

Increasing rice productivity and profitability through irrigation water management and bio-fertilizer in West Nusa Tenggara

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Abstract. Limited water resources in dry land area become a crucial factor in crop production. The research aims were to determine the effect of irrigation network arrangement and application of biofertilizer on rice productivity, and the feasibility of developing irrigation infrastructure to increase farmers' income. The study was conducted in Mbawa Village, Donggo District, Bima Regency, West Nusa Tenggara. In addition to repairing irrigation network, five different cultivation practices were applied, i.e. (1) farmer's practice with integrated crop management, (2) farmer's practices added with biofertilizers, (3) Recommended dosage fertilization, (4) Recommended dosage fertilization added with biofertilizer, and (5) farmer's practices as control. Farming analysis was carried out by calculating farm cash flow, while the feasibility of developing irrigation infrastructure was carried out by calculating IRR, NPV and Net BCR. The results showed that application of biofertilizer increased the production of straw and rice yields. Farming and financial analysis of irrigation infrastructure showed that irrigation infrastructure investment was feasible to develop with a relatively fast return on capital and can increase farmers' income. Through improved irrigation infrastructure, the use of biological fertilizers, and proper irrigation water management can increase rice productivity and farmers' income.

1 Introduction

Management of water resources is one of the important aspects in increasing the cropping index, especially in dry land. Currently, total dry land in Indonesia was 144.47 million ha and around 91.53 million ha (63.35%) was land suitable for agriculture sector, and 36.67% suitable for food crops [1]. Based on the climate classification, the dry land can be grouped into dry land with a wet climate for about 133.7 million ha and dry land with a semi-arid climate for about 10.8 million ha [2]. Almost half of the dry land with a semi-arid climate was located in the Provinces of West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT) (48.2%), and the rest spread in the east area of Indonesia [3].

Bima Regency, NTB Province is part of a dry land with semi-arid climate where the water supply for agriculture is scarce, especially during the dry season of planting. Lack of

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water availability for agriculture causes crop productivity will not be optimal and the average cropping index (IP) was 1 crop per year (IP 100). Water management and the use of drought tolerant varieties, as well as land management through increasing soil fertility could be considered as important factors to increase land productivity and profitability. Water-saving irrigation or supplying crop water requirement can increase the area of irrigation services so as to increase the cropping index and agricultural production [4]. In general, water supply at tertiary level usually was not sufficient to irrigate rice fields. The high water loss on delivering water to the rice fields was generally triggered by the bad condition of the damaged channel. One of the efforts to reduce water loss and increase the discharge in the rice fields is lining the waterways or channel. The loss of water in the canal is generally caused by infiltration, evaporation and water leaks or seepage which caused decrease irrigation efficiency. The decrease in irrigation efficiency in the distribution of semi-technical irrigation networks was reach to 47.61% that was lower than the ideal value of irrigation efficiency of 68.8% [5].

In addition to adequate water availability for plants cultivation, increasing soil fertility through fertilization will result in optimal crop production. Soil fertility in dry land and semi-arid climates was generally low due to shallow soil solum and rocky land, especially on sloping land. However the use of biological fertilizers in flat rice fields can increase land and crop productivity. Biological fertilizers are useful for increasing the growth and productivity of food crops (rice/soybeans), horticulture (chilies/vegetables), and plantations (sugarcane) [6,7,8]. The application of biofertilizer Agrimeth in lowland rice and field rice farming can save the use of inorganic fertilizers N, P, and K by 50% and increase the income of rice farmers [6]. Moreover, the use of biofertilizer can also reduce the use of N, P, and K fertilizers by up to 50% in horticultural crops [7]. The use of biofertilizer was also able to increase rice yield by 1.4 tons/ha or an increase of 20.77% and was able to reduce the use of inorganic fertilizers by up to 25% [8]. Combination of inorganic fertilizer and biofertilizer increase the height, bar diameters, bar weight, and root weight of sugarcane cultivation [9].

