IOP Conf. Series: Earth and Environmental Science **355** (2019) 012054 doi:10.1088/1755-1315/355/1/012054

Dynamic modeling of marketing channels to control the inventory of Black Rice in Yogyakarta Indonesia

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Abstract. Black rice is anthocyanin-containing rice. Black rice farming can be found in several parts of Indonesia, including in Yogyakarta where the harvest is mainly used for self-consumption and to be marketed. In 2018, almost half of the farmers facing the problem to market the harvest. On the other hand, black rice distributors expressed their needs of more supply to meet Yogyakarta market demand. Therefore, it is necessary to do research on modeling the black rice marketing channel system to observe the behaviour of black rice inventory. This study aims to produce a black rice marketing system model and find out the black rice inventory system in Yogyakarta using a dynamic modeling. The sampling techniques used purposive and snowball sampling in the black rice marketing channels. The results show that the system consisted of farmers, collectors, distributors, retailers and consumers subsystems, and the best scenario in the simulation implied the collectors and distributors must increase the sale to other areas outside Yogyakarta.

1. Introduction

Indonesian people mostly consume white rice as staple food. However, nowadays, pigmented rice has become popular. Pigmented rice in the regulation of the Minister of Agriculture of the Republic of Indonesia number 31 / PERMENTAN / PP.130 / 8/2017 classified as special quality class of rice. The regulation states special rice includes sticky rice, brown rice, black rice and other special rice with certain requirements [1]. Black rice contains anthocyanins, research suggests that plant antioxidants which mop up harmful molecules can help to protect arteries and prevent the DNA damage that leads to cancer. Black rice contains many vitamins and minerals, including iron, vitamin A and vitamin B, which are beneficial for overall health and the prevention of heart disease. Black rice may have antiatherogenic activity and may improve certain metabolic pathways associated with diets high in fructose [2].

Black rice farming can be found in several regions in Indonesia, including in the Special Region of Yogyakarta (Yogyakarta), where harvests are mainly used for self-consumption and to be marketed. Increasing public awareness of the importance of health has caused the demand for black rice products to increase. In addition, black rice farmers are also increasing, especially in Yogyakarta because people are beginning to realize the importance of preserving local cultivars of black rice. Based on this, Yogyakarta has the potential and opportunity to develop local cultivars of black rice [3].

In Yogyakarta, the production and demand for black rice has increased in 2010 to 2016. Although, there are farmers who still find it difficult to market black rice from their crops. In 2018 there were 19

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farmers from 39 black rice farmers (48.72%) who had difficulty to market their black rice harvest. On the other hand, collectors and distributors of black rice said that their needs of more black rice to meet the market demand for black rice. Therefore, it is necessary to do research on modeling the black rice marketing channel system to observe the behavior of black rice inventory in Yogyakarta. Marketing channels or distribution channels are interdependent organizations that help provide products or services to be used or consumed by consumers or business users [4].

This research was conducted by tracing the black rice marketing channel to find out the amount of production and the amount of purchases of black rice (inflow) in Yogyakarta and to find out the amount of consumption and amount of black rice (outflow) sales in Yogyakarta. The aim is to produce a black rice marketing system model and find out the black rice inventory system in Yogyakarta uses dynamic modeling.

2. Methodology

The study was conducted in Special Region of Yogyakarta from March 2018 to January 2019. The data collection was done by interviews. The respondents were determined using snowball sampling method because the black rice farmers population is not clear and there is uncertain number of them. The sampling started from government agencies related to agricultural development in the province and regency levels to identify black rice farmers who known as key informants. This snowball sampling method was also used to determine the samples of black rice marketing institutions in Yogyakarta. There were 54 respondents who had been interviewed, consisting of 39 farmers, 10 collectors, 3 distributors, and 2 retailers.

Primary data used in the study was collected from interviews to respondents including planting area, productivity, sales, consumption, purchases, prices and costs. Yogyakarta has the potential and opportunity to develop black rice, but the availability of data on black rice is minimal. The data was annual data from the year of 2015 to 2018.

