Design of subsidized fertilizer prediction information system with safety stock methodology

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Abstract. The purpose of this research is to design a subsidized fertilizer information system equipped with a prediction system with a safety stock method. This study uses the waterfall methodology with stages of Analysis, Design, Coding, and Testing, as well as the safety stock method for prediction. By testing using black-box testing with system modeling using the Unified Modelling Language (UML) and Business Process Model and Notation (BPMN). The results of this research are a prototype of a fertilizer information system for data collection activities, fertilizer expenditure from the warehouse, and fertilizer orders based on predictions. This research takes a case study at PT. Anugerah Ihsan Makmur, which is a company engaged in the distribution of subsidized fertilizers in the Garut region. This information system can help record the distribution of fertilizer, determine the amount of fertilizer procurement that must be ordered to suppliers to meet inventory needs so that there are no shortages, and can use as a management report on the distribution of subsidized fertilizers to the government.

1. Introduction
The use of technology-based information systems has been widely applied throughout the organization to support its activities [1–3]. The use of Information Systems has also entered into various sectors and not only for large organizations, but also supports the activities of small organizations [4]. Information systems have also been used to support agricultural activities, especially in Indonesia [5–8].

PT. Ihsan Anugerah Makmur is a company engaged in the distribution of subsidized fertilizers based in Garut Regency, West Java, which expected to play a role in facilitating the distribution of subsidized fertilizer for every retailer in the Garut region. Subsidized fertilizer is a fertilizer that is regulated by the government [9,10] arranged in the Minister of Trade No.15/MDAG/PER/4/2013 concerning the procurement and distribution of subsidized fertilizer for the agricultural sector. Which stipulates that the distribution of subsidized fertilizer to farmers must pass through four distribution lines, namely: 1) Location of fertilizer warehouse in the area of producing factories in the port destination area for import fertilizers; 2) Location of producer warehouse in the provincial capital region or the Fertilizer Packaging Unit (UPP) or outside the port area; 3) Location of producer or distributor warehouse in the regency or city area designated by the producer, and 4) Location of warehouse or retailer kiosk in the sub-district or village area determined by the distributor [11].

PT. Anugrah Ihsan Makmur is the third line that must guarantee the smooth distribution of fertilizers based on 6 (six) principles, including the right type, quantity, price, place, time, and quality. Subsidized fertilizer policies governed by government regulations can increase the harvested area and national rice
production [12–14]. Although regulated by the government through regulations, it does not mean there are no problems.

Based on observations and interviews, there are several problems, including a lack of fertilizer supply that must be distributed to farmers, which results in some farmer groups not getting fertilizer supplies and sometimes delivery delays. One reason is that the transaction process still uses manual methods in both sales and purchase transactions, which have a non-maximum impact on data input, data search, and difficulties in making reports so that it becomes a problem in determining the subsidized fertilizer supply plan needed for the following month. The purpose of this study is to design a fertilizer distribution information system that equips with a prediction system using safety stock. In contrast, previous studies have made a fertilizer sales system [15–18] or also use predictions in an information system [19–22].

2. Methodology

In this research, the methodology used is Waterfall by adding the safeguard forecasting methodology to the coding activity. The waterfall is a classic method that is systematic, sequential in building software. The name of this model is the "Linear Sequential Model" with the stages: Analysis, Design, Coding, and Testing [23]. The research framework carried out according to the method used is shown in Figure 1.

![Research Framework](image)

**Figure 1.** Research framework.

2.1. Analysis

In the analysis phase, an activity aimed at identifying problems that occur, in this phase, the current system flow is designed, and a proposed system flow is made as a solution to solve the problem.

2.2. Design

The design phase aims to get a good understanding of system flow, process functionality, operating behavior, and information contained in the designed application. At this stage, a system diagram is created and mapped.

2.3. Coding

The coding phase is the implementation of the design results in a form that can be read and understood by computers through programming languages. At this stage, the safety stock formula is applied to predict.

Safety stock serves to protect errors in predicting demand during lead time. The security inventory will function if the actual demand is greater than the average value. To get an idea of how uncertain the demand is during the lead time, companies need to collect data to get their distribution [24], using the formula:

\[
\text{Safety stock} = Z \times S_{dl} \quad [24]
\]

Where, \( Z = \text{Service Level} \) (the company's ability to serve demand), and \( S_{dl} = \) Determined from the demand uncertainty, with the provisions in Table 1.
Table 1. Terms of demand uncertainty.

| Variable | Safety Stock is determined by demand uncertainty. |
|----------|-------------------------------------------------|
| Demand   | No safety stock is needed, a deterministic situation ($S_{dl} = 0$). |
| Constant | Safety Stock determined by lead time. |

At the coding stage, the programming languages used are HTML, CSS, CodeIgniter based on PHP Framework, while the software used to help in making these applications includes web servers and HTML editors.