Irrigation networks on paddy fields in Mbawa village, Donggo sub-district, Bima district, NTB are generally in poorly maintained condition. Water distribution was not optimal due to damage in some parts of channel causing an increase water loss during distribution. Furthermore, the use of biological fertilizers that increase plant productivity has been done somewhere, but has not been used at the farmer level for various non-technical reasons, such as unavailable in market during rice growing season and factors of farmers' habits [3]. This study aims were to understand the effect of biofertilizers and irrigation network infrastructure arrangement on rice productivity and profitability.

2 Materials and methods

2.1 Materials

The research was conducted from January to June 2019 in Mbawa Village, Donggo District, Bima Regency. The materials used in this study were: rice seeds (Situ Bagendit variety), inorganic fertilizers (phonska and urea), biofertilizer, insecticides, pesticides, and building materials (river stone, sand, cement, etc).

2.2 Methods

2.1.1 Arrangement of Irrigation Network

The arrangement of the irrigation network was carried out on the rice farm for length of 900 m. There has been made a new irrigation channel of 600 m and repaired (lining) of existing irrigation channels of 300 m. Irrigation network was improved by repairing on damaged part of channel to normally serve water delivery and can suppress water loss due to seepage or infiltration into the soil.

2.1.2 Experimental design

There were 5 treatment combinations of the experiment applied that was layout as a randomized block design with 4 replications. The rice field used in this experiment was 50 ha, involving 40 farmers as cooperator. Those treatments were:

1. Farmer practice (FP): Fertilizing according to the farmer's method, namely using a dose of 300 kg urea/ha and phonska 50 kg/ha, following the technical guidelines for integrated crop management (ICM) for upland rice cultivation (PHy0),
2. FP + biofertilizer (PHy1),
3. Recommended dose of fertilization (RF) (250 kg urea/ha and phonska 200 kg/ha) applied 3 times (AHy0),
4. RF+ biofertilizer (AHy1),
5. Fertilizing according to the farmer's method, namely using a dose of 300 kg urea/ha and phonska 50-100 kg/ha with their own farmer's cultivation method (non-cooperator farmers) as control (PM).

Parameters measured in this experiment includes yield on dry-harvested rice (DHR) and dry-milled rice (DMG) and the straw. Data was collected by fields' observations and analyzed statistically using analysis of variance (ANOVA) using Minitab 16.

2.1.3 Financial-economic analysis of farming system

Farming feasibility analysis was conducted to determine the feasibility of the farming business developed from a financial aspect. The indicators to determine the feasibility of a project to be disseminated can be through the calculation of the Net Benefit Cost Ratio (Net BCR), Net Present Value (NPV), Internal Rate of Return (IRR) [10]. Net Benefit Cost Ratio (Net BCR) is the ratio between the number of positive NPVs and the number of negative NPVs or the ratio between the benefits and financing of a project to be implemented and is calculated using the formula as follows [11]:

$$BCR = \frac{Benefit}{Cost} \quad (1)$$

The indicators of the BCR value as follows [12]:

BCR>1 indicating the farming is profitable,

BCR<1 indicating the farming is unprofitable or unfeasible,

BCR=1 indicating the value of farming cost and profit was equal.

Net Present Value (NPV) is the present value of the difference between benefits and costs at a certain discount rate.

$$NPV = \text{Present Value Cash Flow} - \text{Present Value Investment} \quad (2)$$

NPV describes profits and feasible if it has a positive value. If $NPV = 0$, then the investment made is neither profitable nor loss (marginal or mediocre), indicating that the investment can be implemented or not. If the $NPV < 0$ then the business is detrimental so it is better not to do it. Internal Rate of Return (IRR) is a project's ability to repay loan interest from internal financial institutions that finance the project/business and calculated using the formula as follows [13]:

$$IRR = i_1 \frac{NPV_1}{NPV_1 - NPV_2} \times (i_1 - i_2) \quad (3)$$

Where, i_1 is discount rate at NPV_1 and i_2 is discount rate at NPV_2 .

