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ANALYSIS AND DESIGN OF WHEAT DISTRIBUTION SYSTEM IN PORT AREA BANTEN

ANALISIS DAN DESAIN SISTEM DISTRIBUSI GANDUM DI WILAYAH PELABUHAN BANTEN

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ABSTRAK

Globalisasi perdagangan bebas menyebabkan bahan pangan impor menjadi alternatif konsumsi karena kemudahan dalam mengonsumsinya, seperti pada makanan cepat saji. Permintaan gandum berfluktuasi akibat peningkatan permintaan pembuatan tepung terigu oleh pabrik-pabrik sekitar wilayah pelabuhan. Indonesia yang tidak memiliki kebun gandum produktif melakukan impor untuk mencukupi kebutuhan nasional. Pemangku kepentingan dalam rangkaian rantai pasok dan distribusi gandum adalah pelabuhan tempat kapal pengangkut sandar dari luar negeri. Di wilayah Banten, pelabuhan Cigading menjadi pelabuhan bongkar muat gandum, jagung, serta komoditas biji-bijian pertanian lainnya. Pengiriman komoditas pertanian dari hasil bongkar muat dikelola oleh perusahaan rekanan dengan bantuan moda transportasi seperti truk, kereta api, maupun konveyor-konveyor untuk pabrik sekitar pelabuhan. Gandum impor dari negara A yang bersandar di pelabuhan melakukan proses bongkar muat hingga pengiriman ke beberapa gudang. Pengiriman dilakukan ke gudang kering di pelabuhan atau ke gudang pabrik sekitar. Cara pengangkutan komoditas gandum dilakukan dengan truk dan kereta api dalam pengirimannya. Tujuan dari penelitian adalah untuk mengoptimalkan jumlah pengiriman moda angkutan truk gandum sehingga diperoleh biaya distribusi minimal per truk menggunakan metode integer linear programming. Hasil penelitian didapatkan minimasi total biaya distribusi sebesar $435,5, dengan rute truk dalam mengirimkan gandum menuju gudang kering di dalam pelabuhan dan gudang pabrik yang berada di luar pelabuhan sebanyak 12 kali ritasi truk. Hal ini disebabkan oleh cuaca, lamanya waktu bongkar muat, kapasitas pengangkutan terbatas, antrian truk yang tidak teratur.

Kata kunci: biaya distribusi, gandum, impor, tepung terigu, ritasi truk

ABSTRACT

The globalization of free trade has caused imported food to become an alternative consumption because of the ease of consumption, such as fast food. Wheat demand fluctuates due to increased demand for making wheat flour by factories around the port area. Indonesia, which does not have productive wheat plantations, imports to meet national needs. The stakeholders in the wheat supply and distribution chain are the ports where transport ships from abroad dock. In the Banten region, the Cigading port is a loading and unloading port for wheat, corn and other agricultural grain commodities. Partner companies manage the delivery of farm commodities from loading and unloading with the help of transportation modes such as trucks, trains and conveyors for factories around the port. Imported wheat from country A is docked at the port, the loading and unloading process and delivered to several warehouses between the dry warehouse at the port and the surrounding factory warehouse. The method of transporting wheat commodities is by trucks and trains when shipping. The research aimed to optimize the number of grain truck transportation modes so that minimum distribution costs per truck can be obtained using the integer linear programming method. Minimize total distribution costs of $435.5, with truck routes sending wheat to dry warehouses inside the port and factory warehouses outside the port 12 times back and forth. That is caused by weather, long loading and unloading times, limited transportation capacity, and irregular truck queues.

Keywords: distribution costs, imported, truck ration, wheat,wheat flour

INTRODUCTION

The COVID-19 pandemic that has hit the entire world has almost halted food globalization activities and changed people's consumption habits. The globalization of free trade has resulted in many imported foodstuffs becoming alternative consumption and convenience, such as fast food. Wheat is an agricultural commodity that is Indonesia's highest imported food, at 11.48% in 2021 (Safaei *et al*., 2018). Wheat (*Triticum Aestivum*) is the most traded food commodity globally (Cheraghalipour *et al.*, 2019). Wheat has strategic value because it is a group of cereal crops made from wheat that are rich in carbohydrates and are usually

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used to produce wheat flour and animal feed (Sanchez-Rodrigues *et al.*, 2010).

