A design of competitive cocoa agro-industry supply chain system in Putat village, Gunung Kidul district

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Abstract. Inconsistency quality and availability of cocoa beans become a serious problem for cocoa agro-industry. In general, we can not trace whose cacao beans are processed in the industry. This is due to the lack of integrated supply chain consisting of farmer, collector, trader, exporter and industry. This study aimed to produce a design of competitive cocoa agro-industry supply chain system with dynamic system approach. Integrated partnership between Sidodadi farmer’s group in Putat village, Patuk subdistrict, Gunung Kidul district with TTP Nglanggeran, Cokelat nDalem and local collector give a competitive value for cocoa agro-industry supply chain. Through this, fermented beans directly distributed to industry and processed. Cocoa supply in scenario increase 2.61% from existing, decreasing the balance of cacao beans supply demand up to 0.7%, raising the first level of cacao beans quality up by 2022, and lifting the accumulation of Farmers group’s profit up to 29.31%. The design of this system is expected to inform cacao stakeholders about the importance of partnerships to improve cocoa agro-industry competitiveness.

Keywords: cocoa, dynamic system, supply chain system

1. Introduction
Cacao as one of the country’s foreign exchange contributors has decreased production which disrupts the supply for cocoa industry. This condition caused by the old age of cacao plant, unsuitable cultivation pattern, pest attacks and climate change [1]. Post harvest handling especially fermentation has not been a priority, direct selling of wet beans, unwell established partnership between farmers and industry, prices fluctuate, and long of supply chain causes low quality of cacao beans [2]. Small land of each farmer (less than 1 acre) and economic needs are being a reason to sell wet and unfermented beans to local collector.

In global trading, our cacao beans has been exported to AS, Europe, Malaysia and Singapore produced as intermediate and end product [3]. It causes lack of beans, less utility of cocoa processing industry and low quality of cocoa products. This is one of reason we have to import cocoa products [4]. It shows a dilemma and contradiction in developing cocoa products with high value added than beans [5].

There are two kind of cocoa agro-industry, one is conventional which use blended fermented and unfermented beans to produce liquor, butter, powder and the other is bean-to-bar which use well fermented beans to produce chocolate, choco drink and nibs. These industries give an option for farmers to differ their quality of beans.
An integrated partnership between farmers’ group and industry give a competitive value for cocoa agro-industry supply chain. An integrated partnership make a distribution line from producer to consumer directly [6]. Fermented beans produced by farmers’ group are distributed to industry and processed. Product and consumer segmentation being an effective input for distribution management [7]. Cocoa supply and quality are one of cocoa competitive factor which must be focused and implemented on the model of small and medium scale of Agrokakao development system in production centre [8]. The goal of this research is continuing supply for cocoa industry, improving quality of beans, and fair of profit share to enhance the competitiveness of cocoa agro-industry. Integrity of supply management, inventory, demand, and price from upstream to downstream is known as a concept of supply chain management. It is a process for improving responsiveness and efficiency [9].

2. Literature

The accuracy of supply information at farmers, availability of inventory at collector/exporter, pengumpul/eksportir, prices fluctuate and batching order are four factor influences Bullwhip effect [10]. Coordination between demand and supply could be done through cooperation contracts such as biofuel supply chain in China [11]. [12] said that resources sharing has a positive influence and will increase the effectiveness of supply chain partnerships. The balance of supply and demand efficiently and effectively, followed by accurate information will improve agro-industry competitiveness [13].

Competitiveness factor including the availability of supply, quality consistency (water content, bean count, waste), fat content, flavour, price, infrastructure and logistic, policy and regulation [2], [14] and [3] said the weakness of competitiveness of Indonesian cocoa caused by the low use of superior seeds, less of post harvest handling, lower quality of human resources and lack of infrastructure.

The balance of supply demand should be supported by distribution channel that can be differentiated in several level. Every actors who distributes product to end consumer form a trading channel [15]. [9] also said that distribution is one of important element of supply chain performance in order to fulfill consumer needs. [16] state that logistic infrastructure is very important for design of industrial distribution networks that are vertically integrated and depend on the source of raw material.

This research focus on design of cocoa agro-industri supply chain system in Putat village Patuk subdistrict Gunung Kidul district, Yogyakarta with dynamic system approach. [17] state that model is an abstract of real object or event with direct and indirect interrelation that show cause and effect, less complex than real world. Dynamic system is systems structure theories and approach which explain system complexity then analyse the changing in its behaviour [18]. It is dynamic, changes along within time and repeated iterations until optimal result are achieved [19]. Dynamic system has been used to evaluate oil supply chain in China for the overcapacity of crude oil refinery industry and energy security [20], the sustainable management of renewable energy involve the interaction of environmental, economic and social aspects [21], dynamic model simulation of CPO transport at PT. XYZ [22], Government program to increase corn production in order to have corn self-sufficiency which based on the consumption need in food and non-food [19].

