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A System Dynamics Simulation of Rice Agroindustry Development by Divestment Pattern for Increasing Rice Production and Farmer Income

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Abstract

About 60 percent of world populations and most of Indonesian people, rice is a staple food that must be available throughout the year. Therefore the existence of a rice mills for rice production become vital. The rice mills need to be developed continually in order to support an increasing of domestic rice production. To increase rice production, postharvest loss can be reduced by replacing the old rice mills with the modern ones. By divestment pattern, a group of farmers can own and operate a rice mill, so they get an additional income from the operation of the rice mill. The main objective of this research was to findout the best scenario for a rice agroindustry development through divestment of ownership to the group of farmers. A system dynamics simulation methodology was applied in this research, with a case study in Cianjur District as a one of main area rice producer in West Java. The result from system dynamics simulation showed that the investment of 10 units of rice mill per year along 10 years by divestment pattern will developed 212 units of rice mill that enough to mill the paddy produced by Cianjur District farmers groups.

Keywords: rice, rice agroindustry, divestment, system dynamics simulation

1. Introduction

Indonesia is located around equator with wet tropical climate. This condition makes this area has long sun sine throughout year, and more rain intensity, between 700-4000 mm. This condition support farmer to develop various of plantation, poultry and fishery. The fisherman could catch the fish almost in a whole year. Based on the conditions above, Indonesia suppposed to have productive agriculture and strong agroindustry with various tropical products.

Dillon (2009), stated that an investment in agroindustrial sector would doubles agricultual share to national economic. First, the need of increasing import commodity subtitute. When people's income decrease, they will change its consumption material to other which is cheaper. Second, through increasing the export of agroindustial products, it will produce more national income. The big market opportunity, both in import and export, can be used to increase economical growth, especially in the rural area.

The development through modernization of agroindustrial sector, at least it will produce more added value of agroindustrial products and absorping more employments (Kasem & Thapa, 2012). Developing of agroindustrial sector will stimulate business development of both agriculture and agroindustrial products.

Rice is one of the most strategic commodity within Indonesian economic. Therefore this research especially concerned with rice processing industry. Rice milling was taken as an example. Most of rice are used for fulfill staple food of population. A little portion are also used as raw material of agroindustry, such as food industry, pharmaceutical and cosmetics.

The urgency of rice in Indonesian economy and food security has been concerned of respective expert researcher and community at large. Rice have been a basic foods which is its needs always increase as the increasing of people population. If the rice is sufficient in the market in affordable price, it will produce safe condition in the

society. In reverse, if there is a price volatility, and the stock is limited, therefore will produce a social unrest. (Patiwiri, 2006).

Domestic rice production is not sufficient to fulfill domestic needs, had already makes Indonesia become the importer of rice. Even more, other foods commodity also be imported in high quantity, therefore make this agrarian country become net foods importer (Abubakar, 2007).

Rice based agroindustry development using the divestment pattern is expected to be easier for implementation, improve farmer income, domestic rice production and more efficent in development financing. As the resume, research about rice based agroindustry development with divestment pattern is very urgent to be started, to produce the system model of agroindustry development that can improve farmer income, domestic rice production, and rice based agroindustry development at minimum cost.

The develpoment of modern rice mill owned by farmers group with divestment mehod, will influence the farmer income and rice production. Many parameters will dynamically interact according to time and condition. To predict future values several methods can be used such as time series method (Herman *et al.,* 2014) and by using dynamics simulation model (Sterman, 2000). Several researchers have been done on system dynamics simulation to findout a solutions of dynamics problem. Somantri and Thahir (2007), used this technique to determine a dynamics system analysis of rice availability in Merauke, East Indonesia. Basith (2012), developed a system dynamics modeling for national rice stock. Antle and Stoorvogel (2006) worked with a topic of agricultural systems, with nature a complex and dynamic, being made up of interacting bio-physical and human sub-systems.

The main objective of this research was to find the best scenario for rice agroindustry development. The detailed objectives were:

1. To simulate the increasing of modern rice mill number when divestment pattern applied.
2. To simulate the increasing of additional farmer income and rice production following the rice mill development with divestment pattern.

2. Methodology

2.1 Framework of Research

Rice is as the main staple food of Indonesian population, and therefore it is a strategic commodity that need special attention in cultivation, supply, distribution, price and quality. In term of volume, it must always be sufficient to avoid a social and economical problems. It is a risky policy to depend on import. The rice exporter countries have high surplus of rice not automatically will to export its rice to international market. They are also will maintenance rice stocks to anticipate their domestic immediate needs.

Indonesia also need to secure its rice supply to fulfill its domestic needs. However, the rice import should be viewed as an alternative way to meet the demand. The main objectve is to meet the domestic demand from domestic production. The framework of rice based modern agroindustry development can be seen in the Figure 1.