Domestic consumers need wheat to produce several foods, such as wheat flour, which will be made into cakes, bread, and noodles, so they need optimal production, procurement, storage, and delivery conditions for stakeholders (Mogale *et al.*, 2017). Wheat stakeholders of food factories around the port obtain wheat through the loading and unloading process of imported ships from Argentina, Ukraine, Australia, and the United States.

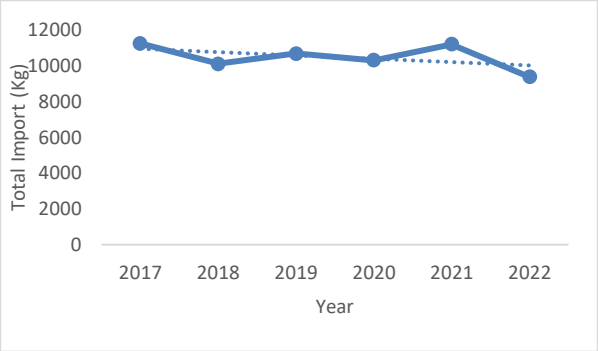

Figure 1. Indonesian Wheat Import Data
Gambar 1. Data Impor Gandum Indonesia
source: *Badan pusat statistika, 2022*

Based on Figure 1, demand for Indonesian wheat imports has fluctuated from 2017 to 2022, based on data from the Indonesian Central Bureau of Statistics for the upload year 2023. Demand for wheat fluctuates due to increased raw materials for making wheat flour by factories around the port area to produce the food. Indonesia imports wheat because it is less competitive, and there are still very few regions capable of growing wheat to meet national needs.

Therefore, to support food security, the government is trying to meet the public's need for wheat flour by importing wheat. According to several experts, the weather and tropical climate conditions in Indonesia are considered an obstacle to wheat growth. Due to fluctuations in demand for wheat, the supply chain for wheat to become flour products is critical. This supply chain involves many stakeholders, from shipping ships to trucks carrying wheat to local factories to process the wheat into wheat flour.

One of the ports where ships carrying wheat dock is in Cigading, located in the Banten region. Cigading Port has busy activities such as exports, imports, loading and unloading, and shipping processes to various factories around the port and outside Banten province. Company partners usually manage the shipping of agricultural commodities with the help of transportation modes such as trucks, trains, or conveyors for factories around ports. The port management company is PT. Krakatau Banda Samudera (KBS). PT KBS won the loading and unloading process for a ship carrying wheat originating from Argentina (A).

Figure 2. PT KBS's Port Pier
Gambar 2. Dermaga Pelabuhan PT KBS
Source: Cigadingport.com, 2023

Figure 2 is a satellite photo of PT KBS, which introduces Cigading port as a gateway to regional and global competitive advantage, as the deepest port in Indonesia prepared to handle all types of cargo, both dry bulk, liquid bulk, and containers. In line with the increasing import and export activities of goods by sea, facilities and infrastructure continue to be developed, including docks, ship unloaders (cranes), conveyors, and warehousing. Currently, Cigading Port is capable of handling cargo of up to 12 million tons and is committed to becoming a port providing world-class bulk services (KBS, 2023)

KBS As a provider of loading and unloading services for bulk commodities, smooth distribution plays an important role. Smooth distribution is problematic due to a need for more information between chains regarding availability in port warehouses, warehouses in nearby factories, and the net weight capacity of ships carrying wheat. One of the routine activities is regarding the number of bulk supplies in the port warehouse, especially wheat. The wheat supply chain starts with the ship docking from the import process, loading, and unloading the ship, choosing a warehouse in the port, or sending it directly to the nearest factory warehouse to be processed into wheat flour.

