is determined by the use of the inputs such as land area, seeds, organic fertilizer (solid and liquid), organic pesticide (solid and liquid), labor (family and non-family), tractor's rental fee, and cultivars used. Analysis of production function describes the relationship between production and inputs where in this research stochastic frontier Cobb-Douglas function of production was used. Estimation was done using MLE. The result of stochastic frontier function of production estimated using nine explanatory variables can be seen in the Table 1 below:

Table 1: Estimation result of variables in stochastic frontier production function

Variable	Parameter	Coefficient of regression	Standard error	t-ratio
Constant	α_0	152.3626	0.8001	9.276
Land area	α_1	0.0011*	0.0676	1.673
Number of organic rice seeds	α_2	-0.0897^{NS}	0.0738	-1.215
Amount of solid organic fertilizer	α_3	-0.0511^{NS}	0.0365	-1.400
Amount of liquid organic fertilizer	α_4	0.0132*	0.0081	1.691
Amount liquid organic pesticide	α_5	0.0010^{NS}	0.0085	0.121
Amount solid organic pesticide	α_6	-0.0489***	0.0104	-4.685
Wage of non-family labors	α_7	0.0115***	0.0031	3.703
Wage of family labors	α_8	0.0375***	0.0053	7.043
Tractor's rental fee	α_9	0.1486***	0.0690	2.153
Dummy 1	α_{10}	0.0424***	0.0069	6.125
Dummy 2	α_{11}	0.0709^{NS}	0.0560	1.267
Dummy 3	α_{12}	-0.0508***	0.0688	1.227
Sigma-square		0.6088	0.1929	3.156
Gamma		0.9877	0.0088	112.678
Log likelihood function		467.5480		
LR test of the one-sided error		152.3626		
Mean efficiency		0.5928		
Number of observations		216		

Source: Analysis of Primary Data 2016
Note:
*** = significant at α=1% t-table 1% = 2,358
** = significant at α=5% t-table 5% = 1,980
* = significant at α=10% t-table 10% = 1,658
NS = non significant at α=10%

From nine variables suspected to affect the production of organic rice, variables that influenced the production significantly were land area, liquid organic fertilizer, solid organic pesticides, labor from family members, tractor's rental fee, and the cultivars used. While variables were including seeds number, solid organic fertilizer and liquid organic pesticides were not statistically significant.

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Variables influencing positively, namely land area, liquid organic fertilizer, non-family labor, labor from family members, and tractor's rental fee illustrated that if those variables are increased at a certain level, they can increase the production of organic rice. While variables influencing negatively (solid organic pesticides) showed their over use by farmers so it is necessary to reduce the use.

From Table 1 can be seen that the value of the log likelihood function with MLE method is 467.5480 much greater than the value of the log likelihood function with Ordinary Least Squares (OLS) is 188.7961. It indicates that the function of the organic rice production by using MLE method was better and in accordance with field conditions. Sigma-square value is 0.6088 which shows the distribution of the inefficiency error term (u_i) and the value is very small so as to be normally distributed. The suspected factors that affect technical inefficiency were farmers' age, formal education level of farmers, organic rice farming period, number of farmers' family members, frequency of participation in extension, frequency of participation in training, counseling, or course about organic rice farming system, the role of farmers' group and counselors, the role of institutional, and management of farming system on organic rice farming.

In Table 1 was showed that gamma value (γ) is 0.9877. It ilustrates that the error term was derived only from the result of inefficiency (u_i) and not from random error (v_i) or factors that can not be controlled by the farmer ($\gamma = 1$ means the frontier model was perfect without any fault). Statistically, the estimated value of γ was significant in the model (112.678). It suggests that the differences in the Cobb-Douglas function of production were able to properly explain the existing data about the occurrence of the phenomenon of technical inefficiency in the rice farming. The results of the calculation of Likelihood Ratio (LR) was 152.3626 which value was greater than the critical value from table of [43] at a significant level of 1%. It means that there were stochastic inefficiency effects in the models. This fact identified that the rice farmers were not totally efficient yet in carrying out their farming system.

If $\sigma_u^2 = 0$, it means that all farming system done by the farmers were 100% efficient. It turned out that based on data analysis, the value of variant > 0. Therefore, it can be concluded that there was no evidence that not all farming systems done by the farmers were 100% efficient, where the value of σ^2 was 0.6088 and statistically significant at $\alpha = 1\%$. It shows that the variation of the production contributed by technical efficiency (sigma-square) was 60.88%.