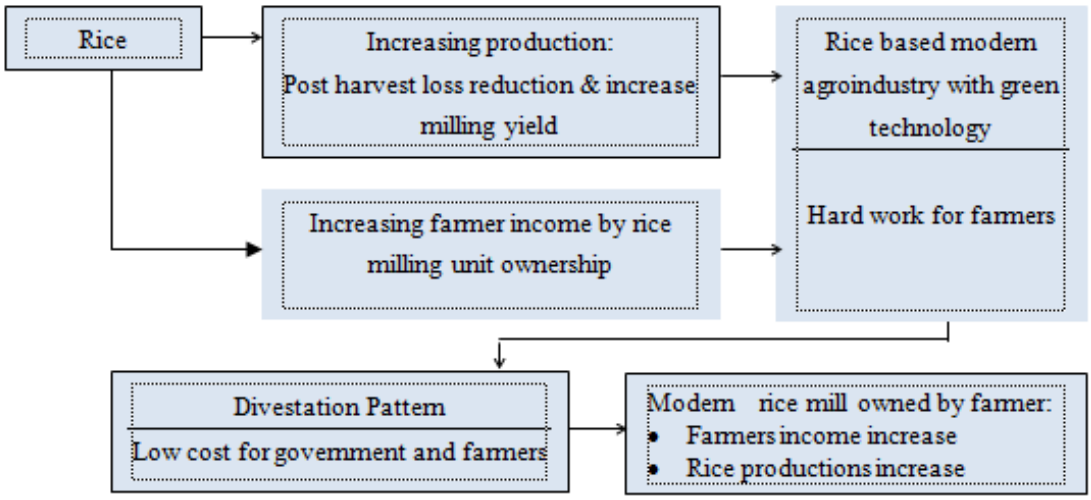

Figure 1. The research framework

2.2 System Dynamics Simulation

System dynamics was originally designated to solve problem faced by industries (Daalen and Thissen, 2001: Muhammdi *et al,* 2001). As its name, dynamic system deals with complex and dynamic system, whether this system is stable or not, fluctuate, growth, de-growth, or stay in the equilibrium condition. Dynamic problem is the problem that corelate to quantity volatility of a variable that's observed with the change of time. In addition, the problem have feedback corelation or feedback system.

The developmnet of a system dynamics simulation follows a generic four-steps, there are: conceptualization, formulation, verification and validation, and policy implementation (Sterman 2000, Daalen and Thissen, 2001).

2.2.1 Conceptualization

Currently, the rice postharvest loss is still high. This loss happen since harvesting, threshing, transporting, drying, milling, and storage. Total domestic volume of rice in 2010 was 38 million tons, if the loss can be decreased by 5%, it means can produce more supply in rice about 1.9 million tons. It is a huge volume of rice.

Efforts to reduce the postharvest loss can be done by two ways that support each other, they are rice farmer empowerment and rice based agroindustry development. The empowerment is a crucial step to increase the farmer prosperity. Through this empowerment, farmers will be able to apply certain measures to reduce and aware of the importance to decrease the postharvest loss. The farmer are requested to work more carefully in the post harvest handling.

The scope of farmer empowerment consist of three aspects, they are:

1. Capacity building or increase the farmer capacity.
2. Hardskill improvement, to master the technique of rice harvesting, threshing, drying, milling, packaging, storage, and transporting.
3. Softskill enrichment, to enhance the management of business capacity including establishment of rice milling industry.

The next step is to develop the rice based agroindustry which is designed by adopting green technology principals:

1. Economic profitability,
2. Quality improvement of rice, and
3. Environmental protection.

These green technology principles can be applied in this agroindustry development:

1. The main activities:
    a. Packaging of high quality rice.

b. Production of rice flour, which produced from splitted rice.
c. Selling of rice bran, as raw material of feed industry.
d. Composting of husk to producing organic fertilizer.

2. The utilization of waste heat of driving engine. The usage of water cooling system as a cooler of engine will be replaced by radiator. The heat released will be flew to the paddy dryer.
3. The utilization of the green house effect heat. The drying room of paddy with greenhouse effect heat is needed to be provided to solved the drying problem especially during rainy season. By providing the drying facilities as stated in point 2 and 3, it is expected the drying process will no longer obstructed especially during rainy season. Actually, to build a farmer based agroindustry is not an easy one, there would be some constraining obstacles. The divestation pattern would eliminate the problem and the limitation. This pattern is initiated by non profit bodies or investors to build the agroindustry. Meanwhile, the farmers must be prepared to conduct farmer empowerment program. After agroindustry have been well established and beneficial, then farmers can take over the ownership. The investor will exit and then move to another location with more modern design. With this pattern agroindustries can gradually be developed that owned by native farmers in the specific location. In brief, the divestation pattern preference is done by based on:
    1. The farmers are preared to participate for owning, operating, and taking the benefit of the agroindustry.
    2. Investor can exit (release a part of whole shares) to the farmers and paralelly move to other locations.
    3. The cost to build modern agroindustry unit can be more easy nationally.
    4. The cost of farmer empowerment program is expected to come from local government.

