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Technical Efficiency Analysis of Potato Farming in Kerinci Regency-Indonesia (Approach Data Envelopment Analysis Method)

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Abstract— *Kerinci regency is the highest production area compared to other potato centers. Kerinci regency has the most composition of 92.98 percent or as much as 76477.4 tons with, productivity of 17.06 tons / ha. The scope of this research is focused on knowing the use of production factors and the level of technical efficiency of respondent farmers. The research was conducted within the scope of West Kayu Aro District, Kerinci District, Jambi Province. The analysis tool used is Data Envelopment Analysis, with input-oriented Return To Scale (VRS) Variable models. The use of inputs in seed potato farming activities as much as 2315,403 kg / ha, SP 36 fertilizer as much as 191,129 kg / ha, KCl fertilizer as much as 137,258 kg / ha, phonska fertilizer 157,419 kg / ha fungicide as much as 452.9 gr / ha, insecticides of 597.4 gr / ha, and labor 73.2 HOK / ha / MT. The average value of technical efficiency obtained by farmers respondents to the research area was 0.936 with the highest value of 1 and the lowest value of 0.763. Farmers respondents who are classified on the IRS scale as many as 21 people or by 33.9 percent, DRS as many as 10 people by or 16.1 percent, and CRS as many as 31 people or by 50 percent.*

Keywords— ***Technical Efficiency, Potato Farming, DEA.***

I. INTRODUCTION

Potato production is generally grown in highland areas. Jambi Province has 3 areas that are in the highlands and produce potatoes, namely Kerinci Regency, Merangin Regency, and Sungai Penuh City. Kerinci Regency is one of the regencies in Jambi Province. Kerinci Regency is mostly located in the highlands, with an altitude of 1,400-1,600 meters above sea level, so the land in some areas of Kerinci is suitable for growing crops, especially potatoes. The majority of the people of Kerinci Regency make a living as farmers.

Kerinci Regency during the period 2005 - 2022 is the main production center area compared to other potato center areas. Kerinci Regency has the most composition of 92.98 percent or as much as 76477.4 tons with a productivity of 17.06 tons/ha and has the widest harvest area among other central areas in Jambi Province, which is 4,482 ha with a composition of 92.72 percent. Meanwhile, Merangin Regency has a land area composition of 6.37 percent and production of 6.21 percent of the total land area and production of Jambi Province. Sungai Penuh City is the area with the least land area and potato production, the composition of potato area planted in Sungai Penuh City is only 0.91 percent and production is 0.81 percent of the total. This proves that Kerinci Regency is the largest center of potato commodities in Jambi Province.

Increasing production requires optimal use of inputs. The optimal use of inputs is the use of inputs appropriately and does not damage the surrounding environment. Farmers do farming with the aim of increasing their productivity and making a profit. Decreased productivity can occur due to several things, such as inefficiency in the use of inputs, damaged land conditions due to inappropriate use of pesticides and drugs, and low quality of seeds used. The

use of inputs that are not optimal will affect productivity. If the use of input is not optimal then the productivity will be low. The use of inappropriate inputs such as excessive fertilizers and pesticides can also affect productivity. For this reason, technical efficiency analysis needs to be carried out to determine the combination of factors that are effective in using inputs to increase farmers' profits. The measurement of technical efficiency in this study uses the Data Envelopment Analysis (DEA) method. The DEA method is a non-parametric approach. The DEA method can handle many inputs and outputs and does not require the assumption of a functional relationship between input or output variables.

II. RESEARCH METHODS

The scope of this research is focused on knowing the use of production factors and the level of technical efficiency of respondent farmers. The research was conducted in the area of West Kayu Aro District, Kerinci Regency, Jambi Province. This location was chosen deliberately because Kerinci Regency is a potato commodity center. The object of the sample in this study is a farmer who grows potatoes.

