TECHNICAL EFFICIENCY AND FACTORS AFFECTING RICE PRODUCTION IN TIDAL LOWLANDS OF SOUTH SUMATRA PROVINCE INDONESIA

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TECHNICAL EFFICIENCY AND FACTORS AFFECTING RICE PRODUCTION IN TIDAL LOWLANDS OF SOUTH SUMATRA PROVINCE INDONESIA

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ABSTRACT

Rice has been the staple food for most Indonesians, so the rice consumption in Indonesia is considerably high. Rice is cultivated in many agroecosystems, including tidal lowlands. Some tidal lowlands are considered suitable for rice cultivation. Therefore, tidal lowlands may support food security in Indonesia. However, productivity remains a problem in which inputs are not used efficiently. This study aims to determine the technical efficiency and identify factors affecting rice production in tidal lowlands of South Sumatra, one of main rice barns in Indonesia. A survey was conducted by interviewing 93 farmers in Telang Rejo Village. A data envelopment analysis (DEA) with output-oriented and variable returns to scale (VRS) approach was applied to measure technical efficiency score from each farm observed. An ordinary least square (OLS) regression with a Cobb-Douglass production function approach was employed to analyse the factors affecting rice production in tidal lowlands of South Sumatra, Indonesia. The results showed that majority of rice farms in the tidal lowlands of South Sumatra Indonesia were inefficient. There were 44 rice farms (47.31%) that were efficient, 5 rice farms (5.38%) that were inefficient under increasing returns to scale and 44 rice farms (47.31%) that were inefficient under decreasing returns to scale. The inputs, such as nitrogen, phosphorus, and potassium fertilisers, herbicides, insecticides and fungicides had positive significant influences on rice production in the tidal lowlands of South Sumatra, Indonesia.

Keywords: technical efficiency; rice production; tidal lowlands; data envelopment analysis; ordinary least square

INTRODUCTION

Rice is a staple food and livelihood platform for Asian countries, such as Vietnam, Indonesia, Pakistan and others **(Roy, Chan and Rainis, 2014; Roy, Chan and Xenarios, 2016; Al-Mashadani and Mahmood, 2019)** Rice is still an income source for rural society in Indonesia. Therefore, it has a strategic position. Moreover, Rice also contributes to 9.5% of the Gross Domestic Product of Indonesia **(Adriani and Wildayana, 2015; Central Bureau of Statistics of Indonesia, 2019)**. According to **Government regulation #12 of 2012** concerning food, the Indonesian government is obligated to guarantee availability, affordability, and fulfilment of food consumption for all Indonesians. However, the consumption rate of rice is very high in Indonesia. The rice consumption of Indonesia achieved approximately 29.13 million tons or 111.58 kg per capita per year **(Central Bureau of Statistics of Indonesia, 2017)**. A population rate increase caused rice consumption to also increase. At the same time, a high land conversion causes unstable rice production for fulfilling rice consumption in Indonesia. This means that the government must take an appropriate decision or policy for solving those problems.

One of the solutions taken by government is the development of agriculture in the suboptimal lands of Indonesia. One of the suboptimal lands in Indonesia is tidal lowland. Tidal lowland is reclaimed swamp land and occurs between the land and the sea. Therefore, tidal lowland depends on the changing tides. Tidal lowland has potential to support food security in Indonesia. One of the available tidal lowlands of Indonesia is in South Sumatra Province. Based on data, the total of tidal lowland area is 266,674 hectares in South Sumatra. A large number of tidal lowlands in South Sumatra are in Banyuasin Regency. Based on the report of statistics, the total of tidal lowlands in Banyuasin is 161,917 hectares **(Central Bureau of Statistics of Banyuasin Regency, 2018)**. Due to the available total area of tidal lowland is being large, it is expected become a food barn or food growing area or rice production centre of Indonesia. On the other hand, tidal lowland is still not reclaimed in large amounts because of peat in tidal lowlands. Therefore, Many tidal lowlands may not be utilised **(Susanto, 2003)**.

