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Analysis Of Environmental Efficiency On Rice Production In Kulonprogo Regency With A Stochastic Frontier Approach

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Abstract
Environmental efficiency is needed to analyze the impact of using agricultural inputs that have the potential to affect the environment with a certain level of efficiency. This study aims to analyze the value of environmental efficiency in inorganic rice production which is influenced by labor, seeds, fertilizer, organic pesticides, chemical fertilizers and chemical pesticides. This research was carried out in the rice fields of the Banjararum Village Farmers Group, Kalibawang District, Kulonprogo Regency, Yogyakarta Special Region Province, Indonesia with a sample of 50 farmers using in-depth interview methods. This research uses a translog stochastic frontier approach. The results of this research state that the labor variable has a negative effect on production. Phonska fertilizer and ZA fertilizer variables have a positive effect on production. The seed and urea fertilizer variables were not significant. The elasticity value of rice seeds is the highest of the other variables, namely 0.1049. Based on the analysis results, the average environmental efficiency value was 0.2264. This means that in general inorganic rice farmers in Kulonprogo Regency are not efficient from an environmental aspect or the use of chemical fertilizers (Phonska and ZA) is not in accordance with the recommended dosage.
Keywords: *environmental efficiency, translog stochastic frontier, production input, Kulonprogo*

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I. Introduction

From the 1970s until now, environmental issues have become a global problem for academics and environmental practitioners. Excessive exploitation of natural resources and environmental degradation has an impact on environmental health. Concern about environmental health has given rise to an approach known as the sustainable development approach. The principle of sustainable development in the Stockholm Declaration contains human responsibility to protect the environment and natural resources for the benefit of present and future generations (Sudrajat et al., 2018).

The use of production inputs in modern agriculture to stimulate production, such as fertilizers and chemical drugs, has a significant impact on reducing environmental quality in the agricultural sector. Modern agriculture which was launched as a green revolution program is closely related to environmental issues (Sudrajat et al., 2017). The green revolution was initially able to bring Indonesia towards food self-sufficiency in 1984 (Manning, 1988). After 1984, the green revolution did not actually increase rice production significantly, in fact the green revolution actually had a negative impact, especially on soil fertility and the soil's ability to produce food of sufficient quality and quantity (Widodo, 1988).

In Indonesia, sustainable agriculture with an environmental perspective is the implementation of the concept of sustainable development which aims to increase the income and welfare of the farming community at large, including increasing agricultural productivity without neglecting attention to the preservation of natural resources and the environment (Rivai & Anugrah, 2011). Sustainable agricultural development must be carried out in a balanced manner and adapted to the carrying capacity of the ecosystem, so that production continuity can be maintained while emphasizing the importance of conserving natural resources (Sudrajat, 2018).

In the 1990s to 2000s, the negative impacts of the use of fertilizers, seeds and chemical pesticides in the green revolution began to be felt by farmers with the destruction of biodiversity and soil biology (Sulaeman, 2012). Apart from that, it is also accompanied by farmers' high dependence on fertilizers, genetically modified seeds, the extinction of local rice varieties, the presence of pesticides which cause immunity to several rice pests, and the elimination of pest predators that are profitable for farmers (Sutanto, 2002).

Apart from that, major environmental problems also arise due to chemical waste pollution in nature, including: (1) the impact of the use of production input facilities on agricultural production and the environment; (2) environmental impact on greenhouse gas emissions; (3) the impact of industrial activities and urban expansion on agricultural land. The use of production inputs in modern agriculture to stimulate production, such as chemical fertilizers and pesticides, has a significant impact on reducing environmental quality in the agricultural sector (Las et al., 2006). Apart from that, major environmental problems also arise due to chemical waste pollution in nature, including: (1) the impact of the use of production input facilities on agricultural production and the environment; (2) environmental impact on greenhouse gas emissions; (3) the impact of industrial activities and urban expansion on agricultural land. The use of production inputs in modern agriculture to stimulate production, such as chemical fertilizers and pesticides, has a significant impact on reducing environmental quality in the agricultural sector (Las et al., 2006).

This research aims to analyze the value of environmental efficiency in inorganic rice production which is influenced by labor, seeds, organic fertilizer, organic pesticides, chemical fertilizers and chemical pesticides. This study was carried out in the rice fields of the Banjararum Village Farmers Group, Kalibawang District, Kulonprogo Regency, Yogyakarta Special Region Province, Indonesia with a sample of 50 farmers using in-depth interviews using a translog stochastic frontier approach.

