Development of Rice Reprocessing to Strengthen Small Scale Rice Mills in Indramayu West Java

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Abstract. Small Rice Mill (SRM) has a very important role in rice production of strong institutional relationships to farmers and rice markets. Nevertheless, the rice produced in low quality and changing consumer preferences cause SRM to have difficulty in maintaining the role. Development of a reprocessing business - called Rice to Rice Processing Plant (R2RP) - as a separate business unit will support their role and existence. This study aimed at analyzing the feasibility of R2RP business that integrates SRM and market as an independent business unit and determines mutual partnership pattern. The study was conducted with special reference to West Java Province. The qualitative method used for non-financial aspects analysis includes raw material, market, technical-technological, management and regulation and partnership pattern. The financial aspect used the quantitative method of Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), Internal Rate of Return (IRR), Payback Period (PP) and Switching Value to check their sensitivity. The results showed R2R business is feasible for non-financially, technical-technological and financial aspects. Technology has evolved to produce various qualities (premium or medium) after the quality of raw materials (low quality or off-grade rice) using profit optimization. Value of the financial parameters was NPV of Rp 137 billion, Net B/C of 5.80, IRR of 84.27 percent and PP of 2.18 years at capacity of 19,800 tons/year with total investment of Rp 30 billion (Rp 13,500/USD). The switching value analysis showed that a decrease in product prices is sensitively influencing the financial feasibility. To strengthen cooperation that enhancing mutually beneficial relationship, R2R assists equipment investment in and buy raw material from SRM at a rational agreed price.

1. Introduction

1.1. Background of the Study

The rice-centered agricultural development program in the late 1960s caused farmers to experience a surplus of grain production. This green revolution was continuing, so rice millers were required to process grain into rice. Since then the development of rice milling industry began at the end of 1960 [1]. At that time the government focused on building a more modern SRM (small-scale rice milling) with low rice quality but better than mashed rice in accordance with current conditions of income and preference [2][3].

The number of rice mills in 2012 reached 182 thousand units were dominated by SRM by 94 percent [4]. SRM activities tended to increase post-harvest [5]. Most SRM produced at 60 percent of yield level
and broken above 20 percent [1]. Patiwiri (2008) stated that the yield of milling in Indonesia was lower than Thailand (69.1 percent) and Vietnam (66.6 percent) [6]. In addition to the yield problem, PERPADI estimated the milling capacity of paddy mill to exceed the annual grain production (75.4 million dried milling paddy while the ideal rice mill was to be 45,452 units. This caused only 40 percent of the units to operate at full capacity and had to stop working in certain months or 3-4 months of production per year [7][8].

Sawit (2014) stated the tight competition of raw material did not reduce the number of SRM equally which continues to increase over the last 10 years. The increase of SRM occurred especially in SMGM (small mobile grinding mill) which had a capacity of 0.6 tons of rice/hour. The government (through BULOG) bought low-quality rice at an increased purchase price (HPP). This made the market share of low-quality rice was still large slowing modernization so did not meet the changing market demand [9]. In Wibowo (2007) study, people tended to select medium quality rice (quality requirement can be seen in table 5)[10]. Shifting demand to better quality of rice (premium) was partly due to the increased of community income [11]. Premium rice production requires modern technology such as RMU (Rice Milling Unit) or RPC (Rice Processing Complex) that could not be achieved by SRM [12]. In addition, SRM was experiencing a high loss in the milling and drying stage due to the limitations of milling technology [13].

In 2015 West Java Province has 1.9 million ha of rice fields with productivity of 6.1 tons/ha. Indramayu, Subang, and Cirebon were the largest rice production centers in West Java. The total land area of Indramayu in 2014 reached 117,792 ha followed by Subang with 84,750 ha and Cirebon of 53,368 ha [14]. Rice production increased in Indramayu in 2015 was a result of improvements in agricultural infrastructure that has been done since 2015. The improvements made were 276 agricultural infrastructures such as farm-level irrigation network (JITUT), farm-level network (JUT), village irrigation networks (Jides) and two units of seed center. This improvement program to increase rice, corn and soybean production (Pajale) in Indramayu Regency had to be achieved in 2017. Supporting rice cultivation facilities in Indramayu had to be balanced by decent postharvest handling [15][16].

1.2. Problems of the Study

One of the problems the milling faced was the high of grain water content [17]. In addition, the number of rice mills exceeded the production (table 1). This excess led to seizure and raised the price of grain. PERPADI (2014) proposed equalization of the ideal number of rice mills in Indonesia. The first alternative was 45,452 units (SRM 94 percent, PPM 4 percent and PPB 2 percent), second alternative of the number of rice mill was 42,979 units (SRM 85 percent, PPM 10 percent and PPB 5 percent) and third alternative was 40,035 units (SRM 75 percent, PPM 15 percent and PPB 10 percent) [8]. All these alternatives still leave SRM production quality problems that did not meet market demand.

| Description | Small | Medium | Large | Total |
|-------------|-------|--------|-------|-------|
| Mills (unit)| 171,495 | 8,628  | 2,076 | 182,199|
| Percentage (%) | 94 | 4.7 | 1.1 | 100 |

Source: BPS 2012

Decreasing of number of rice mills only reduced grain competition between mills but did not solve problems of quality and post-harvest loss. It was in this perspective that organizing SRM investments through cooperation with R2RP required special attention. SRM played a role in the post-harvest loss which was still at 11-20% [18]. The highest loss occurred in drying and rice milling processes [19][20][21]. SRM uses drying with drying floors so it will be physically scattered and in quality, those were unevenly drying causing the rice to break in milling process easily [20]. The high loss was due to engine configuration which was generally a one pass or two pass (two times husking and two times
polishing), without being followed by cleaning that made the grain was dirty. The configuration of mills with twice the breaking of grain skin caused a lot of rice cracked, so the percentage of rice broken was high [12].