The divestation mechanism can be seen in the Figure 2.

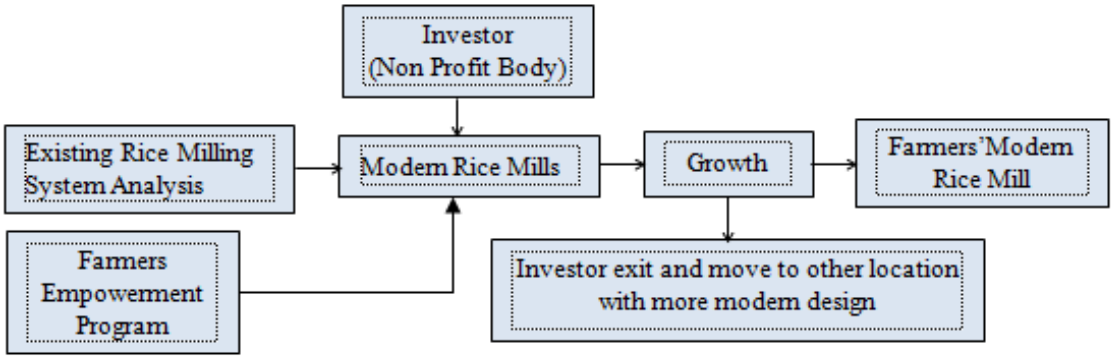

Figure 2. A divestment pattern for modern rice mill development

2.2.2 Model Formulation

Rice milling unit quantity variable which is built divestatively corelate to increasing of farmers income variable and rice productivity. This corelation changing by time variable. Therefore dynamics system simulation can be applied for analyisis purposes. The cause-effect diagram can be seen in the Figure 3 and the flowchart can be seen in the Figure 4.

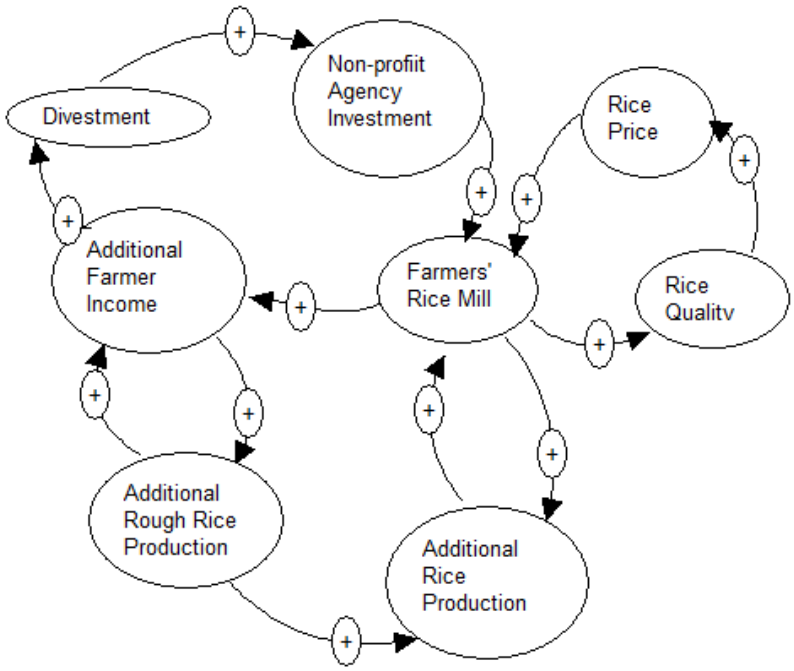

Figure 3. Causal-loop diagram of rice agroindustry development by divestment pattern

The conditions of a modern rice mill design, rough rice transaction, investment and divestment and asumptions are as follows:

• Raw Material

There are two terminologies of rough rice, namely dry-at-harvest rough rice (dhr) and dry-to-mill rough rice (dmr). A dhr contain high moisture content, about 25 %, and dmr contain of 14 % moisture (Patiwiri, 2006; Thahir, 2010).

• Milling Capacity

This rice mill is designed at miliing capacity of 1 ton dmr per hour or 8 tons dmr per day (operation time is 8 hour per day). So the milling capacity is 2400 tons dmr per year, or 2755 tons dhr per year.

• Rough Rice Transaction

The rough rice is supplied by local farmer group in the form of dhr. The market price of dhr was Rp4000,- per kg. An incentive production of Rp500,- per kg dhr will be given to farmers, as stimulant for lifting up rough rice production.

