Rice distribution planning for “the poor people” in Bandung, West Java, Indonesia.

Sutarman¹ and Endang Hidayat²

Industrial Engineering Department, Engineering Faculty, Universitas Pasundan
Jl. Dr. Setiabudi No. 193 Bandung – 40154 Indonesia
¹sutarmanelan4@gmail.com, ²endanghidayat@gmail.com

Abstract: Bandung is one of the big and developed cities in Indonesia. The high economic growth in this city has an impact on increasing the prosperity of its citizens. However, the prosperity has not spread evenly. In fact, many residents of the city are still lack of rice. The party in charge of distributing rice to the poor is a state company called Bulog. Bulog has several warehouses with limited capacity to supply the poor. Three of them are Cisaranten Kidul, Main Warehouse and Citeureup warehouse. Bulog supplies rice to poor villages spread over 30 districts in Bandung. The allocation of rice for all districts needs to be improved so that the needs of the poor can be fulfilled with minimum allocation cost. Distribution planning conducted in this research was used Linear Programming method. Through this method, the optimization of rice allocation for the poor in Bandung can be obtained. Based on the finding, Linear programming method can be recommended as rice distribution pattern for poor people in Bandung with minimal logistics cost.

Keyword: Linear programming, warehousing, inventory, distribution

1. Introduction
Rice is the main food for the people of Indonesia. By 2016, Indonesia's population was 255 million people with a yearly consumption of rice per capita of 98 kg. Thus, the need for rice reaches 25 million tons in a year. Indonesia is able to produce 48 million tons of rice per year, there is an excess supply of 23 million tons. Although the production of rice in Indonesia is excessive, but if the distribution is unplanned and well-controlled, it will lead to instability in food security in Indonesia where people do not get good quality rice at the right time and quantity.

Indonesia has a State-Owned Enterprise called "Bulog" in charge of maintaining price stability and the balance of rice supply and demand for the community, through a planned procurement and distribution process, so as to meet the needs of the poor or in Indonesian commonly referred to as ‘Rumah Tangga Penerima Manfaat’. The process of rice procurement is done in 2 ways, namely domestic and import. Domestic procurement is the cooperation of Bulog and its pre-established partners with various requirements. To support rice distribution activities, Bulog has several warehouses with different locations and capacities. Meanwhile, the demand for rice varies. In order to meet the demand in the right amount and time, Bulog should plan the distribution of rice by determining allocations for each destination and warehouse sources with minimum distribution costs.

Bandung is one of the big cities in Indonesia and the capital of West Java Province consisting of 30 districts wherein each district has a number of poor with varying numbers. Rice supplied by the Bulog Bandung Regional Division, comes from 3 warehouses with different locations and capacities, they are: (1) Main Warehouse; (2) Cisaranten Kidul Warehouse, and (3) Citeureup warehouse.
The problems in this study are: (1) how to determine the allocation of rice for each district so that demand can be met with minimum distribution costs?, (2) how much rice should be stored in each warehouse for minimum storage cost? Based on the two issues, the total minimum distribution cost will be earned.

2. Methods
A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. Supply chain includes not only the manufacturer, but also transporters, retailers, and even customers themselves [2]. The above issues require the support of relevant theories, to obtain the optimum amount of rice allocated from each warehouse to each district in Bandung, with minimum distribution cost. The next step is to determine the cost of the warehouse, because the cost of logistics consists of distribution costs and the storage cost.

2.1 The determination of allocation
The problem faced in this research is how to allocate the rice from several warehouses with different locations and capacities to several districts in Bandung with different locations and the number of requests. This issue is included in the distribution problem. For optimal allocation, the linear programming method is used. The problem can be illustrated as in Figure 1 below:

![Distribution Problem](image)

The problem described above can be modeled with a mathematical formulation, with an objective function to minimize the costs, as in equation 1 below:

$$ Z = C_{11}X_{11} + C_{12}X_{12} + \cdots + C_{ij}X_{ij} $$

To complete the objective function, there are 2 functional constraints, namely (1) the effective warehouse capacity constraint, and (2) the rice demand constraint for each district.

2.1.1. The effective warehouse capacity constraint. The effective capacity is the capacity of each warehouse to meet the rice needs of the poor within a year. This capacity is designed to meet the demand for rice in Bandung and surrounding districts. The mathematical function of this constraint is illustrated in the following equation 2:
The rice demand constraint for each district
The rice demand of the poor in every district in Bandung has been determined by the Indonesian government by "based on name, based on address" in accordance with the 2015 policy. Thus, the mathematical function of this constraint, as in the following equation 3:

\[
\sum_{j=1}^{n} a_{ij} X_{ij} = D_j
\]  

(3)

The third constraint is to explain that the amount of rice allocated to each district in Bandung must be positive, thus the mathematical function as in the following equation 4:

\[
X_{11} \geq 0, X_{12} \geq 0, \ldots, X_{ij} \geq 0
\]  

(4)

Where:

Z: Objective function with minimized distribution cost

\( C_{ij} \): Distribution cost per kg from warehouse i to district j

\( X_{ij} \): Decision variables for the quantity of rice allocated from warehouse i to district j

\( a_{ij} \): The number of warehouses i that used by each district i

\( D_j \): The quantity of rice demand in each district j

\( W_i \): The effective capacity of warehouse i

2.2 The total of distribution cost
The key to achieving economic transportation is summarized in two basic principles. The first, often called the quantity principle, is that individual shipments must be as large as the involved carrier that can legally transport the equipment in use. The second, often called tapered principle, is that the delivery should be transported as long as possible [3].