SRM quality improvement could be performed by perfecting the current SRM engine configuration from H-P (husker and polisher) into C-H-S-P (cleaner, husker, separator, and polisher). The addition of cleaner and separator improved the quality and yield of rice by 0.9-1.9% [20]. The unit refinement by SRM had capital constrain because there were many SRM that got difficulties in purchasing grain continually [22]. Another solution was the current SRM product that was rice (poor quality) was purchased and polished by RMU into high-quality rice or known as R2RP (Rice to Rice Processing Plant). This scheme allows SRM to produce only brown rice.

SRM was expected to gradually extinct as demand for rice quality changed, the gradual competition of grain between both SRM and PPB [23]. The synergy between the two could be developed to maintain SRM as a rural enterprise [24]. The development of cooperation schemes between SRM and R2RP should be economic-based on sustainable growth [25]. Therefore, feasibility studies should be conducted as a basis for developing partnerships between SRM and R2RP.

2. Materials and methods
Averages for the costs and revenues were calculated to be considered the core of the analysis when determining the financial feasibility and other economic considerations. The total fixed, variable costs, and cash flows, as well as the total revenues, were calculated for the next 10 production cycles. Optimization of production can be solved using linear program which has two kinds of function that is objective function and constraint function. The net present value (NPV), internal rate of return (IRR), benefit-cost (B/C) ratio and Payback Period (PP) for the investigated R2RP were the financial indicators calculated in the study [25]:

1. NPV (net present value) = \[ \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} \]
2. IRR (internal rate of return) = \[ i_1 + \frac{NPV_1}{NPV_1 - NPV_2} (i_2 - i_1) \]
3. Net B/C (net benefit-cost ratio) = \[ \frac{\sum_{t=1}^{n} \frac{B_t - C_t}{1+i^t}}{\sum_{t=1}^{n} \frac{C_t}{1+i^t}} \]
4. PP (payback period) = \[ \frac{Capital\ Investment}{Net\ Benefit} \]
5. Optimization of production = \[ Z_{\text{max}} = C_1X_1 + C_2X_2 + \ldots + C_nX_n \]

Where:
- \( B_t \) = Benefit (Rp)
- \( C_t \) = Cost (R)
- \( n \) = Economic age (year)
- \( i \) = Discount rate (%)
- \( t \) = The time of the cash flow (year)

Therefore, data required to solve the above equations among others are capable of the R2RP, machinery investment cost, operational cost, working hours, working days, R2RP yield, economic age of facilities, raw material or low rice quality prices, selling price, operational cost, dollar exchange rate, tax and discount rate.

3. Results and discussion

3.1. Raw material sufficiency analysis R2RP
West Java is known to be one of the main rice producing provinces in Indonesia within which Indramayu is the biggest regency of rice producers. Therefore, Indramayu was taken as the case study for analyzing the possibility to establish cooperation or partnership between SRM and R2RP.
3.1.1. Rice Production West Java and Indramayu. Rice production in West Java in 2015 increased compared to the previous year which reached about 11 million tons. Rice production of West Java Province in 2015 was recorded at 6.9 million tons with the value of conversion of GKG to rice at level of 62.4%. If the consumption rate of rice was assumed to be 98 kg/capita/year [26] with a population of 47 million, the total requirement of West Java's rice was about 4.6 million tons of rice per year or a surplus of 33% of the demand. As a producer that always have surplus, then the potential to develop post-harvest technology and efficiency improvements (volume and quality) is very potential and needed to be optimally utilized.

Indramayu contributed to 11-12% of West Java or 33-35% from total production of the surroundings (Cirebon, Subang, Sumedang, and Majalengka later called as cluster region). This indicated that the regency has strong position in the region and regional. The production was produced from an area of 118,000 ha (figure 1). Therefore, all regencies within the region could be the sources of raw materials for the small rice reprocessing industry to produce medium, low quality and brown rice for further processing in R2RP.

![Figure 1. Paddy production of Indramayu, surrounding regencies (cluster) and West Java](image)

The Indramayu's rice fields have not changed much over the year, which means that the conversion of rice fields to other uses was relatively small [26]. Indramayu along with Subang and Majalengka were strong producers in the region. Procurement of low quality, medium, and brown rice could come from the surrounding area which was not far apart and can even be treated as a source of raw materials in the same area. The location of Indramayu located on the Pantura (northern part of Java) Road has a strategic role to distribute the surplus of rice from regions in the cluster to national distribution channels outside the province. Therefore, all regencies within the area could be a source of raw material for R2RP. In 2014, the total area of rice fields in Indramayu was 117,792 ha which was about 35% of the cluster and 13% of West Java.

