ABSTRACT

Objective: The purpose of this study is to optimize the optimal location and number of distribution warehouses in the face of a significant decrease in the allocation of subsidized Urea and NPK fertilizers. This research is conducted on subsidized fertilizers with multi-product characteristics (Urea and NPK fertilizers), multi-period (2021-2022), and uncertainty (government policy on allocation). The objectives of this study are produce a distribution network design model and optimize the number and location of warehouses needed to minimize total logistics costs.

Methods: This research uses a quantitative approach in solving the problems faced by companies. To obtain the lowest logistics cost, optimization calculations are performed via model development. The model employed is mixed integer linear programming, which employs a combination of multi-source capacitated models, multi-product models, and multi-stage models. Furthermore, by examining storage consumption, the optimization calculation may be utilized to estimate the existing amount of storage facilities. The anticipated goal is to reduce logistical costs and enhance warehouse usage for storing subsidized fertilizer.

Results: The results of this study from 43 warehouses to 33 warehouses located in East Java Province with operational savings costs that can be obtained by PT Petrokimia Gresik amounting to IDR 1,863,794,700.

Keywords: MILP, uncertainty, fertilizers subsidized, warehouse.
RESUMO

Objetivo: O objetivo deste estudo é otimizar a localização e o número ideais de armazéns de distribuição diante de uma diminuição significativa na alocação de Ureia subsidiada e fertilizantes NPK. Esta pesquisa é realizada sobre fertilizantes subsidiados com características multiproduto (Ureia e fertilizantes NPK), multi-período (2021-2022), e incerteza (política do governo sobre a alocação). Os objetivos deste estudo são produzir um modelo de projeto de rede de distribuição e otimizar o número e a localização de armazéns necessários para minimizar os custos totais de logística.

Métodos: Esta pesquisa utiliza uma abordagem quantitativa na resolução dos problemas enfrentados pelas empresas. Para obter o custo logístico mais baixo, os cálculos de otimização são realizados por meio do desenvolvimento de modelos. O modelo empregado é a programação linear de inteiros mistos, que emprega uma combinação de modelos capacitados de várias fontes, modelos de vários produtos e modelos de vários estágios. Além disso, ao examinar o consumo de armazenamento, o cálculo da otimização pode ser utilizado para estimar a quantidade existente de instalações de armazenamento. O objetivo previsto é reduzir os custos logísticos e melhorar o uso do armazém para armazenar fertilizantes subsidiados.

Resultados: Os resultados deste estudo de 43 armazéns para 33 armazéns localizados na Província de Java Oriental com custos de economia operacional que podem ser obtidos pela PT Petrokimia Gresik no valor de IDR 1.863.794.700.

Palavras-chave: MLP, incerteza, fertilizantes subsidiados, armazém.

1 INTRODUCTION

The agricultural sector has a strategic position in national development when it contributes to other development sectors such as employment, supply of industrial raw materials, earning foreign exchange, providing food, increasing people's income, and alleviating poverty [10]. To achieve national food security, the government issues policies annually to regulate the allocation of fertilizer subsidies. The allocation of subsidized fertilizers for the types Urea and NPK in the 2021–2022 period has decreased significantly compared to the 2015–2020 period. The dynamics of changes in the allocation of subsidized fertilizers have had an impact on PT Pupuk Indonesia's (Holding company) subsidiaries, including PT Petrokimia Gresik, which is the sole implementing operator in the procurement of subsidized Urea and NPK fertilizers in East Java. PT Petrokimia Gresik, a producer with the most complete and largest variant of fertilizers in Southeast Asia and a total fertilizer production capacity of 6.5 million tons per year, has the responsibility to produce and distribute subsidized fertilizers to farmers and to sell non-subsidized fertilizers for the commercial market (retail, plantations, and industry).
Until 2022, PT Petrokimia Gresik has 165 fertilizer production units with a total production capacity of 6,500,000 tons per year, including Urea and NPK. Meanwhile, subsidized fertilizers that are produced and distributed to farmer consumers are Urea and NPK. In distributing and procuring subsidized fertilizers, all of PT Pupuk Indonesia's subsidiaries are guided by government regulations, namely the Regulations of the Minister of Trade and the Regulations of the Minister of Agriculture. Procurement and distribution of subsidized fertilizers to farmers are regulated by the Government by involving several parties in the product transfer process, starting with Producers, Warehouses, distributors, and Retailers (4 stages). In the case of the distribution of subsidized fertilizers, producers can own and/or manage warehouses in lines I to III at the Regency and City levels according to the area of responsibility for distribution. The process of determining the location and location of buffer warehouses is important as well as strategic in outbound logistics activities as a series of supply chain management activities for a product. In an effort to increase effectiveness and efficiency to meet market demands and needs, the location of the buffer warehouse affects the distribution process, considering that transportation costs and delivery lead times are also determined by the location of the buffer warehouse. PT Petrokimia Gresik buffer warehouse has a fixed warehousing cost component (warehouse rent and management according to warehouse capacity), which does not directly depend on the number of types and quantities of products, as well as a variable cost component (product loading and unloading according to quantum), which depends on the number of products shipped, managed in a warehouse. With the change in the dynamics of decreasing the allocation of subsidized fertilizers for the types of Urea and NPK, the fixed cost per unit of fertilizer will be higher if there is no adjustment to the management of the number of existing warehouses.