The determination of total transportation cost is done after the allocation of each warehouse to each sub-district, with linear program formulation. Optimal solution assisted with Win QSB software. The optimal allocation amount and minimum distribution cost are obtained because it consider the objectives and functional constraints that have been formulated strictly in the formulation of linear programming.

2.3 The warehousing cost
A warehouse is traditionally viewed as a store or inventory. However, in contemporary logistics systems, the function of a warehouse is more appropriately seen as mixing and inventory modification to meet customer needs [4].

Warehousing costs consist of two types, namely (1) the fixed costs, i.e. the costs that do not depend on the volume of stored rice, and every warehouse has fixed costs differently, including depreciation costs, employees, warehouse management, maintenance, insurance and property taxes, (2) the variable costs, the amount of the cost depends on the volume of stored rice, and the carrying cost per ton of rice has been determined by the company.

Thus the warehousing cost is a fixed and a variable cost function, and based on the result of the study, the total warehousing cost is the fixed cost of the warehouse with the square root of stored rice volume, as in the following equation 5:

\[
C_i = K_i \sqrt{Z_{wit}}
\]  

(5)

Where:

\( C_i \): The warehousing cost of warehouse i

\( K_i \): The fixed cost for each warehouse i

\( Z_{wit} \): The volume of store rice at warehouse i
2.4 Determining the logistics cost

Another term of logistics is the “move and store” activity, the “move” is the movement of goods from the origin place to the destination, while the “store” is the storage of goods at a storage facility. Moving goods from the origin place to the destination is called transportation activities, and it requires transportation costs. Meanwhile, if the goods have arrived at the destination, the goods undergo the storage process to wait for the next process. The storage process requires a fee called warehousing costs. Thus the logistics cost is equal to the amount between transportation cost and warehousing cost.

3. Results and Discussions

The implementation of this research consists of 4 stages, namely: (1) determining the optimum allocation for each warehouse, and obtaining the minimum total transportation costs; (2) determining the warehousing costs of the stored rice; (3) determining the logistics cost (the logistics cost is the total between transportation and warehousing cost), and; (4) determining the efficient distribution patterns. The steps mentioned can be explained as follows:

First, the illustration of the transportation model to determine the allocation of rice from each warehouse to each district in Bandung can be seen in figure 2:

![Transportation Model Illustration](image)

**Figure 2.** The Transportation Model Illustration

Based on figure 2 above, there are 3 warehouse locations with different capacity. They must supply 30 districts in Bandung with the number of different requests. With the Linear programming formulation which consists of an objective function, consideration of warehouse capacity, the demand and the positive constraints, an optimum solution can be obtained, as in table 1.
Minimum transportation cost:
\[ Z = 58,20X_{11} + 57,25X_{12} + 56,42X_{13} + \cdots + C_{ij}X_{ij} + 0S_1 + 0S_2 + 0S_3 \] (6)

a. The warehouse capacity constraint:
\[ X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + \cdots + X_{130} + S_1 = 27,613,989 \]
\[ X_{21} + X_{22} + X_{23} + X_{24} + X_{25} + \cdots + X_{230} + S_2 = 22,091,191 \]
\[ X_{31} + X_{32} + X_{33} + X_{34} + X_{35} + \cdots + X_{330} + S_3 = 14,201,480 \]

b. The districts demand constraint:
\[ X_{11} + X_{21} + X_{31} = 169,560 \]
\[ X_{12} + X_{22} + X_{32} = 377,280 \]
\[ \cdots + \cdots + \cdots = 445,680 \]
\[ \cdots + \cdots + \cdots = 491,400 \]
\[ \cdots + \cdots + \cdots = 123,840 \]
\[ \cdots + \cdots + \cdots = \ldots \]
\[ X_{310} + X_{230} + X_{330} = 320,400 \]

Table 1. The Rice Allocation for 30 Districts

| No | Districts          | Allocation (tons) |
|----|--------------------|-------------------|
| 1  | Sukasarari         | 169.56            |
| 2  | Sukajadi           | 377.28            |
| 3  | Cicendo            | 445.68            |
| 4  | Andir              | 491.40            |
| 5  | Cidadap            | 123.84            |
| 6  | Coblong            | 462.78            |
| 7  | Bandungwetan       | 127.08            |
| 8  | Sumur Bandung      | -                 |
| 9  | Cibeunying Kaler   | 291.24            |
| 10 | Cibeunying Kidul   | 508.86            |
| 11 | Kiaracondong       | 765.00            |
| 12 | Batununggal        | -                 |
| 13 | Lengkong           | -                 |
| 14 | Regol              | -                 |
| 15 | Astana Anyar       | -                 |
| 16 | Bojongloa Kaler    | -                 |
| 17 | Bojongloa Kidul    | -                 |
Table 1. The Rice Allocation for 30 Districts (Cont.)