3.1.2. Sufficiency of raw materials. Indramayu was a competitive and prospective production area because, in addition to having good planting area and productivity, it serves continuous cultivation as well. Many government programs are allocated to this area because of its status as a food barn. Therefore, the availability of raw materials to meet the capacity of the R2RP was easily met (table 2).
Table 2. Calculation of R2RP raw materials necessity relative to raw materials of rice (%).

| Capacity      | Ton/year | Indramayu | Area cluster | West Java |
|---------------|----------|-----------|--------------|-----------|
| Rational      | 19,800   | 2.5       | 0.8          | 0.3       |
| Optimist      | 36,000   | 4.5       | 1.5          | 0.5       |
| Indramayu     | 807,555  |           |              |           |
| Area Cluster  | 2,377,710|           |              |           |
| West Java     | 7,096,841|           |              |           |

Assuming the planned R2RP capacity for rational operating conditions (11 hours per day) was 1,650 tons per month requiring 19,800 tons/year raw material (low quality, medium, and brown rice) regardless their quality. This amount was only about 2.5% of Indramayu rice production. If the purchasing area was expanded to include Subang, Sumedang, Majalengka, and Cirebon, then the raw material needs were about 0.8% of the rice production. If the assumed planned R2RP capacity to be optimistic operating conditions (20 hours per day), it is 3,000 tons per month requiring 36,000 tons/year of low-quality rice at any quality. This amount will be only about 4.5% of Indramayu rice production. If the purchasing area were expanded to cover the surrounding area (cluster), then the raw material needs were about 1.5% of the production of rice. It indicated that the establishment of R2RP is not determined by the production of raw materials of Indramayu and Area Cluster rather than depending on the management and strategy of raw material procurement.

Indramayu Regency had 1,054 mills consisting of 647 small-scale units, 381 units of medium scale and 26 units of large scale. Of all the mills there were 1,048 units operating normally with milling capacity varying from 0.8 tons - 30 tons per day and 6 mills in damaged condition. The improvement and organization of SRM could serve as the raw material base for R2RP. Millers located outside Indramayu Regency could become potential partners as raw material suppliers. The movement of raw materials of this rice is facilitated by the access of Cipali toll and the Pantura line that passed through the area of Indramayu Regency to expand the source of raw materials. R2RP should consider the diversity of rice varieties by adding the blending process as has been done by RMU.

3.2. Market and marketing

Production of R2RP was approximately 36,000 tons/year under optimistic 20 hours operating per day. This production might decrease when using rational operating hours of 11 hours per day into 19,800 tons/year (table 3). R2RP optimistic and rational capacity of the regency rice needs is about 45% based on the predicted figures of consumption or about 30% of the Susenas figure. Theoretically, marketing within the regency could be performed but not fully absorbed. Competition, both with local and foreign mills, is relatively tight. The market orientation should be out of the region due to the large production surplus.

Table 3. Projection of rice demand in Indramayu Regency.

| Year | Population (lives) | Necessity (ton/year) | Optimistic R2RP Proportion (%) |
|------|--------------------|----------------------|--------------------------------|
|      |                    | Prediction | Susenas | Prediction | Susenas |
| 2014 | 1,708,551          | 93,116     | 158,212 | 38.66      | 22.75   |
| 2015 | 1,718,495          | 88,846     | 154,665 | 40.52      | 23.28   |
| 2016 | 1,728,119          | 89,344     | 151,210 | 40.29      | 24.4    |
| 2017 | 1,737,796          | 87,411     | 147,539 | 41.18      | 27.33   |
| 2018 | 1,747,528          | 85,629     | 143,822 | 42.04      | 25.03   |

West Java was a province of rice producers and surplus although some districts (mainly cities) serve as consumer areas. Intra-region distribution could be easily met. Surplus ranges from 3-4.5 million tons annually. The regional orientation was still possible to fulfill the cities and deficit regions within the province (table 4).
Table 4. Calculation of supply and demand of rice in West Java.

| Years | Production (ton) | Availability (ton) | Consumption (kg/capita/year) | Population (jiwa) | Rice Necessity (ton) | Surplus (ton) |
|-------|------------------|--------------------|-----------------------------|-------------------|---------------------|---------------|
|       | Prediction | Susenas | Prediction | Susenas | Prediction | Susenas |
| 2014  | 7,735,422 | 7,251,898 | 54.5 | 92.6 | 46,075,445 | 2,512,012 | 4,266,586 | 4,739,886 | 2,985,312 |
| 2015  | 7,821,399 | 7,366,287 | 53 | 90 | 46,828,323 | 2,484,224 | 4,214,549 | 4,882,063 | 3,151,738 |
| 2016  | 7,888,512 | 7,467,704 | 51.7 | 87.5 | 47,580,407 | 2,462,009 | 4,163,286 | 5,005,695 | 3,304,418 |
| 2017  | 7,966,182 | 7,570,316 | 50.3 | 84.9 | 48,334,948 | 2,432,404 | 4,103,637 | 5,137,912 | 3,466,679 |
| 2018  | 8,065,087 | 7,681,735 | 49 | 82.3 | 49,094,385 | 2,404,830 | 4,040,468 | 5,276,905 | 3,641,267 |

R2RP investments could be positioned as buyers and sellers that tended to face oligopsony and oligopoly market structures. As rice buyer with the presence of R2RP facility had a strong bargaining position because it was more efficient and far beyond the technical and economical scale, compared to farmers, middlemen, even large collectors and small grinders. As a seller, the number of rice factories was also very small compared to the number of distributors. Its market share is quite good and reaches the distributor outside the region.

