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PREFACE: the 1st ICoN-BEAT 2019

On behalf of the organizing committee of the 1st International Conference on Bioenergy and Enviromentally Sustainable Agriculture Technology (ICoN-BEAT 2019) and conjunction with the 2nd Congress Indonesian Agriculture Private University Association (APTSIPI - *Asosiasi Perguruan Tinggi Swasta Ilmu Pertanian Indonesia*). It is an honor and delight to welcome all participants to this conference which be held at the Campus III, University of Muhammadiyah Malang (UMM), Indonesia on November 7th to 8th, 2019. The conference theme is "Bioenergy and Environmentally Sustainable Agriculture Technologies: Toward Food, Energy and Water Sovereignty".

This conference has been organized by Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang. Two main topics have been discussed, i.e. bioenergy and other renewable energy, and environmentally sustainable agriculture. We are perceived confidently that this conference will provide positive influence and contribute to develop the academic field.

Supporting two main topics, the 1st ICoN - BEAT invited five experts in the fields of energy, environment and agriculture from Indonesia, Malaysia, and Thailand. The speakers are Mr. Arfie Thahar (Research and Development Division of the Indonesian Palm Oil Plantation Fund Management Agency, Jakarta), Assoc. Prof. Dr. Maizirwan Mel (Department of Biotecnology Engineering, International Islam University, Malaysia), Asst. Prof. Dr. Khwunta Khwamee (Department of Earth Science, Faculty of Natural Resources, Price of Songkla University, Thailand), Mr. Paulus Tjakrawan (Executive Chairman of the Indonesian Biofuel Entrepreneurs Association, Jakarta), and Assoc. Prof. Dr. Tatang Hernas Soerawidjaja (Chairman of the Indonesian Bioenergy Association, Indonesian Research Council Commission, and Department of Chemical Engineering - Bandung Institute of Technology).

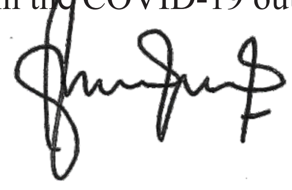
A pride because the number of participants who already send the paper about 116 presenters. After a rigorous selection process, the Scientific & Editorial Board of the 1st ICoN - BEAT 2019 decided to publish 51 papers in E3S Web of Conferences, an open-access proceedings in environment, energy and earth sciences, managed by EDP Sciences, Paris, France and indexed on Scopus, Scimago, Conference Proceedings Citation Index-Science (CPCI-S) of Clarivate Analytics's Web of Science, and DOAJ (Directory of Open Access Journals).

The Proceeding of the 1st ICoN - BEAT 2019, consists of 51 selected papers, amount 38 papers were the results of joint research by Indonesian and overseas scholars. In the collaboration research, 71 institutions were involved 20 of which were from abroad Indonesia. The overseas institutions are from: Australia, Austria, Czech, Estonia, Eswani, Georgia, Germany, India, Japan, Latvia, Lithuania, Madagascar, Malaysia, the Netherlands, P.R. China, Sweden, Taiwan - ROC, Thailand, the United Kingdom, and Uzbekistan. Each of the papers submitted in E3S Web of Conferences was reviewed by at least two experts using the double-blind system. The published papers have passed all necessary improvement requirements in accordance to the Web of Conferences standard, reviewer's comments, SI (*Système International d'Unités*), similarity tests by Turnitin program (with the highest threshold of 20 %), 90 % of references must be at least dated from 15 years, and reflected on Google, as well as editing procedure by professional editors from four countries (Estonia, Indonesia, Lithuania, and Malaysia).

Last but not least, I personally would like to thank you the official committees, organizing partners, and scientific & editorial board. Special thanks as well to our co-host partners: i) APTSIPI, ii) ILUNET (*Ikatan Alumni Energi Terbarukan*) University of Darma Persada, Jakarta, iii) Konsorsium Bioteknologi Indonesia, iv) Merdeka University of Madiun, v) University of Veteran Bangun Nusantara, Sukoharjo, vi) C- BIORE (Center of Biomass and Renewable Energy), vii) ITENAS (*Institut Teknologi Nasional*), viii) ILCAN (Indonesian Life Cycle Assessment Network), ix) *Rumah Paper Kita* as editing and proofreading services for supporting the 1st ICoN - BEAT 2019.

