Design of a website-based traceability information system on subsidized fertilizer supply chain

M Kurniawan¹, D Pramono² and F Amalia²

¹Faculty of Agricultural Technology, Universitas Brawijaya, Malang, Indonesia
²Faculty of Computer Science, Universitas Brawijaya, Malang, Indonesia

Email: miftakhurrizal@ub.ac.id

Abstract: Fertilizer is an important part of agriculture. To ease the burden on farmers, the government assists in the form of subsidized fertilizers to farmers. Limited information on the availability of subsidized fertilizer supplies in stores often makes it difficult for farmers to obtain them. Therefore, a traceability information system is needed that can help farmers to obtain information on the availability of these fertilizers. This information system will also help the supply chain of subsidized fertilizers to be more effective and efficient. This research was conducted for one year to study the supply chain traceability process and the development of a website-based subsidized fertilizer information system. The method used in this research is to use the unified modelling language (UML) method. The UML used to design the system consists of use case diagrams, class diagrams, activity diagrams, and sequence diagrams. The traceability system that has been designed is implemented into a website-based information system. This research produces a website-based information system of the supply chain traceability information system for subsidized fertilizers.

1. Introduction

Fertilizer is one of the essential products in agriculture. The availability of fertilizers, as one of the critical materials for agriculture production process, has to be met in accordance with the six principles, i.e., punctuality, quantity, type, place, quality and price [1]. Therefore, in the management of subsidized fertilizers, it is necessary that there is an understanding by the entire stakeholders to achieve these goals. The government facilitates farmers to meet the availability of fertilizers by providing subsidies for certain types of fertilizers which include Urea, SP36, ZA, NPK, special formula NPK, organic granules and liquid organics. The subsidy comes in the form of a reduction in the selling price of those fertilizers.

The problem encountered in the subsidized fertilizer program is the lack of information about the availability of fertilizers at distributors or stores caused by the limitation of their stocks. Farmers sometimes face difficulty obtaining subsidized fertilizers in certain stores. As a result, they have to trace to stores that still have stock availability manually. This activity affects the financial aspect quite significantly. Based on the problem, it is necessary to develop a traceability system that allows farmers to find the availability of subsidized fertilizers in the listed stores.

A modern fertilizer traceability system can make it easier for farmers to obtain information on the availability of subsidized fertilizers in every store since they can check stock availability through the information system. This method can reduce traceability costs. Traceability is the ability to present information related to the history and movement of an item/good through each stage of the production and distribution process [2]. This system requires supply chain actors to know who supplies the company
and to whom the product is delivered. Hence, each actor has access to information both upstream and downstream [3].

Through the traceability system, a producer is able to identify product lots and their relationship to batches of raw materials, processes, and product delivery. Thus, it is not necessary to withdraw the entire product lots that are yielded. In addition, the traceability system also provides the company with a competitive advantage through the ability to record the product characteristics [4]. The benefits from this traceability system is the strong rationale for companies to implement a traceability system instead of being driven only by compliance with the regulations applied by several importing countries. One of the biggest challenges in developing traceability systems is the way to exchange data between supply chain actors and present information in a standard format [5]. To serve this purpose, traceability systems require the support of information technology (IT)-based devices to support the process of collecting, storing and accessing the data. The development of information technology has been able to encourage a change from the manual concept to digital form. Digital business ecosystem (DBE) is a representation of a business ecosystem where every business actor interacts with each other in a digital environment [6].

From the issue in the tracking process for subsidized fertilizers, this study examines the distribution process and traceability of subsidized fertilizers. This study focuses on planning an information system that can accommodate the information needed for farmers and distributors. The results of this study can simplify the process of finding fertilizer for farmers, reduce traceability costs, and make it easier for distributors to control their inventory.

2. Methods

The process of mapping business processes and information flows is the main activity in developing the information system of subsidized fertilizer traceability. The researchers develop a business process for a traceability system based on the interviews with farmers and distributors of subsidized fertilizers. The flow of information is also identified using observations and interviews with the related stakeholders.