Data was collected by measurable observations of cooperator farmers and interviews with non-cooperator farmer. The median test for each variable (expenditure, income and benefit) of rice farming system for each farming group was calculated by Two-Sample T-test using Minitab 16.

3 Results and discussions

3.1 Characteristics of Bima Regency

Bima Regency, which is part of the Province of West Nusa Tenggara (NTB), is laid at the eastern part of the Province of West Nusa Tenggara (NTB). The total area of Bima Regency was 4,374.65 km², consisting of 315.96 km² or 7.22% of irrigated rice fields and 4,058.69 km² (92.78%) of non-rice fields (dryland) [14]. One of the sub-districts in Bima Regency is Donggo District which has an area of 123.83 ha and was divided into 9 villages, where the largest village is Mbawa Village and the smallest is Doridungga Village. The Donggo sub-district is bordered by the Soromandi sub-district in the north and east, Madapangga and Bolo sub-districts in the south, and Dompu district in the west.

The area of irrigated rice field in Donggo District was 1,376 ha. The harvested area for food crops is 4,031 ha, the harvested area for vegetables is 22 ha, and the harvested area for fruits is 77 ha, and the harvested area for plantation crops is 230 ha. In particular, at the study location in Mbawa Village, the area of rice fields reaches 237 hectares and dry fields/fields reach 741 hectares, as well as state forest which is partly used by the community for agriculture through the PHBM program (Community Forest Management) covering an area of 1,348 hectares [15]. The research location is in Sangari Village, Mbawa Village, Donggo District, Bima Regency, located at the top of a hill with a hilly topography. The slope was slightly steep and contains 25-35% rock on the ground surface. The area of land that has the potential to increase cropping index (IP) was around 30 ha if a water source is available. With river water discharge of around 1.5 – 2.5 l/second, there is a potential for increasing IP through maize cultivation at planting season of 3. In addition, there are potential rice field lands of approximately 50 ha to improve the IP located at the bottom of the hill. The land was irrigated paddy field and its irrigation comes from a reservoir built by the government. The discharge at the top point of the land was about 8 l/second. The land was used for cultivation of several crops such as soybeans, corn, peanuts, and watermelon [16].

3.2 Irrigation network design

The irrigation system in dry and rocky land developed in Mbawa Village, Donggo District, Bima regency comes from a river that was channeled through a channel reservoir built since

2013. However, the condition of the channel in some parts was damaged and other parts the channel was built using soil. Thus, the channel needs to improve and rebuild.

There has been made a new irrigation channel of 600 m and repaired (lining) of existing irrigation channels of 300 m in order to increase land productivity through increasing the cropping index from 1 time to 2 plantings for 50 ha of rice dryland. Channel lining served to reduce water loss, prevent scouring and erosion, prevents the development of aquatic plants, and reduces maintenance costs. Irrigation investment through this lining becomes very important and strategic effort in the context of providing water for agriculture. The decline in the condition and function of the channel lining generally results in leakage and landslide of the channel embankment. Water loss in the channel other than leakage was also caused by the accumulation of garbage in the channel, and the growth of wild plants along the channel [17].

Disruption or damage to one part of irrigation building will affect the performance of water delivering system, resulting decreased in efficiency and effectiveness of irrigation. If this condition is allowed to continue and is not immediately addressed, it will have an impact on the expected decline in agricultural production, and have negative implications for farmers' income and impacted on social and economic conditions around the location [18].



Fig. 1. Channel condition before (A) and after (B) rebuilt

3.3 The effect of biofertilizer on rice cultivation

Rice cultivation in dryland was carried out on a 50 ha, involving 2 farmer groups, namely the Ndano Ranga 1 and Ndano Ranga 2 farmer groups. Land preparation was carried out without tillage by clearing the land and spraying the herbicides gramoxone and lindomin. After the soil moisture was high enough with minimum of 50 mm of rainfall within 20 days, the farmers plant rice by dibbling at spacing of 20 x 20 cm without planting lines. Selective herbicides were sprayed if weeds had grown.