Finally, I would like to express my gratitude feeling for your participations, and please prepare yourself to gain the treasure of knowledge from the passionate experts. Then share the valuable enlightenment for a better future. It is my pleasure to see many of you in the 1st ICoN - BEAT 2019, and see you again in the 2nd ICoN - BEAT 2021.
Stay safe and stay healthy in COVID-19 pandemic.

With warmest regards
Malang - Indonesia, Dec 12, 2020
in the COVID-19 outbreak



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The 1st International Conference on Bioenergy and Environmentally Sustainable Agriculture Technology (ICoN BEAT 2019)
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R. Hendroko Setyobudi, A. Winaya, J. Burlakovs, M. Mel and O. Anne (Eds.)

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Determinants of Technical In-efficiencies in Swamp Rice Farming - Ciamis District, Indonesia

Agus Yuniawan Isyanto*, *Sudrajat* Sudrajat, and *Muhamad* Nurdin Yusuf

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Jl. R.E. Martadinata No.150, Ciamis 46274, Indonesia

Abstract. Rice farming in swamps, a marginal land, has a relatively high risk related to the level of technical efficiency. This research was conducted with the aim of identifying the level of technical efficiency and the influence factors of technical inefficiency in Lakbok Subdistrict, Ciamis District, Indonesia. Simple random sampling was used with a sample size of 41 farmers. The analysis was carried out using a stochastic frontier function. The results showed that the average level of technical efficiency was 0.78. Education and family size have a significant effect on technical inefficiency.

Keywords: Farmer, marginal land, stochastic frontier

1 Introduction

Swamp rice grows in marginal land that has a relatively high risk related to the level of technical efficiency [1]. This farming is carried out in the dry season where water needs depend on rainfall [2]. Swamp rice farming usually faces serious challenges during the rainy season [3].

The main problem in the management of swamp rice farming is the occurrence of floods that inhibit plant growth and production. Farmers in swamp rice often have difficulty in predicting flood levels, so they face the risk of flooded rice plants in the vegetative growth phase [4]. Weather and climate have a direct influence on agricultural production so that weather fluctuations and climate variability play an important role in growth and yields [5].

The crucial problem of rice farming in Indonesia is the low efficiency and productivity thus the production is uncompetitive compared to other rices. Increased rice production can be done through existing technology [6]. Technical efficiency compares the level of output in relation to the level of input used [7].

Lack of skilled farmers in managing the system properly causes inefficient agricultural management leads to reduced yields and increased waste [8]. The low yield is due to several factors including agro-climatological problems and high input costs [9]. Constraints in increasing crop yields can be related to inefficient agricultural management even though inputs are used intensively [10].

The ability to allocate factors of production will affect production and the level of efficiency. The non optimal production indicates the existence of technical inefficiencies [11].

This research was conducted with the aim of identifying the level of technical efficiency and the factors that influence technical inefficiency in swamp rice farming in Lakbok Subdistrict, Ciamis District, Indonesia.

* Corresponding author: gusyun69@gmail.com

2 Methods

The research was conducted in Lakbok Subdistrict, the only sub district that has swamp lanswampland farming. The research was carried out for 3 mo in planting the first season.

The sample size was 41 farmers using simple random sampling. The study utilized stochastic production frontier which builds hypothesized efficiency determinants into the inefficiency error components. The model is defined by Equation (1):

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + vi - ui \quad (1)$$

Where:
Y = output (kg)
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X5 = labor (man-day)
β = coefficient of regression
vi = random error
ui = technical inefficiency effects in the model.

Technical efficiency (TE) effects model developed by Battese and Coelli was employed in this study. In this model a Cobb-Douglas production function and some exogenous factors influencing technical efficiency are determined simultaneously.

Technical efficiency in the context of production relates to the level at which a farmer produces maximum feasible output from a given set of inputs (output-oriented measure), or uses a minimum level of input feasible to produce a certain level of output (a size-oriented input) [12].