The object of this research is Sidodadi farmer’s group that distributed their fermented cacao beans to TTP Nglanggeran, Cokelat nDalem and local collector. The design of supply chain is built by cacao supply subsystem, cacao beans distribution subsystem, and quality improvement sub subsystem. The result of this research may give an input for policy makers and cocoa stakeholder in developing the competitiveness cocoa agro-industry through partnerships.

3. Methodology

Complexity problem of cocoa supply chain and interaction of all stakeholder with their own interest/need make a causal relationship among stakeholder and related factors. In order to accomodate the complexity and relationship along the period of time, a design of cocoa agro-industry supply chain system is built by dynamic system approach. According to [23], we can learn causal interaction between variables with feedback in the system in order to achieve the goal.
3.1. Need analysis, problem formulation and system identification

This step results actors who is getting involve, needs of each actor, contradictory needs between actors, and boundary of the systems. Variables are identified in this system boundary will interact one another to achieve the goals. Through this we can learn and analyse the behavior of the system [24].

3.2. Modelling

Interaction and relationship between variables are formulated in causal loop and flow diagram. Formulation of a dynamic hypothesis based on behavioral theory on the problem, assumption or even general description which influences modelers’ understanding of real conditions [25]. The formulation of model is making structure specifications, decision rules, parameter estimation and consistency test of the goals and boundary that have been set previously [26]. Modeler can set a value of parameter and make experiments on model development, formulated ini mathematic equations [24]. The formulation of this system consist of cocoa supply subsystem, cacao beans distribution subsystem, and quality improvement sub subsystem.

3.3. Verification and validation

Verification to determine the suitability model structure of agro-industry supply chain system with real structure through expert information and scientific theory as well as simulation. Validation model is comparing the simulation results to real system (quantitative behavior pattern comparison).

Validation test use Mean Absolute Percentage Error (MAPE). MAPE test is one of relative measurements of percentage errors. This test is used to determine the suitability of result simulation to empirical data with 5 percent error is allowed [24], [26], [27].

\[
MAPE = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{X_{m} - X_{d}}{X_{d}} \right| \times 100\%
\]

Accurancy of model criteria with MAPE test are:

- MAPE < 5% : precisely
- 5% < MAPE < 10% : precise
- MAPE > 10 : not precise

4. Result

4.1. Need analysis, problem formulation and system identification

Literature study and field visit has been identified need analysis, problem formulation and system identification of cacao supply chain, shown in table 1.

| No | Actor                        | Needs                                                                 |
|----|------------------------------|----------------------------------------------------------------------|
| 1  | Farmer                       | Cocoa seeds and plant rehabilitation                                 |
|    |                              | Input for plantation                                                 |
|    |                              | Productivity improvement and cacao beans quality                      |
|    |                              | Cacao beans price                                                    |
|    |                              | Pests control                                                       |
| 2  | Local collector/trader       | Continuity of cocoa beans supply                                    |
|    |                              | Good quality of cocoa beans                                         |
|    |                              | Minimum price of cocoa beans                                        |
| 3  | Industry                     | Continuity of cocoa seed supply                                     |
|    |                              | Good quality of cacao beans                                         |
|    |                              | Minimum price of cacao beans                                        |
Contradictory needs of actors form problem formulation:
1) The cocoa supply is low
2) The distribution flow of cocoa beans still long
3) The quality of cocoa beans varies
Interconnection needs analysis and problem formulation will form causal loop diagram, as shown below.

4.2. Cacao supply subsystem
The cacao supply of Sidodadi Farmers’ group comes from existing plantation, pests control, maintenance and fertilization of plant, new plantation. This farmers’ group also build partnerships to buy wet beans with other farmers group, then processes them into fermented beans. From wet cacao beans to fermented beans, yields 31.66 percent. The interactions flow of variables, parameters and stock for cacao supply in 13 years of simulation period result an increasing supply is 40.57 % which reduce the balance of cocoa beans supply demand about 18.62%, shown in figure 2.

Result simulation shows an increasing flow of supply demand until 2024 and reaching the optimum level in 2025 to the end of simulation. The main factor of increasing cacao supply are fertilization, maintenance of plant and pests control. These are being a leverage factor in scenario.
4.3. **Cacao beans distribution subsystem**

The fermented beans distributed 50 percent to TTP Nglanggeran, 30 percent to local collector and 20 percent to Cokelat nDalem. This beans are processed into 3 in 1 choco drink, choco candy, and choco bar. The variables used are yield constant, cacao bean fractions, product demand fractions. For 3 in 1 choco drink and choco candy added with the trend of visitors parameter, average purchase of 3 in 1 choco drink, average purchase of choco candy, fraction of visitors who buy those products.

