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UNDERSTANDING CRITICAL FACTORS AND ANTECEDENTS IN INDONESIAN SMALL DAIRY INDUSTRIES

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Abstract-Small dairy farmers in Indonesia typically join dairy cooperatives in order to overcome the limited resources in maintaining fresh dairy products, especially milk. The higher the quality, the better the price paid by milk processing companies. This research aims to better understand the uncertainties that influence the quality of milk by identifying its critical factors and antecedents, using the system dynamics approach. Feed supply, equipment and milk hygiene, milk collection point cooling system, milk storage and transportation, storing time and operating time are the main focus of the simulation model developed in this paper. The main output data supporting the decision-making process are the percentage of the total solid relative to the number of microbes, which describe the stability of feed supply.
Keywords: Supply chain, perishable, System Dynamics, dairy, uncertainty.

I. INTRODUCTION

Fresh milk is categorized as perishable goods. Fresh milk needs cooling at least two hours after milking to prohibit spoilage by the accumulation of microbes. However, small dairy farmers (folk dairy farmers), which has only three to four cows, usually do not have adequate facilities and equipment for an ideal dairy farm. To overcome this resource constraints, individual folk dairy farmers usually join dairy cooperatives in order to better utilise resources, reduce wastage and gain higher economic of scale, thus reducing the total cost of production and marketing (Uotila and Dhanapala, 1994). Dairy cooperatives facilitate production infrastructure, outbound logistics, and marketing in dairy supply chain activities. In terms of production and operations, dairy cooperatives provide the necessary assistance in cow procurement, credit to purchase cows, equipment for milk collection and chilling and vehicles for transport. In outbound logistics, dairy cooperatives handle the collection, chilling, and distribution of milk to milk processing plants. In marketing, dairy cooperatives do collective marketing to give fair prices for dairy farmers. Dairy cooperatives usually market their products to private-sector milk processing industries.

Small dairy farmers are often faced with a classic problem in achieving and maintaining the quality and volume of milk due to the manual methods of milking, less availability of good fodder, and handling of milk for distribution to the cooperatives (Morey, 2011). The low quality of milk is usually showed by the high intensity of microbes, indicated by the Total Plate Counts (TPC) exceeding 1 million per ml. Milk with this kind of problem will be immediately rejected because it cannot be, or is costly when, processed further.

The aim of this research is to better understand the uncertainties that influence the quality of milk by identifying its critical factors and antecedents. To guide the execution of the research, the following research questions (RQs) have been developed:

1. How does a typical dairy supply chain incorporating small dairy farmers look?
2. What factors that affect the quality of the dairy products at these small farmers?
3. How are these factors affecting the uncertainties in a dairy supply chain model?

The method chosen for this research is quantitative, incorporating the development of the dairy supply chain model using system dynamics modelling and simulation. The simulation mainly focuses on the quality of milk and the scope of the model covers dairy farmers and dairy cooperatives in the West Java province of Indonesia.

II. LITERATURE REVIEW

A. *Dairy Supply Chain in Indonesia*

Since 1978, dairy cooperatives have faced fierce competition from low-cost imported milk powder to market their product to private-sector milk processing industries (Uotila and Dhanapala, 1994). The low-cost milk powder originates from dairy cooperatives in Europe and Oceania (Uotila and Dhanapala, 1994). The dairy cooperatives in Europe and Oceania are made up of mostly medium to large size dairy farmers in relatively concentrated regions, e.g. hills. On the other hand, dairy cooperatives in Indonesia constitute small dairy farmers in a rather dispersed area, making it less competitive in price. As a countermeasure to this competition, the dairy cooperatives union of Indonesia has negotiated with the private-sector milk-processing industries for a fairer quota and price of milk supplied by dairy cooperatives, which is reviewed every six-months (Uotila and Dhanapala, 1994). Nevertheless, the price of milk set by the private-sector milk processing industries through the dairy cooperatives for small dairy farmers is considered to be of low value. This is thought to be due to the break-even point, which, according to GKSI, is about Rp 3.500 per litre, but large milk processors pay only Rp 3.600 per litre on average (Morey, 2011). Dairy supply and market chain in Indonesia within its stakeholders are shown in Figure 1.

B. Dairy Supply Chain Model

Mixed Integer Linear Programming (MILP) model has been used by Pooley (1994), Wouda et.al. (2002), and Eksioglu and Jin (2006). Both Pooley (1994) and Wouda et.al. (2002) explored location-allocation cases from the dairy industry, but Wouda et.al. (2002) developed a complex model that integrated by-products movement such as cream and whey. Eksioglu and Jin (2006) developed a network planning of perishable products.

Dairy supply chain model related to milk quality is seen in research by Dooley et.al (2005) who investigated the different types of milk collection. In this transport logistics problem, they maintained the separation of different types of milk along the transportation routes.