In general, the application of biofertilizer at various combinations of fertilizer treatments did not give significantly different rice yields for the dry-harvested rice (DHR). However, in this study there was a tendency to increase the yield of dry-milled rice (DMR) with the application of biofertilizers. Several research results show that the use of biofertilizers can increase rice productivity [19,20]. The use of inorganic fertilizers and biological fertilizers not only increased rice yields but it also reduced the use of inorganic fertilizers [21,22]. The results of other studies show that the right combination of biological fertilizers and inorganic fertilizers can increase rice yields [23,24].

Yield of rice at DHR and at DMR at various treatments is presented at Figure 2. The results of experiment in the Figure 2 shows that the highest yield of rice was obtained at treatment AHy1 (recommended doze of fertilization with biofertilizer) in both grain moisture conditions of DMR and DHR (5.6 ton/ha), although this was not significantly different with

treatment PHy1 (farmer practice with biofertilizer). The lowest rice yield was obtained from PM (non-cooperator farmers method/control) treatment although this was not significantly different with treatment PHy0 (farmer practice) and AHy0 (recommended doze of fertilization without biofertilizer). This result indicated that biofertilizer was able to increase rice yield on average of 0.7 ton/ha on DHR based or 0.9 ton/ha on DMR based compared to PM treatment. Rustiati and Widyantoro state that the application of agrimeth biofertilizer can increase up to 21,72% for Inpago 8 varieties rice yield [25].

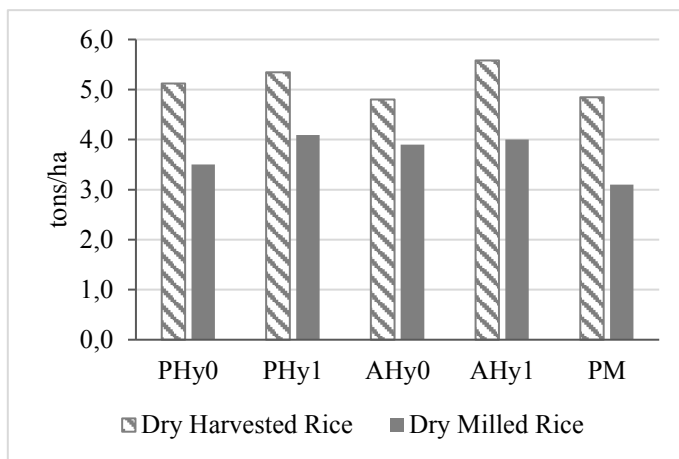


Fig. 2. Rice yield on DHR and DMR based on various treatment of fertilizer.

A two way anova test was conducted to determine the effect of various types of fertilization on rice and straw productivity. The result of analysis showed that the various types of fertilization is not have significant effect on rice productivity with P-value of 0,143 which was greater than the value of $\alpha = 0.05$. However, when further test (Tukey Simultaneous Tests) was carried out, recommended dose of fertilization with biofertilizer (agrimeth) was proven to increase rice yields compared to other fertilization methods showed in Figure 3. We can see the difference of means of each treatment, value of AHy1 is positive compared to AHyo. PHy0, PHy1, and PM are negative compared to AHy1, which means that recommended dose of fertilization with biofertilizer was better than fertilization with other methods.

General Linear Model: Rice Yields versus Treatments; Types of Rice Yields							
Factor	Type	Levels	Values				
Treatments	fixed	5	AHy0; AHy1; PHy0; PHy1; PM				
Types of RY	fixed	2	DHR; DMR				
Analysis of Variance for Rice Yields, using Adjusted SS for Tests							
Source	DF	Seq SS	Adj SS	Adj MS	F	P	
Treatments	4	3,4480	3,4480	0,8620	1,86	0,143	
Types of RY	1	19,8179	19,8179	19,8179	42,87	0,000	
Treatments*Types of RY	4	0,8923	0,8923	0,2231	0,48	0,748	
Error	30	13,8679	13,8679	0,4623			
Total	39	38,0261					
S = 0,679900 R-Sq = 63,53% R-Sq(adj) = 52,59%							