• Investment and Divestment

A non-profit body develops a modern rice mill with total investment and working capital of Rp 5.4 billion per unit. This rice mill will be divest to local farmer group with payment installment of 4 years without interest. The source fund to pay this divestment is an incentives production of dhr.

• Asumptions

A modern machinery will be installed to the rice mill, so polished rice yield will increase, asumed the figure is 2 %, and by better postharvest handling reduce a rough rice loss by 5 %. In the end of fiscal year, all net profit of rice mill operation will be transfer to farmers as an additional income. From the financial analyses (profit and lost balance statement) of the rice mill, the profit reach Rp 800 million per year.

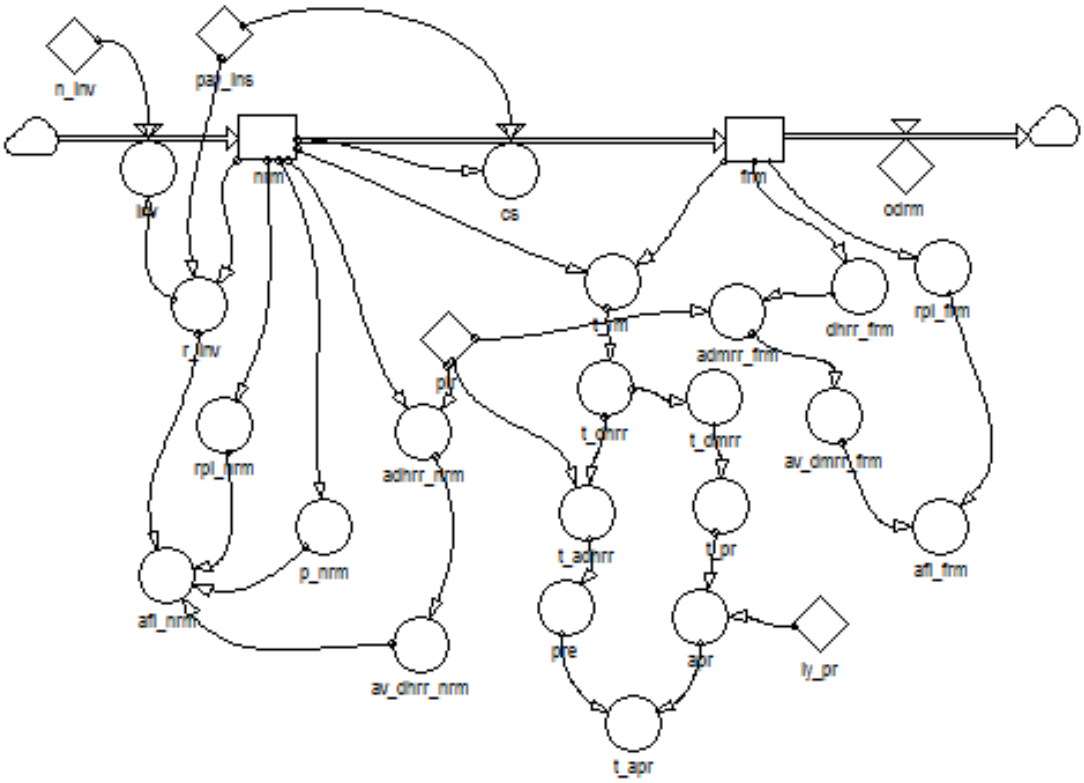

Figure 4. Forrester diagram of interrelation between rice mill number, increasing of additional farmer income, increasing of rice production and another variables

The description of parameter or variable are as follows:

adhrr_nrm	: additional of dry-to-harvest-rough rice at new rice mill, tons/year
admrr_frm	: additional of dry-at-harvest rough rice at farmers' rice mill, tons/year
afi_frm	: additional for farmer income at farmers' rice mill, billion rupiahs/year
afi_nrm	: additional farmer income at new rice mill, billion rupiahs/year
apr	: additional of polished rice, tons/year
av_dhrr_nrm	: additional value of dry-at-harvest rough rice at new rice mill, billion rupiahs/year
av_dmrr_frm	: additional value of dry-at-harvest rough rice at farmers' rice mill, billion rupiahs/year
cs	: change of rice mills status, units/year
dhrr_frm	: dry-at-harvest rough rice at farmers' rice mill, tons
frm	: farmers' rice mill, units
inv	: investment, units/year
iy_pr	: increasing yield of polished rice, tons
n_inv	: new investment, units/year
nrm	: new rice mill, units
odrm	: out of date rice mill, units
p_nrm	: profit of new rice mill, billion rupiahs/year
pay_ins	: payment installment, years
plr	: postharvest losses reduction, %

pre	: polished rice equivalent, tons
r_inv	: reinvestment, units/year
rpi_frm	: rice production incentive at farmers' rice mill, billion rupiahs/year
rpi_nrm	: rice prodction incentive at new rice mill, billion rupiahs/year
t_adhrr	: total of additional dry-at-harvest rough rice,tons
t_apr	: total of additional polished rice, tons
t_dhrr	: total of dry-at-harvest rough rice, tons
t_dmrr	: total dry-to-mill rough rice, tons
t_pr	: total of polished rice, tons
t_rm	: total of rice mill, units

