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Analysis of The Multifunctional Economic Value of Rice Field As Producers of Cultivation Media and Products/ Environmental Services in Sidoarjo District, East Java Province, Indonesia Year 2024

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Abstract: Rice fields managed by farmers or agricultural business actors provide cultivation benefits and environmental services. Research in Japan shows that the environmental benefits of rice fields reach 90%, much higher than its role as a cultivation medium which is only 10%. This study aims to examine the economic value of rice fields as a whole in three main aspects: (1) its value as a rice field medium, (2) its value as an environmental service, especially flood control, and (3) a comparison of these economic values. The method used is economic valuation through the Replacement Cost Method (MBP) and the calculation of farming profits. MBP is used to calculate the economic value of rice fields that do not yet have a market price. Meanwhile, the calculation of farming profits is to assess the cultivation benefits produced by rice fields. The results of the study show that (1) the economic value of rice fields as a rice field medium is IDR 24,750,000 per hectare per year. (2) As a provider of flood control, its economic value reaches IDR. 150,276,000 per hectare per year, and the conversion of 350 hectares could result in an annual loss of Rp. 52.6 billion. (3) The comparison of the economic value between rice fields as a planting medium and as a flood controller is 1:6, highlighting the important environmental benefits provided by rice fields.

Keywords: Cultivation media; Enviromental services; Multifunctional; Valuation

Introduction

So far, rice fields have only been viewed as producers of cultivation media (for example, in rice fields planted with rice, only rice production is assessed) (Moniaga et al., 2018). In fact, when rice fields are cultivated by farmers or agricultural entrepreneurs, in addition to producing cultivation media, they also produce environmental products/services (for example, groundwater suppliers; erosion & sedimentation controllers; flood controllers; landslide controllers; air pollution control; organic waste absorbers; carbon (CO_2) absorbers; oxygen (O_2) producers; biodiversity; habitat conservation; rare species; and natural nutrient providers). Research in Japan actually shows that rice fields as producers of environmental products/services are greater than rice fields as producers of cultivation media (Sonyinderawan, 2020). The value of rice fields as producers of environmental products/services is 90% while rice fields as producers of cultivation media are only 10%. Indeed, the value of rice fields as a producer of environmental products/services does not yet have a market price, so research needs to be conducted to calculate the economic value of rice fields as a producer of environmental products/services so that the total economic value of rice fields can be calculated (Mujahid & Marsoyo, 2019).

The phenomenon of converting rice fields to non-rice fields (settlements, industrial areas, tourism, etc.) can be explained by economic theory, namely through

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the analysis of land rent ratios (Vikriandi, 2020). Based on the results of a study, there is a very real difference between the land rent ratio for the rice field sector and the non-rice field sector. The comparison of the rental value of rice fields for cultivation/farming (rice or secondary crops) with housing is 1: 622; The comparison of the rental value of rice fields for cultivation/farming (rice or secondary crops) with industry is 1: 500; and the comparison of the rental value of rice fields for farming (rice or secondary crops) with tourism is 1: 14 (LI & J., 1996).

However, the weakness of the economic analysis of land rent is that it only assesses the benefits as direct use or as a cultivation medium that has market value, whereas a stretch of rice field in addition to having the benefits of direct use or as a cultivation medium that produces products that have market prices also produces environmental service products that do not yet have a market price (Arviansyah & Murdy, 2021). In addition, the land rent analysis has not taken into account the present value of the results of the rice fields that should always be obtained throughout time (Suprianto et al., 2019).

Paddy fields have benefits of use and non-use benefits (Munasinghe, 1993; Yoshida, 2001). Thus, paddy fields, in addition to being a cultivation medium or source of production that is a source of income for farmers, also have other functions that produce environmental service products or have multifunction whose benefits can be enjoyed by the wider community (Setyaputri et al., 2023). Even in several research results, it is shown that the function of paddy fields as a producer of environmental services is greater than the function of paddy fields as a cultivation/farming medium when assessed economically (Mamondol, 2017).