Fig. 3. ANNOVA Test Result for Rice Yields

Tukey Simultaneous Tests				
Response Variable Rice Yields				
All Pairwise Comparisons among Levels of Treatments				
Treatments = AHy0 subtracted from:				
Treatments	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
AHy1	0,4402	0,3400	1,295	0,6963
PHy0	-0,0287	0,3400	-0,084	1,0000
PHy1	0,3706	0,3400	1,090	0,8101
PM	-0,3657	0,3400	-1,076	0,8174

Treatments = AHy1 subtracted from:				
Treatments	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
PHy0	-0,4689	0,3400	-1,379	0,6451
PHy1	-0,0696	0,3400	-0,205	0,9996
PM	-0,8059	0,3400	-2,371	0,1514

Fig. 4. Anova further test result using Tukey Simultaneous Test

Rice straw production at various fertilization treatments is shown on Figure 4. There was a tendency that rice straw was higher in the (AHy1) compared to other fertilization methods. The yield of wet straw in the AHy1 treatment reached the highest yield of 32.8 tons/ha and the lowest was in the PM treatment, which was 24.0 tons/ha. The production of dry straw in the AHy1 treatment reached 10.3 tons/ha and the lowest was in the farmer method (PM) at 7.0 tons/ha.

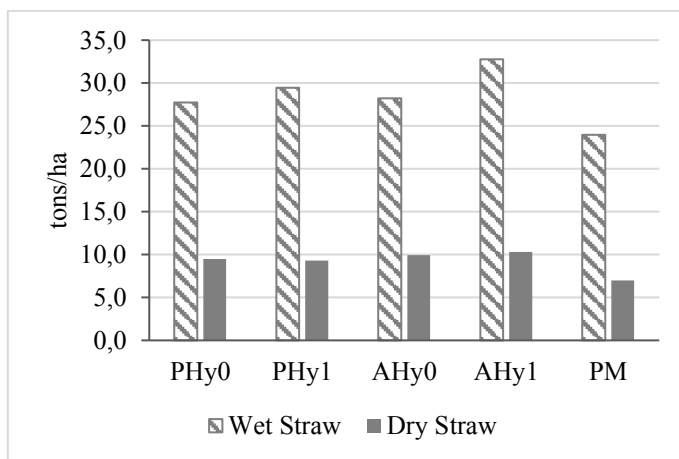


Fig. 5. Wet and dry straw yields at various fertilizer treatments

The result of two way anova test showed that the various types of fertilization is have effect on straw productivity with P-value of 0,000 which was lesser than the value of $\alpha = 0.05$. Recommended dose of fertilization with biofertilizer was proven to increase straw productivity compared to other fertilization methods.

General Linear Model: Straw Yields versus Treatments; Types of Straw							
Factor	Type	Levels	Values				
Treatments	fixed	5	AHy0; AHy1; PHy0; PHy1; PM				
Types of Straw	fixed	2	Dry Straw; Wet Straw				
Analysis of Variance for Straw Yields, using Adjusted SS for Tests							
Source		DF	Seq SS	Adj SS	Adj MS	F	P
Treatments		4	152,17	152,17	38,04	10,41	0,000
Types of Straw		1	3688,33	3688,33	3688,33	1009,60	0,000
Treatments*Types of Straw		4	36,65	36,65	9,16	2,51	0,063
Error		30	109,60	109,60	3,65		
Total		39	3986,75				
S = 1,91135 R-Sq = 97,25% R-Sq(adj) = 96,43%							

Fig. 6. ANNOVA Test Result for Straw Yields

3.4 Financial analysis of farming system and irrigation infrastructure

3.4.1 Financial-economic analysis of farming system

Financial analysis of rice farming system after irrigation infrastructure has been improved is presented in Table 1. In general, BC ratio value that more than zero indicated farmers have gained the profit by using improved infrastructure. The average BC ratio value was obtained at 0.66, meaning that one rupiah of capital used by farmers in their farming expenditure will provide benefits of 0.66 rupiah. The BC ratio was varies in the range of 0.08 – 1.61.