II. Literature Review

In the rice cultivation agricultural system, farming efficiency is needed to increase productivity and at the same time reduce losses, both technical, allocative, economic, and those that impact the environment. Farming efficiency can be in the form of technical efficiency, allocative efficiency, economic efficiency and environmental efficiency (Mkhabela, 2011). Environmental efficiency is a type of additional efficiency (Reinhard et al., 1999). Inputs used in the production process can have a positive or negative impact on the environment, so it is necessary to measure environmental efficiency. Environmental efficiency measurements aim to consider the impact of using inputs that have the potential to affect the environment on economic units according to their level of efficiency. Graham (2004) stated that from efficiency calculations policies can be made to improve agricultural environmental performance and identify the impact of various characteristics of environmental efficiency itself.

Reinhard (1999) initiated research on efficiency to analyze the economic and environmental efficiency of dairy farming in the Netherlands econometrically based on neoclassical production theory. Zhang & Xue (2005) analyzed and estimated environmental efficiency in vegetable production in China. Waryanto et al. (2015) conducted research by estimating environmental efficiency with one detrimental input variable for shallot products using the stochastic frontier analysis (SFA) approach.

In relation to lowland rice farming, both organic and conventional, current research mostly examines technical efficiency using a stochastic frontier production function approach as carried out by (Kadiri et al., 2014; Murniati et al., 2014; Heriqbaldi et al., 2014; ., 2015; Sudrajat, 2019a). Apart from technical efficiency, there are also several studies on allocative efficiency or production cost efficiency using a stochastic frontier approach, such as that carried out by (Ouédraogo, 2015; Ajoma et al., 2016; Rathnayake & Amaratunge, 2016; Sudrajat et al., 2018). Apart from technical efficiency or allocative efficiency, there are also several studies of economic efficiency or profits using a stochastic frontier approach, such as those carried out by (Adamu & Bakari, 2015; Kaka et al., 2016; Chang et al., 2017; Sudrajat et al., 2017). Apart from technical efficiency, allocative efficiency or profit efficiency, there are also several agricultural studies that discuss farmer behavior in facing the risks of rice production, both organic rice and inorganic rice, such as those conducted by (Ahyar et al., 2012; Zakirin et al. , 2013; Suharyanto et al., 2015; Sudrajat, 2019b).

However, there are still some organic and/or conventional rice researchers who estimate environmental efficiency (in addition to technical efficiency, costs and profits) using a stochastic frontier approach. Several conventional rice studies that estimate environmental efficiency were carried out by (Van Hoang & Yabe, 2012; Hoang & Nguyen, 2013; Hossain et al., 2013; Saelee, 2017). Research on organic rice that estimates environmental efficiency using a stochastic frontier approach is still very limited compared to conventional rice. Guo & Marchand (2012) conducted research estimating the environmental efficiency of non-certified organic rice production in China. Prihtanti (2015) conducted a review of several research studies in Indonesia by estimating the efficiency of organic and conventional rice production as well as environmental efficiency using a stochastic frontier approach.

III. Theoretical Framework

Efficiency theories and concepts

The level of farming income is an important factor to support economic growth in general and the main determinant of farmer welfare in particular. The level of farming income is largely determined by the farmer's efficiency in allocating the resources he has to various alternative production activities. Efficient use of resources is an important issue that determines the existence of various opportunities in the agricultural sector related to its contribution to economic growth and increasing farmer welfare (Weersink et al., 1990).

In general, efficiency refers to “how well” or “how effectively” a decision-making unit combines inputs to produce outputs. That is, it expresses the percentage of production that can be achieved, which can actually be distinguished from productivity which considers the amount of output produced with a number of existing inputs (Graham, 2004). Efficiency is a relative concept that is measured by comparing the actual ratio of output to input to the ratio of output to input under optimal conditions. Efficiency is used to measure the economic performance of a company or farm.

Measuring efficiency begins with the concept put forward by (Farrel, 1957) which defines efficiency as the ability of a company or farm to produce maximum output using a certain amount of input. Doll & Orazeem (1984); Debertin (1986); Lipsey et al. (1987) defines efficiency as the maximum amount of output achieved by using a certain amount of input or to produce a certain amount of output using the smallest amount of input. Farrell (1957) stated the reasons for the importance of measuring efficiency, namely: (1) the problem of measuring the production efficiency of an industry is important for economists and economic policy makers; (2) if theoretical reasons for the relative efficiency of various economic systems are to be tested, it is important to be able to make measurements of actual efficiency; (3) if economic planning is closely related to a particular industry it is important to increase output without absorbing additional resources or increasing its efficiency.