One of locations for tidal lowlands is in Telang Rejo Village, Delta Telang I, South Sumatra Province of Indonesia. This location is a reclamation project in the

1970s involving the transmigration program from Java Island to Sumatra Island **(Scholz, 1980; Wildayana, Adriani and Armanto, 2017; Wildayana and Armanto, 2018)**. Telang Rejo Village has type A tidal lowlands. The type A is a tidal lowlands suitable for rice cultivation **(Imanudin and Armanto, 2012)**, it forms by tidal lowlands that are overflowed both large and small tides at all times **(Irwandi, 2015)**.

Besides the good potential of tidal lowlands, the constraints and threats exist, such as the rice productivity of tidal lowlands still being low. The rice productivity of tidal lowlands is approximately 4.10 to 4.43 tons per hectare. Whereas, the average rice productivity is 8 tons per hectare **(Wildayana and Armanto, 2019)**. This difference between actual and expected production was caused by inefficient use of input **(Majumder et al., 2016)**. The other problems of rice cultivation in tidal lowlands are soil acidity, nutrient deficiency, salinity and pyrite (Fe_2S) content **(Armanto, et al., 2013; Armanto, 2014; Wildayana and Armanto, 2018)**. Furthermore, the water is unsuitable for the crop needs for rice cultivation in tidal lowlands agriculture **(Yazid et al., 2015)**. There is no technological recommendation based location, such as fertiliser, variety of rice, land clearing and management, and also water management **(Oemar, 2003)**. These factors are causes of inefficient use of agricultural inputs to rice production in tidal lowland agriculture.

Studies regarding the technical efficiency of rice production become important for estimating the efficiency level of rice production in tidal lowlands agriculture. Technical efficiency refers to achieving a total of potential output though s combination of total of available input **(Iráizoz, Rapún, and Zabaleta, 2003)**. If a business or enterprise can improve output by input use optimisation, the business is efficient **(Coelli et al., 2005)**. Some studies regarding the technical efficiency of rice production in Indonesia have been conducted **(Erwidodo, 1990; Squires and Tabor, 1991; Trewin et al., 1995)**. Even through there have been many studies regarding the efficiency of rice production in Indonesia, they are only a little of them discussing the efficiency of rice production in tidal lowlands of South Sumatra in particular. These previous studies investigated phenomena on Java Island with technical irrigated land agroecosystem. On the other hand, this study investigates the case of Sumatra Island with its suboptimal land agroecosystem, which is tidal lowlands. Therefore, this study is very important to be conducted.

Scientific hypotheses

There were two hypotheses in this study:

1. 70% of rice farms in tidal lowlands of South Sumatra Indonesia are efficient in constant returns to scale condition
2. Land area, seed, fertilizer of N, P, and K fertilisers herbicides, insecticides, fungicides and labour significantly affect rice production in tidal lowlands of South Sumatra Indonesia

MATERIAL AND METHODOLOGY

Location

This study was conducted in Telang Rejo Village, Banyuasin Regency, South Sumatra Province of Indonesia. There are some considerations in choosing the location.

1. This location has tidal lowlands of type A, and this location is suitable for rice cultivation.
2. This location is well known as food barn and production centre of tidal lowland rice for Banyuasin Regency.
3. This location is the largest village in tidal lowland agriculture of South Sumatera.
4. Telang Rejo is one of the transmigration project villages in the 1970s. The tidal lowlands in Telang Rejo was reclaimed by government to transmigrants from Java Island to Sumatra Island.
5. The Water management system was built by the agency of public work through grants from the government. The map of study site is in Figure 1.

Data Collection

Data was obtained by interviewing 93 farmers in Telang Rejo. Therefore, there were 93 decision making units (DMUs). They were selected randomly. This study used a questionnaire as a tool of research. This study was assisted by five master degree students as enumerators. The variables used in this study consisted one dependent variable (Y) and nine independent variables (X). The dependent variable was the rice production of tidal lowlands **(Coelli et al., 2005)**. The independent variables were land area **(Thanh Nguyen, Hoang and Seo, 2012)**, seeds **(Duangbootsee and Myers, 2014)**, chemical fertilisers which are N, P and K **(Hoang and Alauddin, 2012; Hoang and Nguyen, 2013; Jansen et al., 2006)**, pesticides and labour **(Rios and Shively, 2005; (Duangbootsee and Myers, 2014)**.