Table 1. Variation of cost and revenues of cooperator farmer

No	Name	Land size	Cost	Revenue	Benefit	BCR
1	Jaenab	0.49	5,387,000	8,928,000	3,541,000	0.66
2	Anwar, S. Pd	0.50	3,920,000	4,216,000	296,000	0.08
3	Sukardin	0.67	4,164,500	8,400,000	4,235,500	1.02
4	H. Ismail	0.37	3,771,000	7,688,000	3,917,000	1.04
5	M. Umar	0.45	4,754,500	7,200,000	2,445,500	0.51
6	M. Umar Ishaka	0.68	6,614,500	7,200,000	585,500	0.09
7	Ahmad	0.30	4,856,500	6,944,000	2,087,500	0.43
8	Kasmir	0.25	3,140,000	6,448,000	3,308,000	1.05
9	Hadijah Abbas	0.58	6,512,500	12,960,000	6,447,500	0.99
10	Nasrudin, S. Pds	0.60	7,270,500	12,648,000	5,377,500	0.74
11	Ibrahim Tayeb	0.75	5,605,000	7,440,000	1,835,000	0.33
12	Lutfi Manan	0.72	6,752,500	12,896,000	6,143,500	0.91
13	Sukirman	0.24	2,686,000	4,216,000	1,530,000	0.57
14	Suaeb, S. Pd	1.05	11,370,000	21,328,000	9,958,000	0.88
15	Syamsuddin	0.47	4,808,000	9,360,000	4,552,000	0.95
16	Kalisomn	0.25	3,420,000	5,208,000	1,788,000	0.52
17	Rahmah, S. Pd	1.00	6,915,000	10,500,000	3,585,000	0.52
18	M. Nur	0.25	2,920,000	4,760,000	1,840,000	0.63
19	Hadijah AR	0.62	10,437,000	17,608,000	7,171,000	0.69
20	Usman	0.50	4,420,000	7,936,000	3,516,000	0.80
21	M. Said	1.00	8,555,000	12,400,000	3,845,000	0.45
22	Supardi	1.20	8,363,000	16,800,000	8,437,000	1.01
23	Nasarudin	0.30	5,170,000	5,985,000	815,000	0.16
24	H. Ismail	0.60	5,170,000	9,450,000	4,280,000	0.83
25	Amirudin	0.40	3,629,000	4,712,000	1,083,000	0.30
26	Syafrudinn	0.35	5,300,000	7,875,000	2,575,000	0.49
27	Anwar	0.40	5,962,500	8,100,000	2,137,500	0.36
28	Ibrahim	0.35	4,705,000	7,425,000	2,720,000	0.58
29	H. Sulaiman	0.50	5,695,000	9,900,000	4,205,000	0.74
30	Abdullah	0.50	4,820,000	7,200,000	2,380,000	0.49
31	Supriadin	0.50	5,170,000	7,200,000	2,030,000	0.39
32	Burhan	0.43	3,410,000	6,600,000	3,190,000	0.94
33	Abidin	0.35	3,532,500	4,750,000	1,217,500	0.34
34	Hamsidi	0.25	2,260,500	5,850,000	3,589,500	1.59
35	Ibrahim	0.30	2,680,000	5,850,000	3,170,000	1.18
36	H. Abdullah	0.30	3,551,500	5,200,000	1,648,500	0.46
37	H. Ismail	0.80	6,595,000	8,680,000	2,085,000	0.32
38	M. Hasan	0.80	6,260,000	9,207,000	2,947,000	0.47
39	H. Yusuf	0.56	3,551,500	9,272,000	5,720,500	1.61
40	Abakar	0.46	5,305,000	7,800,000	2,495,000	0.47
	Total	21.09	209,410,000	344,140,000	134,730,000	26.59
	Average	0.53	5,235,250	8,603,500	3,368,250	0.66