The main products produced by R2RP will be medium quality 1 and premium rice. The marketing channel of R2RP is divided into two channels namely the first local marketing channel in Indramayu Regency, the second channel is marketing to meet the clusters and West Java Province and met the demand outside the Province (figure 2). The first channel was local oriented marketing starting from R2RP selling its products through retailers. The retailer then sold the rice to the last consumer. In the second channel, R2RP marketed its products in clusters up to outside the province, so its marketing is through distributors. After that the distributor market the product to the retailer and to the final consumer.

Figure 2. R2RP marketing channel

3.3. Technical and technological

3.3.1. Quality of rice, process flow, and equipment. The quality of rice in the market varied widely and the name of which varied depending on each region. This is due to the different ways of classification. Some of the most widely applied and practiced classification methods are: (i) based on rice varieties, (ii) based on their local origin, (iii) based on their processing, (iv) based on their degree of milling, and (v) based on a combination of rice varieties and its polishing. These quality requirements include both qualitative and quantitative requirements (table 5).
Table 5. Quality standard of national rice (SNI No. 01-6128-2015).

| No. | Quality Components          | Quality Class |
|-----|----------------------------|---------------|
|     |                            | Premium       | Medium 1 | Medium 2 | Medium 3 |
| 1   | Level of polishing (%) min | 100           | 95       | 90       | 80       |
| 2   | Water content (%) max      | 14            | 14       | 14       | 15       |
| 3   | Head rice (%) min          | 95            | 78       | 73       | 60       |
| 4   | Broken (%) max             | 5             | 20       | 25       | 35       |
| 5   | Grain grouts (%) max       | 0             | 2        | 2        | 5        |
| 6   | Red grain (%) max          | 0             | 2        | 3        | 3        |
| 7   | Yellow/ damaged grains (%) | 0             | 2        | 3        | 5        |
| 8   | Grains of whitewash (%)   | 0             | 2        | 3        | 5        |
| 9   | Foreign objects (%) max    | 0             | 0.02     | 0.05     | 0.2      |
| 10  | Grains (grains/100g, max)  | 0             | 1        | 2        | 3        |

The selection of technological level used in the establishment of R2RP is based on the characteristics of raw materials (medium quality of rice 2 and 3) and by considering the quality class to be achieved (premium rice and medium quality 1). Based on the quality and characteristics of raw rice as raw material, it could be used as a basis for selecting technology level (table 6).

Table 6. Characteristics of raw materials relatives to selection of technology level (see figure 3).

| Quality parameter                          | Decision in selecting technology level                                                                 |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Level of polishing                         | The value of level of polishing is low namely less than 95 %, as to required polishing machine and/or shining machine. |
| Water content                              | Water content ranging from 14.0-15.0%, it indicates that the water content of rice is good enough to be processed directly without additional drying. However, it is recommended that R2RP management require a raw water content of no more than 15.0%, so it does not require dryer investment. |
| Head rice, whole grain and broken          | Content of head rice varied between 60-78% as to improvement to higher rice quality required length grader machine as separator of rice head and broken. The percentage of head rice could be used as a basis to determine the yield of rice quality class that is going to be produced. |
| Grain grouts                               | Grains grouts ranging from 2-5% or more so rotary shifter machine to separate the grouts was required. Separation of the groats is performed before the shining to make the machine work more efficiently. The resulting grout could be sold or processed into flour as additional income (by-product). |
| Grains of whitewash, yellow/damaged grains, and red grains | Random rice contained grains of whitewash, yellow/damaged grains, and red grains so color sorter is required if premium rice production is desired. However, if it is desired to produce medium quality 1 of rice only, by passing without using a color sorter could be performed. |
| Grains and foreign objects                 | Generally, rice contained grains and foreign objects so paddy separator is required to separate grain and destoner to separate the foreign objects (stone). |
In designing a process flow, it is necessary to consider the condition of raw materials (quality and variety), available space and product quality to be achieved as well as efficiency. The production process run continuously in a closed system where the material flow is controlled using a bucket elevator and piped through pipes.

With this consideration, the design of the process flowchart on the ideal R2RP was as shown in figure 3. The raw materials at any quality could be processed into high-quality products including premium and medium 1. If the quality to be produced is limited to the quality of medium 1, some process stages could be eliminated like a color sorter machine. Generally raw materials of raw rice still contained unhusked rice and also foreign objects (stone). Incomplete husked rice could be overcome using a shining machine with two processes. Destoner is applied to separate stone.

![Figure 3. Design of flowchart of R2RP process](image)

3.3.2. Production capacity. Theoretically, the production capacity must be determined based on the ability of raw material procurement (random rice), rice distribution (market absorption), and machine capacity at each stage of the process and financial feasibility. R2RP used as a reference with capacity of 6 tons/hour of rice and is expandable. Assuming the machine operated for 11 hours/day and 25 days/month then the R2RP have a capacity of about 1,600 tons/month.