Data analysis was performed using quantitative analysis through the design of the black rice marketing channel system model carried out using dynamic models. The essential extension in the case of a dynamic model is the fact that it incorporates the notion of evolution over time [5]. The dynamic model changes with time [6], the modeling steps include:

1) Creating causal loop diagrams (CLD)
   CLD is created based on variables that affect the inventory of black rice and the benefits obtained by black rice marketing channel institutions. The important thing that becomes the first basis in building dynamic systems is the feedback information theory. Dynamic system models combine system theory and computer simulation to examine the causal loop, state of the system and solve systematic problems [7].
2) Model building
   Modeling the black rice marketing channel system using CLDs that is done by making a model structure and entering values and equations in the model structure based on the data that has been collected.
3) Verification and validation of the model
   Verification to determine whether or not there are errors in the model. Validation to find out which model is made in accordance with the actual system. Validity test of the model is done by mean comparison test and error variance test. The mean comparison value can be calculated using the formula 1 while the error variance value can be calculated by the formula 2. This model is classified as valid if the mean comparison is less than 5% and error variance is less than 30% [8].

$$E_1 = \frac{|\bar{S} - \bar{A}|}{\bar{A}} \times 100\% \quad (1)$$

$$E_2 = \frac{|S_s - S_a|}{S_a} \times 100\% \quad (2)$$

$$\text{Average} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (3)$$

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$$\text{Standard deviation} = \sqrt{\frac{n\sum_{i=1}^{n} x_i{}^2 - \left(\sum_{i=1}^{n} x_1\right)^2}{n(n-1)}} \quad (4)$$

where, E_1: mean comparison (%)

$\overline{S}$: average value of simulation

$\overline{A}$: average values of actual data

E_2: error variance (%)

S_s: Standard deviation of simulation

S_a: Standard deviation of actual data

x_i: data in period i

n: amount of data

4) Scenario and model development

Perform simulations with several scenarios and then analyze the results of several scenarios performed.

3. Results and Discussion

3.1. Black rice marketing channel system

The special region of Yogyakarta is one of the provinces in Indonesia. Yogyakarta consists of 1 city and 4 regencies, namely Yogyakarta City, Bantul Regency, Gunungkidul Regency, Kulon Progo Regency and Sleman Regency. Based on interviews from the government agencies related to agricultural development in the province level, it is known that there are 3 regencies that plant black rice namely Bantul Regency, Gunungkidul Regency, and Sleman Regency. The black rice marketing channel in Yogyakarta involves marketing institutions consisting of (1) farmers, (2) collectors, (3) distributors and (4) retailers who are mutually related. The four marketing institutions are hereinafter referred to as subsystems. Based on the results of interviews to local black rice farmers, they said that black rice production still exceeds the demand resulting in a surplus. This shows that there is an inventory of black rice in Yogyakarta at the farmers level, which are 219 kg in 2015, 8,480 kg in 2016, 23,446 kg in 2017 and 34,637 kg in 2018. Black rice inventory in Yogyakarta turned out due to the high volume of black rice inflow from outside the region, which are 7,250 kg in 2015, 20,846 kg in 2016, 11,402 kg in 2017 and 15.311 kg in 2018 that resulted in Yogyakarta farmers facing difficulty in selling out their harvest. This modeling attempted to minimize the inventory in order to maximize profit of the farmer in their marketing activities.

3.2. Causal loop diagrams

To control the inventory in Yogyakarta black rice marketing channel, the diagrams of channel subsystem was described in the following figures. The black rice inventory is influenced by black rice production and sale of black rice. However, the black rice inventory also affects the production and sale of black rice. The causal relationship in the black rice marketing channel system can be seen in figure 1 to figure 4.

The causal loop diagram (CLD) in the black rice marketing channel system in Yogyakarta consists of 4 subsystems, namely the farmer subsystem, collector subsystem, distributor subsystem and retailer subsystem.

1) Farmer subsystem

Apart from planting black rice, farmers also function as marketing institutions that start the black rice marketing channel. Their harvest is for self-consumption and to be marketed. Farmers have been marketed their products in the form of milled dried grain and rice. The factors that influence inventory and profit for farmers described in figure 1.

