The Development of Sustainable Urban Freight Transport Programs of Depok City, Indonesia

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Abstract— This paper is aimed to initially arrange the sustainable urban freight transport program of Depok, Indonesia. The AHP analysis is applied to be the basic of the arrangement. It is combined with heuristic combinatorial approach to set the best list of programs. The combinatorial approach deals with the programs which take into account the two aspects, i.e. operational and sustainable aspects, and consider two opinions of stakeholders, i.e. local government and industries. Both points of view are arranged in a hierarchy of the AHP. Respondents of the AHP consist of expert staffs of local government and logistics manager of private industries. The results show that the first priority group of programs consists of green vehicle, restriction zone and goods terminal, while the second priority group consists of consolidation and night delivery, and the third one is distribution center and parking regulation.

Keywords— Freight Transport, Sustainable, AHP

I. INTRODUCTION

Freight transport system has an important role in supporting economic development of a region. From the economic aspect, freight transport affects the production process, product distribution, and service offerings [1]. However, behind the important role, freight transport is one of the causes of urban transport problems, such as the use of larger road space due to their sizes and movements, greenhouse gas emissions and particulate matter, noise and vibration, safety, road damage, congestion/delays and adverse effects on urban competitiveness and economic growth [2].

Nowadays, urban transport is not sustainable [3]. Cities around the world are currently being intensively discussing the problems of sustainable urban freight transport and apply a variety of rules or policies to reduce the negative impacts such as noise, air pollution, resource depletion, noise pollution caused by urban transport [2]. However, previous studies only considered sustainable aspects. Supposedly, program development also considers the operational aspects in addition to sustainable aspects so that in the implementation the programs can provide maximum positive impacts on cities. In addition, the programs also need to consider the needs and interests of not only city government, but also the ones of other stakeholders of urban freight transport, namely industries.

Sustainable transport can be defined as a collection of transport activities along with the development of infrastructure that does not leave problems or costs of which future generations solve and bear [4]. Sustainable transport has a primary purpose as a driver of economic and social development of urban areas [5], and to support the mobility needs of people, goods and information in a way that is the safest for the environment [6].

Freight transport is the main component of urban life. Every day, urban communities consume and use goods, food, clothing, furniture, books, cars, computers manufactured by humans in various parts of the world. Freight transport should be able to facilitate urban communities to obtain these products wherever and whenever they need [7].

Sustainable urban freight transport should ensure accessibility for all categories of freight, reduce air pollution, greenhouse gas emissions, waste and noise, improve resources and energy efficiency and costs effectiveness of freight transport, and can contribute to improve the quality of urban environment [8].

Sustainability of freight transport can be measured using several indicators [9], [10], namely environmental impacts such as global climate change (CO2 emissions), the use of natural resources; social impacts such as emission risks on public health, injuries and deaths from traffic accidents, noise disturbances, visual disturbances and vibration, decreased quality of life and decreased attractiveness of town center; economic impacts such as inefficiency and waste of resources, decreased reliability of travel and on-time delivery, as well as congestion.
The achievement of sustainable urban freight transport can be made through the implementation of some programs which are initiated by local government or industry, such as: freight terminal [11], [13], parking space planning [11], spatial restriction [11], [13], [14], green vehicles [12], [13], [14], time restriction [11], [14], consolidation [11], [12], [14], distribution center [11], [13].

Depok City is one of the major cities in West Java with an average economic growth based on the Gross Regional Domestic Product (GDP) in 2009-2013 amounted to 6.65%. This suggests that economic activities of Depok have been developed quite well. Such growth affect on the improvement on the logistics activities in Depok city and it also increases the negative impacts caused by the freight transport activities. It then requires the application of urban freight transport programs that aim to build a sustainable urban freight transport system.

The aim of this study was to develop programs related to the urban freight transport that considered operational and sustainable aspects simultaneously and took into account two points of views of city logistics stakeholders, namely city government and industries. The programs could benefit the Depok city government to achieve sustainable urban freight transport.