The multifunctional approach to rice fields is an alternative to minimize the conversion of rice fields to non-rice fields (settlements, industrial areas, tourism, and so on), because the multifunctional approach to rice fields not only assesses the benefits of rice field results financially and in the short term, but also assesses the environmental services of rice fields socially (environmental economy) and long-term benefits (Pamungkas et al., 2018). However, the question is whether the people in Indonesia, especially the people at the research location, have properly understood the multifunctionality of rice fields, especially rice fields (Ayub et al., 2021).

Economic valuation is an effort to provide quantitative (monetary) value to goods or services produced by natural resources and the environment, either based on market value or non-market value (Harini et al., 2022) Therefore, economic valuation of natural resources and the environment is an economic tool that uses certain valuation techniques to estimate the monetary value of goods or services produced by natural resources and the environment (Anwar et al., 2023).

The economic value of rice fields is low because the multifunctional benefits of rice fields have not been internalized into farming. On the other hand, the public's understanding that rice fields are only a cultivation medium that produces products and already has a market price. In fact, a stretch of rice fields cultivated by farmers or agricultural entrepreneurs, in addition to producing benefits as a cultivation medium or direct use that already has a market price, also produce benefits as environmental products/services that do not yet have a market price (Martunisa & Noor, 2018). To assess the benefits of environmental products/services from rice fields that do not yet have a market price, it is necessary to conduct research using the economic valuation method (Gandhi et al., 2022).

The research are: 1) Analyzing the economic value of rice fields as a medium for rice cultivation/farming; 2) Analyzing the economic value of the environmental services benefits of rice fields as flood control; 3) Comparing the economic value of rice fields as a medium for cultivating/farming rice with the benefits of environmental products/services as flood control.

Various studies that apply efficiency calculations in agricultural commodity farming have been widely documented, including technical, allocative, and economic efficiency in rice plants (Junaedi et al., 2023), soybean plants (Rinaldi et al., 2023), corn plants (Edison, 2021), cassava plants (Anggraini et al., 2017); (Abedullah et al., 2006), shallot plants (Laksmayani, 2015), and plantation crops such as cocoa (Nursalam et al., 2021). Several studies on production effectiveness have also been conducted on pig farms (Parisutthikul et al., 2010). Therefore, this study is very important because it can be a reference for future farming efforts.

Method

Research Schedule and Location

This research was conducted from January to April 2024, in Sidoarjo Regency, East Java Province. The method used in determining the location in this research is a method, namely in Sidoarjo Regency, taking into account that in this area the rate of conversion of rice fields to non-rice fields is quite high, namely 350 ha per year.

Sample Determination Method

The number of samples in this research was 35 respondents with the following details: 30 farmers, 2 people from the Agriculture Service officials, and 3 agricultural instructors. The method used in determining farmer samples is the random method. Meanwhile, the method used in determining the sample of agricultural officials and instructors was on the grounds that the head of the Agriculture Service and Head of Divisions understood more about land conversion policies and agricultural instructors understood more about farmers.

Data collection methods

The method used in collecting data is the interview method using a questionnaire.

Analysis method

The method used in calculating the economic value of rice fields as a medium for cultivating rice farming is rice farming income.

TB = BT + BV (1)
TB = Total Cost of Rice Farming per Hectare
BT = Fixed Cost of Rice Farming per Hectare
BV = Variable Cost of Rice Farming per Hectare

TP= Q x P (2)
TP = Total Income from Rice Farming Business per Hectare
Q = Amount of Rice Farming Production per Hectare
P = Rice Farming Production Price per Kilogram

π = TP – TB (3)
π = Rice Farming Profit per Hectare
TP = Total Income from Rice Farming per Hectare
TB = Total Cost of Rice Farming per Hectare.

Meanwhile, the method used in calculating the economic value of the benefits of environmental products/services of rice fields as flood control is the economic valuation method. The economic valuation method used in this study is the Replacement Cost Method (MBP). With the following formula:

NELS s FPB = (Dp x A x α x Pd) (4)
Where:
NELS S FPB = Economic Value of Paddy Fields as a Flood Control Function.
Dp = Water bearing capacity of rice fields (m 3 /ha).
A = Area of rice fields converted to non-rice fields rice fields (ha/yr).
α = Coefficient of rice field capacity to hold rainwater (%).
Pd = Cost of making rice field embankments (IDR/m 3).