The causing factors on stochastic frontier production inefficiency

The variables of farmers age, organic rice farming period, the number of family members, and training/ courses about organic rice farming statistically explained no significant effects on technical inefficiency of organic rice farming at $\alpha = 10\%$. Determinant factors of technical inefficiency of organic rice farming system (formal education level of farmers, the frequency of participation in extension, the frequency of participation in training, the role of farmers' groups and counselors, the role of institutional, and farming system management) had a negative coefficient. It suggests that the higher the value of these variables, then the inefficiency will decrease.

From the most influence variables toward technical inefficiency of organic farming, variable of farming system management was the most dominant variable in determining the technical inefficiency of organic rice farming with coefficient value of -0.4527, which means the higher the value of farm management, the technical inefficiency of organic rice farming will further go down. The second biggest variable was the variable of frequency of participation in training with coefficient of -0.1734, which means the more frequent the farmers join training, the technical

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inefficiency of organic rice farming will further go down. The third biggest factor in reducing technical inefficiency of organic rice farming was the role of institutional with coefficient of -0.1651, which means the greater the role of institutional, the technical inefficiency of organic rice farming will further go down. Furthermore, the role of farmers' groups and counselors, farmers' level of formal education and participation frequency in extension had a coefficient of -0.0995; -0.0451; and -0.0231, respectively, which means the greater the value of the variables will decrease the technical inefficiency of organic rice farming. It can be seen on Table 2 below:

Table 2: Estimation result of factors causing production efficiency on organic rice farming

Variable	Parameter	Coefficient of Regression	Standard Error	t-count
Constant	Z_0	-5.0529	0.0289	-1.760
Farmers age	Z_1	0.0099^{NS}	0.0105	0.939
Formal education level of farmers	Z_2	-0.0451^{*}	0.0281	-1.697
Organic rice farming period	Z_3	-0.0726^{NS}	0.0477	-1.623
Number of farmers' family members	Z_4	-0.0935^{NS}	0.0760	-1.231
Frequency of participation in extension	Z_5	-0.0231^{***}	0.0044	-5.275
Frequency of participation in training	Z_6	-0.1734^{***}	0.0592	-2.930
Counseling/ course about organic farming	Z_7	-0.0359^{NS}	0.0425	-0.845
The role of farmers; groups and counselors	Z_8	-0.0995^{**}	0.0536	-1.856
The role of institutional	Z_9	-0.1651^{***}	0.0531	-3.107
Farming system management	Z_{10}	-0.4527^{***}	0.1461	-3.098

Source: Analysis of Primary Data 2016
Note:

***	=	significant at α=1%	t-table 1%	= 2,358
**	=	significant at α=5%	t-table 5%	= 1,980
*	=	significant at α=10%	t-table 10%	= 1,658
NS	=	non significant at α=10%		

The results of the research showed that the farmers were not capable yet to be technically efficient in carrying out organic rice farming system. The use of the production factors could not be combined well resulting in inefficiency. It was indicated by the average value of inefficiency which was reaching 0.5928 or 59.28% (Table 1). Thus, the farmers technically were not able to combine the actual inputs to produce maximum output efficiently. Therefore, to get the efficient organic rice farming system, it is necessary to increase the value of the variable of formal education level of farmers, the frequency of participation in extension, the frequency of participation in training, the role of farmers' groups and counselors, the role of institutional, and farming system management.

In terms of management of the farm, to reduce inefficiencies in organic rice production, it is necessary to implement good management of farming, such as: the use of good quality cultivars, the use of qualified and labeled seeds, good practice of tillage, good maintenance, good cropping system, application of organic fertilizer as soil requirement, irrigation (irrigating) rice crop done effectively and efficiently in accordance with the soil conditions (intermittent irrigation), pest and disease control in an integrated manner and eco-friendly, weeds control carried out regularly, and the good handling process of harvesting and post-harvest.

CONCLUSION

Organic farming is important because it can indirectly be a long-term alternative solution to the problem of rice production through natural recycling systems to increase soil productivity and environmental health. Organic rice farming system is expected to be efficient so as the organic rice production can be increased to achieve the farmers' welfare.

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The average value of production efficiency of organic rice farming is 0.5928 or 59.28%. It indicated that the farmers technically were not able to combine the actual inputs to produce maximum output efficiently. Variable of farming system management was a variable that most high influence on the technical inefficiency of organic rice farming. Implementation of farming system management will increase the productivity of organic rice farming and make the farmers and the society prosperous.

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