The implemented equations into the simulation software of this model are as follows:

```
init    frm = 0
flow    frm = -dt*odrm
        +dt*cs
init    nrm = 0
flow    nrm = -dt*cs
        +dt*inv
aux     cs = nrm/pay_ins
aux     inv = r_inv+n_inv
aux     adhrr_nrm = plr*nrm*2755
aux     admrr_frm = plr*dhrr_frm
aux     afi_frm = rpi_frm+av_dmrr_frm
aux     afi_nrm = rpi_nrm+av_dhrr_nrm+p_nrm-5.4*r_inv
aux     apr = iy_pr*t_pr
aux     av_dhrr_nrm = adhrr_nrm*0.0045
aux     av_dmrr_frm = admrr_frm*0.0045
aux     dhrr_frm = frm*2755
aux     p_nrm = nrm*0.8
aux     pre = t_adhrr*2400/2755*0.67
aux     r_inv = nrm/pay_ins
aux     rpi_frm = frm*1.4
aux     rpi_nrm = nrm*1.4
aux     t_adhrr = plr*t_dhrr
aux     t_apr = pre+apr
aux     t_dhrr = t_rm*2755
aux     t_dmrr = t_dhrr*2400/2755
aux     t_pr = t_dmrr*0.67
aux     t_rm = nrm+frm
const   odrm = 0
const   iy_pr = 0.02
const   n_inv = 15
const   pay_ins = 4
const   plr = 0.05
```

2.2.3Verification and Validation

The above conceptual models have been validated by face method. Before the models operationally validated, the model must be verified. A check must be performed to ensure that no errors have been made in representing the model in the computer. Another very important check is the dimensional consistency check. The right-side and the left-side of every equations must match in the term of the dimensions (Daalen & Thissen, 2001). All of equations and dimensions in this model have been checked carefully, and no errors have been made in the model. Therefore, validation of the model have been done with facing method by several experts that match in their

expertise and scope of this research.

3. Results and Discussion

A rice based agroindustrial development needs abundant financial support. In other-hand, farmers that inserted in this agroindustry, have lack of capital (Sumaryanto and Nurmanaf, 2007) and managerial skill. To solve this problem, a development with divestment method can be used. One unit of modern rice mill is developed, and to be divested to local farmer group when operation is running well. The payment of the divestation is used to develop another rice mill, namely rolling method in inestment or reinvestment.

Cianjur District as one of main rice production region in West Java, have potential rough rice production about 600 000 tons per year. This region need about 200 units of modern rice mill, with milling capacity of 3000 tons rough rice per unit per year. If the rice mill developed by ordinary method, with allocation of 5 units per year, its take too long time in completion, about 40 yeras. By divestment method, the completion time can be fasten, due to the use rolling investment method. There are two factors that have highly and dinamically interactions, namely fund allocation and completion time.

Consider to the mentioned conditions, that funding allocation is critical and limiting factor, three of scenarios were arranged, namely scenario with small, medium and massive investments, with allocation of 5, 10 and 15 units of rice mill per year respectively.

3.1 Scenario I

In this scenario, fund for developing rice mill is allocated for 5 units per year, or equivalent with 5 times Rp 5.4 billion, totally Rp 27 billion per year. The developed rice mill divested to a local farmer group with payment installment for 4 years. Assumed that all of net profit the rice mill operation given to the farmer group. To individual farmer also given an incentive of Rp500,- per kg rough rice as stimulant for increasing rough rice production. From both source of incomes, farmer groups pay the divestment of rice mill. For this scenario, the simulation result is shown in Fig. 5.