Inefficiency model was defined to estimate the influence of some farmer's socio-economic variables on the technical efficiency of the farmers. Technical inefficiency effects are assumed to be distributed independently [13, 14]. The model was defined by Equation (2):

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Where:
μi = technical inefficiency
Z1 = age (years)
Z2 = education (years)
Z3 = experience (years)
Z4 = family size (persons)
δ = regression coefficient.

3 Results and discussion

3.1 Technical efficiency

The level of technical efficiency achieved by rice farmers in swamps ranged from 0.53 to 1.00 with an average of 0.778 as presented in Table 1.

Table 1. Frequency distribution of technical efficiency

Technical Efficiency	Frequency	Percentage
0.51 to 0.60	5	12.20
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0.71 to 0.80	9	21.95
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0.91 to 1.00	10	24.39
minimum = 0.53; maximum = 1.00; mean = 0.78		

Table 1 showed that the average level of technical efficiency achieved was 0.78, which indicates that swamp rice farming was technically efficient. This efficiency index value implied a technical inefficiency gap of 0.22 which indicates that 22 % of higher production can be achieved by farmers without using additional resources, or the use of inputs can be reduced to achieve the same level of output. The technical efficiency will be considered as efficient if it reaches an efficiency index value of more than 0.70 [15]. The difference in the level of technical efficiency achieved by farmers shows the degree of differentiation in the application of technology [16].

3.2 The stochastic frontier production functions analysis

Analysis of factors affecting production and technical inefficiencies was carried out using the stochastic frontier production function as presented in Table 2.

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Variable	Coefficient	Standard Error	t-ratio
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Log likelihood function	18.2348		
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*significant at 1 % (p > 0.01)

The estimated value of the gamma parameter (γ) of 0.999 9 is statistically different from zero. This indicated that 99.99 % of the variation in the level of output in swamp rice farming is caused by technical inefficiencies in the use of inputs. The model used in this

study is a linear log equation hence the value of each regression coefficient shows the production elasticity of each input. The sum of all regression coefficients is more than one (1.13) which indicates increasing returns to scale.

Table 2 showed only the labor force that has a positive and significant effect on production in swamp rice farming. The results of this study were in line with the other research [1, 17].

3.3 Technical inefficiency

Table 2 showed that education has a positive and significant effect on technical inefficiencies, which shows that improving education will reduce technical efficiency. Family size has a negative and significant effect on technical inefficiency which indicates that increasing family size will increase technical efficiency. The results of this study are in line with the results of another research [18].

Age has a negative but not significant effect on the level of technical inefficiency which indicates that the older the farmer, the more technically efficient. The results of this study are consistent with other findings [19].

Education has a positive and significant effect on technical inefficiency which shows that the more educated farmers, the lower the technical efficiency. The results of this study are in line with other findings [20].

The experience of farmers in swamp rice farming has a negative but not significant effect on the level of technical inefficiency. This shows that the more experienced farmers in carrying out swamp rice farming will increase their technical efficiency. The results of this study are consistent with other findings [21].

Family size has a negative but not significant effect on the level of technical inefficiency. This shows that the more family size will increase the technical efficiency. More family size means more workers are available to carry out rice farming activities in swamps in a timely manner thus the production process becomes more efficient [6]. Farmers who have large family sizes tend to try their best to get higher yields to meet the needs of their families. In addition, large family sizes have the workforce needed to implement agricultural management decisions [22].

4 Conclusion

The level of technical efficiency of swamp rice farming ranged from 0.53 to 1.00 with an average of 0.778 which indicated that swamp rice farming has reached a level of technical efficiency. Labor has a significant effect on production, while seeds, organic fertilizers, chemical fertilizers and pesticides have no significant effect. Education and family size have a significant effect on technical inefficiency, while age and experience have no significant effect.

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3 Results and discussion

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References

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UNIVERSITAS MUHAMMADIYAH MALANG

PREFACE: the 1st ICoN-BEAT 2019

On behalf of the organizing committee of the 1st International Conference on Bioenergy and Enviromentally Sustainable Agriculture Technology (ICoN-BEAT 2019) and conjunction with the 2nd Congress Indonesian Agriculture Private University Association (APTSIPI - *Asosiasi Perguruan Tinggi Swasta Ilmu Pertanian Indonesia*). It is an honor and delight to welcome all participants to this conference which be held at the Campus III, University of Muhammadiyah Malang (UMM), Indonesia on November 7th to 8th, 2019. The conference theme is "Bioenergy and Environmentally Sustainable Agriculture Technologies: Toward Food, Energy and Water Sovereignty".