Data processing consists of the concept of a subsidized fertilizer traceability system by utilizing the Unified Modeling Language (UML) method. This method uses three (3) diagram models, i.e., use case diagrams, class diagrams, and sequence diagrams. This system is divided into two subsystems consisting of a traceability system and a database server [7].

2.1. Data input

The process of mapping business processes and information flows is the main activity in developing the information system for the traceability of subsidized fertilizers. In this research, the researchers develop a business process for a traceability system based on the interviews with farmers and fertilizer distributors.

2.2. Data processing

The model that becomes the reference for making the traceability system consists of a model for the material requisition process, delivery model, inventory model, and material traceability model.

2.3. Design of information flow and material flow

At this stage, the model definition and the location of tracking point are then implemented into the design of the information flow and material flow that is required in the system.

2.4. Traceability system design and stored information

This stage determines the input information that will be stored in the traceability system of subsidized fertilizers.
2.5. Use case diagram design
The design of the use case diagram is developed to display the processes in the traceability system of subsidized fertilizers by each stakeholder.

2.6. Class diagram design
Class Diagram shows each part of the objective orientation of a system. This concept aims to describe the relationship between different entities regarding the relationship between classes and the interface of a subsystem.

2.7. Sequence diagram design
In the design of this sequence diagram, several diagrams were created in the implementation of the process carried out in each object of observation.

2.8. Software trial
At this stage, the program was tested on the system that has been developed. The performance of the search process can be assessed so that it can be determined whether the program runs as expected or not.

3. Results and discussion

3.1. Flow of information and subsidized fertilizer materials
The flow of information and materials of a product shows the process of distributing information and materials that occurs in a product. The flow of information and materials for subsidized fertilizers is represented in the figure as follows.

![Figure 1. Flow of information and subsidized fertilizer materials.](image)

Based on Figure 1, it can be identified that the process of distributing subsidized fertilizers is carried out in a closed system through producers to distributors (distributors in Line III), and then distributors distribute them to retailers (distributors in Line IV). Distribution of fertilizers to farmers is carried out by authorized retailers who have been assigned in their working areas based on the government data which is limited by the allocation of subsidized fertilizers in their territory with the Highest Retail Price (HET). In case of the distribution, it has to be adjusted to the needs of farmers due to shifting planting seasons, area development, special programs from the Ministry of Agriculture and other urgent matters. Reallocations can be organized between regions and time according to the regulation of the Ministry of Agriculture by considering the allocation and HET for subsidized fertilizers. Farmers cannot buy subsidized fertilizers arbitrarily because they need a Farmer Card as a prerequisite for a purchase. Meanwhile, the flow of information runs in the opposite direction of the material flow. The flow of information starts from farmers to retailers. The information provided by farmers is related to the need for subsidized fertilizers by each farmer. The next flow of information started from the retailer to the distributor. The information provided by retailers is connected to the fertilizer needs of each retailer.
The next stream of information flows from distributor to manufacturer. In this case, distributors provide information to producers related to fertilizer needs in each distributor.

3.2. Traceability system design and flow of stored information
Data processing consists of the concept of a material traceability system and determination of the traceability point location. This system is divided into two subsystems consisting of a traceability system and a database server [8]. The model of traceability information system on subsidized fertilizers can be explained by the following figure:

Based on Figure 2, the traceability information system will be divided into 4 layers, i.e., function layer, model layer, software layer and Auto ID layer. Function layer is a layer that contains the functions displayed by the information system. The traceability information system contains three functions, which are information collector, tracking support and inventory model. Model layer contains four options, i.e., material requisition, delivery, inventory model and material traceability. The third layer, i.e., the software layer, is a special layer for the software, which is a website-based traceability system. The operation of this information system uses My SQL. This layer model will be directly related to the server that contains the SQL server and traceability database. Meanwhile, the last layer is the Auto ID layer. This layer contains information related to material traceability that can be accessed directly by the users.