East Java Province is the province that has experienced the highest reduction in the allocation of Urea and NPK fertilizers compared to five other provinces in Indonesia. In addition, East Java Province has the highest contribution to the fixed cost component of warehousing compared to the other four provinces. PT Petrokimia Gresik manages 78 buffer warehouses in East Java Province spread across 28 regencies and cities, with a total warehouse capacity of 352,648 tons. The management of subsidized fertilizer distribution warehouses is one of the aspects that is of concern to the process of audit activities carried out by the AKN IV and AKN VII Annual Audit Board (BPK) institutions. Operational costs for distribution warehouses are one of the cost components charged in subsidy
billing to the Government. Therefore, an increase in the fixed operational costs of warehouses due to the absence of adjustments to the number of warehouses related to a decrease in the allocation of subsidized fertilizers will potentially cause state losses. This can happen because the fixed costs of warehouse management will be charged to subsidized fertilizer products. By adjusting the number and location of subsidized fertilizer distribution warehouses, it is expected to reduce the risk of potential losses to the state due to the high fixed cost of subsidized fertilizer distribution warehouses and increase the efficiency of the company's operational costs.

Several studies related to the location of the new factory and the route of transportation have been done a lot. In his research tried to meet the need for products at consumer locations that vary based on the minimum cost total criterion [1]. In another study tried to determine the set of facilities that would be opened and make the distribution network design to meet consumer needs based on the minimum total cost [3]. The distribution warehouse location determination process, also known as the Facility Location Problem (FLP), is an approach to determining the optimal and efficient location of the facility by considering the cost, quality, and availability components of the product [20]. In solving the problem of location of the distribution facility, there are several alternatives that can be used including factor rating methods, locational break even analysis, center of gravity and transportation [7]. Among several existing methods, the author uses the transportation method with the Mixed Integer Linear Programming approach (MILP). This method is best suited to the conditions and characteristics of the distribution process of subsidized fertilizer products in PT Petrokimia Gresik. The Mixed Linear Integer Programming Model Approach on PT Petrokimia Gresik will be used to minimize transportation costs (delivery costs from Line I to Line III) and storage costs.

Based on the conditions encountered, an analysis of the effectiveness and efficiency of the quantity and location of the subsidized fertilizer distribution warehouse is required to create the ideal conditions for the optimum and efficient quantity of the distribution storehouse in order to meet the demand for subsidised fertilizers with minimal distribution costs. Subsidized fertilizer distribution warehouses in East Java Province are the subject of research, considering that the province has experienced the greatest decrease in subsidized ZA and SP-36 fertiliser allocation and contributes to the highest fixed cost of warehousing management compared to other provinces. The decisions taken could be the termination of the lease agreement/reduction of the number of
warehouses deemed inefficient, the relocation of the warehousing location or the reduction of excess storage capacity for as long as possible. The number and location of the subsidized fertilizer distributors’ warehouses greatly influence the sale price of subsidised fertilizers at the farmers’ level. Thus, the modeling of the proposals produced in this study has never been done in any previous research, so this research has contributed to the research as a whole, as presented in the previous research in Table 1. So this research has novelty in the distribution of subsidized fertilizer which has multi-product and multi-location types, apart from that, it is also optimized using the center of gravity, clustering and optimization methods carried out by MILP.