The sampling technique in this study uses Simple Random Sampling, which is a sampling method where each population has an equal opportunity to be selected as a sample. Sampling is done by lottery. The size of the sample drawn is as many as 62 farmers.

There are two types of data sources in this study, namely primary data, which is data obtained directly from respondents' interviews using questionnaires. Secondary data is data obtained from offices or institutions related to potato farming, as well as literature studies in the form of books, journals, and scientific writings.

The data analysis method used is to analyze the technical efficiency and scale of farmers and to find out the distribution of technical efficiency based on the characteristics of farmers. The analytical tool used is Data Envelopment Analysis, with an input-oriented Variable Return To Scale (VRS) model using DEAP 2.1 software. measuring the technical efficiency of farmers using the following equation:

$$Maximize\ \theta, \lambda\ \theta$$

$$-\theta yi + Y\lambda \geq 0,$$

$$Xi - X\lambda\ \geq 0,$$

$$\mathrm{N1}'\lambda = 1$$

$$\lambda\ \geq 0$$

Where θ is the technical efficiency score (TE), Yi is the amount of potato production from farmer to i, xi is vector Nx1 of the number of production inputs for the farmer to i, Y is a vector is 1xM for production, N is the NxM matrix of the number of production inputs used. is used, is the Mx1 vector of weighting, and is the switch.

Technical efficiency by using the VRS model will produce scale efficiency by decomposing the total technical efficiency of Constant Return To Scale (CRS) into technical efficiency of Variable Return To Scale (VRS) and scale efficiency. While the scale efficiency (SE) is calculated:

$$SEi = \frac{\theta i\ CRS}{\theta i\ VRS}$$

III. RESULTS AND DISCUSSIONS

Characteristics of Respondent Farmers

The characteristics of respondent farmers in West Kayu Aro Subdistrict, Kerinci Regency, which were examined in this study included land area, farmer's age, farming experience, and farmer's level of education. The area of land owned by respondent farmers varies from 0.1 ha to 2 ha. The distribution of farmer characteristics by age is in the age range of 20 to 61 years. In terms of farming experience, respondent farmers in the area have a relatively high average of 13.13 years. Most of the farmers graduated from high school by 41.9 percent, did not finish elementary school by 6.5 percent, elementary school by 19.4 percent, junior high school by 29 percent, and undergraduate by 3.2 percent. This can be seen in table 1.

Table 1. Characteristics of farmers in the Research Area, 2020

Description	Minimum	Maximum	Average
Land Area (ha)	0.1	2	0.75
Age (Years)	20	61	39,9
Farming Experience (Years)	4	35	13.13
Education (Years)	3	16	9.52

Production Input Usage

The use of inputs in potato farming in West Kayu Aro District, Kerinci Regency, is in the form of land area, seeds, fertilizers, pesticides, and labor. It can be seen in table 2.

Table 2. Allocation of Potato Farming Production Input Range in the research area in 2020

Decription	Range	Average	Recommendation
Land Area (ha)	0.1-1.80	0.75	
Seeds (kg/ha)	220-3,000	1,880	1,250-1400
SP 36 Fertilizers (kg/ha)	50-400	1805	200-250
Phonska Fertilizers (kg/ha)	50-300	256.6	300-450
KCl Fertilizers (kg/ha)	50-250	120.3	150-200
Herbicide (gr/ha)	100-1,000	450.5	
Fungicide (gr/ha)	80-800	672.8	
Insecticide (gr/ha)	750-4,000	893.4	
Labor (HOK/ha)	40-165	132.2	

Source: processed primary data.

The types of potato seeds planted were granola varieties with grades G0 to G7. The number of seeds used varies from 220 kg to 5.7 tons. In this study, there were 3 types of fertilizers used by all respondents, namely KCl fertilizer, Phonska fertilizer, and SP 36 fertilizer. The average dose of SP 36 fertilizer was 191.129 kg/ha, KCl fertilizer 137,258 kg/ha, and Phonska fertilizer 157.419 kg /Ha. The dose of fungicide usage was 452.9 g/ha and the insecticide was 597.4 g/ha. The average use of labor in potato farming is 73.2 HOK, whereas the amount of labor used in HPT control activities.