Technical Efficiency

Efficiency is the ratio between output and input. If the ratio is high, the efficiency score will be high. The efficiency score is between 0 to 1. It can be defined mathematically $0 \leq TE \leq 1$. Efficiency score can be obtained by **(Arnade, 1994)**:

$$Efficiency = \frac{\sum_k u_k y_{k,j}}{\sum_i v_i x_{i,j}}$$

Where :
y = output
x = input
u, v = average weight
i,j,k = 1,2,3,...n

Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) is a method to estimate efficiency with linear programming nonparametric approach **(Charnes, Cooper and Rhodes 1978; Charnes, Cooper and Rhodes, 1979)** DEA identifies the best frontier solution involving all observation of decision making units (DMUs). Therefore, it is called an envelope model. The DEA model also can be applied to estimate efficiency or performance in some sectors such as hospital **(Gholami, Higón and Emrouznejad, 2015; Khushalani and Ozcan, 2017)**,

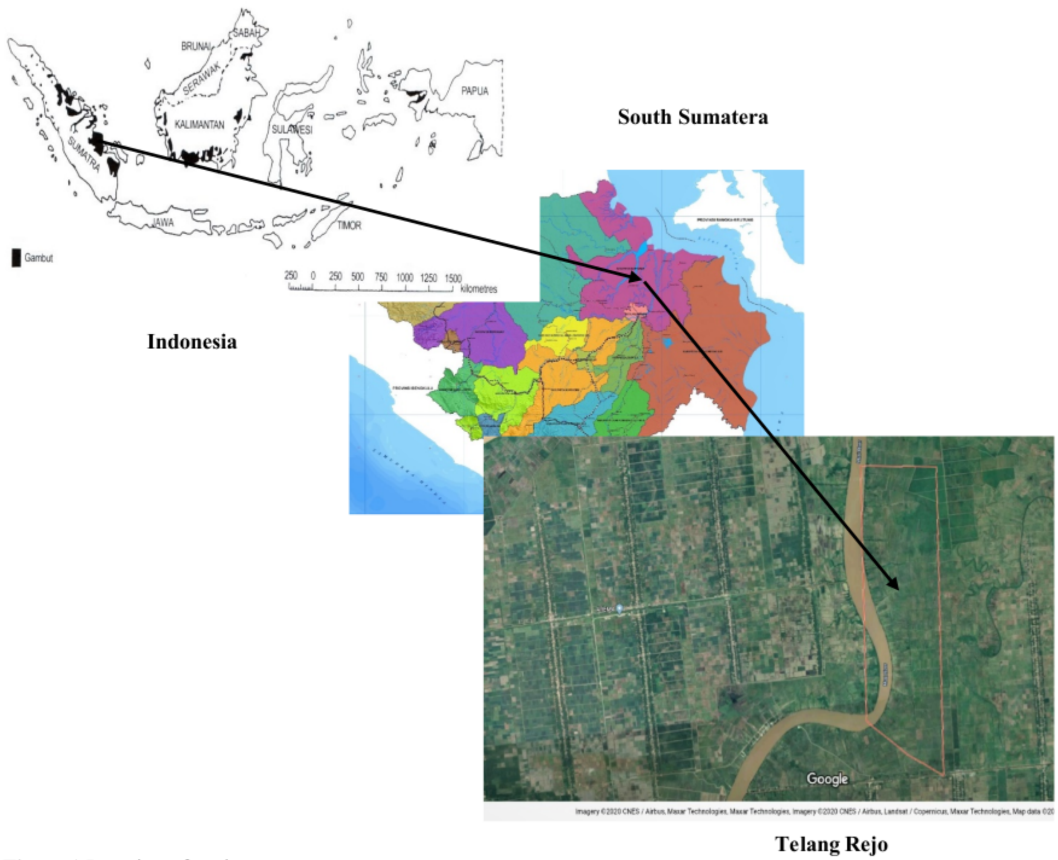

Figure 1 Location of study.

school **(Fatimah and Mahmudah, 2017)**, construction **(Hu and Liu, 2016)**, banking **(Wanke and Barros, 2014; Avkiran, 2015)**, port operation **(Rajasekar and Deo, 2014; Nguyen et al., 2016)**, industry and manufacture **(Kotey and O'Donnell, 2002)**, agriculture **(Haji, 2007; Guzman et al., 2009; Mardani and Salarpour, 2015)** and among others.