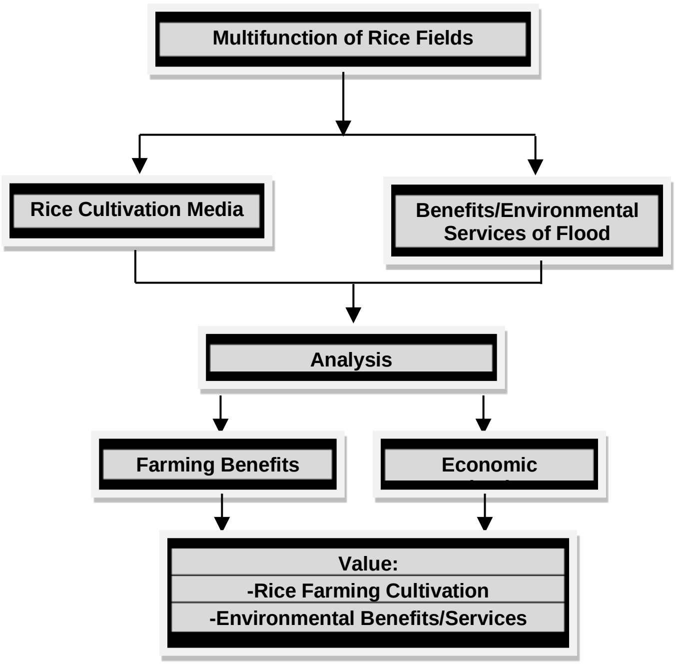

Figure 1. Research Flow

Result and Discussion

The Economic Value of Paddy Fields as a Medium for Rice Farming.

From the analysis results, it was found that in one hectare of rice fields used to plant rice, a total cost of IDR 14,250,000 was needed, while the production produced was 5 tons of dry harvested grain. The price of dry harvested grain was IDR 4,500 per kilogram. The total income from rice farming was IDR 22,500,000. So, the profit from rice farming was IDR 8,250,000 per planting season. Because in the research location, it can be harvested 3 times a year, the total income from rice farming was IDR 24,750,000 per hectare per year (Wihardjaka, 2021).

Table 1. Economic Value of Paddy Fields as a Medium for Rice Farming

No	Description	Unit	Value
	Area of Paddy Fields Converted to Non-Paddy Fields	Ha/Year	350
	Planting Index	%	300
	Average Cost of Rice Production	Million IDR/Ha	14.25
	Average Paddy Field Production	Ton/Ha/MT	5.0
	Average Price of Harvested Dry Paddy	IDR/Kg	4,500
	Economic Value of Paddy Fields as a Producing Function Rice Farming Production	Million IDR/Ha/Year	24.75
	Economic Value of Paddy Fields as a Producing Function Paddy Farming Production (350 Ha)	Billion (IDR/Year)	8.7

From table 2, it appears that the economic value of rice fields as a cultivation medium for rice farming is IDR. 24,750,000,- per hectare per year. The rice fields in the research location that are converted each year are around 350 ha. So, the loss incurred as a result of the conversion of rice fields is IDR. 8.7 billion.

Economic Value of Paddy Fields Benefits of Environmental Service Products as Flood Control

Paddy fields, especially paddy fields as flood control, are the ability of paddy fields to temporarily hold rainwater during and immediately after rain occurs. Paddy fields can function as natural pools in the form of small dams that can accommodate or hold rainwater before it flows downstream through water bodies, such as rivers, irrigation channels, and others. Paddy fields will function more in areas with high rainfall intensity, because they are able to hold surface water that can cause flooding.

The ability of rice fields to support or temporarily accommodate rainwater after rain occurs can be influenced by the area of the existing rice fields, the difference in the height of the embankment with the height of the water pool before the rain. Because the surface area of rice leaves is relatively small and the water content of the soil is relatively constant, the rice canopy and the absorption capacity of the soil in rice fields are very small in holding rainwater. So, what plays an important role here is the area and height of the rice field embankment. The height of the embankment at the research location can be seen in Table 2.