Designing and optimizing the supply chain for factories that process agricultural commodities consists of the design, the input needed to develop the mathematical model, and the desired output following the constraints or assumptions of the system (Bassett, 2018). The problem at PT KBS is the distribution system and placement of wheat to be sent to the port warehouse or nearest factories. In the agricultural commodity distribution system, there is often a mismatch between supply and demand quantities; this is due to quantity leakage during transit and inaccurate inventory quantities in warehouses (Kozicka *et al.*, 2016).

The port management design consists of a dry warehouse type, distribution with scheduling, and determining optimal routes using linear mixed integers (Crainic *et al.*, 2015). Dry port development is an integral part of intermodal transportation using

Delphi, Fuzzy Dematel, and SEM (Hatami Nasab *et al.,* 2016). Developing competition between dry ports by optimizing port stakeholder relationships around the location is one strategic strategy (Feng *et al.,* 2013). A distribution system that discusses inventory and transportation routes and focuses on warehouse management with sugar product export routes is completed using a Genetic Algorithm (Chiadamrong *et al.,* 2008). Meanwhile, disaster emergency distribution considers time uncertainty due to time deviations using a multi-commodity, multi-period distribution model due to different regional demands (Liu *et al.,* 2018). The logistics contribution in implementing delay consists of suppliers at ports, dry warehouses, and processing plants. Parameters The wheat supply chain scenario in the importing country minimizes the costs of transportation, storage, and wheat delivery operations from producers to consumers (Gholamian *et al.,* 2017). The dry port problem has been discussed by Crainic *et al.* (2015), Kozicka *et al.* (2016), and Feng *et al.* (2013), who analyzed dry ports to calculate optimal performance with the help of several methods, such as algorithms Genetics, Multi Linear Programming, Fuzzy Dematel, Delphi, search engine marketing.

Logistics networks, due to uncertainty, can arise due to risks inherent in delivery times changing quantities (Li *et al.,* 2011). Micro-level uncertainty has its roots in decision theory, which 'focuses on mathematical models' in assigning probabilities to events (Flynn *et al.,* 2016). Supply uncertainty causes decision-makers to be unsure about what to decide due to a lack of information about the environment and an ineffective capacity for control (Simangunsong *et al*., 2012). In addition, distribution networks are at risk due to uncertainties related to stock holding costs, delivery frequency, transportation rates, and changes in customer volume (Anwar *et al*., 2018). Meanwhile, uncertainty in decision variables aims to minimize distribution costs based on the number of requests and several transportation modes (Gossler *et al.,* 2019). The uncertainty grouping is differentiated based on factory-to-consumer consisting of pick-up/delivery delays (Wang, 2018). Demand and supply uncertainty in optimizing agricultural chain commodity flows and minimizing supply risks (Dempe, 2018). Green Opportunistic Supply Chain (GrOSC) and lean manufacturing design consider information uncertainty regarding market conditions (Golpîra *et al*., 2017). While the uncertainties discussed by Li *et al*. (2011), Flynn *et al.* (2016), Simangungsong *et al.* (2012), and Anwar *et al.* (2018) state that uncertainty is a condition resulting from deviations that occur due to time.

In this research, we develop a distribution system design at the company level for storage problems that is adapted to port warehouse capacity. Assuming the port warehouse is still full, the wheat storage is sent to the factory warehouses closest to the port. That was due to an error in the delivery of wheat, where the amount of wheat already at the port needed to match the amount sent to factories producing wheat around the harbor. Due to delivery error. Uncertainty in loading and unloading time for wheat using jute sacks, which require many workers and a long time. Meanwhile, wheat distribution uses truck transportation to send wheat from the loading and unloading location at the port to the warehouse. Based on the classification of problems that have been discussed in the previous article and the problems that exist at the site, the research aims to optimize the number of wheat truck transportation modes to obtain minimum distribution costs per truck using the integer linear programming method.