DEA has also been applied widely to estimate farm and agricultural performance worldwide **(Kočišová, 2015; Wang et al., 2017, Wang et al., 2018; Adeyonu et al., 2019)**. DEA has been used as a tool for decision making in a businesses, organisations, and governments as well. DEA has some advantages. It can be applied simultaneously by multiple inputs and ouputs. Without the need to previously determine weights. Furthermore, DEA does not need a functional form and specific production function such as input-output relationship.

DEA is divided by 2 orientations. The first is oriented input. It minimises input to achieve a potential output level. The second one is oriented output. It maximises output bundle while keeping the input level constant. Both of them minimise input and maximise output for achieving efficiency, DEA model oriented input focuses on operational and managerial problems while DEA model oriented output is in regards to planning and strategy **(Cullinane, Song and Wang, 2005)**.

The asssumptions of the DEA model are constant retun to scale (CRS) and variable returns to scale (VRS). These assumptions affect the envelope frontier. CRS is difined as a proportion of input addition equaling proportion of output addition. VRS is defined as production technology showing increasing, constant or decreasing returns to scale. The VRS assumption is appropriate for agriculture study because agricultural production may occur in 3 situations which are increasing, constant or decreasing returns to scale.

The DEA model in this study applied oriented output. The model can defined as **(Färe, Grosskopf and Lovell, 1985; Ali and Seiford, 1993; Färe et al., 2017; O'Donnell, 2018)**:

$$Max\ \theta i \quad (1)$$

Subject to:

$$u_{jm} \leq \sum_{j=1}^{j} z_j u_{jm} \quad (2)$$

Where:

θ = output efficiency of DMU's being estimated by DEA

u_{jm} = amount of output m produced by DMU j

z_j = intensity variable for DMU j

j,m = 1,2,3...n

The model obtained is a CCR or CRS model. To transform the model to be VRS or BCC Model, this constraint below should be add in the model.

$$\sum_j \lambda_j = 1 \quad (3)$$

A DEA model with oriented output and VRS approach estimates technical efficiency though measuring potential output by 93 farmers or DMUs. The level of input (λ) is kept constant so that it obtains three stages of production, namely increasing, constant or decreasing returns to scale.

Ordinary Least Square (OLS)

The use of OLS has been widely applied by many scholars. OLS is amethod to identify the factors affecting agricultural production. OLS is also used as a second phase analysis of the DEA. According to **Banker, Natarjan and Zhang (2019)** the application of the combination between DEA and OLS is better than the Simar-Wilson model in measuring productivity at the second stage. The application of OLS is also more consistent when combined with DEA in second stage **(Simar and Wilson, 2007)**. The OLS equation used in this study is the Cobb-Douglass production function equation. We can define it as :

$$Y = f(X1, X2, X3 \ldots Xn) \quad (4)$$

$$Y = \beta 0 X1^{\beta 1} X2^{\beta 2} X3^{\beta 3} \ldots Xn^{\beta} \quad (5)$$

The estimation of the above OLS equation was transformed by natural logarithm (Ln). It was created to obtain the equation or model easier to interpret **(Koutsoyiannis, 2001)**.

$$LnY = Ln\beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 \ldots \beta_n LnXn \quad (6)$$

Where:

Y	= Production
$\beta 0$	= Intercept
$\beta_1, \beta_2, \beta_3 \ldots \beta n$	= Parameter
$X_1, X_2, X_3 \ldots Xn$	= Input
n	= 1,2,3....n

Statistical analysis

The software used for data analysis in the study was the Data Envelopment Analysis Program (DEAP) software version 2.1. The software was developed by Tim Coelli from the Centre of Efficiency and Productivity Analysis (CEPA) in the University of Queensland, Australia. In addition, the Statistical Package for Social Science (SPSS) version 23 was also used for OLS analysis. The *p*-values used in OLS analysis were $p < 0.01$; 0.05 and 0.10