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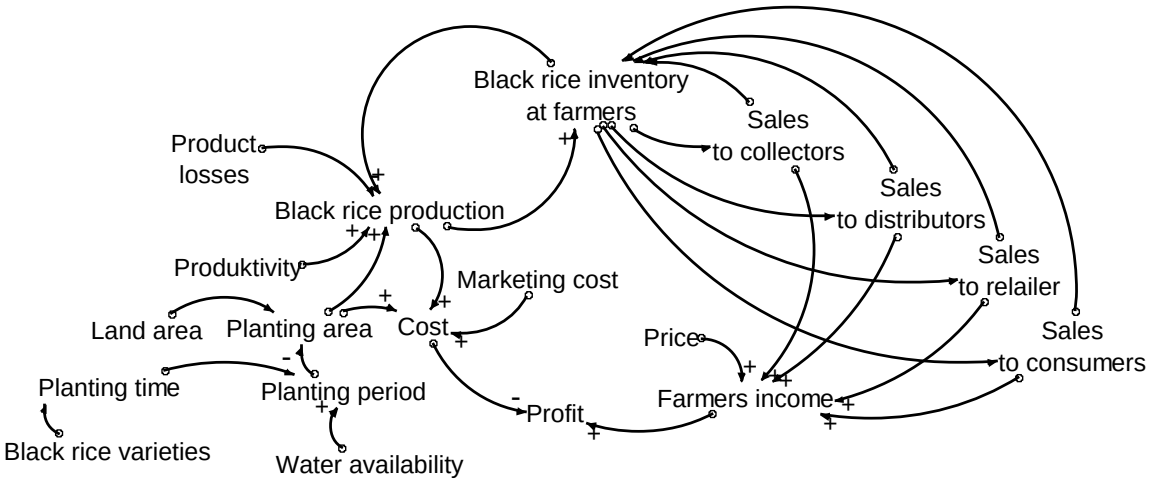

Figure 1. Causal Loop Diagram of Farmer Subsystem in Black Rice Marketing Channels

The farmer subsystem was developed based on production and sales of black rice. Black rice inventory at farmer was affected positively by the production and negatively by the sales of black rice to collector, distributor, retailer, and consumer. In addition to that, black rice production was affected positively by its productivity and planting area and negatively by its product losses. Planting area was affected by land area and planting period includes planting time, water availability and black rice varieties. Farmer profit was affected positively by farmers income and negatively by cost. Farmer income was affected positively by price dan sales. Cost was affected positively by marketing cost, planting area and black rice production.

2) Collector subsystem

Collectors are people who buy grain and black rice from farmers. The factors that influence inventory and profit for collectors described in figure 2.

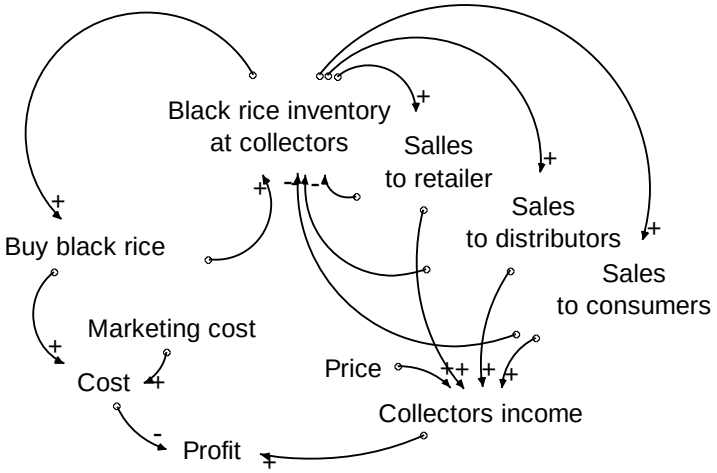

Figure 2. Causal Loop Diagram of Collector Subsystem in Black Rice Marketing Channels

The collector subsystem was developed including buy and sales of black rice. Black rice inventory at collector was affected positively by buy black rice and negatively by sales of black rice to distributor, retailer, and consumer. Collector profit was affected positively by collector income and negatively by cost. Collector income was affected positively by price dan sales. Cost was affected positively by marketing cost and buy black rice.

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3) Distributor subsystem

Distributors are person or entity that distribute black rice from collectors or farmers to retailers. The factors that influence inventory and profit for distributors described in figure 3.