This conference has been organized by Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang. Two main topics have been discussed, i.e. bioenergy and other renewable energy, and environmentally sustainable agriculture. We are perceived confidently that this conference will provide positive influence and contribute to develop the academic field.

Supporting two main topics, the 1st ICoN - BEAT invited five experts in the fields of energy, environment and agriculture from Indonesia, Malaysia, and Thailand. The speakers are Mr. Arfie Thahar (Research and Development Division of the Indonesian Palm Oil Plantation Fund Management Agency, Jakarta), Assoc. Prof. Dr. Maizirwan Mel (Department of Biotecnology Engineering, International Islam University, Malaysia), Asst. Prof. Dr. Khwunta Khwamee (Department of Earth Science, Faculty of Natural Resources, Price of Songkla University, Thailand), Mr. Paulus Tjakrawan (Executive Chairman of the Indonesian Biofuel Entrepreneurs Association, Jakarta), and Assoc. Prof. Dr. Tatang Hernas Soerawidjaja (Chairman of the Indonesian Bioenergy Association, Indonesian Research Council Commission, and Department of Chemical Engineering - Bandung Institute of Technology).

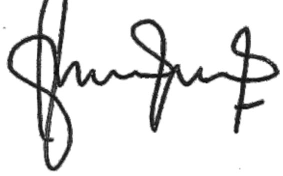
A pride because the number of participants who already send the paper about 116 presenters. After a rigorous selection process, the Scientific & Editorial Board of the 1st ICoN - BEAT 2019 decided to publish 51 papers in E3S Web of Conferences, an open-access proceedings in environment, energy and earth sciences, managed by EDP Sciences, Paris, France and indexed on Scopus, Scimago, Conference Proceedings Citation Index-Science (CPCI-S) of Clarivate Analytics's Web of Science, and DOAJ (Directory of Open Access Journals).

The Proceeding of the 1st ICoN - BEAT 2019, consists of 51 selected papers, amount 38 papers were the results of joint research by Indonesian and overseas scholars. In the collaboration research, 71 institutions were involved 20 of which were from abroad Indonesia. The overseas institutions are from: Australia, Austria, Czech, Estonia, Eswani, Georgia, Germany, India, Japan, Latvia, Lithuania, Madagascar, Malaysia, the Netherlands, P.R. China, Sweden, Taiwan - ROC, Thailand, the United Kingdom, and Uzbekistan. Each of the papers submitted in E3S Web of Conferences was reviewed by at least two experts using the double-blind system. The published papers have passed all necessary improvement requirements in accordance to the Web of Conferences standard, reviewer's comments, SI (*Système International d'Unités*), similarity tests by Turnitin program (with the highest threshold of 20 %), 90 % of references must be at least dated from 15 years, and reflected on Google, as well as editing procedure by professional editors from four countries (Estonia, Indonesia, Lithuania, and Malaysia).

Last but not least, I personally would like to thank you the official committees, organizing partners, and scientific & editorial board. Special thanks as well to our co-host partners: i) APTSIPI, ii) ILUNET (*Ikatan Alumni Energi Terbarukan*) University of Darma Persada, Jakarta, iii) Konsorsium Bioteknologi Indonesia, iv) Merdeka University of Madiun, v) University of Veteran Bangun Nusantara, Sukoharjo, vi) C- BIORE (Center of Biomass and Renewable Energy), vii) ITENAS (*Institut Teknologi Nasional*), viii) ILCAN (Indonesian Life Cycle Assessment Network), ix) *Rumah Paper Kita* as editing and proofreading services for supporting the 1st ICoN - BEAT 2019.

Finally, I would like to express my gratitude feeling for your participations, and please prepare yourself to gain the treasure of knowledge from the passionate experts. Then share the valuable enlightenment for a better future. It is my pleasure to see many of you in the 1st ICoN - BEAT 2019, and see you again in the 2nd ICoN - BEAT 2021.
Stay safe and stay healthy in COVID-19 pandemic.