RESULTS AND DISCUSSION

Characteristics of farmers

Based on Table 1, farmers were in productive age group. The majority of farmers aged 40 – 49 years. The household size was 2 people for the majority. A small percentage of respondents were elderly and whose wife or husband has passed away lived alone. These respondents normally had children who were married and lived nearby. A low percentage of respondents had two or more children. These respondents normally are middle aged with children who are still young and unmarried. However, the education of farmers is still relatively low. The length of education only 4 to 7 years, which is equivalent to primary school. The majority of farmers had 11 – 20 years of farming experience. This was because farmers in Telang Rejo Village are the second and third generation of transmigrants of the transmigration project from Java Island to Sumatra Island in the 1970s. The land status of farmers in Telang Rejo Village was mainly private ownership. This is because at the beginning of the transmigration program each household was given 2 hectares of reclaimed tidal lowlands by the government **(Arsyad, Saidi and Enrizal, 2014)**.

Table 2 showed agricultural input uses and output produced in tidal lowlands of Telang Rejo Village. According to The Ministry of Agriculture of Indonesia (2007) the uses of N, P and K fertilisers are 200 $kg.ha^{-1}$, 75 $kg.ha^{-1}$ and 50 $kg.ha^{-1}$ resepectively . In fact, the uses of N, P and K fertilisers in tidal lowlands were higher than the recommendation. This could be a threat for sustainability and environmental integrity in tidal lowlands with theses surpluses.

Characteristic of Tidal Lowlands

Tidal lowlands contain pyrite and peat. Pyrite was formed when the tidal lowlands were flowed by sea water in dry season. It will be dangerous to rice when it was oxidized. Furthermore, peat was cause of soil acidity **(Shamshuddin et al., 2004; Nurita and Ar-Riza, 2014)**.

The tidal lowlands' problem are pH, nutrient deficiency, high content of Fe and Al and uncontrolled water **(Purnomo et al., 2005)**. Water management in tidal lowlands was different with irrigation system. The government had built some primary and secondary canals with the sliding gate and flap gate. In the rice farm, The intensive shallow canals were conducted which function to wash acidic and toxic substances from the field **(Widjaja-Adi, Ratmini and Swastika, 1997)**. However, the maintenance of the canals need to consider because some gates were broken **(Ar-Riza and Alkasuma, 2008)**.

Identification of efficient and inefficient rice farms in tidal lowland

A total of 93 farms were used for each efficiency score using the DEA method. The result of DEA showed that most of the tidal lowlands rice farms in Telang Rejo Village were inefficient. There were only 44 (47.31%) efficient rice farms that were in constant returns to scale condition, while there were 49 inefficient farms. Where 44 (47.31%) of those in decreasing returns to scale condition and 5 (5.38%) that were in in increasing returns to scale condition. Figure 2 is presented to show the results of the DEA.

There were 44 rice farms that had decreasing returns to scale caused by the excesses of input use. Therefore, to achieve efficiency the input uses need to be reduced. The purpose of reducing input use on the farms for the law of diminishing returns has not occurred. Whereas the farms with increasing returns to scale (five rice farms) should increase the input uses to achieve efficiency because it is still possible for them to increase production. The finding of a study stated that rice farms in Vietnam operated with less than the optimal scale **(Linh, 2012)**. The result supported this study.

Table 1 Descriptive statistics of farmers in Telang Rejo Village (n = 93).

Characteristics	Frequency	Percentage (%)
Age (year)		
20 – 29	12	12.90
30 – 39	23	24.73
40 – 49	36	38.71
50 – 59	18	19.35
60 – 69	4	4.30
Household size (individual)		
1	20	21.51
2	34	36.56
3	30	32.26
4	8	8.60
5	1	1.08
Education (year)		
0 – 3	3	3.23
4 – 7	52	55.91
8 – 11	17	18.28
12 – 15	20	21.51
≥16	1	1.08
Farming experience (year)		
0 – 10	18	19.35
11 – 20	38	40.86
21 – 30	18	19.35
31 – 40	18	19.35
41 – 50	1	1.08
Land Status		
Renter	4	4.30
Owner	80	86.02
Renter and Owner	9	9.68

Table 2 Descriptive statistics of input and ouput (n=93)