MATERIALS AND METHODS

The material presented in this research is imported wheat agricultural commodities from country A. The ecosystem design starts from the ship docking at the port, the loading and unloading process, and delivery to several warehouses between the dry warehouse at the port and the surrounding factory warehouse. The method of transporting wheat commodities is by truck and train if delivery is outside the city. As for warehouses, there are dry warehouses located at the port and wheat processing factories around the harbor.

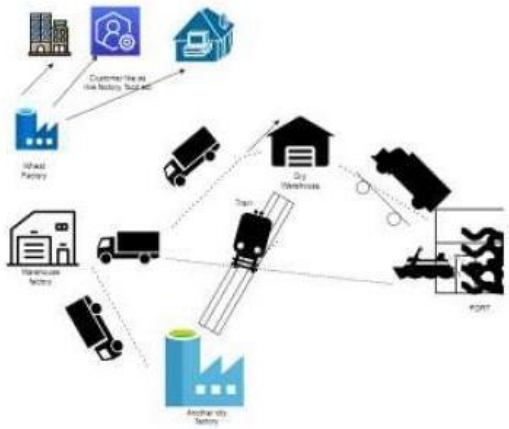

Figure 3. Distribution system activity diagram
Gambar 3. Diagram aktivitas sistem distribusi

Figure 3 explains the truck distribution process from the port to the dry warehouse at the port and warehouses at factories around the harbor. The available trucks are parked at the Cigading port so that when the residue docks, the trucks are ready at any time to transport wheat. The limit on the number of trucks parked based on port capacity is five. The car's power is 27,500 tons of wheat, which will be moved using a ship unloader (SU). Trucks will also be weighed to ensure the weight of the wheat being transported, with administrative records by the port. Meanwhile, the loading and unloading process from the truck to the warehouse uses an excavator.

The data used in the research include the ability of ships transporting imported wheat, the amount of wheat requested, the costs required for transportation and distribution, warehouse capacity at ports and processing factories, minimum wheat requirements for availability in warehouses and factories, the amount of wheat that must be transported to warehouses or factories. The assumption in this research is that only one ship carries wheat and docks at the port for loading and unloading. The mathematical model design provides that the shipping center is a ship that docks at Cigading port and a dry warehouse center to regulate which warehouse will send wheat based on distance and time.

Here is the mathematical model built in this research and will be solved using integer linear programming, binary 0-1. The tool used is Excel solver to solve this problem.

Purpose Function

$$Min \sum C_{ij}X_{ij} + \sum C_{jk}X_{jk} + \sum C_{ik}X_{ik}$$

Subject To

$$\sum_j X_{ij} \leq S_i \qquad \forall m, i$$

$$d_{jk} - \sum_j y_{jk} \leq I_{jk} \qquad \forall m, k$$

$$\sum_j y_{jk} \geq \omega d_{jk} \qquad \forall m, j$$

$$\sum_i x_{ijk} = \sum_k y_{ijk} \qquad \forall m, j$$

$$\sum_i x_{ijk} \leq V_j z_j \qquad \forall j$$

$$x_{ijk} \geq 0$$

$$z_j \epsilon \{0,1\}$$

RESULT AND DISCUSSION

In the use case illustration, a ship carrying imported wheat from country A docks at the port, the loading and unloading process, delivery of wheat, and storage in port warehouses and factories around the harbor.

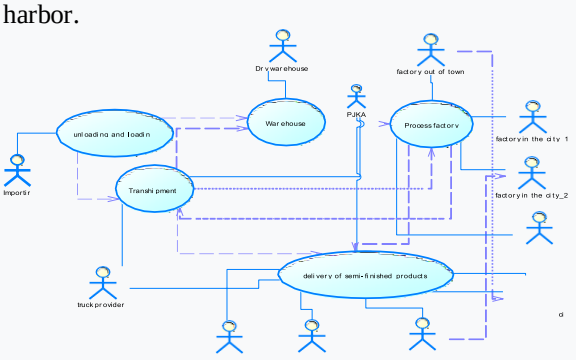

Figure 4. Use case of the port truck distribution system and surrounding factories

Gambar 4. Use case sistem distribusi truk pelabuhan dan pabrik di sekitarnya

Figure 4 depicts the flow of ships carrying wheat docking at the port for distribution to warehouses inside and factory warehouses around the harbor. Trucks were prepared in the port queue area to load and unload wheat from the ship. If the weather does not permit rain, loading and unloading will be carried out via a closed conveyor to the warehouse closest to the port. However, if the nearest warehouse still has sufficient capacity, the trucks will be distributed to the nearest factory warehouse when the weather returns to normal. That aims to ensure that the wheat does not get wet, the quantity of wheat weight does not decrease, and the quality of the wheat is still well maintained.