3.3.3. Equipment. Overall the complete tool/machine configuration for R2RP could be categorized into 4 parts: (i) raw material handling part, (ii) milling parts, (iii) packing parts, and (iv) dust collecting parts and other supporting equipment.

3.3.4. The layout of machinery and equipment. The machine has diverse dimensions and sizes, so the layout in the area depended on the type and shape of the selected machine. Each engineering company has different technical specifications for each machine and tool at the same capacity. Based on this consideration, the area used is the optimal dimension of the machine and the tools already manufactured by the main manufacturers based on the widely used process flow.

It is important to note that the calculation of the minimum and sufficient area could be developed for the ideal area that could be rounded up to 125 x 50 m² or equivalent to 6.250 m² area. (0.625 Ha). The layout could be adapted to the conditions and contours of the land (figure 4).
3.3.5. Building needs. Machinery and equipment should be placed in a building or room to protect from weather disturbances (rain and heat). Each manufacturer had different specifications and tool dimensions. In general, the height of the R2RP tool/machine was relatively similar so that it could be placed in one building with the office and laboratory. However, to avoid contamination, the enclosure of R2RP space with offices, laboratories, raw material warehouses, packing chambers, and finished product warehouses are required. Security post and supporting buildings, if required, are made separately from factory buildings. The height of the production room followed the highest two layer equipment which was about 12 m, i.e., 25 m x 20 m x 12 m.

3.4. Need for Workforce
Most of the workforce tasks such as lifting, shifting, moving, observing, cleaning, and the like have been replaced by machines. The series of machines and devices are connected to a computer control system so they could be executed and stopped by one operator. Likewise, the loading and unloading activities could be done mechanically, so it does not require a lot of workforces. Based on these considerations, the core workforce required consist of management, operators, and technicians, supporting workforce and security (figure 5).

![Figure 4. Design of R2RP factory layout on land (m)](image)

**Figure 4. Design of R2RP factory layout on land (m)**

3.5. Optimization of rice production based on quality
Characteristics of raw material quality determined the potential of product quality that could be produced. Estimated product quality is prepared based on material balance (mass balance) corrected with shrink coefficient and damage though. The calculation of the mass balance of R2RP processing is performed by approaching the example of rice analysis from West Java, especially Pantura and the efficiency of the tool (assumption). Processing of raw rice from raw materials of Medium 2 and Medium
3 to produce Premium (X1) and Medium 1 (X2) quality products is shown in table 7. Profit coefficient was obtained from the calculation of product cost (including the price of grouts) plus the selling price minus the sum of operating costs plus raw material costs. The calculation of the profit coefficients a and b can be seen in table 8.

**Table 7.** The stages of random rice processing in variety of quality class.

| Quality of raw material | Process stages | Quality of product | Profit coefficient |
|-------------------------|----------------|--------------------|--------------------|
|                         | a   | b   | c    | d   | e   | f   | g   | h   | Premium | 1.718 |
| Medium 2                |     |     |      |     |     |     |     |     | Medium 1 | 1.238 |
|                         |     |     |      |     |     |     |     |     | Premium | 1.534 |
|                         |     |     |      |     |     |     |     |     | Medium 1 | 863   |
| Medium 3                |     |     |      |     |     |      |     |     | Premium | 1.534 |
|                         |     |     |      |     |     |     |     |     | Medium 1 | 863   |

Description: a = destoner, b = paddy separator, c = whitening, d = rotary sifter, e = color sorter, f = shining, g = length grader, h = packaging. Price of raw materials Medium 2 = Rp. 7,300,- Medium 3 = Rp 7,150 Selling price of Premium quality = Rp. 11,000, Medium 1 quality = Rp 10,000

**Table 8.** Calculation of profit coefficient.

| Quality of Raw Materials | Quality of Product | Operating Cost (Rp/kg) | Price of Raw Materials (Rp/kg) | Raw Materials Coefficient | Yield | Grout Coefficient |
|-------------------------|--------------------|------------------------|---------------------------------|---------------------------|-------|-------------------|
| Med 2                   | Premium            | 750                    | 7,300                           | 1.22                      | 0.82  | 0.18              |
| Med 1                   | 650                | 7,300                  | 1.12                            | 0.89                      | 0.11  |
| Med 3                   | Premium            | 750                    | 7,150                           | 1.3                       | 0.77  | 0.23              |
| Med 1                   | 650                | 7,150                  | 1.25                            | 0.8                       | 0.2   |

**Table 8.** Calculation of profit coefficient (continued)

| Quality of Raw Materials | Quality of Product | Cost of Raw Materials (Rp/kg) | Packing Cost (Rp) | Selling price of grouts (Rp) | Product Selling price (Rp/kg) | Profit (Rp/kg) | Margin Percentage (%) |
|-------------------------|--------------------|------------------------------|-------------------|------------------------------|-------------------------------|----------------|-----------------------|
| Med 2                   | Premium            | 8,902                        | 350               | 720                          | 11,000                        | 1,718          | 17.20                 |
| Med 1                   |                    | 8,202                        | 350               | 440                          | 10,000                        | 1,238          | 13.50                 |
| Med 3                   | Premium            | 9,286                        | 350               | 920                          | 11,000                        | 1,534          | 14.80                 |
| Med 1                   |                    | 8,938                        | 350               | 800                          | 10,000                        | 863            | 8.70                  |