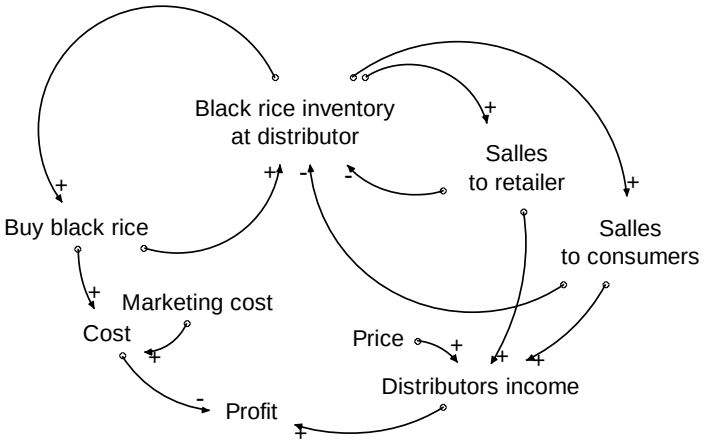

Figure 3. Causal Loop Diagram of Distributor Subsystem in Black Rice Marketing Channels

The distributor subsystem was developed including buy and sales of black rice. Black rice inventory at distributor was affected positively by buy black rice and negatively by sales of black rice to retailer and consumer. Distributor profit was affected positively by distributor income and negatively by cost. Distributor income was affected positively by price dan sales. Cost was affected positively by marketing cost and buy black rice.

4) Retailer subsystem

Retailers are people who buy black rice in large scale then sell black rice little by little [9]. The factors that influence inventory and profit for retailers described in figure 4.

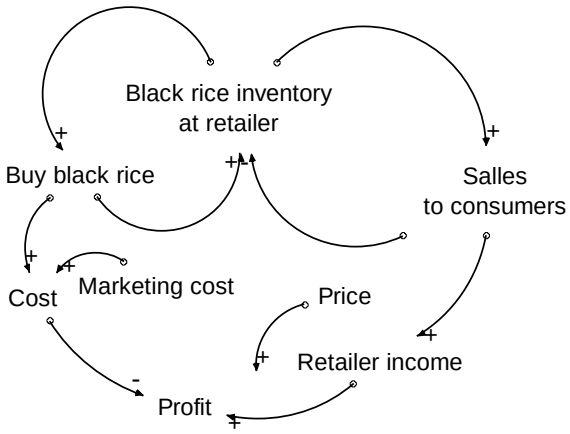

Figure 4. Causal Loop Diagram of Retailers Subsystem in Black Rice Marketing Channels

The dynamic modeling system (retailer subsystem) that was developed that were related to buy and sales of black rice. Retailer profit is affected positively by retailer income and negatively by cost. The retailer subsystem was developed including buy and sales of black rice. Black rice inventory at retailer was affected positively by buy black rice and negatively by sales of black rice to consumer. Retailer profit was affected positively by retailer income and negatively by cost. Retailer income was affected positively by price dan sales. Cost was affected positively by marketing cost and buy black rice.

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3.3. System modeling

The four CLDs as shown in figure 1 to figure 4 are used as the basis to build the black rice marketing channel model. The variables in CLD used to build the model is the variables that have a direct effect on the model, that are productivity, product losses, planting area, buy, sales, cost, and price

Figure 5 to figure 9 are an influence diagram of the black rice marketing channel model. Figure 5 and figure 6 show the black rice marketing channel model on Bantul. In this study, influence diagrams such as figure 5 and figure 6 also were made for each regency.

