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THE FINANCIAL FEASIBILITY OF RICE DRYERS: A Case Study in Subang District, West Java

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ABSTRACT

Drying is a critical activity in rice postharvest handling. Any delay in drying will result in quality and quantity losses. Farmers and traders prefer to sell wet grain rather than dried grain of unhulled rice due to less attractive incentive for them to do drying. The study was conducted in Subang District, West Java, during March-June 2011 using survey method to analyze the financial feasibility of rice dryers. The respondents interviewed were 15 rice millers who have either sun-drying floor or mechanical dryer, or both. The main collected data were the investment cost, operational cost, maintenance cost, and the revenue of the dryers. The data were analyzed by using short-term and long-term financial analyses to assess the profitability and feasibility of some drying technologies. The results showed that there were at least three drying technologies in the study area, namely sun-drying floor, flatbed dryer using gas fuel (gas dryer), and flatbed dryer using rice husk fuel (husk dryer). Under the mean capacity, the short-run MBCR of technological change from sun dryer to gas dryer was 1.29, while from sun dryer to husk dryer was 1.45. The long-run analysis showed that the IRRs were 44.44% for sun dryer, 233.47% for gas dryer, and 260.49% for husk dryer. These results showed that among the three drying technologies, husk dryer is the most profitable, most feasible, and most prospective to be adopted. Therefore, this type of dryer should be intensively promoted to the farmers' group associations, rice traders, and rice millers. The government support in terms of rice dryers for farmers' group associations should be focused on husk dryer.

[***Keywords***: Rice, dryers, economic analysis, feasibility study, West Java]

INTRODUCTION

Drying is a critical activity in rice postharvest handling. Rice is usually harvested at grain moisture content between 24% and 26%. Any delay in drying, incomplete drying, or uneven drying of harvested rice will result in quality and quantity losses, including yellowing or discoloration, reduced milling yields, loss of seed germination and vigor, and damage caused by insects that are more active at high moisture content (IRRI 2009).

The types of dryers currently used by the rice millers in Indonesia much depend upon the scale of rice millers. The small rice millers are commonly using sun-drying floor. Most of medium rice millers are using both sun-drying floor and flatbed mechanical dryer and some of them remains using sun-drying floor only. The big rice millers are mostly using sun-drying floor, flatbed mechanical dryer, and continuous vertical dryer.

The problems of using sun-drying floor, among other are: (1) it needs more space, while land is becoming limited; (2) it much depends upon weather condition, especially during wet season; (3) it causes a higher loss due to animal and other disturbances; and (4) it results in low quality of grain due to sudden rain, dust, and other foreign materials contamination (Nugraha *et al*. 2007; Swastika and Sutrisno 2010). The flatbed mechanical dryers are mostly using kerosene as fuel (called kerosene dryer). The problem occurred when the price of kerosene was sharply increasing due to subsidy removal. Many flatbed dryers with kerosene fuel were idle because drying using kerosene dryer is costly. Therefore, some rice millers currently convert their kerosene furnaces into gas furnaces for rice dryers. However, since the gas is being subsidized, it is remain fine, but if in the future gas is not subsidized anymore, the same problem with kerosene dryers will occur. The vertical continuous dryer using high technology is very expensive and unaffordable for the small and medium rice millers.

The most prospective rice dryer in the future is flatbed dryer using rice husk as fuel. Rice husk at the rice millers is now abundant and remain considered as a waste. This by-product of rice millers is a prospective source of energy for rice drying to maintain even to improve rice quality.

Adnyana *et al*. (2003) reported that the main problem of rice quality improvement in Indonesia is that there is less attractive incentive for farmers to do drying. On the other hands, farmers need immediate cash, so that they mostly sell wet rice grain. Swastika (2010) also reported that farmers and traders in

Subang, West Java, prefer to sell wet rice grain rather than dried rice grain because selling dried rice grain is currently less profitable compared to selling wet rice grain.