3.3. Use case diagram design
The entire activities related to the traceability process of subsidized fertilizers can be implemented in a use case diagram as exhibited in the following Figure. This subsidized fertilizer traceability system has three users, who are customer, store/distributor, and admin. Each user has their own role. Consumers can execute four activities, i.e., checking stores that sell fertilizers, checking store locations and checking the number of available stocks. Stores/distributors have several activities, which are updating stock quantities, updating prices for each product, and updating the latest information related to the products. Meanwhile, the admin functions to manage and control all processes that occur in this information system. In addition, each user is required to log in to know the role of each user.
3.4. Class diagram design

The function of a class diagram is to describe the structure of a programming system that shows the static structure of classifiers in a system [10]. An overview of the class diagram can be observed in the following figure.

![Class diagram](image_url)

**Figure 3.** Use case diagram of traceability information system of subsidized fertilizers.

The class diagram of the traceability system of subsidized fertilizers will be divided into 6 classes, i.e., Check Store for the classes containing store data, Check Store Loc for the classes containing store locations, Check Stock for the classes containing details of the number of stocks available in each store, Stock Update for the classes containing data for the stock updates, Price Update which contains the classes to update prices, and Information Update which contains the related classes to update information.

3.5. Sequence diagram design

Sequence diagram is the one that explains how an operation is performed, what messages are sent and when they are executed [10]. This diagram is organized by time. The sequence diagram for the traceability system of subsidized fertilizers can be viewed in the figure as follows.
The traceability system of subsidized fertilizers is a closed system and requires a login to enter the system. After logging in, the users will be taken to the interface according to the main function of each user. Farmers as the consumers can register as users by using the registration number listed on the farmer card. Meanwhile, stores or distributors use the registered official registration number to carry out the login process.

3.6. **Software trial**

The validation model carried out in this study used two methods, namely the Response for Class (RFC) method and the Benefit-cost ratio method. The validation of the traceability system of subsidized fertilizers was carried out after the implementation of the overall design of the traceability system of subsidized fertilizers in the form of the Traceability information System that was tested by parties related to the subsidized fertilizer supply chain, who are farmers and retailers.

Response for Class (RFC) calculations were carried out to measure the level of adaptability and coupling, as well as class understanding [7]. The level of adaptability if using the RFC metric will be indicated with a value of 1-69 are Adaptable, 70-100 Quite Adaptable, and > 100 Poorly Adapted [11]. The results of the RFC calculation can be seen in the following table.

Based on Table 1, it is known that the average value of the RFC is \( \frac{30}{6} = 5 \). The average RFC value (5) is still within the RFC value between 1 to 69. If the RFC value is between 1 to 69, the relationship between modules is very adaptable when there are system changes. The fewer functions or the lower the RFC value, the easier it is to test and debug classes because they have low complexity [11].
### Table 1. RFC values.

| Class controller | RFC value |
|------------------|-----------|
| Check store      | 5         |
| Check store loc  | 5         |
| Check stock      | 6         |
| Stock update     | 6         |
| Price Update     | 4         |
| Information update | 4    |
| **TOTAL**        | **30**    |

### Table 2. Cost components.

| NO | Components                              | Cost           |
|----|-----------------------------------------|----------------|
| 1  | Equipment investment costs (Lenovo Ideapad 320) | Rp. 5,799,000  |
| 2  | Web design and hosting costs            | Rp. 5,000,000  |
|    | **Total cost**                          | **Rp. 10,799,000** |

In addition to conducting the RFC test, it is also necessary to analyze the effect of the cost value by using the Benefit-Cost Ratio (BCR). Cost analysis is conducted to determine whether there are benefits in terms of costs from the implementation of the system that has been designed [11]. The cost in question is the amount of money invested to support the system which is then analyzed regarding the profits obtained by implementing this system as a whole. The costs associated with the implementation of this system can be observed in the following table.