The height of the embankment at the research location ranged from 55-60 cm with an average of 53.67 cm. while the height of the water puddle in the rice fields before the rain ranged from 5-10 cm with an average of 5.50 cm. Therefore, the water holding capacity of the rice fields averaged 53.67 cm. so that one hectare of rice fields can support rainwater of 53.67 cm x 10,000 m2 or 5,367 m3/ha.

Therefore, the height of the embankment is one of the factors that can be manipulated to increase the rainwater buffer capacity in rice fields. The higher the embankment, the greater the rainwater buffer capacity and vice versa. At the research location, because farmers are more engaged in rice farming, the height of the embankment is not a problem. In contrast, farmers who can cultivate fish prioritize embankments or in other words, the embankment must be higher (Susanti et al., 2024).

Considering the large role of rice fields in temporarily accommodating rainwater before flowing downstream, if there is a conversion of rice fields to non-rice fields (into housing, industry or others) it will result in the loss of flood control capacity of rice fields equivalent to the amount of water accommodated as high as 53.67 cm (53.67 cm - 2.0 cm) or 5,367 m3/ha (5,367 cm x 10,000 m2). The value of 2.0 cm is the water holding capacity of built-up land.

Table 2. Height of Embankments and Water Levels in Rice Fields at the Research Location

No	Height of Embankment (cm) (A)	Height of Water Level Before Rain (cm) (B)	Difference Between A and B (cm) (AB)
1	60	5	55
2	60	5	55
3	55	5	50
4	60	5	55
5	60	5	55
6	60	5	55
7	60	5	55
8	60	10	50
9	60	5	55
10	55	5	50
11	60	5	55
12	60	5	55
13	60	5	55
14	60	5	55
15	60	10	50
16	60	5	55
17	60	5	55
18	60	5	55
19	60	5	55
20	60	5	55
21	60	5	55
22	60	10	50
23	60	5	55
24	60	5	55
25	55	5	50
26	55	5	50
27	60	5	55
28	55	5	50
29	60	5	55
30	60	5	55
Amount	1775	165	1610
Average	59.17	5.5	53.67

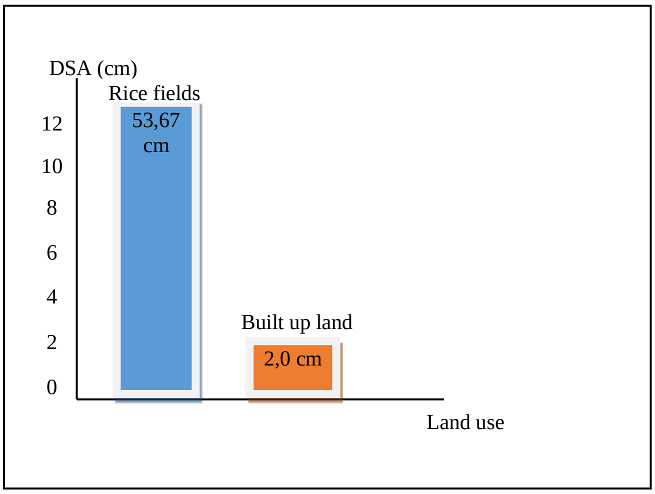

Figure 2. Water Support Capacity of Paddy Fields and Built-up Areas

Referring to the conversion of rice fields that occurred in Sidoarjo Regency, which is an average of 35.0 ha per year, while the area of rice fields in Sidoarjo Regency is 22,219 ha. In extreme cases, if all rice fields (22,219 ha) in Sidoarjo Regency are converted to non-rice fields, while other conditions do not change (ceteris paribus), then the volume of water that cannot be accommodated by rice fields in Sidoarjo Regency can be calculated as 119,249,373 m3 (22,219 ha x 5,367 m3/ha).

From the data obtained in the research area:

The height of the embankments in rice fields ranges between 55-60 cm with an average of 59.17 cm. Meanwhile, the height of the water puddles in the rice fields before the rain ranged between 5-10 cm with an average of 5.50 cm. The average water holding capacity of rice fields is 53.67 cm. So that one hectare of rice field can support rainwater of 53.67 cm x 10,000 m2 or 5,367 m3/ha.

Therefore, the height of the embankment is one of the factors that can be manipulated to increase the rainwater buffer capacity in rice fields. The higher the rice field embankment, the greater the rainwater buffer capacity and vice versa. Farmers who are more engaged in rice farming, the height of the embankment is not a problem. It is different with farmers who cultivate fish who prioritize the embankment or in other words the embankment must be higher.