Variable	Mean	Std. Deviation	Min.	Max.
Production (kg.ha^{-1})	6,602.15	142.66	3,000.00	10,000.00
Land area cultivated (ha)	4.83	3.52	0.50	20.00
Seeds (kg.ha^{-1})	86.40	18.71	50.00	120.00
N fertiliser (kg.ha^{-1})	329.57	1.61	50.00	650.00
P fertiliser (kg.ha^{-1})	223.66	1.14	50,00	500.00
K fertiliser (kg.ha^{-1})	195.16	1.09	50.00	400.00
Herbicide (L.ha^{-1})	6.90	3.59	2.00	20.00
Insekticide (L.ha^{-1})	6.41	3.83	1.00	17.00
Fungicide (L.ha^{-1})	5.99	3.22	1.00	17.00
Labour (day.ha^{-1})	3.78	3.36	1.00	14.00

Farm performance can also be divided based on the efficiency score. **Jalilov et al. (2019)** divided 3 performance using efficiency scores based on: 1) the best performance which has an efficiency score between 0.90 to 1.00 or 90% to 100%. Farming in this category was called efficient farming 2) good performance, or farming that has an efficiency score of 0.80 to 0.89 or 80% to 89% also included in the efficient category, while for 3) poor performance is farming that has efficiency score under 0.79 or 79%. Farming with this score is categorised as inefficient.

Based on this grouping, there were 68 (73.12%) farms that had efficiency scores from 90% to 100%. Then, there were 17 (18.28%) farms that had efficiency scores between 80% and 89%. Meanwhile, 8 (8.60%) farms had score of less than 79%. Figure 3 was given to show the categorisation

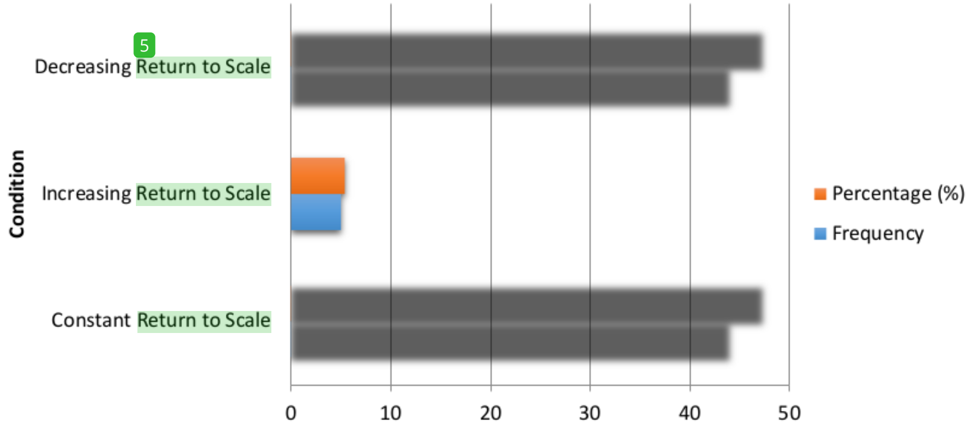

Figure 2 Distribution of farming based on returns to scale condition.

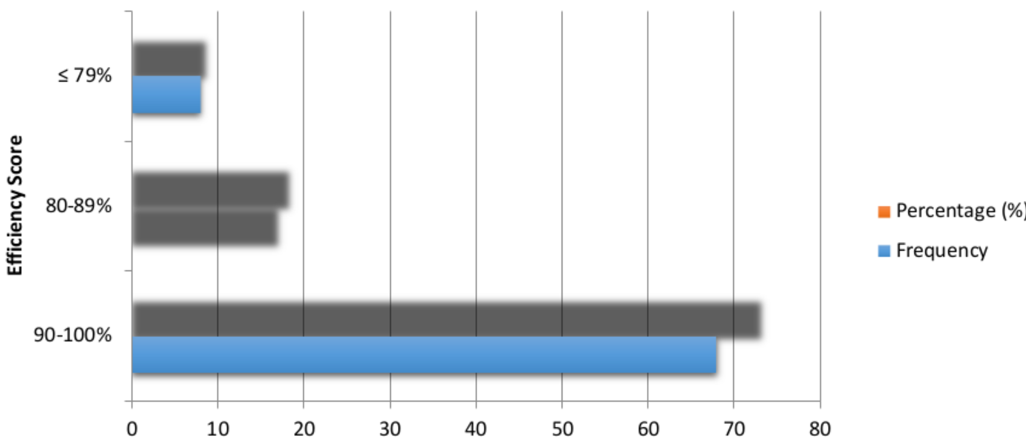

Figure 3 Categorisation of rice farming performance based on efficiency scores.