In second line, fermented beans are distributed to local collectors, the flow of beans processing does not continue because the industry is outside of Yogyakarta. The last line, fermented beans are processed into choco bars by Cokelat nDalem. The flow of distribution is shown in figure 3:

![Figure 3. Cacao beans distribution.](image)

![Figure 4. Demand of choco products.](image)

The flow shown in figure 3 and figure 4 explain the same behaviour of supply and demand. The flow is reaching optimum level from 2025 to the end of simulation period, same as flow of cacao supply. Rate of increasing of cacao has a higher value until 2024, after that the pattern is moving on the optimum level. This pattern shows the increasing of cocoa beans distribution influenced by cacao supply and cocoa products.

Each product will benefit supply chain actors. Profit is influenced by cacao beans price, product price, production cost, distribution cost, post harvest cost, the amount of supply processed, number of products. The accumulation profit in the end of simulation period shows the highest is TTP Nglanggeran and the lowest is local collector. Local collector only sell the cocoa beans to industry without processing, it does not give added value. The accumulation profit of farmers’ group is about 3.4 billion rupiahs.
4.4. Quality improvement

Improvement quality of cacao will be achieved by implementing SOP of cultivation, harvest and post harvest. For this sub subsystem, parameter of management, input for plantations, technology, period of SOP implementation program, farmer interest in implementing SOP, and quality gap are connect and interact each other to achieve quality values. If farmers implement SOP consistently, it will improve the quality of cacao beans with time. However, this effort is often constrained by industry’s impartiality to good quality beans and planting cacao is not the main livelihood. These factors will decrease the quality. Quality affects the price of cacao beans directly.

In this study, the quality of cacao beans is divided into 3 levels with 3 different prices. The price is become a leverage variable of farmer interest in implementing SOP. Cacao beans price and the quality affect price index. Best quality and good price index will increase cocoa competiveness. This process is the goal of developing cocoa agro-industry to compete with foreign cocoa products.

4.5. Validation

Model of design of cocoa agro-industry supply chain that has been made, must be assessed the validity to determine the suitability of simulation results with real systems. The data used are the production and
sales of Choco drink 3 in 1, Choco candy, and Choco bar from January to December 2017. The result of validation using MAPE method is shown below.

| Product                      | Activity | MAPE result |
|------------------------------|----------|-------------|
| Choco drink 3 in 1           | Production | 5.03 %     |
|                              | Sale     | 8.06 %     |
| Choco candy @ Rp 2000,-      | Production | 0.09 %     |
|                              | Sale     | 4.11 %     |
| Choco candy @ Rp 2500,-      | Production | 0.13 %     |
|                              | Sale     | 2.74 %     |
| Choco bar                    | Production | 9.06 %     |
|                              | Sale     | 1.65 %     |

Result shows that all the processes are valid. The model is reflecting the real system of cocoa agro-industry supply chain.

4.6. Scenario
According to the existing result, it need to make an effort in minimizing the balance of supply-demand of cacao and improving the quality of cocoa beans. A leverage factor in the cacao supply subsystem such as fertilization, maintenance of plant and pests control, losses and new plant area are changed. Also in sub-subsystem of improvement quality, a leverage factor such as management, technology and production input are increased, shown in Table 3.

| Leverage factor       | Existing | Scenario |
|-----------------------|----------|----------|
| Fertilization         | 90%/yr   | 100%/yr  |
| Maintenance of plant  | 90%/yr   | 100%/yr  |
| Pests control         | 0.65%/yr | 2%/yr    |
| Losses                | 10%      | 8%       |
| New plant area        | 0        | 0.25 ha  |
| Management            | 30%      | 50%      |
| Technology            | 40%      | 50%      |
| Production input      | 30%      | 50%      |

The result of cacao supply increase about 43.18%, decrease the balance of supply-demand of cocoa beans about 18.62%, and the highest quality level of cocoa beans is reached in 2020. Compare to existing condition, increasing of cacao supply up to 2.61% and decreasing of the balance of cocoa beans supply demand is 0.7%. It is giving the improvement profit of farmers is about 4.4 billion rupiahs or equal to 29.31% than existing.

5. Conclusion
Integrated partnership between farmers’ group and industry will form a traceability system of cocoa supply chain. The involvement of all actors and supply flows from upstream to downstream makes clear the flow of information on supply, demand and profit. Efforts that have been made by farmers are a key factor to increase the price and competitiveness of cacao beans.

The results of scenario should be carried out with operational regulation by government together with farmers’ group and all related stakeholders. The operational regulation will be a guideline to achieve the added value and competitiveness of the cocoa agro-industry.
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