The main problem is that, if the marketing channel of rice grain is long enough and all traders selling wet rice grain, the drying process will be late. Consequently, the rice grain will be easily to damage and yellowing, resulting in a deterioration of grain quality before reaching rice millers. This quality loss will significantly reduce the quality and then the value of milled rice. If this case continuously happened, the Indonesian rice will not be able to compete in both domestic and international market. Meanwhile, most of rice producing countries are currently giving more attention to improvement of rice quality to meet the consumers' demand for high quality rice. Thailand, for example, pays much attention to the development of premium products by improving postharvest handling and processing to ensure higher grain quality (Isvilanonda *et al*. 2008). This country has rapidly developed the quality of its rice to serve the high demand for premium rice, especially among upper class consumers in European countries who have high purchasing power (Pratruangkrai 2010).

The objectives of this study were: (1) to identify the drying technologies being used in the study area; (2) to assess which technology is the most profitable and feasible to be adopted; and (3) to design policy recommendations that will make the drying business more attractive in Indonesia.

METHODOLOGY

Justification

Rice drying is the activity to remove moisture content of grain to make it more storable without causing quality deterioration and ready to mill. Since drying is the key point to maintain and improve the grain quality, then it is a very important activity to be done before rice grain is reaching rice miller. However, some traders claimed that drying is expensive and not a profitable business. Thus, they are not interested to do investment in drying. This claim is questionable and needs to be proven. The author was interested to prove the above claim by doing a feasibility study of rice drying in Subang District, West Java, where the project on "Strategy for Improving the Rice Postharvest System in Indonesia", the collaborative project between FAO and Ministry of Agriculture, took place.

Location, Time, and Respondents

The survey was conducted in Subang District, West Java, from 25 March to 5 June 2011. The respondents of the study were the rice millers who have some types of dryers, such as sun-drying floor, mechanical flatbed dryer using gas fuel, and mechanical flatbed dryer with rice husk fuel. A number of 15 rice millers who have either sun-drying floor or mechanical dryer or both sun-drying floor and mechanical dryer were interviewed. The interview was also done for some resource persons such as scientists from the Indonesian Center for Postharvest Research and Development, Indonesian Center for Agricultural Engineering Research and Development, and some resource persons from the Directorate of Postharvest, Directorate General of Food Crops. As a comparison, the experience of other countries in drying development was also investigated through published articles. In addition, the local workshop that makes the dryers was also interviewed.

Data Analysis

The data were collected by interviewing the above mentioned respondents using structured questionnaire. The data collected consisted of investment cost, rate of interest of capital, estimated economic life of the dryer, annual maintenance cost, annual operational cost, renting rate of dryer, capacity of dryer per load, duration of drying per load, price of wet grain, price of dried grain for each type of dryer, conversion rate from wet to dried rice grain and from dried grain to milled rice for each type of dryer, and other relevant data and information.

The data analyses consisted of short-term analysis, such as annual profit and annual marginal benefit-cost ratio (MBCR), and long-term analysis consisting of pay back period (PBP), net present value (NPV), benefit-cost ratio (B/C), and internal rate of return (IRR). The annual profit is the profit earned from a technology in one year. The MBCR is the ratio between the additional benefit and the additional cost due to change in technology. It means the amount of additional income earned per unit of additional cost as a consequence of changing a technology.

The PBP is representing the duration (year) when the cumulative value of return is equal to cumulative value of investment and operational cost (without discount factor). The B/C is the ratio between total discounted benefit and total discounted cost along the economic life of the investment. The investment is feasible if the B/C is greater than 1.00. The NPV is the total discounted profit along the economic life of the dryer. The dryer is feasible if the NPV is markedly positive. Meanwhile, the IRR is the discount rate where the NPV is equal to zero (Gittinger 1982). The investment is feasible if the IRR is greater than the interest rate of cash capital.

In mathematical form, the analysis can be formulated as follows.