Profit estimation was obtained by taking loss coefficients, operational costs, by-products and raw material prices, selling prices and by-product prices into account. Suggestion of processing based on raw materials with profit maximization purpose function was as follows:

Purpose Function \( Z = a X_1 + b X_2 \) where a and b were the coefficients of profit (table 9).
Table 9. Profit coefficient of premium and medium 1 rice production.

| Quality class of raw materials | Premium (X1) | Medium 1 (X2) |
|--------------------------------|--------------|---------------|
| M2                             | 1.718        | 1.238         |
| M3                             | 1.534        | 863           |

Notes:
- Price of raw materials Medium 2 = Rp7,300.- Medium 3 = Rp7,150.-
- Selling Price of Premium quality = Rp11,000.- Medium 1 = Rp10,000.-
- Price of Grouts = Rp4,000.-

Limiting Function (table 10)
1. Capacity: \( m X1 + n X2 \leq 66 \) where \( m \) and \( n \) were coefficients of raw materials.
2. Raw Materials: the number of rice head on each quality class of raw materials.

Table 10. Limiting function on optimization of premium and medium 1 rice production.

| Quality class of raw materials | M2 | M3 |
|--------------------------------|----|----|
| \( X1 \leq \)                  | 50.7| 41.7|
| \( X2 \leq \)                  | 61.8| 50.8|

From the above data, the optimization calculation of each class of quality class of Medium 2 and Medium 3 became product of Premium (X1) and Medium 1 (X2) quality with production capacity of 66 ton/day and if the raw material was Medium 2 quality then it was processed into premium rice by 93 percent and Medium 1 quality rice by 7 percent. For Medium 3, it was processed into premium rice by 76 percent and Medium 1 by 24 percent (table 11).

Table 11. Rice production optimization.

| Quality of Raw materials | Quality of product (%) |
|--------------------------|------------------------|
|                          | Premium    | Medium 1 |
| Medium 2                 | 93         | 7        |
| Medium 3                 | 76         | 24       |

3.6. Financial analysis

3.6.1. Costs of investment. The R2RP reference capacity for calculation was 19,800 tons/year or about 66 tons/day equivalent to 6 tons/hour. The investment cost consisted of purchasing machinery, factory buildings, supporting buildings and other infrastructures (table 12).

3.6.2. Fixed cost. Fixed costs included the salaries of permanent employees, office operations, administration and depreciation. All these costs were calculated in an annual period. The economic life was 10 years with depreciation using the straight-line method (table 13).

3.6.3. Variable costs. Cost of production calculated and with real influence were raw materials, packing materials and energy. The ideal R2RP raw material was rice in brown rice form. The variable cost component of R2RP was shown in table 14.
Table 12. Costs of R2RP investments

| Investments                      | Amount (Rp)   |
|----------------------------------|---------------|
| Machines and equipment           | 11,606,520,000|
| Factory building                 | 1,750,000,000 |
| Supporting building              | 15,140,000,000|
| Other infrastructures            | 1,304,326,000 |
| Land purchase                    | 1,500,000,000 |
| Land preparation                 | 500,000,000   |
| **Total investment out of land** | **29,800,846,000** |

Table 13. Fixed cost of R2RP.

| Type of cost                      | Total (Rp/month) | THR (Rp/year) | Total (Rp/year) |
|-----------------------------------|------------------|---------------|-----------------|
| Salary of leadership and employees| 55,500,000       | 126,500,000   | 1,644,500,000   |
| Operating costs                   | 5,000,000        | -             | 60,000,000      |
| Marketing                         | 2,000,000        | -             | 24,000,000      |
| Equipment and machine shrinkage   | 91,676,250       | -             | 1,100,115,000   |
| Building shrinkage                | 14,583,333       | -             | 175,000,000     |
| Equipment and machine maintenance | 48,360,500       | -             | 580,326,000     |
| **Total of fixed cost**           | **217,120,083**  |               | **3,583,941,000** |

THR = Bonus

Table 14. Variable costs of R2RP.

| Costs component         | Volume (unit/year) | Price per unit (Rp) | Total (Rp/year) |
|-------------------------|--------------------|---------------------|-----------------|
| Raw rice                | 19,800             | 7,150               | 141,570,000,000 |
| Fuel                    | 281,472            | 8,600               | 2,420,659,200   |
| Oil                     | 250                | 40,000              | 10,000,000      |
| Packing materials       | 3,840,000          | 500                 | 1,920,000,000   |
| Electricity             | 30,000             | 1,467               | 44,010,000      |
| **Total of variable costs (Rp/year)** |                 |                     | **145,964,669,200** |

3.6.4. Financial assumption. The local assumptions used in the calculation were the price of raw rice and the price of the rice (premium). Raw materials used were only those in medium 2 and 3 quality for premium and medium 1 rice production:

a. The purchase price of rice was Rp7,150.- / kg with the sale of premium rice at Rp 10,000 / kg at the factory site. The market price ranged from Rp. 11,000 - Rp 12,000,

b. The yield of random rice to premium rice was 82% to anticipate the quality of diverse raw rice.

c. The by-product obtained was calculated at 18% of the unrefined rice or 3,456 tons at an average price of Rp 4,000.-
3.6.5. Total revenue. The main product was premium rice with excellent quality because it used destoner, length grader, and color sorter. In the polishing there was no foreign object so the obtained bran as well as grouts and colored rice were clean. Therefore, these by-products could also be sold at a relatively good price as shown in table 15.