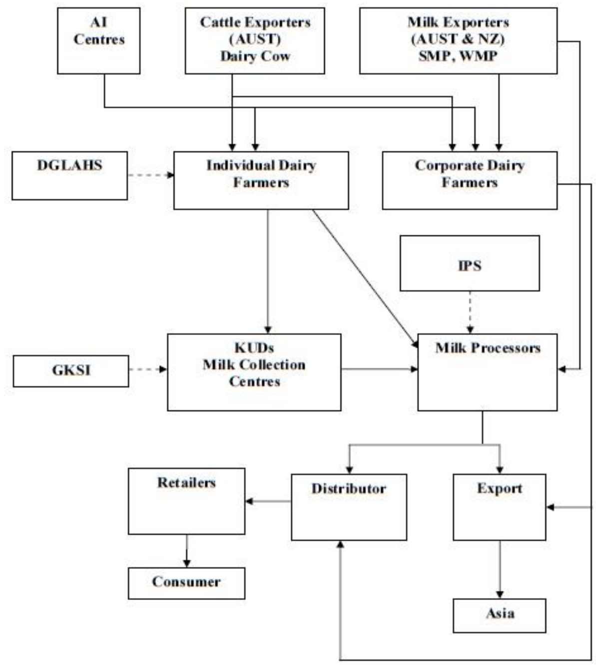

Fig 1. Dairy Supply and Market Chain. (References: Morey, 2011)

Marquez and Ramirez (2009), Schimith et.al. (2015), Lie and Rich (2016), Suryani et.al. (2017), Lie et.al. (2017), and Lie et.al. (2018), all applied system dynamics in the dairy supply chain modelling. Marquez and Ramirez (2009) observed the matured cheese production; Schimith et.al. (2015) focused on the genetic improvement technology in milk production; Lie and Rich (2016) developed a value chain of small producers focusing on the feeding systems improvement; Suryani et.al. (2017) determined the national fulfilment ratio of milk based on cow's milk supply and demand; Lie et.al. (2017) emphasised on the importance of the participatory model building process; and finally, Lie et.al. (2018) identified the linkages between policies and feeding system improvements.

III. METHODOLOGY

To provide answers to the research questions, the research adopted a qualitative approach in designing the theoretical framework that describes the dairy supply chain in general. The data were collected from literature relevant to the dairy industries, as well as also the latest reports about dairy supply chain and market research in Indonesia (Morey, 2011).

Having built the theoretical underpinning, we carried out interviews and observation to corroborate the dairy supply chain concept. The scope of the interviews and observation was the West Java province of Indonesia, and the unit of analysis was the dairy farmers joining in the cooperatives. The usage of observation helped in triangulating the data and information collected from the interviews.

System dynamics was adopted, not only as a tool to layout the critical factors affecting the quality of milk produced, hence price, but also to illustrate the dynamics of the changes of the parameters due to interventions and disturbances (Sterman, 2000).

IV. RESULTS AND DISCUSSION

Based on the interviews with the head of KUDs (*Village cooperatives*), there are some additional concepts in dairy cooperatives in Indonesia, as listed below:

1. Additional task of dairy cooperatives in terms of KUDs: KUDs have a task to give training about good practices in feeding, milking method, husbandry, and other supporting activities
2. Purchasing of fresh milk by milk processors: Payment of fresh milk from milk processors to KUDs accumulated per half month and payment of fresh milk from KUDs to dairy farmers accumulated per month; and there is a table to do milk pricing based on quality
3. Fresh milk flow from dairy farmers to milk processors shown in Figure 2.

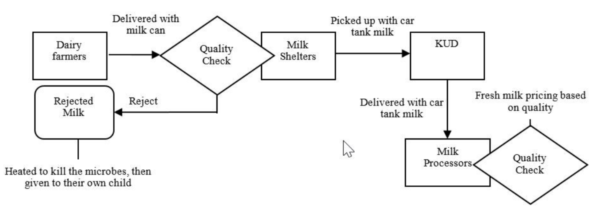

Fig 2. Fresh milk flow from dairy farmers to milk processors

4. Distribution problems from KUDs to milk processors occurred because of traffic jam resulted in the increase of TPC
5. Quality of fresh milks: the quality of fresh milk from cows milked in the morning is different from that in the afternoon

A. Model Structure

The conceptual model developed in this research shown in Figure 3. The model consists of four main modules: 1) milk production, 2) microbes accumulation, 3) milk quality (%total solid), and 4) profit margin based on feeds expense but in this research we will focus on milk production and profit margin. In this model, lactation cow quantity overtime was assumed to be constant, so there was no cow herd dynamics module. Another assumption in this model was water source that has good quality and also sustains each cow genetics assumed to be uniform. The model was developed using Vensim PLE 7.3.5 software.