of rice farming performance based on efficiency scores. This finding is same like a study in Turkey. The average efficiency score of rice production in Marmara region was 92%. It means performance of rice farming in Turkey was the best performance **(Tipi et al., 2009)**.

The poorly performing farms occurred due to the input use not being optimal. The achievement of actual total production was not in accordance with the expected total production. It was further determined that poorly

performing farms were on decreasing returns to scale. The well performing farms with efficiency scores of 80% to 89% had worked on optimal input use. Furthermore, the best performing farms with efficiency scores of 90% to 100% had been on the efficiency frontier **(Jalilov et al., 2019)**.

Factors affecting rice production in tidal lowlands

This study applied an OLS analysis as the second stage analysis of DEA. The classic assumption test (data normality, heteroscedasticity and multicollinearity) was applied in OLS model. It was applied to obtain a free errors OLS model. In addition to obtain factors affecting rice production in tidal lowlands, OLS can also obtain an equation of the Cobb-Douglass production function for rice production in tidal lowland. The production functions obtained from OLS analysis were:

$$Y=127938130X1^{0.023}X2^{0.030}X3^{0.049}X4^{0.072}X5^{0.057}X6^{0.097}X7^{0.039}X8^{0.082}X9^{0.003} \quad (7)$$

Where:

Y = Tidal lowland rice production ($kg.ha^{-1}$)
X1 = Land area cultivated (ha)
X2 = Seed ($kg.ha^{-1}$)
X3 = N fertiliser ($kg.ha^{-1}$)
X4 = P fertiliser ($kg.ha^{-1}$)
X5 = K fertiliser ($kg.ha^{-1}$)
X6 = Herbicide ($L.ha^{-1}$)
X7 = Insecticide ($L.ha^{-1}$)
X8 = Fungicide ($L.ha^{-1}$)
X9 = Labour ($day.ha^{-1}$)

Table 3 The result of OLS analysis.

Variable	β	Std. Eror	t-stat	*p*
Intercept	8.107	0.274	29.549	0.000
Land area cultivated (X1)	0.023	0.027	0.862	0.391
Seed (X2)	0.030	0.061	0.498	0.620
Fertilizer N (X3)	0.049	0.026	1.885***	0.063
Fertilizer P (X4)	0.072	0.029	2.463**	0.016
Fertilizer K (X5)	0.057	0.032	1.794***	0.076
Herbicide (X6)	0.097	0.031	3.159*	0.002
Insectiside (X7)	0.039	0.022	1.809***	0.074
Fungicide (X8)	0.082	0.032	2.549**	0.013
Labour (X9)	0.003	0.022	0.135	0.893

Note: F-stat = 30.682; R-Square = 0.769; Adjusted R-Square = 0.744; * Significant at $p < 0.01$; ** Significant at $p < 0.05$; *** Significant at $p < 0.10$.

Based on the OLS analysis (Table 3), it was found that herbicides had a positive significant influence on rice production in tidal lowlands ($p < 0.01$), and P fertiliser and fungicides had a positive significant influence on rice production in tidal lowlands ($p < 0.05$).
Furthermore, N Fertiliser , K Fertiliser and insecticides also had a significant influence on rice production in tidal lowlands ($p < 0.10$). The findings supported a study by **Piya, Kiminami and Yagi (2012)**. The result of study stated that chemical fertilizer, pesticide and fungicide were positive and statistically significant to rice production in Nepal. Furthermore, pesticide and herbicide also affected rice production in Sri Lanka **(Gedara et al., 2012)**. Meanwhile, the land area cultivated, seeds and labour did not significantly influence rice production in tidal lowlands. A study stated that farm size did not affect rice production in Nigeria **(Ahmaedu and Alufohai, 2012)**. Many the land used by farmers in Telang Rejo Village were fragmented. The impact of fragmented land was that farmers had difficulty in managing rice farms. This was caused by the scattered distribution of land. Therefore, the management of rice farms in tidal lowland became ineffective. This case began when many farmers took a credit or loan from a wealthier farmer or *toke*. The land became a guarantee in this loan system. It was an informal credit with high interest. The interest applied by the *toke* is approximately 30% – 40% per year in a term of one to five years. The informal credit is absolutely not profitable for farmers in tidal lowland area. The loan system had terms and conditions as agreement between farmer and the *toke*. The farmers were not allowed to cultivate rice in their lands until they were able to pay their loan during the repayment period. The farmers who were not able to pay the loan according to agreement had to give their land to the *toke*. This situation created rich farmers with large land areas and poor farmers with small land area, so there was significant inequality among the farmers in tidal lowlands.