The use of seeds in the research area is more than the use of potato seeds in the Bumiaji sub-district of Batu Malang City as much as 2115.27 kg/ha (Rizkiyah et al., 2014). The use of potato seeds in Pagar Alam City is relatively low at 968.12 kg/ha, while the use of fertilizers is also relatively low, with the use of SP 36 fertilizers at 78.38 kg/ha and Phonska at 97.01 kg/ha (Maryanto et al., 2018).

Technical Efficiency Analysis

Based on the calculation results, the results that show the average value of the technical efficiency of respondent farmers can be seen in table 3. Table 3 shows as many as 16 respondents or 25.8 percent are technically efficient, while 46 respondents, or 74.2 percent have not reached efficient value. Overall, the average value of the VRS technical efficiency obtained by the respondent farmers in the research area is 0.936 with the highest value of 1 and the lowest value of 0.763. Analysis of the technical efficiency of the CRS model is known as many as 14 respondents or 22.6 percent have been technically efficient, while 48 respondents, or 77.4 percent have not reached their efficient value. Overall, the average value of CRS technical efficiency obtained by the respondent farmers in the research area is 0.924 with the highest value of 1 and the lowest value of 0.706.

Table 3. The average value of the calculation of constant return to scale (CRS), returns to scale (VRS) variable, and scale efficiency (SE)

Description	CRSTE	VRSTE	SE
Mean	0.924	0,936	0,987
Max	1,000	1,000	1,000
Min	0.706	0,763	0,898
Number of Farmers Value E = 1	14 people	16 people	31 people
Number of Farmers Value E < 1	48 people	46 people	31 people

Source: processed primary data.

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The technical efficiency of potatoes in the Gowa district, South Sulawesi, shows an average technical efficiency of 0.842 with a minimum value of 0.421 and a maximum value of 1,000, with a total of 23 farmers who have an efficient value equal to one (Arifin *et al*., 2021). Pahlavan *et al.* (2011) also found that as many as 27 respondent farmers studied, 15 farmers who had an efficiency value equal to one, or about 55.5 percent could be declared technically efficient. Meanwhile, according to Utami (2016), the technical efficiency of farmers in Wajak District, Malang Regency, around 41.94 percent of the efficiency value is equal to one.

Consistent with Afifah (2017) with the research title "Analysis of the Efficiency of the Use of Production Factors in Potato Farming in Batur District, Banjarnegara Regency" the results of this study state that the production factor of the land area is negative and insignificant to potato production with an elasticity coefficient of -0.0,01. It is suspected that the land used in the research area is too large. Seed production factors, pesticides, fertilizers, and labor, have a positive and significant effect on production results. The value of technical efficiency is 0.83 or 83 percent. This number shows that the use of production factors is not efficient. Because the average productivity that can be achieved is 83 percent based on the frontier calculation (maximal production that can be achieved). Muarip *et al.* (2019), in their research on Technical Efficiency Analysis of the Use of Potato Farming Production Factors (Solanum tuberosum L) in Wonokitri Village, Tosari District, Pasuruan Regency, in their research concluded that seven variables had a significant effect on potato production results in Wonokitri Village, namely area land, urea fertilizer, SP36 fertilizer, ZA fertilizer, organic fertilizer, medicine, labor. These production factors affect the yield of potato production.

Technical Efficiency Distribution Based on Farmer Characteristics

The area of land, farmers who have an efficiency value of > 0.950 are obtained in a land group of 0.1 to 0.5 ha. It can also be seen that farmers who have achieved their efficient value are mostly found in the group of the land areas of 0.1 – 0.5 ha and 0.6 to 1 ha.