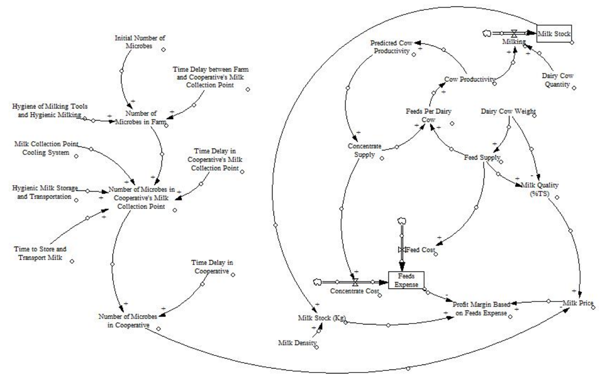

Fig 3. Conceptual System Dynamics Model

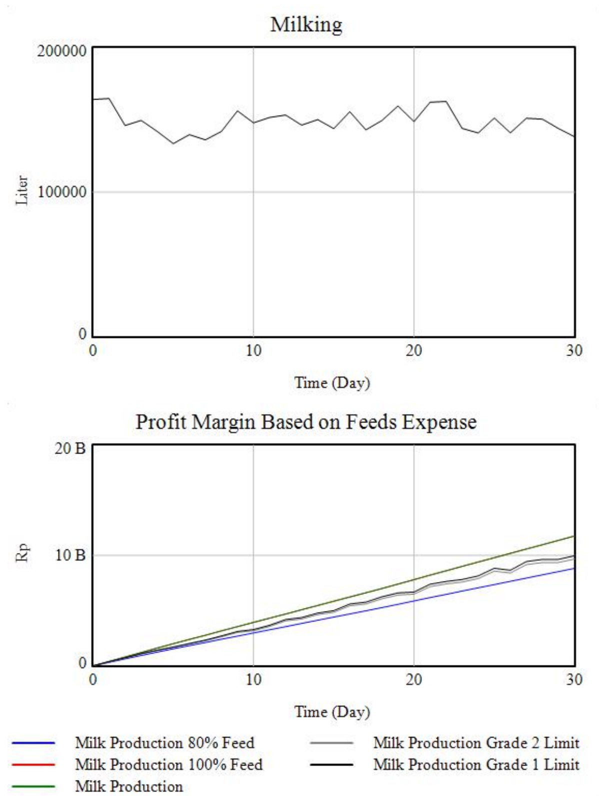

Fig 4. Milking graph and profit margin based on feeds expense

As a result, the simulation model shows a similar pattern with the time series data from observation. Milking graph explains those patterns shown in Figure 4. The patterns shown in Figure 4 illustrate unstable feed availability that affects the quantity of milk produced. Unstable feed availability occurs because of the competition in obtaining feed with goat breeder, sheep breeder, and beef cattle breeders. Furthermore, self-procurement of feed is constrained in the availability of suitable land. The results of simulation when feed can be hold at 80% and 100% overtime shown in Figure 4. This illustrates a circumstance when folk dairy farmers have to sustain a certain amount of feed supply. Milk grade 1 production with 80% feed supply scenario has lower profit than milk grade 2 production with unsustainable feed supply scenario. In conclusion, feed supply must be considered to be maintained at the optimal input.

V. CONCLUSION

Dairy supply chain for smallholders' dairy farmers consists of dairy farm, cooperative, and milk processing industry. Dairy farm produces fresh milk transported as soon as possible to cooperative's milk collection point or cooperatives. Milk quality assessment is done there, and continued with milk cooling at 4oC. Cooled milk is transported into milk processor for further processing into dairy products.

Smallholder dairy farmers supported by cooperatives must attain to make the quality of milk as good as possible to get better payment from milk processing industries. To provide good milk quality, smallholder dairy farmers and cooperatives must pay attention to feed supply and concentrate supply in addition to maintaining clean water availability. To maintain quality of milk, smallholder dairy farmers and cooperatives must pay attention to milking tools hygiene and hygienic milking; milk collection point with cooling system; hygienic milk storage and transportation; and short time to store and transport milk in addition to maintaining shortest possible operating time. Milk with high percentage of total solid and low number of microbes will be sold at a good price.

The main challenge faced smallholder dairy farmers in obtaining good quality milk is the unstable feed supply. This is due to the competition to obtain feed and limited availability of suitable land to do self-procurement of feed. Developing feed substitutes such as rice silage by product of rice harvest can be an option to overcome feed availability. This condition paved the way for further research in feed substitutes using abundant resource that can come from agricultural byproducts and self-procurement of feed or optimal feed substitutes with restrictions on land competition.

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