With warmest regards
Malang - Indonesia, Dec 12, 2020
in the COVID-19 outbreak



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R. Hendroko Setyobudi, A. Winaya, J. Burlakovs, M. Mel and O. Anne (Eds.)

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Determinants of Technical In-efficiencies in Swamp Rice Farming - Ciamis District, Indonesia

Agus Yuniawan Isyanto*, *Sudrajat* Sudrajat, and *Muhamad* Nurdin Yusuf

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Abstract. Rice farming in swamps, a marginal land, has a relatively high risk related to the level of technical efficiency. This research was conducted with the aim of identifying the level of technical efficiency and the influence factors of technical inefficiency in Lakbok Subdistrict, Ciamis District, Indonesia. Simple random sampling was used with a sample size of 41 farmers. The analysis was carried out using a stochastic frontier function. The results showed that the average level of technical efficiency was 0.78. Education and family size have a significant effect on technical inefficiency.

Keywords: Farmer, marginal land, stochastic frontier

1 Introduction

Swamp rice grows in marginal land that has a relatively high risk related to the level of technical efficiency [1]. This farming is carried out in the dry season where water needs depend on rainfall [2]. Swamp rice farming usually faces serious challenges during the rainy season [3].

The main problem in the management of swamp rice farming is the occurrence of floods that inhibit plant growth and production. Farmers in swamp rice often have difficulty in predicting flood levels, so they face the risk of flooded rice plants in the vegetative growth phase [4]. Weather and climate have a direct influence on agricultural production so that weather fluctuations and climate variability play an important role in growth and yields [5].

The crucial problem of rice farming in Indonesia is the low efficiency and productivity thus the production is uncompetitive compared to other rices. Increased rice production can be done through existing technology [6]. Technical efficiency compares the level of output in relation to the level of input used [7].

Lack of skilled farmers in managing the system properly causes inefficient agricultural management leads to reduced yields and increased waste [8]. The low yield is due to several factors including agro-climatological problems and high input costs [9]. Constraints in increasing crop yields can be related to inefficient agricultural management even though inputs are used intensively [10].

The ability to allocate factors of production will affect production and the level of efficiency. The non optimal production indicates the existence of technical inefficiencies [11].

This research was conducted with the aim of identifying the level of technical efficiency and the factors that influence technical inefficiency in swamp rice farming in Lakbok Subdistrict, Ciamis District, Indonesia.

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2 Methods

The research was conducted in Lakbok Subdistrict, the only sub district that has swamp lanswampland farming. The research was carried out for 3 mo in planting the first season.

The sample size was 41 farmers using simple random sampling. The study utilized stochastic production frontier which builds hypothesized efficiency determinants into the inefficiency error components. The model is defined by Equation (1):

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + vi - ui \qquad (1)$$

Where:
Y = output (kg)
X1 = seed (kg)
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β = coefficient of regression
vi = random error
ui = technical inefficiency effects in the model.

Technical efficiency (TE) effects model developed by Battese and Coelli was employed in this study. In this model a Cobb-Douglas production function and some exogenous factors influencing technical efficiency are determined simultaneously.

Technical efficiency in the context of production relates to the level at which a farmer produces maximum feasible output from a given set of inputs (output-oriented measure), or uses a minimum level of input feasible to produce a certain level of output (a size-oriented input) [12].

Inefficiency model was defined to estimate the influence of some farmer's socio-economic variables on the technical efficiency of the farmers. Technical inefficiency effects are assumed to be distributed independently [13, 14]. The model was defined by Equation (2):

$$\mu i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \qquad (2)$$

Where:
μi = technical inefficiency
Z1 = age (years)
Z2 = education (years)
Z3 = experience (years)
Z4 = family size (persons)
δ = regression coefficient.

3 Results and discussion

3.1 Technical efficiency

The level of technical efficiency achieved by rice farmers in swamps ranged from 0.53 to 1.00 with an average of 0.778 as presented in Table 1.