To find out changes in the scale of farming from the development of irrigation infrastructure, it is necessary to compare between farmers who are involved in the research (cooperative farmers) and farmers who are not involved in the research (non-cooperative) in the area. A total of 11 non-cooperative farmers have been interviewed as shown in Table 2. It can be seen that the value of the BC Ratio of cooperative farmers (Table 1) was greater than that of non-cooperative farmers. Data obtained from non-cooperator farmer is the result of interviews so that data b Through the improvement of irrigation infrastructure, the cooperative farmers are able to expand their irrigated land which impact on their rice

productivity and income. It also caused by some of non-cooperative farmer are unable to do farming due to their land does not have water supply so that farmers' income were considered zero.

Table 2. Variation of cost and revenues of farmer non-cooperator

No	Name	Land size	Cost	Revenue	Benefit	BCR
1	Lutfi	0.25	2,530,000	2,976,000	446,000	0.18
2	H. M. Saleh	1.25	8,835,000	12,648,000	3,813,000	0.43
3	M. Amin	0.91	7,220,000	19,680,000	12,460,000	1.73
4	M. Nur	0.43	3,753,500	7,056,000	3,302,500	0.88
5	NurIna	0.25	-	-	-	0.00
6	Ahmad Kosimi	0.40	-	-	-	0.00
7	Fuad	0.38	3,998,000	6,944,000	2,946,000	0.74
8	Cahyadin	0.31	4,164,000	6,240,000	2,076,000	0.50
9	H. Hasan Musa	0.71	6,353,000	15,103,200	8,750,200	1.38
10	Nurasia	0.50	-	-	-	0.00
11	Mukmina	1.20	-	-	-	0.00
	Total	6.59	36,853,500	70,647,200	33,793,700	5,84
	Average	0.60	5,264,786	10,092,457	4,827,671	0.53

Furthermore, the median test for each variable was conducted in order see partially between expenditure, income and benefit of rice farming system for each farming group using Two-Sample T-test level 95%. The result of analysis showed that the construction of irrigation infrastructure increased farmers' expenditure for their farming business with P-value of 0.086 which was greater than the value of $\alpha = 0.05$. In term of revenue, it indicated that the construction of irrigation infrastructure increases farmers' income for their farming business with a P-value of 0.821 which was greater than $\alpha = 0.05$. The value of revenue was greater than expenditure indicating that even though the construction of irrigation infrastructure increases farming expenses, farmers still benefit from the results of their rice farming culture.

3.4.2 Financial analysis of irrigation infrastructure

Financial analysis of irrigation infrastructure was carried out to see the feasibility of investing in irrigation infrastructure development. The benefit provided from irrigation infrastructure is the addition of agricultural income of farmers due to an increase in the cropping index. Table 1 was used to calculate the flow of benefits and expenditure of irrigation infrastructure investment for 10 years at an average general investment interest rate of 6% as referred to Bank Indonesia in April 2019 [26] (Table 3).

From the three criteria for assessing financial feasibility, namely IRR, NPV and Net BCR, it is shown that the irrigation infrastructure investment in the research location was very feasible with a fairly fast return on capital at the 3rd year after irrigation infrastructure development.

Table 3. Criteria for assessing financial feasibility irrigation infrastructure investment at the site.

No	Feasibility criteria	Feasibility limited	Value	Note
1	IRR	> 6%	> 50%	Feasible
2	NPV	> 0	802,945,283	Feasible
3	Net BCR	> 1	14	Feasible
4	Payback Periode	Fast	3 year	Very fast return

4 Conclusions

In general, the application of recommended doze of fertilization with biofertilizers increase rice and straw yields compared to control (PM), although it is not significantly different compared to farmers’ practice with biofertilizer. The income of farmers who utilize irrigation infrastructure was higher than farmer who not use irrigation infrastructure. Improvement of irrigation infrastructure will increase planting area and cropping index of rice which may increase farmers' income.

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