|   | District          | Allocation | Slack |
|---|-------------------|------------|-------|
| 18| Babakan Ciparay   | -          | 757.98|
| 19| Bandung Kulon     | 596.70     | -     |
| 20| Antapani          | 213.12     | -     |
| 21| Arcamanik         | 218.70     | -     |
| 22| Ujungberung       | 411.84     | -     |
| 23| Cibiru            | 310.86     | -     |
| 24| Rancasari         | 246.78     | -     |
| 25| Buahbatu          | 437.40     | -     |
| 26| Bandung Kidul     | -          | 250.92|
| 27| Gedebage          | 129.06     | -     |
| 28| Panyileukan       | 136.80     | -     |
| 29| Cinambo           | 153.00     | -     |
| 30| Mandala Jati      | 320.40     | -     |
| 31| S1                | 23,470.93  | -     |
| 32| S2                | -          | 19,296.87|
| 33| S3                | -          | 9,932.96|
|   | **Total**         | **27,613.99** | **22,091.19** | **14,201.48** |

The allocation of rice at each warehouse for each district is the total allocation minus the unused amount (slack variable). The allocation of rice from Cisaranten Kidul warehouse to fulfill the demand of Bandung is 4,143.06 tons. Meanwhile, the allocation of rice from Main Warehouse as much as 2,794.32 tons, and from Citeureup warehouse is 4,268.52 tons. The surplus of 52,700.76 tons of rice supply is allocated to other areas outside Bandung. After the optimum allocation is obtained, substitute the allocation quantity as a decision variable to the equation in the objective function. With assisted by Win QSB software, the total transportation cost is IDR 602,797,400, equivalent to US $ 46,370.

Second, as explained above that the warehousing cost is the total between fixed cost and variable cost where the fixed cost of each warehouse is determined by the company. While the variable cost is the square root of the amount of rice allocated to each warehouse. The warehousing cost is the total of the three warehouse costs, namely: Cisaranten Kidul, Gedebage (Main Warehouse) and Citeureup, as can be seen in Table 2.

Table 2. The Total Warehousing Cost

|   | Warehouses   | Fixed Cost ($K_i$) | Amount allocated ($Z_i$) | $C_i = K_i\sqrt{Z_i}$ |
|---|--------------|--------------------|--------------------------|------------------------|
| 1 | Cisaranten Kidul | 53,264             | 4,143.06                 | 3,428,431              |
| 2 | Main Warehouse | 71,598             | 2,794.32                 | 3,784,785              |
| 3 | Citeureup     | 77,463             | 4,268.52                 | 5,060,948              |
|   | **Total**     | **11,205.90**      | **12,274,165**           |                        |

Third, the logistics cost is obtained by totaling the transportation cost and the warehousing cost. Based on the above calculation, the transportation cost is IDR 602,797,400 and the warehousing cost is IDR 12,274,165, thus the logistics cost is IDR 615,071,565, equivalent to US $ 47,313.20.

Fourth, in accordance with the above description, an efficient distribution pattern can be determined, because: (1) rice allocation can be optimized with minimum transportation costs, (2) rice allocation can be optimized with minimum warehousing costs. Although transportation costs and warehousing costs
are minimum, but all the rice demand for the whole district are fulfilled. For that reason, the design of rice distribution patterns for the poor in Bandung can be obtained, as can be seen in the figure 3.

**Figure 3. Rice distribution pattern**

From the above distribution pattern, the rice demand for 13 districts can be supplied from Cisaranten Kidul Warehouse totaling 4,143.06 tons, while 8 districts can be processed by the Main Warehouse of 2,794.32 tons, and 9 districts of Citeureup warehouse totaling 4,268.52 tons.

4. **Conclusion**

Based on the use of theories, the steps and calculations that have been done, the conclusions of this study are as follows: (1) rice allocation for the poor in 13 districts in Bandung can be fulfilled from Cisaranten Kidul Warehouse as 4,144.06 tons, while 8 districts can be supplied by Main Warehouse as much as 2,794.32 ton while the remaining 9 districts can be supplied by Citeureup Warehouse as much as 4,268.52, with the transportation cost Rp 602,797,400; (2) the warehousing cost as optimal allocation result of Cisaranten Kidul warehouse is Rp 3,428,431, while the warehouse costs in the Main Warehouse amounting to Rp 3,784,785 and the warehousing costs in Citeureup Warehouse is Rp 5,060,948. Thus, the total cost of logistics if it is using the design of the distribution pattern is Rp 615,071,565.
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