The Effect of Considering Environmental Aspect to Distribution Planning: A Case in Logistics SME

Yudha Prambudia¹, Andri Andrian Nur
Center for Sustainable Systems – Faculty of Engineering
Widyatama University –Cikutra 204A, Bandung, Indonesia
¹Email: yudha.prambudia@widyatama.ac.id

Abstract. Environmental aspect is often neglected in traditional distribution planning process of a product. Especially in small-medium enterprises (SME) of developing countries where cost efficiency is the predominant factor. Bearing in mind that there is a large number of SME’s performing logistics activities, the consideration of environmental aspect in their distribution planning process would be beneficial to climate change mitigation efforts. The purpose of this paper is to show the impact of environmental aspect should it be considered as a contributing factor in distribution planning. In this research, an adoption of CO2-emission factor in an SME’s distribution planning in Indonesia was simulated. The outputs of distribution planning with and without the factor consideration are then compared. The result shows that adoption of CO2-emission factor would change the priority of delivery route.

Keywords: CO2 emission, Distribution Planning, SME.

1. Introduction
Economic development has led mankind to face global warming and climate change challenges. It is generally agreed that the impacts of using resources (for economic goals) to the environment and social life need to be balanced [1]. That has been the concept of Sustainable development [2] which is a common term used to describe the attempt to realize a profitable economic activities without making any damage to the environment for the future generation.

In the context of logistics business, cost aspect is basically the main driver of any attempt to improve efficiency. It is more often than not that environmental impact of logistics activities is neglected or put into the bottom of priority. However, attempts to promote environmental aspect as part of factors in improving logistics performance can be found under the topic of green logistics and has been progressing increasingly in developed countries [3]. However, in many developing countries, the progress has not been as much.

In Indonesia, logistics service providers are mostly in the category of small and medium enterprise (SME) and many are operated informally. They tend to neglect their contribution to environmental problems in favor of lower operational cost. This is partly because of high competitive market which determined that cost is their main key success factor [4]. In addition, there is not yet any government regulation that regulates how their operation should be conducted in order to lessen environmental impact.

In this research, distribution planning of a logistic SME in Indonesia is studied by simulating vehicle routing prioritization. The simulation was run with and without environmental aspect in several conditions. This research aims to show that small logistics providers will be facing a
dilemma should the government enforce a strict regulation related to environmental aspect of logistics operation. The government should take notice on this and think of something that will make environmental aspect more interesting to be considered in distribution planning process of every logistics SME.

2. Logistic in Indonesia
Logistics has strong relationship with Indonesia’s economic development. Along with economic growth, logistics activities in Indonesia are growing as well [5]. In 2009, the volume of national goods movement is at 44 million items. The volume of freight movement on land alone is around 39 millions trucks [6].

The number of companies providing logistical service is growing rapidly in the last few years. A report in 2014 mentions that there are 60 3PL companies and about 4200 transporter and expedition companies operating in Indonesia. In addition, many of the companies are SME and operated informally [7]. Looking at the numbers above, it is easy to say that a small change of consideration from cost oriented aspects towards environmental aspect would contribute greatly to climate change and global warming mitigation target.

3. Research Methodology
This research is conducted in two parts; the first part is model development, second is model simulation. In the developing the model part, there are three steps required; (1) Define the basic routing model that fit to the problem, (2) Define the measurement factors, (3) Define data requirement and collect the data. In the second part, two steps were conducted; (1) Develop scenarios and (2) Run the model. Afterwards the simulation result then analyzed. The methodology is presented in figure 1 below.

![Figure 1. Research Methodology](image-url)
3.1 Routing Model
The routing model used in this research is based from the combination of vehicle routing problem with time windows or VRPTW [8] and vehicle routing problem with multiple trip (VRPMT). The decision on this is related to the fact that VRPTW cannot address a multiple trip problem which is actually faced in real situation. On the other hand, the problem can be approached by the VRPMT model. Figure 2 below illustrates the basic setup of a vehicle routing problem.

![Image](209x485 to 370x633)

**Figure 2.** Basic Vehicle Routing Problem Solution [9]

The algorithm being used to find the best route is saving heuristics algorithm [10]. The basic concept of this method is to find the highest “cost saving” route by joining two or more destination as a route. The figure 3 below illustrates the saving heuristics mechanism.

![Image](209x485 to 370x633)

(a) (b)

**Figure 3.** Savings Concept (Lysgaard, 1997)

The algorithm proceeds as follow:

- **Allocation step:** Start with allocating all possible vehicles to destinations.
- **Calculation step:** Calculate the saving made by joining two or more destination iteratively. The calculation is $S_{ij} = C_{i0} + C_{0j} - C_{ij}$ where $S$ is savings, $C$ is cost, $i$ is first destination point, $j$ is subsequent destination and $0$ is the starting point. Sort the results in increasing direction.
- **Decision step:** In each iteration, find the highest saving where $i$ and $j$ does not use the same path and cross the capacity and time constraints.
- **Connection step:** Connect $i$ and $j$ to create a new route
3.2 Factors
The factors used in this research can be categorized into cost and environmental factors. The traditional factors related to cost considered in this research are operational cost and lost sale. Operational cost is defined as a function of driver-cost, fuel and maintenance cost and overtime cost. Lost sale is defined as the amount of product not sold to the customer when there is a demand. On the other hand, CO2-emission is used as a factor representing the environmental aspect. CO2 emission in this case is expressed as the amount of CO2 emitted from the use of different type of fuel used by the delivery vehicle.

The factors are weighted in proportion to the importance of the factors. Since, the interest of this research is the environmental aspect; CO2-emission factor is given higher weight than cost and lost sale factors. The weight was assigned base on a series of interviews with the distribution manager of the company and experts from academic and government.