Stochastic frontier analysis to measure environmental efficiency

SFA was first introduced by Aigner, Lovell and Schmidt in 1977. SFA is an econometric method used to calculate the level of efficiency of using certain inputs. Farmer production is said to be efficient, if a farmer's production level is higher than the best production level limit. To this function a non-negative random variable (Ui) is added to capture inefficiency factors such as the farmer's education level, farmer's age, and how long he has been a farmer, so that the general form of SFA for one input variable (Safitri, 2014) can be written as follows:

$$Y_i = f(X_i; \beta) \times exp\{V_i - U_i\} \quad (1)$$

where Yi is the level of production (output), Xi is the input variable used, β is the parameter to be estimated, Vi is a random variable related to external factors such as climate and pests and its distribution is symmetrical and normally distributed, and Ui is a random variable non-negative which influences the level of inefficiency and is related to internal factors which are assumed to be half-normally distributed.

Reinhard (1999) applies SFA by adding one variable that is considered to be detrimental to the environment with the aim of getting value from environmental efficiency. The general form of the SFA can be written as follows:

$$Y_i = f(X_i; Z_i; \beta) \times exp\{V_i - U_i\} \quad (2)$$

Equation (2) is the same as equation (1) except that there is an additional factor Zi, namely an input variable that is considered to be detrimental to the environment. With the translog production function, the complete model (Reinhard, 1999) can be expressed as follows:

$$lnY_i = \beta_0 + \sum_j \beta_j \, ln(X_{ij}) + \beta_z \, ln(Z_i) + 0.5 \sum_j \sum_k \beta_{jk} \, ln(X_{ij}) \, ln(X_{ik}) + \sum_j \beta_{jz} \, ln(X_{ij}) \, ln(Z_i) + 0.5 \, \beta_{zz}(lnZ_i)^2 - u_i + v_i \quad (3)$$

where i = 1, ..., n is the 1st farmer to the nth farmer, j, k = 1,2, ..., p is the input variable used, ln (Y_i) is the logarithm of the output of farmers to i, ln (X_{ij}) is the logarithm of the input variable to j used by the farmers to i, ln (Z_i) is the logarithm of the input variable which is considered to damage the environment by farmers to i, u_i is a non-negative random variable, and affects the level of inefficiency and is related to internal factors and is assumed to be half-normal spread ($u_i \sim |N(u,\sigma_u^2|$), v_i is a random variable related to external factors (climate, pests), the distribution is symmetrical and spread normally ($v_i \sim N(0,\sigma_v 2)$), also β_j, β_z, β_{jk}, β_{jz}, β_{zz} are the parameters to be estimated.

Reinhard (1999); Mkhabela (2011); Guo & Marchand (2012) formulated environmental efficiency in equation 4 below:

$$lnEE_i = [-(\beta_z + \Sigma\beta_{jz}lnX_{ij} + \beta_{zz}lnZ_i) \pm \{(\beta_z + \Sigma\beta_{jz}lnX_{ij} + \beta_{zz}lnZ_i)^2 \; 2\beta_{zz}U_i\}^{0.5}]/\beta_{zz} \quad (4)$$

where lnEEi is the environmental efficiency of the i-th farmer, X_{ij} is the variable of farmer input, Z_i is the detrimental input of the i-th farmer, U_i is the inefficiency factor, and β_z, β_{jz}, β_{zz} are the parameters to be estimated. Reinhard et al. (1999) states environmental efficiency is basically one aspect of technical efficiency because it focuses on one input that has negative consequences on the environment. This measurement is then a non-radial input oriented measurement because only one of the many inputs is examined. The decrease in the level of pollution input will have an impact on both technical efficiency and environmental efficiency.

IV. Materials And Method

Time and place of research

This study was conducted at Kelompok Tani in Banjararum Village, Kalibawang District, Kulonprogo Regency, Yogyakarta Special Region Province, Indonesia from September to November 2023. The place has a height of 437 meters above sea level, with regosol soil type, soil pH of 5.2-6.8, average temperature of 20-24° Celsius, and rainfall of 3,482 mm/year.

Research sample

In this research, 67 inorganic rice farmers were interviewed in depth. After interviews, 50 samples of farmers were determined who met the requirements. They are members of the Farmers Group in Banjararum Village, Kalibawang District, Kulonprogo Regency, Yogyakarta Special Region Province, Indonesia who have more than 10 years of experience processing rice plants.