Table 1. Previous Research

<table>
<thead>
<tr>
<th>Article</th>
<th>Title</th>
<th>Objective</th>
<th>Method</th>
<th>Product</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eulalia (Kahar) Sitiardan (2018)</td>
<td>Analysis of location determination of non-seen distribution point using cluster center and gravity (CGC) methods at PT Gembong Indonesia (PTG) in Surabaya</td>
<td>to determine the location of the best optimal distribution point obtained from minimizing the total logistics cost using the cluster method as well as the center of gravity approach.</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Ruhani Grahadi Setiawan (2018)</td>
<td>Fertilizer Post-Processing Fertilizer Storage Capacity Analysis at PT Krakatau Gresik</td>
<td>to analyze and determine the capacity requirements of Fertilizer warehouse for post-processing of the fertilizer plant</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aditya Cahyo Woroedina (2018)</td>
<td>Supply Chain Improvement through Assessment of Number of Inventories of NPK Fertilizer Using Linear Programming Model (LP)</td>
<td>to conduct an evaluation of the location and number of warehouses of PT Krakatau Gresik in the province of West Java as well as to carry out an analysis of the effectiveness and efficiency of the site and the number of warehouses resulting from the calculation with the reveal integer linear programming model</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Arista Purwadi (2018)</td>
<td>Determination of optimum location of distribution of fertilizer to farmers and wholesalers in the region</td>
<td>solve the problem of location of the distribution of fertilizer optimally using linear integer programming</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Suryani F.H. (2018)</td>
<td>Optimal Selection of Fertilizer Distribution System Design in East Java Province</td>
<td>to solve the problem of production planning with fluctuations in demand for uncertain goods that lead to inefficiency of operational activities. Besides, in the production planning process there are also limitations of available resources, i.e., the quantity of raw materials, the working hours of the machinery, and the amount of labor.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>This research</td>
<td>Optimization of Subsidized Fertilizer Distribution System Design in East Java Province</td>
<td>The objectives of this study are (1) to produce a distribution network design model for subsidized fertilizers, and (2) to optimize the number and location of warehouses needed to minimize total logistics costs.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

2 THEORETICAL FRAMEWORK

Supply chain management is the management of activities to obtain raw materials, turn them into work-in-progress, semi-finished or finished products, and then send these products to consumers through a system [6]. These activities include the purchasing function and other important activities related to suppliers and distributors. Procurement is one of the important parts of supply chain management, which includes purchasing raw materials, supplies and components for the business [16]. The description of the distribution of fertilizer is explained in the following:
2.1 DISTRIBUTION NETWORK IN SUPPLY CHAIN

The distribution process is closely related to a series of processes for moving and storing products from producers to consumers in the supply chain system. Every step in the supply chain has a distribution process, including raw materials and components that move from suppliers to manufacturers to manufacturers to consumers. Distribution affects the supply chain's operational costs as well as the company's service level towards consumers [2]. The distribution network used can be adjusted to the company's supply chain objectives, such as low cost but low responsiveness or high responsiveness with high costs. Changes to the distribution network design will affect supply chain operational costs such as inventory costs, transportation costs, facility costs, and loading and unloading costs. The distribution network is not only related to a series of facilities that carry out physical functions but is also an integral part of supply chain activities and has a strategic role as a distribution point for products and information as well as a medium for creating added value [6].

The decisions taken in designing a distribution network relate to the role of facilities, manufacturing locations, storage locations, and facilities related to transportation. In general, there are 3 (three) product distribution strategies from factories to consumers, and each strategy has advantages and disadvantages as follows [5]:

- Direct shipment
- Delivery through the warehouse
- Cross-docking

2.2 WAREHOUSE

A warehouse is a supporting facility that aims to store products to support demand so that consumer needs can be met on time. In addition, the warehouse also functions as a product delivery point where all products can be sent and received as effectively and efficiently as possible [9]. Warehouses can be seen as a component of a company's logistics system that serves to store goods and offer details about the condition of product inventories, ensuring that this information is always current and accessible to those interested. Challenges in the current supply chain flow, such as increased market volatility and the need for consumers to shorten consumer lead times, all depend on the expected role of a warehouse [18], warehouse management goals:

- Speed;
- Efficiency;
- Effectiveness;
- Reliability;
- Assembly facility;
- Transshipment point;
- Returned goods center.