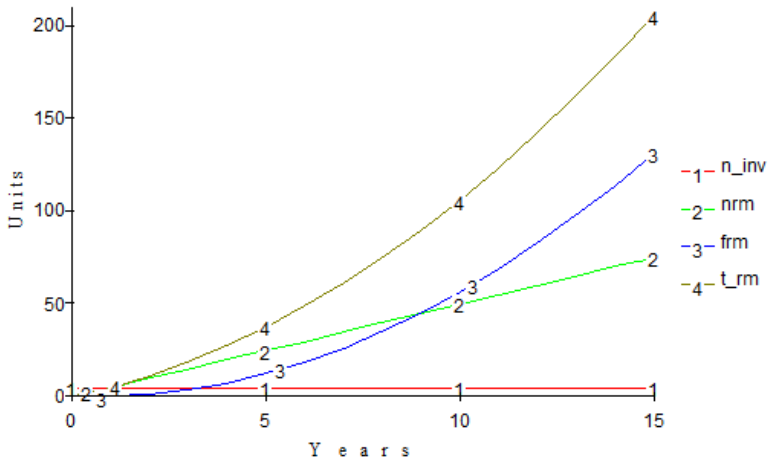

Figure 5. The growth of rice mill number at the allocation of 5 units per year

The investment its conducted at 5 units of rice mill per year constantly. By divestment and reinvestment method, the number of new rice mill increased (line no.2 in Fig 5), and the number of total rice mill increased rapidly. To reach of 200 units rice mill will be completed in 15 years, which is faster than ordinary method of 40 years.

The rate of additional farmers income is shown in Figure 6. The term of additional farmers income is more simply than total farmers income. Garcia-Alonso *et al.* (2009) stated that the process of farm gross margin determination is complicated and expensive because it is necesssary to find the value of all the inputs and outputs produced.

In the developing country such as Indonesia, farmers as the rough rice producer always sell their harvest immediately after harvested at given price. Generally, the market price in harvest time is low due to the

abundant supply in the market. They sell their product in unhusked form, without storing any stocks for their own need. The low revenue from rice production implies the difficulties in fulfilling their everyday living needs. So, any additional incomes is very important for them. The existence of modern rice mill is designed to create a secure additional incomes for them as an effort to improve their welfare.

The magnitude of individual farmers additional incomes based on rough rice productions and rice mill status. In the first year, they must pay their rice mill divestation, so in this period they recieve only partial addional income. After four years, therefore the rice mill was fully paid, they recieve ful additional incomes.

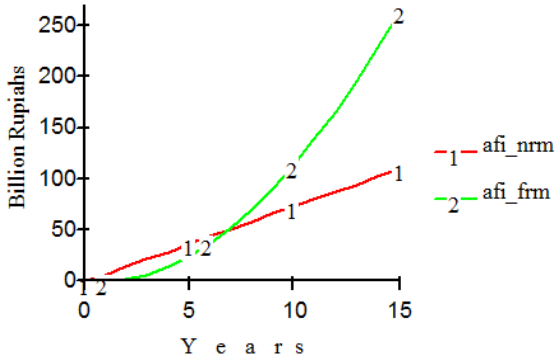

Figure 6. The additional farmer income profile at the allocation of 5 units rice mill per year

Total additional farmers income always increase, and at the end of development period, after 15 years, the magnitudes of additional incomes reached of Rp110 billion per year for the new rice mill group, and Rp266 billion per year for the farmers' rice mill group.

Postharvest losses of rice in Indonesia is still high. It is assumed that by practicing better harvesting, threshing, transporting and drying will reduce the losses of 5%, similarly by improvement of milling process increase the yield of 2%. Thus, the production improvement, obtained an additional product in the form of polished rice as showed in Figure 7. The magnitude of additional polished rice will increase, corelated with the growth of modern rice mill number. At the end of development period, the magnitude of additional polished rice will reach 23 206 tons per year.

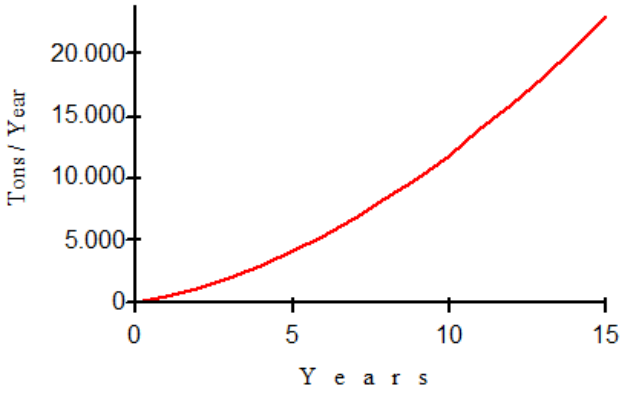

Figure 7. The growth of additional polished rice production
at the allocation of 5 units per year

At the end of the program, in the year of 15th, since the year, the invested fund can be withdrawal and then bring it for development funding in another regions. This is the advantage of the development by divestment pattern, the fund can be withdrawal after completion the program.

3.2 Scenario II

In this scenario, the investment fund is allocated twice of scenario I, there will be 10 times Rp5.4 billion, totally Rp54 billion per year, the completion time is faster, 10 years only. The growth of modern rice mill number, the increasing of additional farmers income, and additional of rice production is shown in the Figures 8, 9 and 10 respectively. Starting from the year of 11th, the rice milling became stable, equilibrium with rough rice supply.