This traceability information system is an information link between consumers and retailers. The availability of this information system can help ease the process of finding subsidized fertilizers for farmers. Farmers often spend higher transportation costs because the search process is performed manually from one store to another. This information system can help reduce costs in the search process. Based on the interview process with several consumers, it was identified that the average cost incurred in this search process reached Rp3,000,000 for every departure. If the farmer makes several departures, this cost will increase even higher. This information system can provide benefits that in one departure, it can be ensured that consumers obtain the desired material. One method that can be carried out to analyze the implementation costs is to use the Benefit Cost Ratio (BCR) method. This method can be calculated by the formula as follows:

\[
BCR = \frac{\text{Equivalent Benefit}}{\text{Equivalent Cost}}
\]

Where: \( BCR \) = Equivalent Benefit / Equivalent Cost

Equivalent Benefits = the whole benefits after deducting the negative impacts expressed in currency values.

Equivalent Costs = the whole costs after deducting the amount of savings.

The value of BCR coefficient can be obtained using an annual interest rate of 11% and a traceability system for subsidized fertilizers is planned for a period of five years. The multiplier used in calculating the annual value of the investment is \((A|P, 11\%, 5)\) which means that the annual is obtained from the present value \((P)\) which is known with an interest rate of 11% and for a period of five years. The value of the multiplier factor is obtained from the discrete compounding table for \((A|P, 11\%, 5)\), which is
Therefore, the annual investment value for investment with the purchase of a computer as an instance is obtained by Rp10,799,000 x 0.27057 = Rp2,921,885. Thus, the BCR value obtained is:

$$BCR = \frac{3,000,000}{2,921,885} = 1.0267$$

(2)

In accordance with the results of this calculation, it is identified that the BCR value is still higher than one (1), meaning that the investment value still provides benefits to its users [11]. The design of this traceability system is able to represent the data sources used, the direction of information flow, the data storage, and a number of transformations related to the process of searching for subsidized fertilizers.

4. Conclusions

The conclusions that can be drawn from this research include the following:

1. The implementation of this website-based traceability information system of subsidized fertilizers can provide several benefits, such as simplifying the process of finding fertilizers for farmers, reducing the search costs, and facilitating the inventory control for distributors.

2. In the process of making an application for a traceability information system of subsidized fertilizers, a validation process is also carried out at the final stage. Based on Responses for class (RFC) and Benefit-cost ratio (BCR) analysis, this information system is feasible to implement because it can provide value for farmers and distributors.

References

[1] Rahmah M 2017 The Protection of agricultural product under geographical indication: an alternative tool for agricultural development in Indonesia J. Intellec. Prop. Rights 22 90-103

[2] Aung M M and Chan Y 2014 Traceability in a food supply chain: safety and quality perspectives Food Control 39 172-84

[3] Bosona T and Grebesenbet G 2013 Food traceability as an integral part of logistics management in food and agricultural supply chain Food Control 33 32-48

[4] Mgonja J T, Luning P and Van D V 2012 Diagnostic model for assessing traceability system performance in fish processing plants J Food Eng. 118 188–197

[5] Thakur M and Donnelly K A M 2010 Modeling traceability information in soybean value chains J Food Eng. 99 98–105

[6] Hu J, Zhang X and Moga L M 2012 Modeling and implementation of the vegetable supply chain traceability system Food Control 30 341-353

[7] Kurniawan M, Setiyawany D T and Amalia F 2019 Designing traceability information systems for processed apple products chain IOP Conf. Ser.: Earth Environ. Sci. 475 012055

[8] Dabbene F, Gay P, and Tortia C 2014 Traceability issues in food supply chain management: a review Biosyst.Eng. 120 65–80

[9] Lei L and Peng W L 2012 Research on design information management system for leather goods Phys. Proc. 24 2151 – 8

[10] Effendi M, Cahyono E and Effendi U 2016 Perancangan sistem informasi efektivitas dan efisiensi peralatan berbasis website (studi kasus di PT Kediri Matahari Corn Mills, Kediri) Website-based equipment effectiveness and efficiency information system design (Case Study at PT Kediri Matahari Corn Mills, Kediri) Industria: J. Teknol. dan Manaj. Agroindustri 5 3 159-68 [in Bahasa Indonesia]

[11] Kurniawan M, Santos I and Kamal M A 2019 Risk management of shallot supply chain using failure mode effect analysis and analytic network process (Case study in Batu, East Java) IOP Conf. Ser.: Earth Environ. Sci. 230 012055