The goal of storage and the general role of warehousing is to make the best use of already-existing resources while providing the best possible service to customers with limited resources. Consumers need a warehousing function to get the goods they need quickly and in good condition. So in designing warehouses and warehouse systems, the following things are needed, according to [12]:

- Maximize the use of space.
- Maximizing the use of equipment and manpower
- Maximizing convenience in receiving and shipping products
- Maximizing product protection

2.3 WAREHOUSE LOCATION

Determination The location of the warehouse is an important consideration because it will impact how competitively a firm is with other businesses. The warehouse's location must contribute to the company's long-term profits, which is one factor that must be taken into consideration while making this decision. To facilitate the smooth, effective, and efficient operation of the business' operational activities, it is necessary to ascertain the precise location of the warehouse. Numerous aspects must be taken into account when choosing the location of the warehouse since they have an impact on the costs associated with the items' distribution [15]. There are several studies that can be carried out comprehensively before determining the location of a warehouse. The criteria for selecting a warehouse location also apply to those who want to build a new warehouse or rent a warehouse. There are six criteria for choosing a fertilizer warehouse location at PT Petrokimia Gresik, including:

- External Factors
- Labor
- Infrastructure
- Environment
3 METHODOLOGY

An applied research methodology was used to carry out this investigation. Aiming to be able to accomplish something much better, more effectively, and more efficiently, applied research is study that has a practical purpose, a curiosity to learn, and a desire to know. In order to use research findings for the benefit of people, whether they be individuals, groups, or organizations, applied research seeks solutions to issues that arise [19].

The reason for using an applied research approach is because the scope of the research is to explore data on the distribution of subsidized PT Petrokimia Gresik with Urea and NPK fertilizers during the 2021–2022 period. The instrument in this research is the researcher himself, who must have the insight, knowledge, and theoretical basis to carry out the analysis and collect data and facts from the conditions and situations experienced by the company. In the process of data collection activities, there are two types of data used, namely primary data and secondary data. The primary data collection mechanism uses a face-to-face interview system, namely with the Vice President of Logistics Region 4A East Java, the Assistant Vice President of Logistics Operations Region 4A East Java, and the Head of the Subsidized Fertilizer Distribution Warehouse. Secondary data used in this study include data on the location of supply points and buffer warehouses, data on the number of districts and distributors, data on actual sales for the last 3 years, future sales plans, and data on transport routes and their rates. The output produced with this approach is expected to be solutive and provide an efficient solution to warehouse problems to meet market demands. In addition, the expected output can explain the relationship between market demand and the resulting solution in the form of the number and location of warehouses.

Optimization is a condition in which results are achieved according to what is expected. Optimization is the measure that leads to the achievement of a goal. When viewed from a business perspective, optimization is an attempt to maximize the activity to the desired profit [22]. So, optimization is a process, activity, and activity to find the best solution in solving problems with specific criteria and approaches. In this study, the topic raised is the optimization of the quantity and location of fertilizer warehouses so
that it can improve the accuracy of delivery of fertiliser products up to the consumer according to the exact 6 (quantity, time, type, quality, price, and place) set by the government.

3.1 CLUSTER MODEL

Clustering is a method of statistical analysis that aims to group data for a specific purpose. Clustering is a process for grouping data into clusters or groups so that data in 1 (one) cluster has the maximum level of similarity and data between clusters has a minimum similarity [16].

Cluster analysis is a multivariate statistical analysis method which aims to group individuals into clusters based on certain characteristics [21]. This method principally classifies sub-groups based on the similarity principle. Respondents who are close to each other or give more or less the same response will be included in the same sub-group (cluster). Meanwhile, respondents who give different responses will be grouped into other subgroups who give responses similar to those respondents. In this analysis, distance measurement is important because it will determine who will become individuals in a cluster. The purpose of using cluster analysis in this research is to determine consumer groups into several groups based on demographic, psychographic and behavioral variables [10]. The segment profiles resulting from these groupings can be used as the basis for market strategy policies.