**Table 15.** Projection of R2RP revenue.

| Revenue     | Total (ton/year) | Price (Rp/kg) | Revenue (Rp/year) |
|-------------|------------------|---------------|-------------------|
| Premium Rice| 16,236           | 10,000        | 162,360,000,000   |
| By-product  | 3,564            | 4,000         | 14,256,000,000    |
| **Total**   |                  |               | **176,616,000,000** |

3.6.6. Profit and loss. R2RP with medium and large capacity, when it was managed and run well, might produce an adequate profit. Profit started to be earned in the second year of the project or the first year of production until the 10th year at the rate of Rp12,361,574,550.- per year. Total revenue for 10 years reached Rp123,615,745,500.-.

3.6.7. Investment Criteria. Revenue earned was five times more than the investment value at a rate of 84.27% of the investment value. This business could grow quickly if the market could be developed, so the return of capital was relatively fast which was about 2.18 years (table 16).

**Table 16.** The result of calculation of investment criteria of R2RP.

| Investment criteria | R2RP investment | R2RP investment + Husker | R2RP investment + Dryer |
|---------------------|-----------------|--------------------------|--------------------------|
| NPV (Rp)            | 136,669,185,414 | 131,699,185,414          | 124,699,185,414          |
| Net B/C             | 5.80            | 4.93                     | 4.08                     |
| IRR (%)             | 84.27           | 71.52                    | 58.85                    |
| PP (year)           | 2.18            | 2.39                     | 2.68                     |

3.6.8. Sensitivity analysis (switching value). Switching value was to perform a sensitivity analysis by simulating changes to financial feasibility parameters (NPV, Net B / C, IRR, and PBP) (table 17).

**Table 17.** Sensitivity Analysis.

| Sensitivity                        | Increase of Purchase Price of Random Rice | Decrease of Selling Price of Rice |
|-----------------------------------|-----------------------------------------|----------------------------------|
| Change of price (%)               | 14.06                                   | 12.26                            |
| Level of Price (Rp)               | 8,115                                   | 8,774                            |

3.7. Partnership between SRM and R2RP
SRM was a small-scale business both technical and economical, so it had many limitations and advantages. R2RP is a relatively large scale business that could help small businesses to overcome the problems while utilizing the advantages to reduce the constraints. The advantages of SRM included having cultural attachment with the upstream (farmers) and the downstream (traditional rice market) in the value chain, more flexible to changes in production level (operational capacity). The disadvantage is the limited capital so the use of technology and market run is relatively limited. In contrast, R2RP only has a business relationship in the value chain so it is very vulnerable to change and the occurrence of price competition (table 18).
Table 18. Strengths and Weaknesses of SRM and R2RP

| Strengths | SRM | R2RP |
|-----------|-----|------|
| • Having cultural relationship with the farmers | • The capital was relatively adequate | |
| • Having cultural relationship with the market (sellers) | • Advanced technology | |
| • Is spread in production center of raw materials | • High-quality product and could be adjusted | |
| • Flexible toward operating capacity | • Production cost was efficient and competitive | |

| Weaknesses |
|-----------|
| • Capital limitation | • Relationship in value was pure business |
| • Narrow market reach | • Did not have cultural relationship with actors in value chain |
| • Relatively low product quality | • Raw materials access was through free competition |
| • Low production efficiency | |
| • Limited technology | |

The cooperative relationship between SRM and R2RP could overcome weaknesses while utilizing each other's strengths. Strengthening the power to overcome weaknesses would result in an integrated business unit as follows:

(1). SRM would utilize cultural links with farmers to obtain relatively reliable raw materials at market prices and diverse quality;

(2). SRM with flexibility on operational scale (production) could continuously reproduce to produce raw materials (rice and or rice) to support R2RP production throughout the year;

(3). R2RP would assist SRM in financing to improve the ability to produce higher quality raw materials through equipment investment (dryer and huskers);

(4). R2RP continuously bought random rice and prospective rice from SRM in any amount at an agreed level of price (including market price),

(5). R2RP developed a premium rice market and/or medium 1, so the partnership relationship grew and developed continually on the basis of business.

The relationship could be mutualistic (or referred to as Symbiotic Innovative Relationships) [27], i.e., the weakness of SRM is covered by the power of R2RP. Likewise, the weakness of R2RP is covered by the power of SRM. The synergy of this relationship would make SRM's business survived as a rural economic power based on local resources, culture and ownership (the synergy of large and small enterprises in the strategic alliance relationship according to Rothkegel [28]. R2RP grow and develop the strength of SRM, so market growth impacted rural economic growth (figure 6).
Figure 6. Partnership relationship base between SRM and R2RP

A mutually beneficial relationship (partnership) that relied on strength optimization and weakness minimization (eradication) of each side would create a strong and sustainable, new business entity (James 2014). This relationship could only be maintained if the business profits grew and adapted to a highly dynamic environmental change. Adaptability [28] should be built on upstream competition (raw material procurement) and downstream (rice market). Therefore, strengthening SRM with dryers to be able to purchase raw materials at any time at any quality and any market price through drying investments was helpful.