Table 1. Frequency distribution of technical efficiency

Technical Efficiency	Frequency	Percentage
0.51 to 0.60	5	12.20
0.61 to 0.70	6	14.63
0.71 to 0.80	9	21.95
0.81 to 0.90	11	26.83
0.91 to 1.00	10	24.39
minimum = 0.53; maximum = 1.00; mean = 0.78		

Table 1 showed that the average level of technical efficiency achieved was 0.78, which indicates that swamp rice farming was technically efficient. This efficiency index value implied a technical inefficiency gap of 0.22 which indicates that 22 % of higher production can be achieved by farmers without using additional resources, or the use of inputs can be reduced to achieve the same level of output. The technical efficiency will be considered as efficient if it reaches an efficiency index value of more than 0.70 [15]. The difference in the level of technical efficiency achieved by farmers shows the degree of differentiation in the application of technology [16].

3.2 The stochastic frontier production functions analysis

Analysis of factors affecting production and technical inefficiencies was carried out using the stochastic frontier production function as presented in Table 2.

Table 2. Maximum likelihood estimates and inefficiency functions

Variable	Coefficient	Standard Error	t-ratio
Production function			
Constant	3.106 7	0.651 8	4.766 6
Seed	–0.066 8	0.240 8	-0.277 4
Organic fertilizer	–0.001 3	0.013 3	-0.100 8
Chemical fertilizer	–0.045 4	0.165 1	-0.275 3
Pesticide	–0.099 4	0.091 6	-1.085 8
Labor	1.353 1	0.438 8	3.083 9*
Inefficiency function			
Constant	–0.209 2	0.068 0	3.075 6
Age	–4.868 0	0.447 1	0.108 9
Education	0.308 8	0.011 4	27.077 8*
Experience	–0.119 4	0.328 0	-0.364 1
Family size	–0.008 5	0.001 4	-5.985 7*
Sigma squared	–0.056 5	0.003 4	16.376 8
Gamma	0.999 9	0.002 4	425.254 4
Log likelihood function	18.2348		
LR Test	12.8942		

*significant at 1 % (p > 0.01)

The estimated value of the gamma parameter (γ) of 0.999 9 is statistically different from zero. This indicated that 99.99 % of the variation in the level of output in swamp rice farming is caused by technical inefficiencies in the use of inputs. The model used in this

study is a linear log equation hence the value of each regression coefficient shows the production elasticity of each input. The sum of all regression coefficients is more than one (1.13) which indicates increasing returns to scale.

Table 2 showed only the labor force that has a positive and significant effect on production in swamp rice farming. The results of this study were in line with the other research [1, 17].

3.3 Technical inefficiency

Table 2 showed that education has a positive and significant effect on technical inefficiencies, which shows that improving education will reduce technical efficiency. Family size has a negative and significant effect on technical inefficiency which indicates that increasing family size will increase technical efficiency. The results of this study are in line with the results of another research [18].

Age has a negative but not significant effect on the level of technical inefficiency which indicates that the older the farmer, the more technically efficient. The results of this study are consistent with other findings [19].

Education has a positive and significant effect on technical inefficiency which shows that the more educated farmers, the lower the technical efficiency. The results of this study are in line with other findings [20].

The experience of farmers in swamp rice farming has a negative but not significant effect on the level of technical inefficiency. This shows that the more experienced farmers in carrying out swamp rice farming will increase their technical efficiency. The results of this study are consistent with other findings [21].

Family size has a negative but not significant effect on the level of technical inefficiency. This shows that the more family size will increase the technical efficiency. More family size means more workers are available to carry out rice farming activities in swamps in a timely manner thus the production process becomes more efficient [6]. Farmers who have large family sizes tend to try their best to get higher yields to meet the needs of their families. In addition, large family sizes have the workforce needed to implement agricultural management decisions [22].

4 Conclusion

The level of technical efficiency of swamp rice farming ranged from 0.53 to 1.00 with an average of 0.778 which indicated that swamp rice farming has reached a level of technical efficiency. Labor has a significant effect on production, while seeds, organic fertilizers, chemical fertilizers and pesticides have no significant effect. Education and family size have a significant effect on technical inefficiency, while age and experience have no significant effect.