In principle, cluster analysis is a method of grouping nearby markets, then an analysis of the location of potential facilities is carried out through the center of gravity. The cluster algorithm is as follows:

- Start with a warehouse at each demand or market site. The resulting total cost is the highest total logistics cost because it is obtained with the maximum number of facilities.
- Reduce the number of warehouses one by one by grouping nearby markets into a new group with one potential warehouse location.
- Determine the center of gravity of this new group and set that point as the warehouse location.
- Calculate the total logistics costs after experiencing a reduction in the number of warehouses.
Repeat steps 2-4 until no further grouping is possible, in other words there is only one warehouse facility.

From the cluster algorithm, alternatives will be obtained from the number and location of warehouses. Furthermore, the alternative cluster will be selected as an alternative that has the smallest total logistics cost. The cluster method has the premise that the more warehouses owned will improve service to consumers with the risk of bearing high warehouse costs but small transportation costs. The problems with these 2 (two) cost components need to be traded off, the result of the trade off is the optimal number of warehouse facilities with the smallest logistics cost criterion [10]. In the cluster method, the required input data to complete the determination of the optimal location and number of warehouses are as follows:

- Grid map of each area, so that the coordinates of each area are obtained.
- Data on forecasting results for each marketing area.
- Grouping regions with other nearby regions, which already have demand data and a center of gravity.
- Fixed cost data.
- Data on the transport cost function and storage cost function (warehousing).

After the data is obtained, the iteration process is then carried out. The initial iteration was carried out by allocating warehouses in each market area, so that total logistics costs would be large. The large number of warehouses will result in high storage costs, even though transportation costs are low. In this condition, the level of service to consumers will be high but the company's operational costs will also be very large.

The iteration process continues, by grouping adjacent market areas, in other words, the number of warehouse allocations will decrease from before because there are unified market areas, then Storage costs will decrease but transportation costs will begin to increase. The iteration will stop when the grouping has been completed, in other words, there is only one market left and only one warehouse allocation. In this condition, the number of warehouses is the smallest, and storage costs are the lowest, while transportation costs are the highest.
3.2 CENTER OF GRAVITY

Center of gravity is a method that can help analyze the effectiveness of a location of a facility (Warehouse or Factory) which is a link between the source of production of goods and the location of market demand. So, if the location of the facility in question is a warehouse, then the goal is to find a location that minimizes product transportation costs from the producer to distribution to the final consumer.

This method has several assumptions in its application. First, transportation costs are assumed to increase linearly in direct proportion to the quantity of product distributed. Second, sources of supply and markets can be located on a map with x and y coordinates. So, some of the data needed in this model are transportation costs per unit, load per unit distance from all supply positions to candidate facility locations and from candidate facility locations to all markets, volume to be moved, as well as coordinates of supply locations and market locations [14].

3.3 MIXED INTEGER LINEAR PROGRAMMING

Since the business location deals directly with buyers or consumers, it is also referred to as the company's distribution channel. This will have an impact on business development in the future. One of the things to consider carefully is location, as it can help a business, such as a retail store, survive. Location is a term that refers to various marketing activities aimed at accelerating and facilitating the spread of goods and services from producers to consumers, state that location includes company activities that make products available to target consumers [24]. Example of using MILP in the case of determining facility location to determine which warehouse provides the most optimum costs is as follows:

Minimize Z: Transportation costs from the factory to the warehouse + Transportation costs from the warehouse to the destination city + Warehouse rental costs + Warehouse operational costs + Warehouse inventory costs.

The formulation used for the location of the buffer warehouse is:

- Notation
  - i= Product Source
  - j= Intermediary Nodes
  - k= Suppliers who have location and demand
  - t= Time (month)
n= Types of products

- Parameters
  Git= Factory production capacity (node i) at time t
  hkn= Demand at node k at time t for product n
  Dij= The distance between factory ii and warehouse ij
  Djk= Distance between warehouse ij and demand node k
  Cij= Transportation cost (per km per tonne) from factory i to warehouse j
  Cjk= Transportation cost (per km per tonne) from warehouse j to demand node k
  Fj= Operational cost at the warehouse j
  Xj= Capacity in the warehouse j

- Variables
  Xijt= (1,2,...n), the amount of fertilizer sent from factory i to warehouse ij at time t
  0, if no delivery
  Yjkt= (1,2,...r), if the capacity of city j can be delivered to demand node k at time t
  0, if no delivery
  Sj= 1, if warehouse j is opened at that location
  0, if no delivery
  Vjkt= Inventory in buffer warehouse j for city k at time t