Data analysis

Stochastic frontier translog model can be used to estimate the technical efficiency of rice production with the equation:

$$Y_i = F(X_i, \beta) \exp\{V_i - U_i\} \quad (5)$$

Based on the estimated frontier and the level of technical inefficiency, the equation is obtained:

($TE = Y_i/[F(X_i, \beta) \exp\{V_i\} = \exp\{-U_i\}$, used a method developed (Reinhard et al., 2000) to estimate environmental efficiency.

The Cobb-Douglas function does not add any new information to the analysis of environmental efficiency. Therefore, the translog production function is used to estimate environmental efficiency (Reinhard et al., 2002) as below:

$$\ln Y_i = \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + 0{,}5\beta_{11} \ln 2X_1 + 0{,}5\beta_{22} \ln 2X_2 + 0{,}5\beta_{33} \ln 2X_3 + 0{,}5\beta_{44} \ln 2X_4 + 0{,}5\beta_{55} \ln 2X_5 + 0{,}5\beta_{66} \ln 2X_6 + \beta_{12} \ln X_1 \ln X_2 + \beta_{13} \ln X_1 \ln X_3 + \beta_{14} \ln X_1 \ln X_4 + \beta_{15} \ln X_1 \ln X_5 + \beta_{16} \ln X_1 \ln X_6 + \beta_{23} \ln X_2 \ln X_3 + \beta_{24} \ln X_2 \ln X_4 + \beta_{25} \ln X_2 \ln X_5 + \beta_{26} \ln X_2 \ln X_6 + \beta_{34} \ln X_3 \ln X_4 + \beta_{35} \ln X_3 \ln X_5 + \beta_{36} \ln X_3 \ln X_6 + \beta_{45} \ln X_4 \ln X_5 + \beta_{46} \ln X_4 \ln X_6 + \beta_{55} \ln X_5 \ln X_6 + (V_i - U_i) \quad (6)$$

where:
Y_i = the total value of the output for i year of agriculture
X_1 = labor input for i year of agriculture
X_2 = seed input for i year of agriculture
X_3 = organic fertilizer input for i year of agriculture
X_4 = organic pesticides input for i year of agriculture
X_5 = chemical fertilizer input for i year of agriculture
X_6 = chemical pesticides input for i year of agriculture

For each input X_i (i = 1, 2,..., 5) there is an appropriate output elasticity which is explained as a variation of the percentage of the output value for each 1% change in the i year input factors.

In the Cobb-Douglas production function, the estimated parameter is the output elasticity itself, while in this study the production translog function, the output elasticity differs from the estimated parameter and is calculated using a total differential to estimate the translog function. According to Reinhard et al. (2002) its deduction function can be stated as follows:

$$əY/Y = (əX_1/X_1)(\beta_1 + \beta_{11} \ln X_1 + \beta_{12} \ln X_2 + \beta_{13} \ln X_3 + \beta_{14} \ln X_4 + \beta_{15} \ln X_5 + \beta_{16} \ln X_6) \quad (7)$$

The environmental efficiency index is the ratio of minimum visibility to the observed inputs that are detrimental to the environment: $EE = \min\{Ø{:}F(X, ØZ) \geq Y\} \leq 1$ where f (X, ØZ) is a frontier function, X is a vector of inputs, Z is a vector of environmental determinant inputs and Y is the value of the output.

To produce an environmental efficiency index, a new frontier function can be generated by replacing the observed Z input with θZ and $U_i = 0$. To make the development of new functions come from the original or old translog function, if there is only one input that damages the environment, for example X_6 as the only input that damages the environment (Reinhard et al., 2000), so the results can be written as follows:

$$0{,}5\beta_{66}(\ln ØZ - \text{Ln}Z)^2 + [\beta_6 + \beta_{16} \ln X_1 + \beta_{26} \ln X_2 + \beta_{36} \ln X_3 + \beta_{46} \ln X_4 + \beta_{56} \ln X_5 + \beta_{66} \ln Z](\ln ØZ - \ln Z) + U_i = 0 \quad (8)$$

Because lnEE = lnØ = ln (ØZ-lnZ, the above function can be written in equation 8 as follows:

$$0{,}5\beta_{66}(\ln EE)^2 + [\beta_6 + \beta_{16} \ln X_1 + \beta_{26} \ln X_2 + \beta_{36} \ln X_3 + \beta_{46} \ln X_4 + \beta_{56} \ln X_5 + \beta_{66} \ln Z] \ln EE + U_i = 0 \quad (9)$$