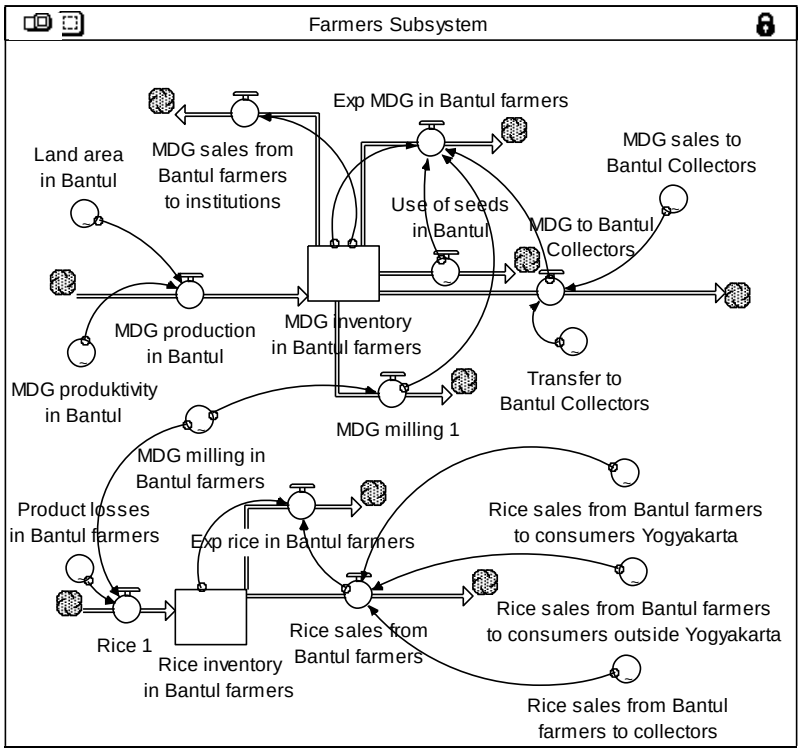

Figure 5. Influence Diagram of Farmers Subsystem

Influence diagram of farmer subsystem was made to explain the inventory of black rice at farmer subsystem arranged from production and sales.

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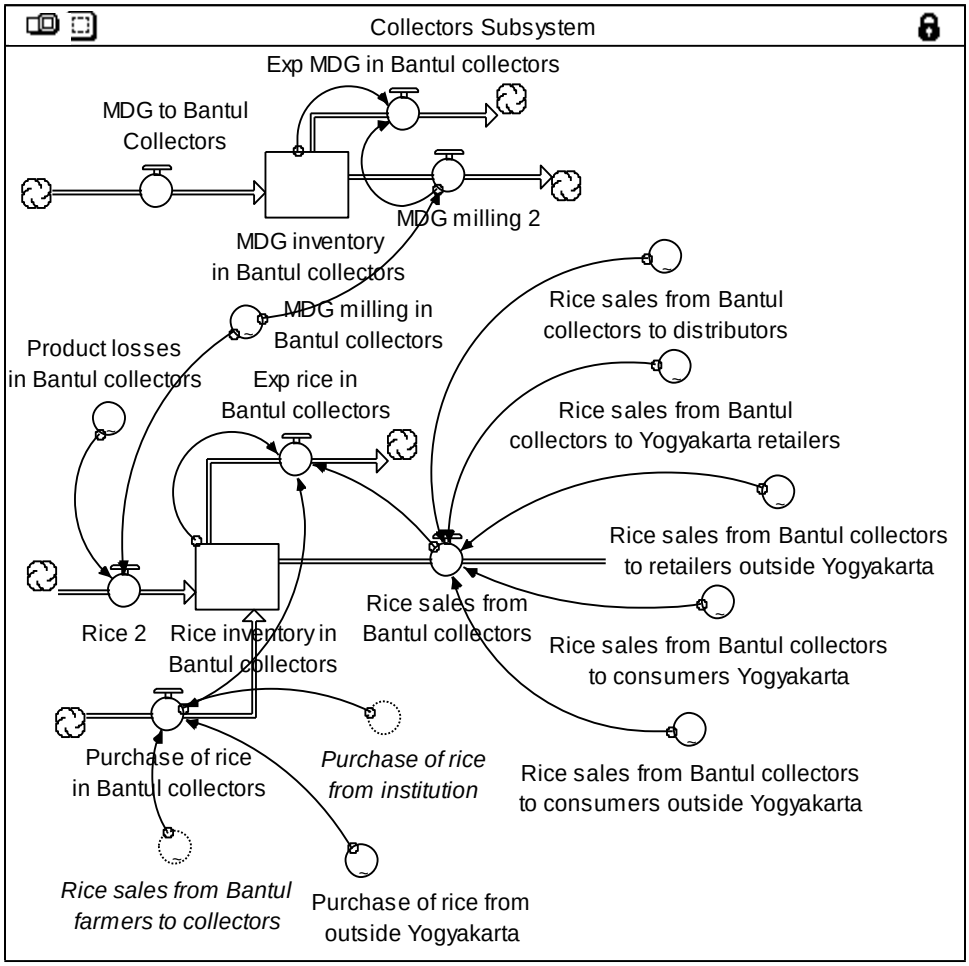

Figure 6. Influence Diagram of Collectors Subsystem

Influence diagram of collector subsystem was made to explain the inventory of black rice at collector subsystem arranged from production and sales.