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Agribusiness Department, Faculty of Agriculture, Universitas Galuh,
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Z3 = experience (years)
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Table 1. Frequency distribution of technical efficiency

Technical Efficiency	Frequency	Percentage
0.51 to 0.60	5	12.20
0.61 to 0.70	6	14.63
0.71 to 0.80	9	21.95
0.81 to 0.90	11	26.83
0.91 to 1.00	10	24.39
minimum = 0.53; maximum = 1.00; mean = 0.78		

Table 1 showed that the average level of technical efficiency achieved was 0.78, which indicates that swamp rice farming was technically efficient. This efficiency index value implied a technical inefficiency gap of 0.22 which indicates that 22 % of higher production can be achieved by farmers without using additional resources, or the use of inputs can be reduced to achieve the same level of output. The technical efficiency will be considered as efficient if it reaches an efficiency index value of more than 0.70 [15]. The difference in the level of technical efficiency achieved by farmers shows the degree of differentiation in the application of technology [16].

3.2 The stochastic frontier production functions analysis

Analysis of factors affecting production and technical inefficiencies was carried out using the stochastic frontier production function as presented in Table 2.

Table 2. Maximum likelihood estimates and inefficiency functions

Variable	Coefficient	Standard Error	t-ratio
Production function			
Constant	3.106 7	0.651 8	4.766 6
Seed	–0.066 8	0.240 8	-0.277 4
Organic fertilizer	–0.001 3	0.013 3	-0.100 8
Chemical fertilizer	–0.045 4	0.165 1	-0.275 3
Pesticide	–0.099 4	0.091 6	-1.085 8
Labor	1.353 1	0.438 8	3.083 9*
Inefficiency function			
Constant	–0.209 2	0.068 0	3.075 6
Age	–4.868 0	0.447 1	0.108 9
Education	0.308 8	0.011 4	27.077 8*
Experience	–0.119 4	0.328 0	-0.364 1
Family size	–0.008 5	0.001 4	-5.985 7*
Sigma squared	–0.056 5	0.003 4	16.376 8
Gamma	0.999 9	0.002 4	425.254 4
Log likelihood function	18.2348		
LR Test	12.8942		

*significant at 1 % (p > 0.01)

The estimated value of the gamma parameter (γ) of 0.999 9 is statistically different from zero. This indicated that 99.99 % of the variation in the level of output in swamp rice farming is caused by technical inefficiencies in the use of inputs. The model used in this

study is a linear log equation hence the value of each regression coefficient shows the production elasticity of each input. The sum of all regression coefficients is more than one (1.13) which indicates increasing returns to scale.

Table 2 showed only the labor force that has a positive and significant effect on production in swamp rice farming. The results of this study were in line with the other research [1, 17].

3.3 Technical inefficiency

Table 2 showed that education has a positive and significant effect on technical inefficiencies, which shows that improving education will reduce technical efficiency. Family size has a negative and significant effect on technical inefficiency which indicates that increasing family size will increase technical efficiency. The results of this study are in line with the results of another research [18].

Age has a negative but not significant effect on the level of technical inefficiency which indicates that the older the farmer, the more technically efficient. The results of this study are consistent with other findings [19].

Education has a positive and significant effect on technical inefficiency which shows that the more educated farmers, the lower the technical efficiency. The results of this study are in line with other findings [20].

The experience of farmers in swamp rice farming has a negative but not significant effect on the level of technical inefficiency. This shows that the more experienced farmers in carrying out swamp rice farming will increase their technical efficiency. The results of this study are consistent with other findings [21].

Family size has a negative but not significant effect on the level of technical inefficiency. This shows that the more family size will increase the technical efficiency. More family size means more workers are available to carry out rice farming activities in swamps in a timely manner thus the production process becomes more efficient [6]. Farmers who have large family sizes tend to try their best to get higher yields to meet the needs of their families. In addition, large family sizes have the workforce needed to implement agricultural management decisions [22].

4 Conclusion

The level of technical efficiency of swamp rice farming ranged from 0.53 to 1.00 with an average of 0.778 which indicated that swamp rice farming has reached a level of technical efficiency. Labor has a significant effect on production, while seeds, organic fertilizers, chemical fertilizers and pesticides have no significant effect. Education and family size have a significant effect on technical inefficiency, while age and experience have no significant effect.

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