This equation can be solved as follows:

$$\ln EE = \{-(\beta_6 + \beta_{16} \ln X_1 + \beta_{26} \ln X_2 + \beta_{36} \ln X_3 + \beta_{46} \ln X_4 + \beta_{56} \ln X_5 + \beta_{66} \ln X_6 + (\beta_6 + \beta_{16} \ln X_1 + \beta_{26} \ln X_2 + \beta_{36} \ln X_3 + \beta_{46} \ln X_4 + \beta_{56} \ln X_5 + \beta_{66} \ln X_6 [\beta_{66} \ln X_6]^2 - 2\,\beta 6_6 U_i]^{0,5}\} / \beta_{66} = 0 \quad (10)$$

If there are 2 inputs that damage the environment, for example X5 and X6 as two inputs that damage the environment, the results can be written as follows (Reinhard et al., 2002):

$$(0{,}5\beta_{66} + 0{,}5\beta_{55} + \beta_{56}) \ln 2EE + [\beta_5 + \beta_{15} \ln X_1 + \beta_{25} \ln X_2 + \beta_{35} \ln X_3 + \beta_{45} \ln X_4 + \beta_{55} \ln X_5 + \beta_{56} \ln X_6 +$$

$\beta_5+\beta_{15}\ln X_1+\beta_{25}\ln X_2+\beta_{35}\ln X_3+\beta_{45}\ln X_4+\beta_{55}\ln X_5+\beta_{56}\ln X_6+\beta_6+\beta_{16}\ln X_1+\beta_{26}\ln X_2+\beta_{36}\ln X_3+\beta_{46}\ln X_4+\beta_{56}\ln X_5+\beta_{66}\ln X_6)\ln EE + U_i = 0$ (11)

This can be solved as follows:

$\ln EE=\{-(\beta_5+\beta_{15}\ln X_1+\beta_{25}\ln X_2+\beta_{35}\ln X_3+\beta_{45}\ln X_4+\beta_{55}\ln X_5+\beta_{66}\ln X_6+\beta_6+\beta_{16}\ln X_1+\beta_{26}\ln X_2+\beta_{36}\ln X_3+\beta_{46}\ln X_4+\beta_{56}\ln X_5+\beta_{66}\ln X_6)^2-4(0,5\beta_{66}+ 0,5\beta_{56}+0,5\beta_{55})U_i]^{0,5}\}/(\beta_{66}+\beta_{55}+2\beta_{45})$ (12)

In this function, "+√" is included in the model because if Ui=0, only when "+√" is used, lnEE is equal to "0". Therefore, in this model, the environmental efficiency index can be calculated using: EE = exp (lnEE) = Ø = (ØZ)/Z, where Ø is the environmental efficiency index. In this case, software 4.1 can be used to estimate the stochastic frontier function (Coelli, 1996).).

V. Results And Discussion

From the table of environmental efficiency value analysis results, it can be seen that the labor variable has a negative effect on production. The variables Phonska fertilizer and Za fertilizer have a positive effect on production. The seed and urea fertilizer variables were not significant. Kulonprogo Regency has a Gamma or inefficiency value of 0.665. This shows that Kulonprogo Regency is experiencing environmental degradation. In other words, the contribution of inputs, namely phonska fertilizer and manure, to environmental pollution is quite influential. The higher the inefficiency value, the greater the contribution of chemical fertilizer and pesticide inputs to environmental degradation. The results of the estimation of factors causing production efficiency in Kulonprogo Regency can be seen in Table 1.

Table 1. Estimation results of factors causing production efficiency in Kulonprogo Regency

Variable	Parameter	Coefficient	Standard Error	Z	P>|Z|
Labor	X_1	-0.5612407	0.281735	-1.99	0.046
Seed	X_2	0.0343931	0.1695717	0.20	0.839
Urea Fertilizer	X_3	-0.0545695	0.0325659	-1.68	0.094
Phonska Fertilizer	X_4	0.0102269	0.0122317	0.84	0.403
ZA Fertilizer	X_5	1.128659	0.2143454	5.27	0.000
Constant		19.21986	2.475445	7.76	0.000
$\ln Sigma^2 v$		-1.971032	0.564435	-3.49	0.000
$\ln Sigma^2 u$		-1.285361	0.8535339	-1.51	0.132
Sigma v		0.3732466	0.1053367		
Sigma u		0.525881	0.2244286		
Sigma-squared		0.4158639	0.1773109		
Lambda		1.408937	0.3166416		
Gamma		0.665			
Number of objects		50			