A. Short-term analysis (annual profit and MBCR)

$$\Pi t = (B_t - C_t) \quad \ldots (1)$$

$$MBCR = (B_{tj} - B_{ti}) / (C_{tj} - C_{ti}) \quad \ldots (2)$$

Where:

Π_t = annual profit
B_t = total benefit in year t
C_t = total cost in year t
MBCR = the marginal benefit cost ratio
B_{tj} = benefit in year t of j-technology
B_{ti} = benefit in year t of i-technology
C_{tj} = total cost in year t of j-technology
C_{ti} = total cost in year t of i-technology

B. Long-term analysis

Pay back period is the period (t = n), such that:

$$\sum_{t=1}^{n} (B_t) = \sum_{t=1}^{n} (C_t) \quad \ldots (3)$$

$$NPV = \sum_{t=1}^{n} ((B_t - C_t) / (1+r)_t) \quad \ldots (4)$$

$$B/C\ ratio = \frac{\sum_{t=1}^{n} ((B_t) / (1+r)^t)}{\sum_{t=1}^{n} ((C^t) / (1+r)^t)} \quad \ldots (5)$$

The IRR is the discount rate (r) such that:

$$\sum_{t=1}^{n} ((B_t - C_t) / (1+r)^t) = 0 \quad \ldots (6)$$

Where :

NPV = the net present value
r = the discount rate, is assumed at 12%
t, ... n = the life time of the project
$1 / (1+r)^t$ = the discount factor
$(1+r)^t$ = the compounding factor
Σ = the summation

All investment costs of dryers before 2010 were converted into 2010 value by using the compounding factor. Thus, the starting year of long-term analysis was 2010. The economic life time of the dryers was assumed to be 15 years.

RESULTS AND DISCUSSION

Types of Dryers Used by Rice Millers

There were at least three types of dryers observed in the study area, namely sun-drying floor, flatbed (mechanical) dryer using gas fuel, and flatbed dryer using rice husk fuel. There was also a vertical continuous dryer with the higher level of technology, but it was used by the big rice millers because it is not affordable for the medium and small scale rice millers. This finding is in agreement with the study of Swastika and Sutrisno (2010). Currently, none of rice millers used kerosene fuel anymore for drying rice grain due to expensive price of kerosene. All kerosene furnaces have been converted into gas furnaces.

Some rice millers have constructed mechanical dryers with rice husk furnaces. Unfortunately, most of them did not confident yet about the technology of using husk fuel. They thought that the ash of rice husk will contaminate the grain and its smoke causes a bad smelt of the grain. Actually, if they use this technology properly, there will be no ash contamination and no smelt of smoke. As a result, most of rice millers were reluctant to use husk dryer and converted husk furnaces into gas furnaces. They preferred to use liquid petroleum gas (LPG) which is now subsidized by the government. In the future, when the gas is not subsidized anymore, drying rice grain using gas will be expensive. Thus, using rice husk is the most prospective technology, along with anticipating the price hike of LPG.

In terms of drying technology development, Indonesia remains left behind compared to other rice producing countries. Currently, there are many types of mechanical drying technologies using various sources of energy, such as kerosene, gas, rice husk, and other sources of energy. They are widely spread in the rice producing countries. McLeod *et al*. (1999) stated that there are many mechanical dryers used in Thailand including column dryers, fluidized-bed, and in-store aeration systems. The fluidized-bed rice dryer was first commercialized in Thailand in 1995. Soponronnarit (1999) and Srzednicki and Driscoll (2008) reported that in Thailand, more than 100 fluidized-bed dryers have been adopted by rice millers or feed millers (for corn). The new prototype of rice dryer, called microwave-vacuum, was also introduced in Thailand. Microwave-vacuum drying offers a feasible alternative for drying rice grain. The rate of drying varies within the microwave powers. The volume expansion and water absorption for a microwave-vacuum drying were lower than that of conventional process (Cheenkachorn 2007). The prototypes of fluidized-bed dryers were also developed in Vietnam, the Philippines, and India (Wiset *et al*. 2005). Srzednicki and Driscoll (2008) reported that in China, particular emphasis has been put on refining the design of in-store dryers. To be able to efficiently use the floor space, the designers choose vertical silos with a radial flow from bottom to top, instead of the horizontal flow.

Guo *et al*. (2010) reported that since the 1980s, China began to study in-store drying of grain in the mid-1990s. The advantages of this technology, among other are: (1) lower energy consumption; (2) the initial moisture content of grain is allowed to increase from 16% to 25%; (3) the bulk allowable depth of rice increased from 1.8 m to 6.0 m; and (4) it was competitive with rice drying throughout the world.