The conversion of rice fields that occurs in Sidoarjo district averages 350 ha per year. Meanwhile, the area of rice fields in Sidoarjo district is 22,219 ha. In extreme cases, if all rice fields (22,219 ha) in Sidoarjo Regency were converted to non-rice fields, while other conditions remained unchanged (ceteris paribus), then it can be calculated that the volume of water that cannot be accommodated by rice fields in Sidoarjo Regency is 119,249,373 m3 (22,219 ha x 5,367 m3/ha). By knowing the water capacity of rice fields is 5,367m3 / ha,

The area of rice fields converted to non-rice fields is 350 ha/year, The capacity coefficient of rice fields to accommodate rainwater is 80 %, and the cost of making embankments at the research location by making mounds is IDR. 35,000/m3. The cost of making this embankment is the market price. Thus, to find out the economic value of rice fields as a flood control function, it can be calculated by referring to the equation formula:

$$\mathbf{NELS_s\,FPB} = (\mathbf{D_p \times A \times \alpha \times P_d})$$
$$= 5.36\,7\ m^2 \times 350\ ha \times 0.8 \times IDR.\ 3\,5\,.000/m^2$$
$$= IDR.\ 5\,2.\ 5\,96{,}600{,}000\ /year\ or$$
$$= IDR.\ 150{,}276{,}000\ /ha/year$$

flood control in the research area is IDR. 150,276,000/ha/year or IDR. 52.6 billion/350 ha. If the conversion of rice fields in the research area continues with the same proportion, the potential for the lost water buffer capacity of rice fields will be even greater and this will result in high costs for flood control required.

Table 3. Economic Value of Rice Fields Benefits of Environmental Service Products As a Flood Controller.

Description	Unit	Value
Area of rice fields converted to non-rice fields	Ha/Year	350
Water holding capacity of paddy fields	m3/Ha	5,367
Coefficient of Paddy Field Capacity to Accommodate Rainwater	%	80
Cost of Making Embankments by Making Mounds	IDR/m3	35,000
Average Economic Value of Beneficial Rice Fields Environmental Products/Services as Flood Control	Million (IDR/Year)	150.28
Average Economic Value of Beneficial Rice Fields Environmental Service Products as Flood Control (350ha)	Billion (IDR/Year)	52.6

Comparison of the Economic Value of Paddy Fields as a Medium for Rice Farming Cultivation with Environmental Service Products as Flood Control.

A benefit of rice farming cultivation media compared to the economic value of environmental service products as flood control of IDR. 24,750,000 per hectare/year compared to IDR 150,276,000 per hectare per year (1: 6).

Table 4. Economic Value of Rice Fields

Description	Unit	Value
A. As a Producer of Rice Production Cultivation Media Products		
Area of Paddy Fields Converted to Non-Paddy Fields	Ha/Year	350
Planting Index	%	300
Average Cost of Rice Production	Million IDR/Ha	14.25
Average Paddy Field Production	Ton/Ha/MT	5.0
Average Price of Harvested Dry Paddy	IDR/Kg	4,500
Economic Value of Paddy Fields as a Producing Function Rice Farming Production	Million IDR/Year	24.50
Economic Value of Paddy Fields as a Producing Function Paddy Farming Production (350 Ha)	Billion (IDR/Year)	8.7
B. Environmental Service Product Producers as Flood Controllers		
Area of rice fields converted to non-rice fields	Ha/Year	350
Water holding capacity of paddy fields	m3/Ha	2,725
Coefficient of Paddy Field Capacity to Accommodate Rainwater	%	80
Cost of Making Embankments by Making Mounds	IDR/m3	35,000
Average Economic Value of Beneficial Rice Fields Environmental Services Products as Flood Control	Million (IDR/Year)	150.28
Average Economic Value of Beneficial Rice Fields Environmental Service Products as Flood Control (300ha)	Billion (IDR/Year)	52.6

By analyzing one type of multifunctional rice field as a producer of environmental service products, namely as a flood controller, it can provide an assessment of the theory of rice field rental value. The comparison of rice field rental value for farming (rice or secondary crops) with tourism is 1:14 (LI & J., 1996). From the results of the analysis by including one type of function of the environmental product/service of rice fields as a flood controller, the comparison of the economic value of rice field rental with tourism is (1 : 6) Not counting all types of multifunctional rice fields as benefits of environmental service products. If calculating all the economic values of multifunctional rice fields for environmental service products will provide a much greater total economic value of rice fields.