II. RESEARCH METHODS

Programs are prepared on the basis of subjectivity, through two stages of questionnaire, namely preliminary questionnaires and Analytical Hierarchy Process (AHP) questionnaires. AHP method is a method of simplifying a complex issue that is not structured, strategic and dynamic into sections arranged in a hierarchy. AHP method is commonly developed to solve the problems of decision-making that have a lot of goals or criteria. The importance level of each variable used is given a numerical value and compared with one another [15]. AHP hierarchy in the preparation of the programs is illustrated in Figure 1 and Figure 2.

The respondents of preliminary questionnaire and AHP questionnaire consisted of expert staffs of the City Government and logistic managers of private industries.

The results of AHP questionnaire and interviews with stakeholders were analyzed using Expert Choice 11 software to rank the programs based on two aspects and two points of view of stakeholders. The optimization result of this subjective approach were in the form of ranks and weights of programs based on the following aspects: the operational aspect according to the City Government, the operational aspect according to industries, sustainable aspect according to the city government, as well as sustainable aspect according to industries.

Operational aspects were aspects affecting the ranks of proposed program when viewed from the perspective of execution/implementation of the programs. Operational aspects consisted of 3 (three) criteria, i.e. the importance of the implementation of proposed programs; the ease of programs implementation; costs to be incurred to implement the proposed programs.

Sustainability aspects were aspects affecting the determination of proposed program ranks when viewed from the perspective of the following aspects: environmental criteria, defined as the impacts of proposed program on environment preservation; social criteria, which are defined as the impacts of proposed program on social sustainability; economic criteria, which were defined as the impacts of proposed program on economy sustainability.

The optimization results by using subjective approach were then optimized with heuristic combinatorial approach to get the best program composition from some alternative compositions of the programs, in which each program had a weight calculated from various viewpoints. Combinatorial approach was used to optimize problems that had a finite set of feasible solutions [15]. Heuristic approach was used to set the final decision in the form of priority quadrant. Weights and ranks of each program for various combinations of interests and viewpoints were scattered into quadrant to see the program deployment and arrange those programs.
III. RESULTS AND DISCUSSION

Preliminary Questionnaire

The results of preliminary questionnaire, which are in the form of Likert scale illustrated the views of respondents to Depok city transport condition. The results indicated people understanding on sustainable freight transport, their opinion on the city government concern on freight transport, as well as the efforts and the importance of achieving the sustainable urban freight transport. The understanding of stakeholders on sustainable freight transport was minimum. Overall, only 6.25% of respondents were familiar, while 68.75% of respondents were quite familiar and 25% of respondents felt less familiar. They only understood the impacts of sustainable freight transport in the form of congestion, air pollution, noise and accidents.

In the context of city government’s concern on the achievement of sustainable urban transport of Depok, 50% of respondents considered government gave attention, 19% of respondents felt it was just sufficient, and 31% of respondents considered the freight transport got less special attention from the government. The special attention given by the City Government today was in the form of network establishment of freight transport, freight transport zone restrictions, decisive action to freight transport that exceed the maximum load, warehouse/industry owners’ liability to provide parking space, and loading and unloading zones. While the special attention given by industries was in the form of scheduled delivery, provision of Distribution Center and consolidation.

In terms of efforts of the government to achieve sustainable freight transport of Depok city, 50% of respondents answered “no effort” and 50% of respondents said “there is effort”. All stakeholders should have joined in the efforts to achieve sustainable urban freight transport of Depok city. According to the city government, the efforts made were the arrangement of freight transport operation area and setting the time windows of freight transport operation. Meanwhile, according to industries, efforts made were in the form of scheduled shipment, consolidation of shipment, night delivery, and the effort to replace diesel freight car by green freight car.

The importance of achieving sustainable urban freight transport of Depok city according to 31% of respondents was very important, 51% of respondents saw it was important, 6% of respondents saw it was quite important and 6% of respondents saw it was less important.

Issues related to the freight transport which were most dominant in Depok city according to stakeholders based on the weight of the Likert scale were as follows: road accident or safety (4.81), damage of infrastructure (4.75), congestion (4.69), economic growth (4.38), air pollution and greenhouse gas (4.19), noise and vibration (4.00), public health (3.88), environmental damage (3.63), and the depletion of natural resources (3.56).
According to the all results, it can be concluded that the urban freight transport of Depok was not sustainable yet. Programs that can be applied in Depok city according to the stakeholders based on the weight of the Likert scale were freight terminal (4.25), access/zone restrictions (4.25), green vehicles (4.06), consolidation (4.00), night delivery (3.75), Distribution Center (3.56) and parking arrangement (3.38).