On the other hand, competitiveness in the rice market could only be achieved if it were able to provide quality products at a price level that compete with good quality and good delivery of goods. All of these were rooted in the power of efficient raw material procurement. Therefore, husker investment would increase the efficiency of SRM processing at adequate price and quality level. R2RP has advanced technology with high efficiency reinforced by efficient SRM; it would form an integrated business entity with high adaptability (to changes in raw material production) and high market competitiveness (quality and price).

At a capacity of 80 tons of raw materials/day, R2RP required 10 SRM with a capacity of 8 tons/day. SRM have better level of market certainty to sell the product or investment assistance (husker or dryer). If the pricing were in accordance with market price or more competitive, then this working relationship would run well and sustainable. On the contrary, if the price was not competitive and commitment was not strong then SRM might sell the product directly to the market. The determinant of the success of cooperation is whether or not an agreement to be made and whether or not the parties implemented the contents of the agreement consistently. Therefore, the performance of R2RP as an initiator of cooperation would determine the success of this cooperation pattern. So far, SRM had a weakness in the competition of raw materials and product marketing. The cooperation between R2RP and SRM is mutually beneficial where R2RP gets the supply assurance of raw materials, and SRMs get market assurance for their products.

4. Conclusions and suggestions

4.1. Conclusions
The development of R2RP through SRM strengthening investments could be done as well as feasible in non-financial, financial and partnership. Dryer and huskers investment by R2RP on SRM forms the basis of mutually reinforcing partnership cooperation. This scheme required investment cost of Rp30 billion, fixed cost Rp 3.6 billion/year, the variable cost of Rp146 billion/year. The profit earned is
equivalent to IRR 84.27% and re-investment is within 2 years 2 months at the level of raw material price of Rp 7,150.- and selling price of premium rice products is Rp10,000.-

4.2. Suggestions

Further review is required to specify the partnership agreement between the parties that determine the rights and obligations stated in the purchase price of the underlying rice. The continuation of cooperation determines the economic (financial) benefits obtained by the parties.

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Appendix A. The needs of equipment/machine on technology level (Capacity 6 ton/hour)

| NO. | Description                        | Model     | Capacity Ton/hour | Power (HP) | Total |
|-----|------------------------------------|-----------|-------------------|------------|-------|
|     | **Raw Material Revenue Section**   |           |                   |            |       |
| I-1 | In-Take Hopper                     |           |                   | 1          |       |
| I-2 | Bucket elevator + motor            |           | 10                | 1          | 1     |
| I-3 | Brown rice Tank                    | 1 ton     |                   | 1          |       |
|     | **Rice to Rice Processing Section**|           |                   |            |       |
| R-1 | Bucket elevator + motor            |           | 10                | 1          | 2     |
| R-2 | Damper Tank                        | +800Kg    |                   | 2          |       |
| R-3 | Whitening machine                  | Stand Pole| 3                 | 120        | 2     |
| R-4 | Bucket elevator + motor            |           | 10                | 1          | 1     |
| R-5 | Damper Tank                        | +800Kg    |                   | 1          |       |
| R-6 | Polishing machine                  |           | 3                 | 50         | 2     |
| R-7 | Bucket elevator + motor            |           | 10                | 1          | 1     |
| R-8 | De-stoner + motor                  |           | 3                 | 2          | 2     |
| R-9 | Rotary Sifter + motor              |           | 6                 | 1          | 1     |
| R-10| Bucket elevator + motor            |           | 10                | 1          | 1     |
| R-11| Damper Tank                        |           |                   | 2          |       |
| R-12| Color Sorter                       | 384 channel| 3                | 2          |       |
| R-13| AVR                                |           |                   | 2          |       |
| R-14| Air Compressor & Air Dryer         |           | 40HP              | 40         | 1     |
| R-15| Bucket elevator + motor            |           | 10                | 2          | 2     |
| R-16| Length grader                      |           | 1                 | 4          | 8     |
|     | **Packing Section**                |           |                   |            |       |
| P-1 | Bucket elevator + motor            |           | 10                | 1          | 1     |
| P-2 | White rice Tank                    |           |                   | 2          |       |
| P-3 | Automatic Scale                    |           | 1                 | 2          |       |
| P-4 | Thread Packing machine             |           | 1                 | 2          |       |
| P-5 | Plastic Packing machine            |           | 1                 | 2          |       |
|     | **Building and Electricity Installation Section** | | | | |
| O-1 | Structure, Piping & Elbow Part     |           |                   | 1          |       |
| O-2 | Air Line Part                      | 10HP      | 30                | 2          |
| O-3 | Cyclone                            |           |                   | 2          |
| O-4 | Air Line Part                      | 15HP      | 15                | 1          |
| O-5 | Cyclone                            |           |                   | 1          |
| O-6 | Electric wire & wire gutter        |           |                   | 1          |
| O-7 | General electric Control box       |           |                   | 1          |
| O-8 | Accessory & E.T.C                  |           |                   | 1          |
|     | **The Need of Workforce**          |           |                   | 273 HP     |

18