3.3 Data
The SME in this research is a transport company. They specialized in distributing drinking water product in gallon container. The company profitability is depending on client satisfaction and the amount of cost they can save.
The operational characteristic of the company is as follow:
• 5 vehicles to operate their distribution plan.
• The vehicles includes 1 driver and 1 assistant
• Distribution area is only in West Bandung.
• 30 customers to serve their needs
• Delivery can only be done in opening hour of clients.

Data are collected by observations and interviews in the company. Detailed operation data such as number of vehicles available, demand, loading and unloading time, customers address, working hours, opening hours, vehicles costs and driver costs are recorded.

Data related to distance was obtained through the use of Google Earth to increase its accuracy. In order to do this, customer address is used as the basis for latitude and longitude coordinate. Figure 4 below shows a representation of distances between the depot as starting point and customers, and customers to customers.
3.4 Simulation
The simulation was implemented in optimization software. Several scenarios were developed and ran using two parameters: number of vehicles and whether or not overtime is permitted. Scenario 0 is the base scenario. The following table 1 shows the scenarios.

| Scenarios | Number of Vehicles | Overtime |
|-----------|--------------------|----------|
| 0         | 5                  | No       |
| 1         | 5                  | No       |
| 2         | 4                  | No       |
| 3         | 3                  | No       |
| 4         | 2                  | No       |
| 5         | 1                  | No       |
| 6         | 5                  | Yes      |
| 7         | 4                  | Yes      |
| 8         | 3                  | Yes      |
| 9         | 2                  | Yes      |
| 10        | 1                  | Yes      |

4. Simulation Results and Analysis
The results of the simulation are presented in table 2 below. Total cost and lost sale are express in monetary term while CO2 emission in liter per day. Looking at the factors respectively, scenario 0 or the base scenario is the worst scenario in term of both total cost and emission. The best scenario is selected based on the highest score scenarios.
**Table 2. Raw Result from simulation**

| Scenarios | Total Cost  | Lost Sale | Emission CO² (litre/day) |
|-----------|-------------|-----------|--------------------------|
| 0         | Rp 1.071.654| Rp        | 108.2933                 |
| 1         | Rp 934.706  | Rp        | 36.9782                  |
| 2         | Rp 765.489  | Rp        | 36.9782                  |
| 3         | Rp 597.041  | Rp        | 36.9782                  |
| 4         | Rp 416.208  | Rp 2.773.000 | 34.3369               |
| 5         | Rp 207.734  | Rp 5.062.200 | 15.8478               |
| 6         | Rp 934.706  | Rp        | 36.9782                  |
| 7         | Rp 765.489  | Rp        | 36.9782                  |
| 8         | Rp 597.042  | Rp        | 36.9782                  |
| 9         | Rp 479.576  | Rp        | 36.9782                  |
| 10        | Rp 346.208  | Rp 3.894.000 | 31.6956               |

Scoring the scenarios was done by normalizing the results by min-max method. The results of Total Cost, Lost Sale and CO2 Emission were converted to points. So when scenarios have a total point, scenarios with highest point will be selected as chosen scenario. The score of scenarios are presented in the table 3 below.

**Table 3. Scenarios Scores**

| Scenarios | Total Cost (30%) | Lost Sale (10%) | Total point | Emission CO² (60%) | Total point with CO2 |
|-----------|------------------|-----------------|-------------|--------------------|----------------------|
| 0         | 0.00             | 1.00            | 1.00        | 0.00               | 0.10                 |
| 1         | 0.16             | 1.00            | 1.16        | 0.77               | 0.53                 |
| 2         | 0.35             | 1.00            | 1.35        | 0.77               | 0.59                 |
| 3         | 0.55             | 1.00            | 1.55        | 0.77               | 0.65                 |
| 4         | 0.76             | 0.45            | 1.21        | 0.80               | 0.67                 |
| 5         | 1.00             | 0.00            | 1.00        | 1.00               | **0.80**             |
| 6         | 0.16             | 1.00            | 1.16        | 0.77               | 0.53                 |
| 7         | 0.35             | 1.00            | 1.35        | 0.77               | 0.59                 |
| 8         | 0.55             | 1.00            | 1.55        | 0.77               | 0.65                 |
| 9         | 0.69             | 1.00            | **1.69**    | 0.77               | 0.69                 |
| 10        | 0.84             | 0.23            | 1.07        | 0.83               | 0.69                 |

The score in Table 2 shows that if CO2 emission is not considered than the best scenario is scenario 9 (score = 1.69). It should be noted that the weight of Total Cost and Lost Sale in this case is the same. On the other hand, when CO2 emission is considered, the weight is changed as follow; Total Cost is 30%, Lost Sale is 10% and CO2 emission is 60%. Therefore, the best result is changed to scenario 5 (score = 0.80).
The weights were changed due to the fact that there was a change of view from the SME viewpoint to the government viewpoint. The SME does not consider CO2 emission as an important factor and regards Total Cost and Lost Sale as equally important. Meanwhile, the government view CO2 emission as an important factor in mitigating GHG, hence give more weight in it.

5. Conclusion
The government has been promoting integration of environmental aspect in logistics activities. By considering environmental aspect in distribution planning, the contribution of logistics activities to CO2 emission, thus global warming and climate change, can be reduced. Bearing in mind that there are great number of logistic SME operating in Indonesia, this small change would multiply greatly and deliver a significant impact to GHG reduction.

However, from the SME perspective, this can lead to higher cost. It is almost certain that the SME will consider the cost perspective more important than the environmental aspect. This may render efforts to improve global warming and climate change situation become less effective. Therefore, in order to improve the situation, the government may opt to put forward policies that give a kind of appreciation (e.g. incentives) to SME for the saved CO2 not emitted.

6. References

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