Short-Term Profitability of Three Types of Dryers

From all samples, the average volume of rice drying were 25, 30, and 25 tonnes per process, respectively, for sun-drying floor, gas dryer, and husk dryer. The frequency of drying were 31, 43, and 48 times per year, for the consecutive dryers. The lowest frequency was the sun-drying floor because the use of this dryer is highly dependent upon weather condition.

By taking into account the fixed and operational costs, the average costs of rice drying were Rp109, Rp150, and Rp113 kg^{-1} of wet grain, respectively, for sun-drying floor, gas dryer, and husk dryer. In terms of mechanical dryer, using husk dryer is the cheapest way to dry rice grain. Sudaryono *et al*. (2003) reported that the average cost of rice drying using mechanical husk dryer in Karawang laboratory was Rp43.53 kg^{-1} of wet grain. By using compounding factor, the cost was equivalent to Rp96.23 kg^{-1} of rice in 2010.

In this study area, most of respondents did not sell dried rice grain. Instead, they were milling their dried grain and sold rice. By applying equation (1), the annual profit of the millers who were milling rice from sun-drying floor was Rp28.06 million $year^{-1}$ or Rp36.69 kg^{-1} of wet rice grain. This short-term profit was lower than that of selling wet rice grain that was about Rp50 kg^{-1} of wet grain. The higher profit was earned from the broken rice and rice bran as the by-products of rice millers.

On the other hands, the profits of the millers who milling rice from mechanical dryers were Rp367.21 million and Rp462.95 million $year^{-1}$, or Rp282.87 and Rp385.79 kg^{-1} of wet grain, respectively, for gas dryer and husk dryer. Apart from higher annual volume of drying by using mechanical dryer, the higher profit was also due to better quality of rice resulted from mechanical dryer compared to that from sun drying. The better quality is indicated by the higher price of rice resulted from mechanical dryers compared to that from sun-drying floor (Table 1). All respondents stated that the rice resulted from mechanical dryer had a better quality compared to that from sun drying. This result is confirmed with some earlier studies done by Abilowo (2008) and Bhandari and Gaese (2008), who reported that rice quality resulted from mechanical dryer is always better compared to that resulted from sun drying. All respondents also stated that the milling rate of rice from mechanical dryer was higher due to better quality, compared to that of from sun-drying floor, as shown in Table 1. This result is consistent with the study of Sutrisno and Rahardjo (2009) in South Sumatra. They reported that the milling rate of rice dried by mechanical dryer and sun-drying floor were 65% and 62%, respectively.

By taking into account the by-products (broken rice and rice bran), the total annual profits were Rp127.16 million, Rp537.16 million, and Rp622.12 million $year^{-1}$, or Rp166, Rp414, and Rp518 kg^{-1} of wet grain, respectively for sun-drying, gas dryer, and husk dryer. Assuming that sun-drying floor is the initial technology, then the MBCRs were 1.29 and 1.45, respectively, for technological change from sun drying to gas dryer and husk dryer.

The technological change from sun-drying floor to gas dryer and husk dryer was financially feasible indicated by the MBCR values. The change in technology from sun-drying floor to gas dryer gave an additional benefit of about 29% higher than its additional cost. Similarly, the change in technology from sun-drying floor to husk dryer provided an additional benefit of 45% higher than its additional cost. Thus, it is the time for rice businessmen to invest in mechanical dryers, either gas dryer or husk dryer. The husk dryer is prospective and profitable to adopt, since rice husk is abundant and remains considered as a waste of rice millers.

Table 1. Cost and benefit analysis of three types of rice dryers based on mean capacity and frequency of drying per year, Subang District, West Java, 2011.