Distribution of Farmers' Technical Efficiency by Age

The age of the farmer is considered one of the causes of technical inefficiency in farming activities. By classifying the age of farmers, it can be seen that the efficient value > 0.950 is widely distributed in the age range of 34 to 40 years. This shows that the older the farmers, the more difficult it is for them to receive new information and their physical strength begins to decrease. Sahara stated that the higher the age of the farmer, the lower the efficiency value. This is also supported by Mandei's (2015) statement that farmers who have a productive age range have the motivation to increase production and are more prepared to take risks, but the older the farmers, the lower their efficiency value (Manurung et al., 2018).

Distribution of Farmers' Technical Efficiency Based on Farming Experience

Farming experience of farmers whose efficiency value > 0.950 is found in the range of farming duration between 4 to 11 years. This indicates that the longer farmers carry out farming activities can lead to saturation and trust in the habits carried out. In Sahara *et al.*'s research (2019) the efficient value of >80 is in the range of 11 to 20 years of farming experience, about 16 farmers, or 53.33 percent of farmers who has a high-efficiency value. This is in line with the research of Hoar and Fallo (2017), suggesting that the more experienced a farmer is, the more difficult it is for a farmer to accept innovations and suggestions because farmers have high confidence in carrying out their farming activities.

Distribution of Farmers' Technical Efficiency Based on Education Level

The formal education of farmers whose efficiency value is > 0.950 was obtained by farmers at the high school level as many as 15 farmers. This indicates that the higher the education of farmers, the higher the value of technical efficiency. Consistent with Fahriyah *et al.* (2018) stated that the higher the level of education of farmers, the higher the value of efficiency. This is because the knowledge and insight of farmers affect farmers in carrying out their farming activities. However, this research is inversely proportional to the Sahara *et al.*'s research (2019) in the Sahara study, the distribution of farmer efficiency based on the level of education is widely distributed among farmers with less than 10 years of education (junior high school equivalent), in his research he stated that the higher the level of education of farmers, the lower the value of technical efficiency.

Analysis of the Efficiency of the Use of Production Inputs for Potato Farming

Data Envelopment Analysis (DEA) can show trends in farmers in the research area. The DEA CRS (constant return to scale) model and the DEA VRS (return to scale variable) model were used to see the trend of the respondent farmers. The trend in the research area belongs to the Increasing Return To Scale (IRS), namely the increase in output is greater than the increase in input, Decreasing Return To Scale (DRS), namely the increase in output is smaller than the increase in input, and Constant Return To Scale (CRS).), i.e. increased output and balanced input.

The scale efficiency of respondent farmers in the research area can be seen in Figure 1 Respondent farmers belonging to the Increasing Return To Scale (IRS) of 33.9 percent or as many as 21 people, this shows that the addition of the input proportion will produce an output that is greater than the number of inputs. used, even though the respondent farmers have achieved an efficient value, but with the addition of inputs proportionally will increase the optimal output. Respondent farmers belonging to the Decreasing Return To Scale (DRS) of 16.1 percent or as many as 10 people, shows that the addition of the input proportion will produce a smaller output than the input used, so respondent farmers need to reduce the number of inputs used to a more suitable proportion. Respondent farmers who are classified as Constant Return To Scale (CRS), by 50 percent or as many as 31 people, show that the use of inputs used is optimal and the output produced is optimal.

The measurement of the technical efficiency of the respondent farmers in the research area who has achieved an efficient value equal to one and operates on a Constant Return To Scale (CRS) scale, is 14 people, or 22.66 percent of the total respondent farmers.