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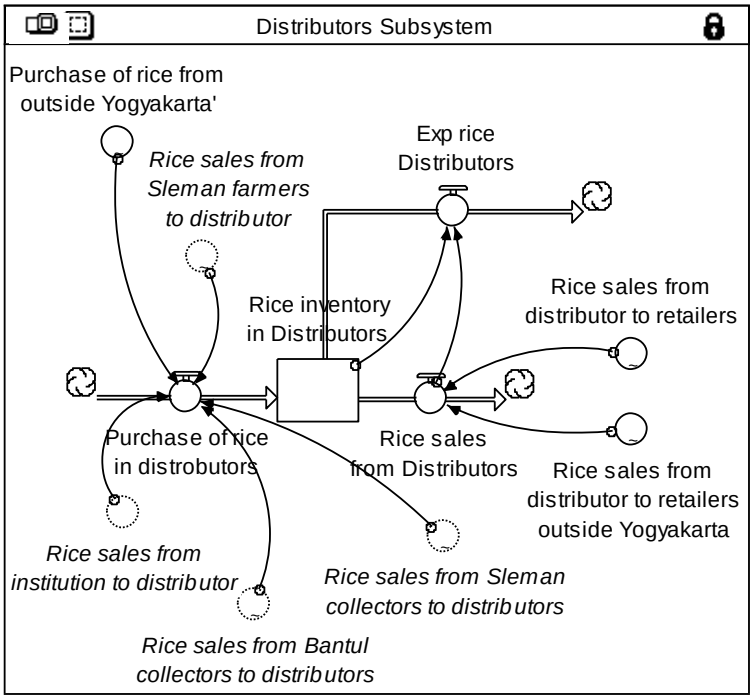

Figure 7. Influence Diagram of Distributors Subsystem

Influence diagram of distributor subsystem was made to explain the inventory of black rice at distributor subsystem arranged from purchase and sales.

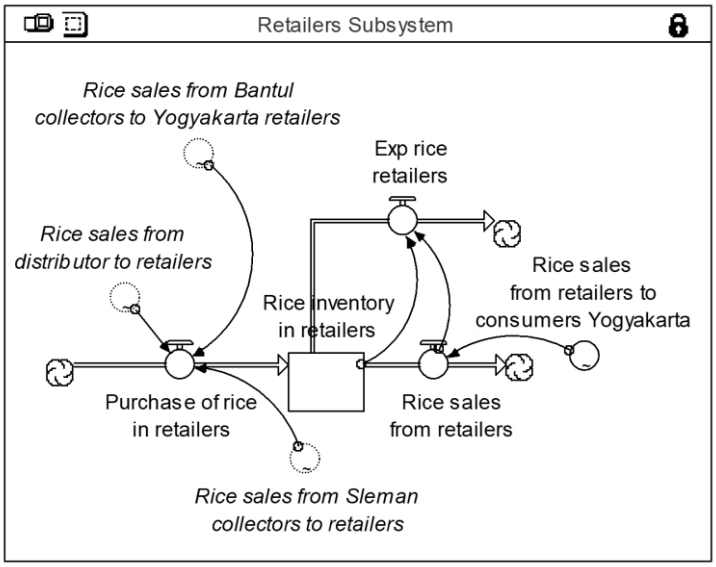

Figure 8. Influence Diagram of Retailer Subsystem

Influence diagram of retailer subsystem was made to explain the inventory of black rice at retailer subsystem arranged from purchase and sales.