Cost and benefit component	Sun drying	Gas dryer	Husk dryer
Volume of dryer per process (t)	25	30	25
Frequency of drying	31	43	48
Price of per tonne of wet rice grain (Rp000)	3,167	3,036	3,000
Total volume of wet rice grain (t)	765	1,298	1,200
Total value of wet rice grain (Rp000)	2,421,444	3,941,752	3,600,000
First year drying cost (Rp000)	83,690	195,017	135,849
Total cost up to drying (Rp000)	2,505,134	4,136,769	3,735,849
Cost of milling (Rp000)	96,960	161,358	151,200
Total cost up to milling (Rp000)	2,602,094	4,298,128	3,887,049
Benefit-cost when selling rice			
Conversion from wet rice grain to rice (%)	55.93	57.50	58.00
Total volume of rice (t)	428	746	696
Price per tonne of rice (Rp000)	6,150	6,250	6,250
Total value of rice (Rp000)	2,630,153	4,665,341	4,350,000
Profit of selling rice (Rp000)	28,059	367,213	462,951
Profit per tonne of wet rice grain (Rp000)	36.69	282.87	385.79
Value of broken rice (Rp000)	39,301	66,662	62,400
Value of rice bran (Rp000)	59,797	103,283	96,768
Total profit with by-product (Rp000)	127,157	537,158	622,119
Profit per tonne of wet rice grain/by-product (Rp000)	166	414	518
B/C ratio with by-product	1.05	1.12	1.16
MBCR	-	1.29	1.45

Short-Term Sensitivity Analysis of Three Types of Dryers

The sensitivity analysis was done based on the minimum and maximum capacity and frequency of drying obtained by the rice millers at the study area. At the minimum capacity and frequency of drying, the profits earned were Rp125,000, Rp281,000, and Rp299,000 t^{-1} of wet grain, respectively, for sun-drying floor, gas dryer, and husk dryer. Meanwhile, the results of analysis at the maximum capacity and frequency showed that the profits earned were Rp226,000, Rp361,000, and Rp407,000 t^{-1} of wet grain, respectively, for sun-drying floor, gas dryer, and husk dryer, as presented in Table 2.

At the minimum capacity, the MBCRs were 1.29 and 1.76, respectively, for technological change from sun-drying floor to gas dryer and husk dryer. It means that the Rp1,000 additional cost spent to change the technology from sun-drying floor to gas dryer will result in Rp1,290 additional revenue. Similarly, the Rp1,000 additional cost spent to change the technology from sun-drying floor to husk dryer will result in Rp1,760 additional revenue.

Under the maximum capacity, the MBCRs were 1.32 and 23.29, respectively, for technological change from sun-drying floor to gas dryer and husk dryer. It means that the Rp1,000 additional cost spent to change the technology from sun drying floor to gas dryer will result in Rp1,320 additional revenue. Surprisingly, the Rp1,000 additional cost spent to change the technology from sun-drying floor to husk dryer will result in Rp23,290 additional revenue. Thus, more profit is earned per tonne of wet rice grain when the mechanical dryers are used at their maximum capacity, especially husk dryer.

Similarly to the results of analysis by using the mean of capacity and frequency of drying, the husk dryer is the most profitable and the most feasible dryer. It is mainly due to low operational cost, since rice husk is abundant at each rice miller. Therefore, this kind of dryer should be intensively promoted to anticipate the expensive price of gas when gas subsidy is removed by the government.

Long-Term Financial Feasibility of Three Types of Dryers

The long-term financial feasibility analysis was applied for each type of dryer. The base year was assumed to be in 2010, when the investment was assumed to start. All investments before 2010 were converted into 2010 value by using compounding factor. This approach aimed to make the same starting point of the analysis and to make them comparable.

Tabel 2. Cost and benefit analysis of three types of rice dryers based on minimum and maximum capacity and frequency of drying per year, Subang District, West Java, 2011.