Business process modeling notation (BPMN) is the primary tool for analyzing (Djatna *et al*., 2014), facilitating graphical displays of data flow control between processes at each level, building systems (Safriyana *et al.*, 2019) and developing process flow analysis (Usman *et al.*, 2018). BPMN produces optimal design as a decision (Ekawati *et al.*, 2021).

PT KBS carries out the port managerial process for ship berthing to distribute wheat to surrounding factories. PT KBS, as the port manager, also has a warehouse for temporary wheat transit if weather conditions are wrong and the trucks need to be ready to transport and distribute wheat. Optimization of transportation distribution by truck, adjusted to the time, capacity, and wheat transportation cycle. Meanwhile, transportation to factory warehouses around the port is carried out by PT KBS partners. Trucks that have been queued will transport wheat according to the capacity of the truck bed, then carry out weight weighing before and after the wheat is thrilled and distribute the wheat to factory warehouses.

An overview of the system built based on BPMN can be seen in Figure 5, where this research aims to describe the flow of information on system activities from ship berthing to wheat distribution. Meanwhile, the distribution system seeks to minimize truck delivery costs based on capacity. The availability of warehouses so that the wheat sent remains of good quality and is not contaminated by foreign substances during transit or loading and unloading (Zokaee *et al.*, 2016).

The system to be built consists of an internal ecosystem as a description of conditions at the port and an external ecosystem as an explanation of the situation at the processing plant (Ekawati *et al.*, 2020). The inner ecosystem consists of the loading and unloading process at the port, which begins with the arrival of a ship carrying imported wheat, the amount of port capacity, the loading and unloading process from ship to truck, the weighing process, completeness of documents related to truck operations and travel, transportation services as a provider of truck transportation modes.