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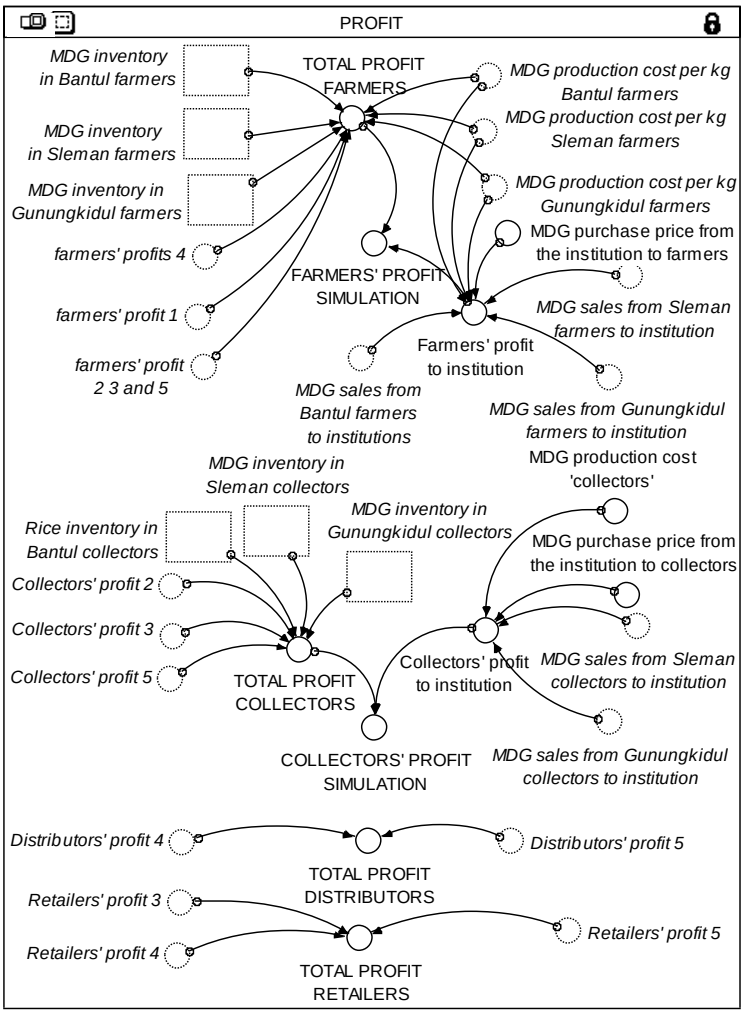

Figure 9. Influence Diagram of the Marketing Channel Profit for Black Rice in Yogyakarta

Influence diagram of marketing channel profit was made to explain the profit of black rice marketing institutions, consists of farmer's profit, collector's profit, distributor's profit and retailer's profit.

The results of the E_1 test and E_2 test on the model show that E_1<5% and E_2<30% so it can be ascertained that the model that has been built is valid model.

3.4. Simulation with 4 scenarios

Based on black rice inventory annual data in Yogyakarta between 2015 to 2018, 4 scenarios were prepared. These four scenarios were simulated to find out which scenario produces the maximum sales conditions for Yogyakarta local rice so that it can minimize inventory of black rice in Yogyakarta. The increase of the amount of black rice sold is expected to increase profits obtained by the black rice marketing institutions. Each scenario has a policy that is manifested through the value changes of local black rice purchase, black rice sales to outside of the region, and black rice purchase from outside the region. Each scenario has a policy, each policy is realized by changes in the value of the variable [10]. Comparison of the variables values in each scenario can be seen in table 1.

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Table 1. Scenario in the simulation model of the black rice marketing channel in Yogyakarta

Scenario	Local black rice purchase	Black rice sales to outside of the region	Black rice purchase from outside the region
1	Normal	Normal	0 kg
2	Increased 15,311 kg	Normal	Normal
3	Increased 15,311 kg	Normal	0 kg
4	Normal	Increased 27,793 kg	Normal

The simulation results from the four scenarios can be seen in table 2.

Table 2. Simulation results of the black rice marketing channel model in Yogyakarta

Scenario	Inventory of black rice (kg)	Total profit (IDR)
1	51,865.9	1,095,414,437
2	53,500.3	944,289,445
3	18,395.2	1,350,273,407
4	10,029.8	1,407,251,067

Scenario 4 is a scenario that can help minimize black rice inventories and maximize profits, this is possible through an increase in sales of black rice outside the region by 28.30%.

4. Conclusion

The existence of black rice inventory in Yogyakarta turned out due to the high volume of black rice inflow from outside the region that resulted in Yogyakarta farmers facing difficulty in selling out their harvest. In order to help local farmers to minimize the inventory and to maximize the profit, scenario 4 is chosen. The scenario implied black rice inventory of 10,029.8 kg and total profit earned by all black rice marketing institutions in Yogyakarta includes farmers, collectors, distributors and retailers 1,407,251,067 IDR. The selected scenario will be made possible by increasing sales to outside the region by 28.30%.

Acknowledgments

This research was supported by the RTA Program under The Directorate of Research UGM to DI and AAP.

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