Cost and benefit components	Sun drying		Gas dryer		Husk dryer	
	Min	Max	Min	Max	Min	Max
Volume of dryer per process (t)	10	40	10	40	20	40
Frequency of drying	20	42	24	48	48	48
Total volume of drying (t)	200	1,680	240	1,920	960	1,920
Drying cost per process (Rp000)	450	2,075	1,730	4,297	1,400	2,460
Total cost of drying (Rp000)	9,000	87,150	41,520	206,256	67,200	118,080
Price of wet grain (Rp kg^{-1})	2,800	3,500	2,800	3,500	3,000	3,500
Total value of wet rice grain (Rp000)	560,000	5,880,000	672,000	6,720,000	2,880,000	6,720,000
Conversion from wet to dried rice grain	0.80	0.86	0.80	0.85	0.83	0.85
Conversion from wet rice grain to rice	0.52	0.60	0.55	0.62	0.56	0.62
Cost of milling (Rp000)	16,000	216,720	19,200	244,800	79,680	244,800
Total cost up to milling (Rp000)	585,000	6,183,870	732,720	7,171,056	3,026,880	7,082,880
Production of rice (t)	104	1,008	132	1,190	538	1,190
Production of broken rice (t)	1.60	21.67	1.92	24.48	7.97	24.48
Production of rice bran (t)	1.28	14.45	1.54	16.32	6.37	16.32
Price of rice at the miller (Rp/kg)	5,800	6,400	6,000	6,500	6,100	6,500
Price of broken rice (Rp kg^{-1})	3,500	4,300	3,500	4,300	3,500	4,300
Price of rice bran (Rp kg^{-1})	1,000	1,300	1,000	1,300	1,000	1,300
Value of rice (Rp000)	603,200	6,451,200	792,000	7,737,600	3,279,360	7,737,600
Value of broken rice (Rp000)	5,600	93,190	6,720	105,264	27,888	105,264
Value of rice bran (Rp000)	1,280	18,782	1,536	21,216	6,374	21,216
Total value of rice + byproducts (Rp000)	610,080	6,563,172	800,256	7,864,080	3,313,622	7,864,080
Total profit (Rp000)	25,080	379,302	67,536	693,024	286,742	781,200
Cost per tonne of wet grain (Rp000)	2,925	3,681	3,053	3,735	3,153	3,689
Revenue per tonne of wet grain (Rp000)	3,050	3,907	3,334	4,096	3,452	4,096
Profit per tonne of wet grain (Rp000)	125	226	281	361	299	407
MBCR			1.29	1.32	1.76	23.29

Milling dried grain and selling rice with by-products provided an attractive incentive for the rice millers. That is why almost none of respondent was selling dried grain. As shown in Table 3, the payback period of sun drying floor was three years. The NPV was Rp759,67 million, with the B/C ratio of 3.66 and IRR of 44.44% within the period of 15 years. These results indicated that sun-drying floor is financially feasible for the rice millers. The existing sun-drying floor can be maintained and repaired, since it has already constructed.

The use of mechanical dryers provided much higher profitability compared to sun-drying floor. The pay back period of gas dryer was one year, meaning that without considering discount factor, the investment cost will be back within one year or two seasons. The NPV was Rp4.06 billion with B/C ratio of 18.63 and the IRR of 233.47% within the period of 15 years. Meanwhile, the use of husk dryer gave a higher profit. The pay back period of husk dryer was also one year. The NPV, B/C ratio, and IRR were Rp4.72 billion, 20.77, and 260.49%, respectively, for the period of 15 years. These results indicated that both gas dryer and husk dryer are highly feasible for the rice millers.

Table 3. Financial feasibility of three types of rice dryers when operating at mean capacity, Subang District, West Java, 2011.

Components of feasibility	Sun drying	Gas dryer	Husk dryer
Pay back period (year)	3	1	1
Discounted net present value (Rp000)	759,667	4,055,421	4,720,832
Net B/C ratio	3.66	18.63	20.77
Internal rate of return (%)	44.44	233.47	260.49

Long-Term Sensitivity Analysis

The results of financial feasibility analysis when the dryers are operating at the minimum capacity are presented in Table 4. Sun-drying floor needs 12 years to obtain pay back period, while gas and husk dryers only need 2 and 1 year, respectively, to obtain pay back period. Surprisingly, when sun-drying floor is operating at its minimum capacity and frequency, it get loss of about Rp48.92 million for the period of 15 years, indicated by the negative value of NPV. So that, it should be operated at least at its mean capaci-

Table 4. Financial feasibility of three types of rice dryers when operating at minimum capacity, Subang District, West Java, 2011.