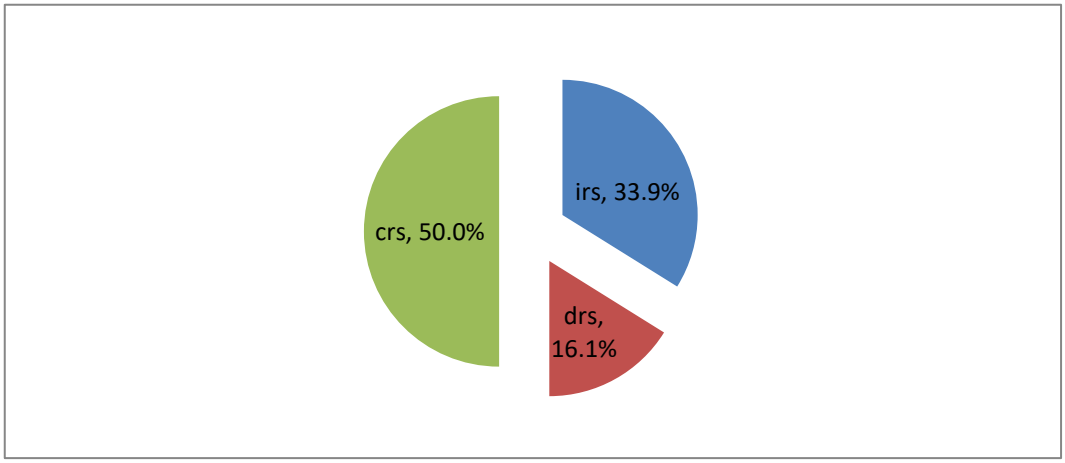

Fig.1. Efficient scale of potato farming

The results of Amandasari *et al.*'s research (2014), "Technical Efficiency of Sweet Corn Farming in Gunung Malang Village, Tenjolaya District, Bogor Regency" explained the number of farmers who were used as respondents as many as 31 people, as many as 18 people or 58.06 percent belonging to the increasing return to scale (IRS), as many as 3 people or 9.68 percent belong to the decreasing return to scale (DRS), and as many as 10 people or 32.26 percent belong to the constant return to scale (CRS). This explains that the research area is in a position where the increase in output is greater than the increase in input. Meanwhile, the results of Fahriyah *et al.*'s research (2018) "Analysis of Technical Efficiency of Farming in Rice Fields and Dry Land", explained that the number of farmers who became respondents was as many as 87 respondents in sugar cane in paddy fields, and 114 respondents in dry sugar cane fields. A total of 78 respondents or 90 percent belong to the increasing return to scale (IRS), 2 respondents or 2 percent belong to the decreasing return to scale (DRS), and as many as 7 respondents or 8 percent belong to the constant return to scale (CRS). While in dry land sugarcane the number of respondents was 114 farmers. As many as 101 respondents or 88 percent belong to the increasing return to scale (IRS), 2 farmers or 2 percent belong to the decreasing return to scale (DRS), and 11 farmers or 10 percent belong to the constant return to scale (CRS).

IV. CONCLUSION

The use of inputs in potato farming is relatively not as recommended. The average land area is only 0.56 ha, the seeds used for granola types G0 to G7 on average are 2315,403 kg/ha, SP 36 fertilizer is 191.129 kg/ha, KCL fertilizer is 137,258 kg/ha, Phonska fertilizer 157.419 kg/ha fungicide 452.9 g/ha, insecticide 597.4 g/ha, and labor 73.2 HOK/ha/MT. Potato farming is relatively technically efficient

Efficiency distribution is based on characteristics with an efficient value >950. Based on the land area, the ET value > 0.950 is in the range of 0.25 to 0.5 ha. The distribution of efficiency based on age is widely spread in the age range of 34 to 40 years, the distribution of efficiency based on farming experience ranges from farmers who already have 4 to 11 years of experience, while the distribution of efficiency of farmers based on education level whose ET value > 0.950 is at the high school education level. The potato farming scale is relatively in the Constant Return to Scale. Respondent farmers belonging to the IRS scale as many as 21 people or 33.9 percent, DRS as many as 10 people or 16.1 percent, and CRS as many as 31 people or 50 percent.