The results of research in Japan (Yoshida, 2001) the multifunctional value of rice fields and rural areas throughout Japan, covering an area of 4,100,000 ha reached US$ 68.80 x 109 and of that amount, US$ 30.33 x 109 is the economic value of dry land in the form of hills and mountains, covering an area of 2,200,000 ha. At an exchange rate of IDR. 9,000/US$ the multifunctional value of rice fields in Japan reached IDR 151,000,000/ha. The greatest benefit of this economic value (90%) is the value of environmental service products as flood control, groundwater source suppliers, recreation and pleasure. Therefore, it is very reasonable for the Nagoya District Government in Japan to provide assistance to farmers of US$ 3,300 or IDR. 29.7 million/ha/year as long as farmers maintain their agricultural/rice fields.

The results of research in South Korea (Suh, 2001) show that local people are already familiar with the function of rice fields, both positive, such as providing food and food security stability, controlling erosion and flooding, and negative, such as being a source of water and soil pollution. Then (Eom & Kang, 2001) stated that there are 11 socio-economic cultural functions of rice field management /utilization known to the South Korean people. Based on the results of the study, there are 8 (eight) functions of rice fields that have received high appreciation from the community, namely: (1) as a supplier of food, (2) a source of water, (3) a binder of emotions for rural residents, (4) a provider of places or media for environmental education, (5) a place for recreation and natural scenery, (6) controlling air pollution, (7) preserving or conserving ecosystems, and (8) preventing soil erosion. Meanwhile, the functions of rice fields that have received less appreciation include (1) as a controller of the Labor market, (2) a shaper or conventional opinion, (3) a provider of burial places for corpses. Then Chen (2001) studied public perceptions regarding the environmental services of rice fields in Taiwan and the results showed that most people were familiar with the environmental services of rice fields, especially the very important ones as erosion prevention, water source providers, and flood control.

When the conversion of rice fields to non-rice fields continues to increase, for various reasons, it actually shows the low understanding and knowledge of the community about the multifunction of rice fields. So that the assessment of the economic value of the benefits of rice fields is also relatively low. As a result, farmers are only valued based on the market value of the commodities produced from their rice fields, while the value of the benefits of environmental services produced has not been taken into account.

Understanding the concept of economic valuation allows policy makers to determine the effective and efficient use of natural resources and the environment. This is because the economic valuation of natural resources and the environment can be used to show the relationship between the conservation of natural resources and the environment and economic development, so that economic valuation can be an important tool in efforts to increase public appreciation and awareness of natural resources and the environment.

Conclusion

From the results of the analysis of the economic value of rice fields as a medium for cultivating/farming rice plants in Sidoarjo Regency in 2024, it is IDR 24,750,000 per hectare/year. The conversion of rice fields to non-rice fields is 350 hectares per year, so that the economic loss of rice fields when converted is Rp. 8.7 billion. Environmental service products of rice fields as flood control are IDR 150,276,000 per hectare per year. The conversion of rice fields in the research area is 350 hectares per year, so the loss due to the conversion of rice fields as flood control is IDR 52.6 billion. The comparison of the economic value of rice fields as a benefit of rice farming cultivation media with the benefits of environmental products/services as flood control is 1: 6. This means that when rice fields are cultivated by farmers or agricultural entrepreneurs, the results obtained simultaneously are rice farming of IDR 24,750,000 per hectare per year while the results of environmental production/services as flood control are IDR 150,276,000 per hectare per year.

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Author Contributions

M.P and N.S.W: Conceptualization, developing ideas, analyzing, writing, reviewing, responding to reviewers' comments; M.P: analyzing data; M.P and N.S.W: overseeing data collection, reviewing scripts.

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Conflicts of Interest

The authors declare no conflict of interest.

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