- Formulation

\[
\text{Min } Z = \sum_i \sum_j \sum_t \sum_n D_{ij} C_{ijn} X_{ijtn} + \sum_j \sum_k \sum_t \sum_n D_{jk} C_{jkn} Y_{jkt} + \sum_j F_j X_{jt} + \sum_j \sum_t \sum_n V_{jtn} \tag{1}
\]

While the simplified form of the above equation is:

\[
\text{Min } Z = \sum_j \sum_t \left[ \sum_i \sum_n D_{ij} C_{ijn} X_{ijtn} + \sum_k \sum_n (D_{jk} C_{jkn} Y_{jkt}) + F_j X_{jt} + V_{jtn} \right] \tag{2}
\]

- Limitation
\[ \sum_j X_{ijtn} \leq G_{it} \quad \forall i, t \]  

The quantity of product \( n \) sent to each warehouse \( j \) from factory \( i \) at time \( t \) must not exceed the production capacity of factory \( i \) at time \( t \).

\[ \sum_i X_{ijtn} \leq X_{jt}.S(j) \quad \forall j, t \]  

The quantity of product \( n \) sent to each warehouse \( j \) from factory \( i \) at time \( t \) must not exceed the capacity of warehouse \( j \) if warehouse \( j \) is established there.

\[ \sum_i X_{ijtn} = \sum_k Y_{jktn} \quad \forall j, t \]  

The stock balance function \( j \) where the number of products \( n \) sent to each warehouse \( j \) from factory \( i \) at time \( t \) must be equal to the number of products sent from warehouse \( j \) to city \( k \) at time \( t \).

\[ \sum_j Y_{jktn} \geq h_{ktn} \quad \forall k, t, n \]  

The demand for city \( k \) at time \( t \) cannot exceed the quantity of product \( n \) shipped from warehouse \( j \) at time \( t \).

\[ \sum_i X_{ijtn} \geq \sum_k Y_{jktn} + V_{jtn}.S_{(j)} \quad \forall j, t, n \]  

The quantity of product \( n \) sent to each warehouse \( j \) from factory \( i \) at time \( t \) plus the initial inventory must be greater than the quantity of product \( n \) sent from warehouse \( j \) to warehouse \( k \) at time \( t \) plus the quantity inventory of warehouse \( j \) at time \( t \) if warehouse \( j \) is opened at this location.

\[ X_{ijtn} = \text{integer} \quad \text{(8)} \]

If there is a delivery equal to 1 and if there is no delivery equal to 0.

\[ Y_{jktn} = \text{integer} \quad \text{(9)} \]

If there is a delivery equal to 1 and if there is no delivery equal to 0.
\[ S_j = \text{integer} \quad (10) \]

Warehouse \( j \) equals 0 when closed and warehouse \( j \) equals 1 when opened.

The MILP method was chosen as the model in this research because it is closest to the company's conditions and can match the conditions and characteristics of the existing distribution system at PT Petrokimia Gresik. MILP modeling will be used to analyze PT Petrokimia Gresik's distribution system with the aim of analyzing its effectiveness in terms of transportation costs and warehousing costs (fixed and variable costs). With the reduction of subsidy allocations and changes in the policies of those responsible for the supply and distribution of Urea and NPK fertilizers, the efficiency and effectiveness of the number and location of buffer stock must be analyzed or evaluated to create the optimal composition to meet the obligation to purchase and distribute fertilizers with minimal distribution costs. The final decision that can be taken after this evaluation is to reduce the number of inefficient warehouses, terminate warehouse leases, and reduce existing warehouse capacity by sharing with other companies or by moving warehouses.

4 RESULTS AND DISCUSSION

4.1 DETERMINATION OF NORMAL AND PEAK SEASON

Based on the pattern and intensity of rainfall that has occurred in East Java Province for the last 5 years, it can be seen which months fall into the categories of the rainy season (peak season) and the dry season (normal season). The rainy season period (peak season) ranges from May, June, July, August, and September, while the dry season period (normal season) ranges from October to April.