Components of feasibility	Sun drying	Gas dryer	Husk dryer
Pay back period (year)	12	2	1
Discounted net present value (Rp000)	-48,921	295,763	2,046,193
Net B/C ratio	0.83	2.29	9.64
Internal rate of return (%)	6.61	26.70	120.06

Table 5. Financial feasibility of three types of rice dryers when operating at maximum capacity, Subang District, West Java, 2011.

Components of feasibility	Sun drying	Gas dryer	Husk dryer
Pay back period (year)	3	1	1
Discounted net present value (Rp000)	2,756,994	5,290,078	19,773,616
Net B/C ratio	10.66	23.99	83.80
Internal rate of return (%)	132.91	310.21	1,056.18

ty and frequency to avoid the loss. The net B/C ratio was less than one (0.83), meaning this business is financially not feasible. The IRR (6.61%) was less than the discount rate (12%). Thus, both net B/C and IRR indicate that sun-drying floor is financially not feasible if it is operated at minimum capacity.

Differently from sun-drying floor, the gas and husk dryers could get the net present profit of Rp295.76 and Rp2,064.19 million, respectively, with the net B/C values of 2.29 and 9.64 during the period of 15 years. The IRR of these dryers were 26.70% and 120.06%, respectively, which are much higher than the discount rate. Both net B/C and IRRs indicate that both gas and husk dryers are financially feasible. Similarly to the analysis under the mean capacity, the results of the analysis at their minimum capacity showed that husk dryer is the most profitable and most prospective drying technology to be promoted in the future.

Under the maximum capacity, all three types of dryers were financially feasible, indicated by net B/C ratios and IRRs of all dryers covered in this study. As shown in Table 5, the net B/C ratios are much greater than one and the IRRs are much greater than 12% per year for all types of dryers during the period of 15 years. The results of this analysis also showed that husk dryer is the most profitable and most prospective technology to be introduced and promoted in the future, because this technology uses rice husk as the cheapest fuel for rice drying.

In the future, the demand for high quality rice in domestic and international market will be rising. To anticipate the rising demand, there is a need to maintain and improve rice quality. Drying is the key point to avoid quality deterioration. Therefore, Indonesia should develop and promote the drying technology, by which the rice businessmen can get attractive incentive to do drying. The mechanical dryers will highly contribute to the improvement of rice quality (BBPMP 2011). The most prospective type of mechanical dryer to be introduced and promoted is husk dryer.

CONCLUSION AND POLICY IMPLICATION

Conclusion

In the short run, all the three types of rice dryers are profitable, even under minimum capacity and frequency of drying. Among the three types of dryers, husk dryer gives the highest profit.

In the long run, all the three types of rice dryer are also profitable and feasible, except sun drying floor under its minimum capacity. Similarly to short-term analysis, the results of long-term analysis also showed that husk dryer is the most profitable and feasible dryer. Thus husk dryer could be the most prospective mechanical dryer to be promoted. The problem is that husk dryer have not yet well known and adopted by most of rice millers and rice traders. Another constraint to adopt mechanical dryer is cash capital to invest in husk dryer.

Policy Implication

Based on the results of this study, some strategic policies are required, such as:

1. Intensive introduction and promotion of mechanical dryer using rice husk fuel to the farmers' groups, rice traders, and rice millers.
2. The rice millers can maintain and repair their existing sun-drying floor, since they have constructed it. The use of sun-drying floor should not be under its minimum capacity to avoid the loss. However, under the scarcity of land in West Java, it is not recommended to construct the new sun-drying floor. The rice millers can construct the new mechanical husk dryer.
3. The government support in terms of rice dryer for the farmers' group associations should be focused on the mechanical dryer using rice husk fuel. This support should be followed by the strong agreement between the government and the recipients,

that the machines will be optimally utilized to reduce quality losses, for the benefit of farmers' group associations. The lesson learned regarding the neglect of some government granted machineries should be taken into account.

4. A proper determination of government procurement price of wet rice grain, dried rice grain, and rice is highly important to provide incentive for farmers, traders, and rice millers to do rice business, including rice drying. These prices can be determined by considering farmers' profit, cost of procurement, cost of drying, conversion from wet to dried rice grain, cost of milling, conversion from dried grain to rice, reasonable profit margin for traders and rice millers, and other handling costs.

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