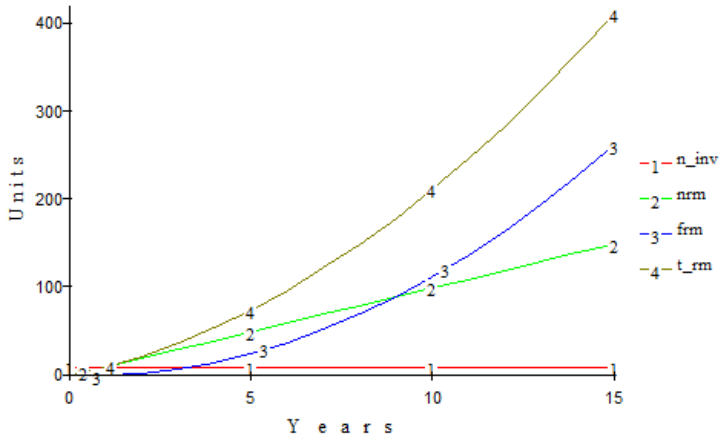

Figure 8. The growth of rice mill number at the allocation of 10 units per year

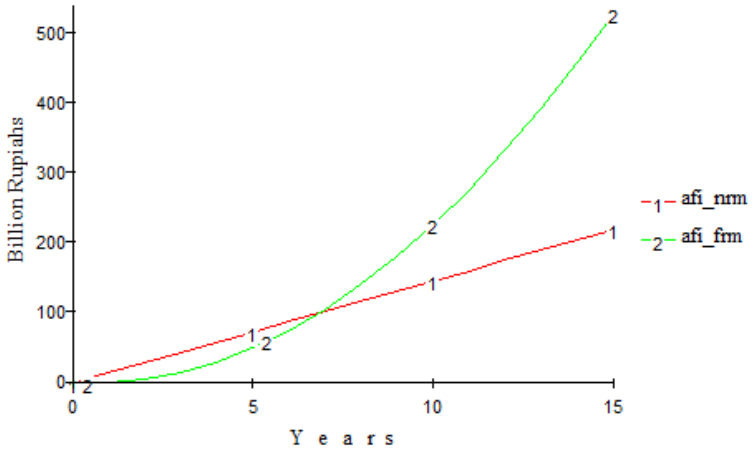

Figure 9. The formation of additional farmer income at the allocation of 10 units per year

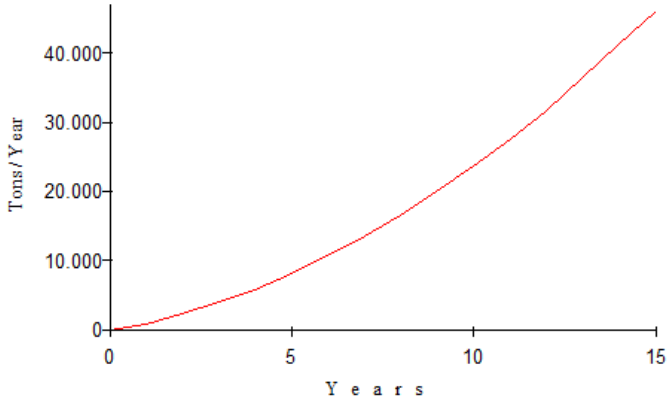

Figure 10. The growth of additional polished rice production at the allocation of 10 units per year

3.3 Scenario III

For this scenario, the allocated investment fund is three times of scenario I, total of Rp81 billion per year, the completion time is seven years and half only. The demand and supply of rough rice is balanced. The growth of modern rice mill numbers, the increasing of additional farmers incomes, and the additional of rice production showed in the Figures 11, 12 and 13 respectively.

3.4 Managerial Implications

The comparison in term of additional rice production and farmers income accumulation, its seen that the best scenario was scenario III, then scenario II and finally scenario I, as shown in Table 1.

Table 1. The comparison of additional rice production and farmers income accumulations during 15 years

Scenarios	Investment Funds (Billion Rupiahs)	Completion Time (Years)	Accumulation of additional:	
			Polished Rice Production (tons)	Farmer Income (Billion Rupiahs)
I	405	15	123 112.50	1 920.49
II	540	10	204 015.00	3 138.56
III	607.5	7.5	231 916.96	3 498.14

The implementation of rice agroindustrial development by divestment pattern, need two prerequisite, namely the funding support and the readiness of human resources. They are two groups of human resources. First group is the management of non-profit agency. This agency have a jobs and responsibility to plan, design and execute all programs to develop modern rice mill. Second group is farmers groups which will operate modern rice mill in the future. A farmer group as social structure have many relations to each other by various interdepencies (Bhaswar & Thakur, 2013). The form of farmers group institution is important factor. In case of both prerequisites are fulfilled then the Scenario III is recommended due to its shorter in completion time, only takes seven years and half. Otherwise, if the fund and human resources are less available then the choise is change to Scenario II. The last choice is to run Scenario I, wherever the fund and human resource are not suitable to run Scenario II. For further development it is possible to be cosidered for rice field extensification (Oladele &Wakatsuki, 2009).