REFERENCES

[1] Afifah, A. (2017). Analysis of the Efficiency of the Use of Production Factors in Potato Farming in Batur District, Banjarnegara Regency. In *Universitas Islam Negeri Sunan Kalijaga*.

[2] Amandasari, M., Nurmalina, R., & Rifin, A. (2014). Technical Efficiency of Sweet Corn Farming in Gunung Malang Village Tenjolaya Distric Bogor Regency. *Forum Agribisnis*, *4*(2), 121–138. https://doi.org/10.29244/fagb.4.2.121-138

[3] Arifin, A. M., Fariyanti, A., & Tinaprilla, N. (2021). Technical Efficiency of Potato Farming in Gowa Regency South Sulawesi. *Forum Agribisnis*, *11*(1), 65–74. https://doi.org/10.29244/fagb.11.1.65-74

[4] Fahriyah, F., Hanani, N., Koestiono, D., & Syafrial, S. (2018). Technical Efficiency Analysis of Sugarcane Farming on Wet and Dry Land Using Data Envelopment Analysis (DEA) Approach. *Jurnal Ekonomi Pertanian Dan Agribisnis*, *2*(1), 77–82. https://doi.org/10.21776/ub.jepa.2018.002.01.8

[5] Hoar, E., & Fallo, Y. M. (2017). The Influence of Farmers' Socio-Economic Factors on Corn Farming Production in Badarai Village Wewiku District Malacca Regency. *Agrimor*, *2*(3), 36–38. https://doi.org/10.32938/ag.v2i03.307

[6] Mandei, J. R. (2015). Technical Efficiency of Corn Farming in Remboken District Minahasa Regency. *Agri-Sosioekonomi*, *11*(1), 28. https://doi.org/10.35791/agrsosek.11.1.2015.7168

[7] Manurung, H. A., Asmara, R., & Maarthen, N. (2018). Technical Efficiency Analysis of Maize Farming's at Maindu Village, Montong Subdistrict, Tuban Regency. *Jurnal Ekonomi Pertanian Dan Agribisnis (JEPA)*, *2*(4), 293–302. https://doi.org/10.21776/ub.jepa.2018.002.04.4

[8] Maryanto, M. A., Sukiyono, K., & Sigit Priyono, B. (2018). Analysis of Technical Efficiency and Its Determinants in Potato (Solanum Tuberosum L.) Farming in Pagar Alam City South Sumatra Province. *AGRARIS: Journal of Agribusiness and Rural Development Research*, *4*(1). https://doi.org/10.18196/agr.4154

[9] Muarip, S., Siswadi, B., & Sudjoni, M. N. (2019). Technical Efficiency Analysis of the Use of Potato Farming Production Factors (Solanum tuberosum L) . *Jurnal Sosial Ekonomi Pertanian Dan Agribisnis*, *7*(4), 1–7.

[10] Pahlavan, R., Omid, M., & Akram, A. (2011). Energy Use Efficiency in Greenhouse Tomato Production in Iran. *Energy*, *36*, 6714–6719. https://doi.org/10.1016/j.energy.2011.10.038

[11] Rizkiyah, N., Syafrial, & Hanani, N. (2014). Factors Affecting of Technical Efficiency of Potato (Solanum Tuberosum L) Farming With Stochastic Production Frontier Approach (Case in The Sumber Brantas Subdistrict, Bumiaji District, Batu City). *HABITAT*, *XXV*(1), 26–31.

[12] Sahara, D., Kurniaty, E., Basuki, S., & Hermawan, A. (2019). Distribution of Technical Efficiency Based on Source of Inefficiency in Maize Farming in Kendal District, Central Java. *Jurnal Pangan*, *28*(2), 121–134. https://doi.org/10.33964/jp.v28i2.433

[13] Utami, D. C. (2016). Analysis of Production Functions and Technical Efficiency in Corn Farming. *Universitas Yudharta Pasuruan*, *1*(1), 46–55.