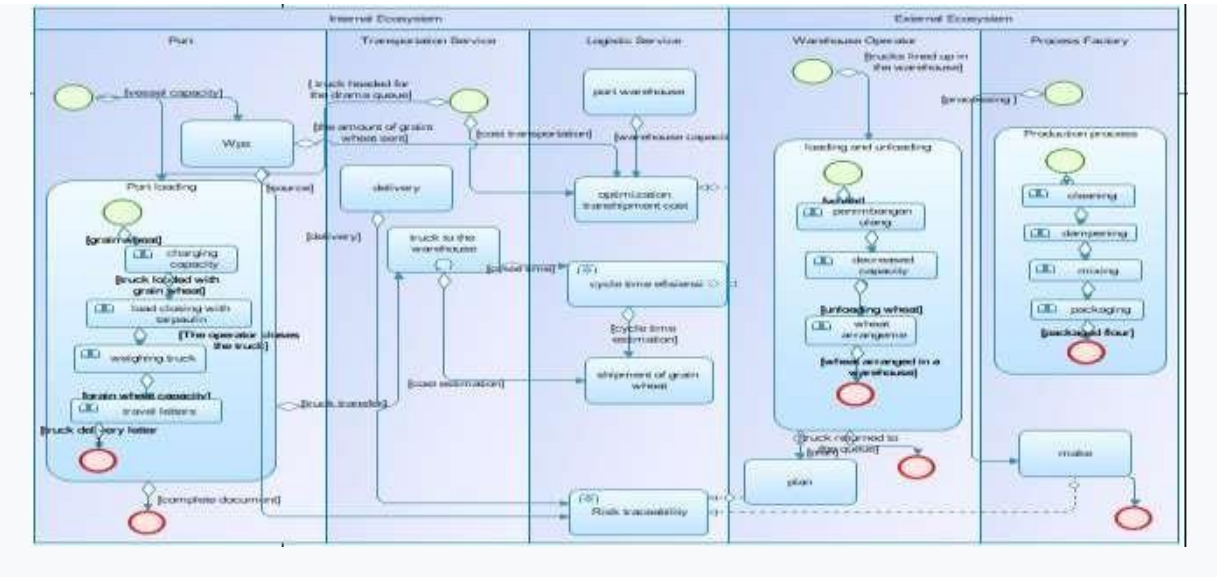

Figure 5. Business Process Modeling Notation (BPMN) Wheat distribution system
Gambar 5. Notasi Pemodelan Proses Bisnis (BPMN) Sistem Distribusi Gandum

The loading and unloading process consists of three types, namely loading and unloading for delivery based on packages to available warehouses, non-package deliveries based directly on processing plants, and mixed deliveries, which are deliveries to open warehouses in ports or directly to processing plants (Li *et al.*, 2018). The production process at the wheat processing factory is cleaning, dampening, mixing, and packaging, where the flour will be sent in sacks.

A mathematical model to translate Figure 5, which is a wheat loading and unloading scenario by considering capacity, truck capacity, and number of delivery routes for available warehouses (Iqbal *et al*. 2018). Based on the mathematical model, which is written in materials and methods, it has the aim of minimizing distribution costs. This model produces a total distribution cost of $435.5, with the truck route delivering wheat to dry warehouses inside the port and factory warehouses outside the port 12 times back and forth (truck rotation). These results differ from the actual situation in the field, where the truck delivery route goes back and forth less than 12 times. That is due to unfavorable weather or less than optimal ship berthing, so it takes a long time for the loading and unloading process. The small amount of wheat causes the extended loading and unloading process from the hopper and the operator's slowness in operating the SU machine. Limited picking capacity, damp wheat, small hopper diameter, and lack of operator training. Queues at the scales occur because the weighing process takes a very long time due to the small bandwidth space and the scales used for various loads. Irregular columns of trucks when they want to enter the pier. The availability of truck parking spaces that do not meet needs causes the queuing time from trucks entering to leaving the dock to be unused. Plus, there must be coordination between ships breathing and loading and unloading in the port logistics division.

The long queues left many drivers unemployed while waiting for the wheat loading and unloading process. In addition, only one excavator was operating; the excavator fuel arrived late, and the excavator operator arrived late. Queues during unloading at the destination warehouse occurred due to a lack of maintenance on the excavator machine. There is no definite schedule for when fuel will run out engine failure, and lack of supervision from port operators. The difference in the amount of wheat sent to the port dry warehouse is one of the causes of inefficient wheat distribution at the Cigading port.

PT KBS logistics services strive to reduce inefficiencies that occur in wheat distribution. Based on field observations, inefficiencies arise due to uncertainty in real-time information provided by warehouse operators at ports and processing warehouse operators. Optimizing truck distribution costs from loading and unloading locations to dry warehouses and factory warehouses using an integer programming mathematical model resulted in the number of wheat deliveries being 12 times the delivery route with the same truck in one loading and unloading session and an increase of 71.43%.

CONCLUSIONS AND RECOMMENDATION

Conclusions

The scarcity of raw materials for wheat flour has become a consideration for the government to import more wheat than other commodities. In this research, we developed a 0-1 integer programming mathematical model to find distribution costs and the optimal number of routes trucks must take to deliver wheat to dry warehouses and factory warehouses around the port. Based on the calculations, it was found that the total cost of wheat distribution was

435.5 $ with 12 wheat delivery routes by trucks queuing at the port. The analysis is that if the warehouse still has stock, the car will turn around and deliver wheat to processing factories.

Recommendation

Suggestions for further research are to calculate shipping distances so that the number of routes can be optimal and develop a queuing system for the loading and unloading process of ships and trucks carrying wheat. Meanwhile, companies can use truck traceability and conduct time management training for truck drivers and loading and unloading operators.

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