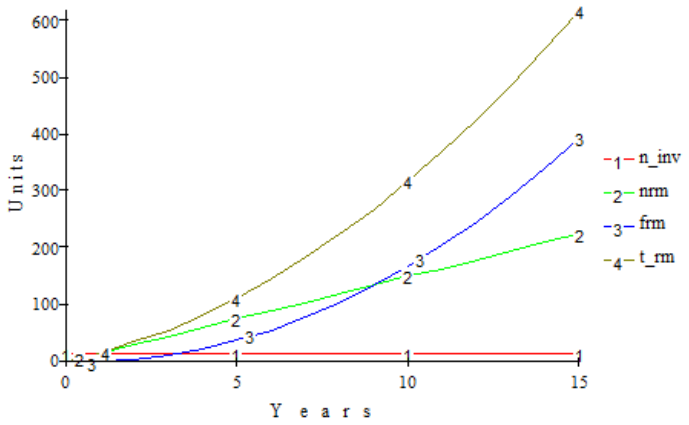

Figure 11. The growth of rice mill number at the allocation of 15 units per year

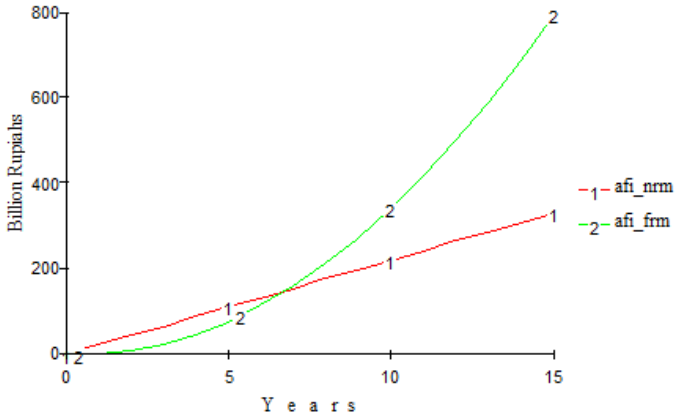

Figure 12. The formation of additional farmer income at the allocation of 15 units per year

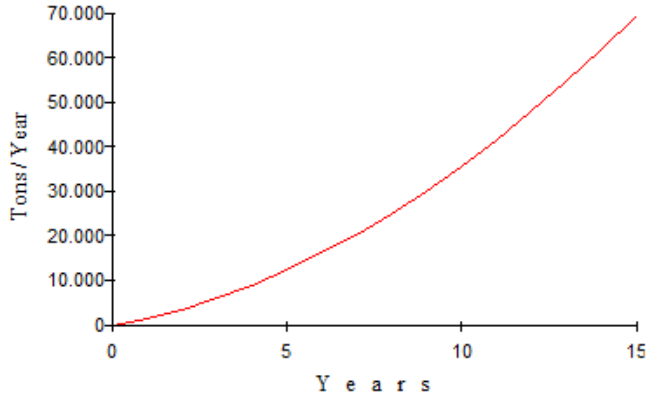

Figure 13. The growth of additional polished rice production at the allocation of 15 units per year

4. Conclusions

The current progress in modern rice mill development for increasing farmers income and rice production are constrained by limited fund. The divestment pattern is proposed as an alternative is lower to finance and shorten to completion time. The case study in Cianjur District as the main rice producer region in West Java. In this case study, if Scenario III is applied, the program needs a budget allocation of Rp 81 billion per year, and the completion time takes seven years and half. While applying Scenario II, the completion time takes longer time, 10 years with budget allocation of Rp54 billion per year. Finally, if applying Scenario I, the completion time takes 15 years and budget allocation of Rp27 billion per year.

By adopting divestment method, the investment fund can be revolved at the end of the program and to funding similar program in other location. This is the advantage of divestment method.

5. Recomendations

In the implementation of rice agroindustrial development by divestment method, the readiness of farmer group is very important. The farmer group will take over the ownership, operate, and manage a modern rice mill. Preparation of farmer group is necessary prior to implementation. Relation with farmer group readiness, the existence of farmers group institution is essential. The form of farmers groups institution model needs to be carefully studied, in order to find out the farmers group readiness for ownership, management and operasionalization of modern rice mill.

In the periods of construction and production trial, the matching between personnel and job requirement is very important factor. The team member is composed of experts and practisionners in the relevant fields. They must have good track record and competencies in the development and operation modern rice mill. Even they can communicate and have link to the actors in the real rice chain supply.

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