2.4. Testing
During the testing phase, activities are carried out to ensure that all commands in the information system have been tried and functioned according to plan. Besides, testing is also done to ensure that the input of a function will produce the output as desired.

3. Result and discussion

3.1. Analysis
At this stage, several analysis activities are carried out, with activities:

3.1.1. Problem analysis. This analysis is a stage that is carried out before carrying out the process of designing a program or software, where a system analysis is carried out to find out the main problems faced at this time and what are the needs of the system. The main problems are 1) Incompatibility of subsidized fertilizer data because the data processing is still using semi-manual so that the report on the distribution of subsidized fertilizer is experiencing delays; 2) Lack of an integrated and coordinated distribution system of subsidized fertilizers that is accurate and efficient; 3) Facing difficulties in determining the planning of subsidized fertilizer supplies needed for the following month.

3.1.2. Forecasting analysis of procurement amounts. The forecasting method used is Single Exponential Smoothing. Based on the data found is a fixed pattern that shows the existence of regular fluctuations with an average value that does not change over time. Data that will be sampled are subsidized urea fertilizer data.

3.1.3. Analysis of monitoring and preparation of safeguards. After conducting the forecasting stage, the next step is to monitor the inventory and determine the safe limits that must be in the fertilizer warehouse to avoid fertilizer shortages or vacancies using the Safety stock method. In this company, the time required is two weeks, and the service level ($z$) used is 90% in the form of inverse = 1.28. The calculation of fertilizer safety stock in the planting season 1-3 is shown in Table 2.

| Table 2. Calculation of subsidized fertilizer safety stock. |
|------------------------------------------------------------|
| Type of Fertilizer | Urea (Kg) | SP 36 (Kg) | Za (Kg) | NPK (Kg) | Organic (Kg) |
| Maximum use       | 16733     | 3211       | 990.2   | 4536.4   | 1617         |
| Average use       | 2699      | 906        | 185     | 1214     | 445          |
| Minus             | 14034     | 2305       | 805     | 3322     | 1172         |
| Multiplied by Lead time | 2     | 2          | 2       | 2        | 2            |
| Safety Stock      | 35972     | 4610       | 1611    | 6645     | 2345         |
Based on the calculations in table 3, the amount of Safety Stock for each growing season is urea 36 tons, Sp36 4.6 tons, ZA 1.6 tons, NPK 6.6 tons, and Organic 2.3 tons which must be provided by the company to anticipate possible delays in inventory that is being ordered.

3.2. Design
This stage is made a diagram that can help in understanding the system to be built.

3.2.1. Actor identification. At this stage, identifying the actors of a system that is built, where the actor is a set of roles of people, processes, or other systems that interact with the system to be created [25]. Actors in the subsidized fertilizer information system are 4 (four) actors, namely: Administrator, Manager, Marketing Section, and Warehouse Section.

3.2.2. Use case diagram. Use case diagrams and scenarios for this subsidized fertilizer information system follow the target user data that has been obtained and identified in the previous step, the use case diagram designed in Fig. 2.

![Use case diagram subsidized fertilizer information system.](image_url)

The actors contained in the subsidized fertilizer information system are the administrator, manager, marketing department, and warehouse department. As for the identification of actors from the system, the administrator acts as the operator responsible for managing the data requirements of the subsidized fertilizer information system, and the manager can access the system as needed, verification of fertilizer procurement and reports, the marketing department can access the system as needed, manage ordering transactions and fertilizer procurement while the warehouse can access the system in accordance with the needs to make delivery orders and verify orders.

3.3. Coding
The coding phase is the implementation of the layout design that has been made into the programming language, subsidized fertilizer information systems using a built-in stock safety prediction approach using programming languages including PHP Framework Codeigniter, database servers using MySQL, and Cascading Style Sheets (CSS). At this stage, the safety stock formulation method is also applied. As for one of the layout design and implementation results, it is shown in Figure 3.
3.4. Testing
At the testing stage, the subsidized fertilizer information system uses a safety stock prediction approach that is built and will be tested using the black-box testing method. Based on functional testing of software built, there are no bugs or gaps in every page and function of the system.

The use of safety stock predictions has been successfully paired and can predict fertilizer status; this status can only be seen by a few users who can access data on the amount of subsidized fertilizer needed. In figure 3, it can be seen that there are statuses in green and red, with status information green as a safe indicator and red with an unsafe sign.

4. Conclusion
Based on the results of the research conducted, it can be concluded that the information system that was built has supported the digital report of the definitive recapitulation management process of group needs, sales, procurement, and detailed reports to managers. With the use of this information system also makes it easy for PT. Anugerah Ihsan Makmur in the distribution of fertilizer in the Garut region.

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