4.2 DETERMINATION OF OPTIMAL BUFFER WAREHOUSE

The solution for determining the optimal buffer warehouse during the dry season (normal season) is to utilize only 16 (sixteen) buffer warehouses to meet the demand for subsidized fertilizer in the observed area. Support warehouses that can be utilized for subsidized fertilizer needs include the Talun and Kanigoro Warehouses located in Blitar Regency; Gatsu Warehouse in Jombang Regency; Kajen Warehouse, Gurah 2, and Ngadiluwih in Kediri Regency; Kaligunting Warehouse in Madiun Regency; Maospati Warehouse in Magetan Regency; Trowulan Warehouse in Mojokerto Regency;
Warehouse Loceret 3 in Nganjuk Regency; Warehouses Ngawi and Karangjati in Ngawi Regency; Cokro 1 and Cokro 2 Warehouses in Ponorogo Regency; Trenggalek Warehouse in Trenggalek Regency; Gondang Warehouse in Tulungagung Regency. Meanwhile, there are 17 (seventeen) buffer warehouses that no longer need to be utilized to meet subsidized fertilizer needs, namely the Sukorejo and Garum Warehouses in Blitar Regency; Jatipelem Warehouse in Jombang Regency; Warehouse Gurah 3 in Kediri Regency; Sumberbening, Balerejo, and Purworejo Warehouses in Madiun Regency; Warehouse Sooko in Mojokerto Regency; Nganjuk Warehouse, Loceret 2, and Pehserut in Nganjuk Regency; Warehouses in Sidokerto and Paron in Ngawi Regency; Balong and Badegan Warehouses in Ponorogo Regency; Gondang Warehouse in Trenggalek Regency; Ngantru Warehouse in Tulungagung Regency. The operational cost savings that can be obtained are IDR 4,163,022,200 when compared to the current use of buffer warehouses.

The optimal solution during the rainy season (peak season) is to use 33 buffer warehouses to meet the demand for subsidized fertilizer in the observed area. Twenty-five buffer warehouses that can be used to meet subsidized fertilizer needs, including the Talun, Kanigoro and Garum Warehouses located in Blitar Regency; Gatsu and Jatipelem Warehouses located in Jombang Regency; Kajen, Gurah 2, and Gurah 3 warehouses located in Kediri Regency; Kaligunting Warehouse located in Madiun Regency; Maospati Warehouse in Magetan Regency; Trowulan Warehouse located in Mojokerto Regency; Warehouses Nganjuk, Loceret 2, Loceret 3, and Pehserut located in Nganjuk Regency; Warehouses of Ngawi, Karangjati, and Paron located in Ngawi Regency; Cokro 1, Badegan and Cokro 2 Warehouses located in Ponorogo Regency; Trenggalek and Gondang Warehouses in Trenggalek Regency; The Ngantru and Gondang warehouses are located in Tulungagung Regency. The cost of operational savings that can be obtained by the company is IDR 1,863,794,700.

The results of the analysis produce two (two) alternative optimal solutions that are different in determining buffer warehouses based on the dry season (normal season) and rainy season (peak season) in each district. The difference between the two alternative solutions is caused by several conditions, including warehouse capacity and increased shipments due to the need for subsidized fertilizers. Considering that there are differences in optimal solutions from the results of the analysis of determining buffer warehouses in two different seasons, it can be said from the results of the model analysis that there is no
alternative optimal solution that is robust enough to be implemented in the dry season (normal season) and rainy season (peak season). Therefore, the optimal solution used is the solution produced during the rainy season (peak season).

5 CONCLUSION

Based on the interpretation of the results of the survey above, it can be concluded in this study there are two solutions, first is the demand for fertilizer subsidized need to be classified into 2 (two) seasons, i.e. spring season (normal season) and rainy season (peak season) as the approach conditions and characteristics of the spread of demand of fertilizers subsidised in the area in the period of 1 (one) year. Second, the optimal solution for determining the storage storage used is the optimum solution in the conditions of the rain season (pick season) by considering the obstacles to finding the addition of storage in the peak season conditions as well as the obligation of companies to meet the granting of the distribution of fertiliser subsidiated from the government. Third, of the 43 storage areas located in the conservation area, there are 33 storage selected and 10 storage unused with the Operational savings cost that the company can obtain is Rs 1.863.794.700. This solution will provide an overview for stakeholders in defining policies in the distribution of fertilizers, especially subsidized fertilizer.

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REFERENCES