(Source: Primary Data Analysis, 2024)

From Table 1 it can be seen that the estimated value of the sigma-squared parameter (σ2) which is the total diversity contributed by inefficiency effects and external effects is 0.1773. The estimated value of the sigma-squared parameter (σ2) is real at the 0.05 level with a rice production diversity of 17.73%. The second parameter is gamma (γ) which is the ratio of the diversity of inefficiency effects (ui) to the diversity of total production (σ2) with an estimated value of 0.665 or diversity contributed 66.5%. The estimated value of this second parameter is not significant at the 0.05 level, meaning that the total diversity (σ2) is contributed more by external effects than by inefficiency effects. External effects that influence production include climate, pest attacks and modeling errors (Ojo et al., 2009).

The results of the stochastic frontier translog regression analysis show that there are two independent variables that influence inorganic rice production in Kulonprogo Regency. The variables that have a big influence are the interaction of labor and seeds, labor and urea fertilizer and seeds and urea fertilizer. The magnitude of the influence between the two production factors can be seen from the elasticity value of each production factor. Elasticity states the rate of change in production factors regarding production. The estimated parameter coefficient β in the translog production function is not an input elasticity value. The elasticity values in the translog frontier stochastic production function can be seen in Table 2.

Table 2. Value of elasticity of production factors

Production Factors	Elasticity Value
Labor	-0.0053
Seed	0.1049
Urea fertilizer	-0.0029
Phonska Fertilizer	-0.2832
ZA Fertilizer	-0.3295

(Source: Primary Data Analysis, 2024)

From Table 2 it can be seen that the elasticity value for rice seeds is the highest, namely 0.1049. This means that every 10% increase in seed use will increase production by 1.049%. Apart from rice seeds, the elasticity values for labor and urea fertilizer are quite large when compared with the variables for Phonska fertilizer and ZA fertilizer, namely -0.0053 and -0.0029. The decline in production due to labor and urea fertilizer is not too large, but if this continues, rice production will continue to decline, even having a negative impact on the surrounding agricultural environment (Reinhard, 1999).

Environmental efficiency calculations are carried out using the estimated β value that has been obtained from the stochastic frontier translog production function equation. The beta values used are only those that interact with Z. The beta values are βz, βzz, β1z, β2z, β3z, β4z, and β5z. Based on the results of analysis from 50 rice farmers in Kulonprogo Regency, an average EEnv value of 0.226 was obtained. In general, farmers are not efficient from an environmental aspect or the use of chemical fertilizers is not in accordance with the recommended dosage. The highest environmental efficiency value obtained was 0.435, while the lowest environmental efficiency value was 0.050 (Table 3).

Table 3. Value of farmers' environmental efficiency

Environmental Efficiency	Number of Farmers	Percentage (%)
$0.0 \leq$ EEnv < 0.1	2	4
$0.1 \leq$ EEnv < 0.2	23	46
$0.2 \leq$ EEnv < 0.3	16	32
$0.3 \leq$ EEnv < 0.4	4	8
$0.4 \leq$ EEnv < 0.5	5	10
Amount	50	100

(Source: Primary Data Analysis, 2024)

VI. Conclussion

Nowadays environmental efficiency as a form of additional efficiency is becoming increasingly important. Agricultural inputs used in the production process can have both positive and negative impacts on the environment. From the environmental efficiency index obtained from an agricultural area, it can be seen to what extent the agricultural area has an influence or impact on the degradation of the surrounding environment.

The results of the analysis of environmental efficiency values can be seen that the labor variable has a negative effect on production. Phonska fertilizer and Za fertilizer variables have a positive effect on production. The seed and urea fertilizer variables were not significant. The elasticity value of rice seeds is the highest, namely 0.1049. This means that every 10% increase in seed use will increase production by 1.049%. Based on the results of the analysis of 50 rice farmers in Kulonprogo Regency, an average environmental efficiency (EEnv) value of 0.2264 was obtained. In general, inorganic rice farmers in Kulonprogo Regency are not efficient from an environmental aspect or the use of chemical fertilizers (Phonska and ZA) is not in accordance with the recommended dosage. If this is allowed to continue to drag on, this will result in degradation of the agricultural environment.

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