Seed did not significantly affect rice production in tidal lowlands. The use of seeds was very high in the rice farms of tidal lowlands. This finding was supported by **Dhungana, Nuthall and Nartea (2004)** and **Linn and Maenhout (2019)** . They stated that use of seed was very high in rice farming in Nepal and Myanmar. The use of excess seeds caused many farms to be in decreasing returns to scale condition. The use of excess seeds was mostly encouraged by cultivating system in tidal lowland. *Tabela* is well-known seedling system by farmers. In fact, the optimal use of seeds was 20 kg to 30 kg per hectare with seeding. *Tabe*la is abbreviation from three words (*Tebar Benih Langsung*) in Bahasa Indonesia. *Tabela* was done by spreading seed out directly to land without first seeding. When *tabela* was applied, seeds would flow out with water. Therefore, seeds were useless. *Tabela* is often known as *sonor*. *Tabela* was followed by burning land in land preparation **(Wildayana, Armanto and Junedi, 2017)**. This cultivation system was a local wisdom for tidal lowland farmers in Telang Rejo Village. The cultivation system made spacing of crops irregular, and caused the rice production of tidal lowlands to be low. Furthermore, the varieties used by farmers are ciherang, IR 42 or others. That was developed by farmers with technology limitations. In addition, it is possibly not water stress tolerant variety. One of the problems in tidal lowlands is a need for water because tidal lowlands depend on tides. Therefore, a water stress tolerant variety is needed by farmers in tidal lowland agriculture to increase rice production. Inpara-3 is a suitable variety to tidal lowlands **(Saidi et al., 2014)**. However, the farmers do not adopt it yet.

Labour was also a factor that did not affect rice production in tidal lowlands. The available labour force in tidal lowland agriculture is very low. In fact, many transmigrant farmers sold their land and farms given by the government to return to their homeland on Java Island. Then, many farmers migrated to find other work in the capital city of South Sumatra Province (Palembang). It occurred along cultivation season. Therefore, a large labour force for agriculture and farming in Telang Rejo Village was not available. Moreover, some farmers changed their jobs from agricultural jobs to non-agricultural jobs. The majority of them worked in construction in the capital city of South Sumatra Province or became workers on an engine boat in the Musi River. Musi River is the longest river of South Sumatra. It is also used as transportation like Mekong River in Vietnam. The case of labour migration also occurred in China. The available labour for agricultural jobs has decreased significantly **(Peng, Tang and Zou, 2009)**. It will be a challenges of rice production. The other cause was agricultural mechanisation. Many farmers used machines for land preparation, harvesting and other activities.

CONCLUSION

This paper concluded that rice production on tidal lowlands was inefficient. Only 47.31% of rice farming was efficient. They were in constant returns to scale. Meanwhile, 5.38% of rice farming was inefficient under increasing returns to scale and 47.31% of rice farming was inefficient under decreasing returns to scale. The factors affecting rice production in tidal lowlands were N, P, and K fertiliser, herbicides, insecticides and fungicides. In terms of policy implications, the need for rice varieties tolerant to tidal lowlands, use of organic fertilizer such as livestock dung, compost and others to achieve sustainability of tidal lowlands, seed nursery training by agricultural extension and also policies regarding the use of agricultural inputs, including doses and the other factors, so that rice production in tidal lowlands can be improved to achieve efficiency and food security in Indonesia.

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