### AHP questionnaire

AHP questionnaire results were in the form of weights and ranks of programs based on the operational aspects (Table 1) and sustainable aspects (Table 2) according to the city government and industries.

#### Table 1 Weight and Rank of programs based on Operational Aspects according to City Government and Industries

<table>
<thead>
<tr>
<th>Program</th>
<th>City Government</th>
<th>Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Rank</td>
</tr>
<tr>
<td>Freight terminal</td>
<td>0.219</td>
<td>6</td>
</tr>
<tr>
<td>Parking arrangement</td>
<td>0.094</td>
<td>3</td>
</tr>
<tr>
<td>Green vehicles</td>
<td>0.130</td>
<td>7</td>
</tr>
<tr>
<td>Access/zone restrictions</td>
<td>0.174</td>
<td>5</td>
</tr>
<tr>
<td>Night Delivery</td>
<td>0.146</td>
<td>4</td>
</tr>
<tr>
<td>Consolidation</td>
<td>0.117</td>
<td>2</td>
</tr>
<tr>
<td>Distribution Center</td>
<td>0.099</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1 shows the differences of opinion between the City Government and industries in the operational aspect. According to the city government, the most importance program is freight terminal (valued as 0.219). Based on the operational aspects, freight terminal, zone restriction and green vehicles were important to apply. Meanwhile, according to industries, the most important program was Distribution Center (valued as 0.272). Distribution Center has been applied by several industries in Depok city, therefore the industries argue that this program is cheaper, more important and more easily implemented than other programs.

#### Table 2 Weight and rank of programs based on Sustainability Aspects

<table>
<thead>
<tr>
<th>Program</th>
<th>City Government</th>
<th>Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Rank</td>
</tr>
<tr>
<td>Freight terminal</td>
<td>0.134</td>
<td>6</td>
</tr>
<tr>
<td>Parking arrangement</td>
<td>0.055</td>
<td>7</td>
</tr>
<tr>
<td>Green vehicles</td>
<td>0.256</td>
<td>1</td>
</tr>
<tr>
<td>Access/zone restrictions</td>
<td>0.177</td>
<td>2</td>
</tr>
<tr>
<td>Night Delivery</td>
<td>0.116</td>
<td>5</td>
</tr>
<tr>
<td>Consolidation</td>
<td>0.153</td>
<td>3</td>
</tr>
<tr>
<td>Distribution Center</td>
<td>0.109</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2 shows that the difference of opinion in aspects of sustainability between the City Government and industries is not quite significant. According to these stakeholders, green vehicles is top priority program when viewed from the aspect of sustainability, given that the green vehicles is very good for the environment.

### Program Development

In program development, optimization method with heuristic combinatorial approach was used to optimize the sets of programs resulted from AHP (i.e based on the operational aspects according to the City Government, operational aspects according to the industries, sustainability aspect according to the city government, sustainability aspect according to industries) to produce a set of the best programs. Combinatorial optimization made use of parameter of combined importance weight as a determining parameter which was obtained by combining the weight of operational and sustainability aspects according to the following equation:

\[ Y_{pk} = (\alpha x O_{pk}) + (\beta x S_{pk}) \]  

(1)

Where:

- \( Y_{pk} \) = Combined importance weight of program-\( p \) based on the views of stakeholders -\( k \)
- \( \alpha \) = Priority weight of operational aspect
- \( \beta \) = Priority weight of sustainability aspect
- \( O_{pk} \) = Importance weight of program-\( p \) based on operational aspect according to stakeholder -\( k \)
- \( S_{pk} \) = Importance weight of program-\( p \) based on sustainability aspect according to stakeholder -\( k \)

Combining the two aspects (namely operational and sustainability aspects) involves parameters \( \alpha \) and \( \beta \) which provide level of priority on each aspect. By using equation (1), the combined importance weight of each program for various priority level of operational and sustainability aspects can be calculated from the view of the city government and industries. By combining the two aspects of interests, the rank of the program may be changed from the original one when it is only seen from single aspect. Figure 1 shows the importance weight of each program based on the combined aspects of operational and sustainability according to the city government and industries. Ratio of 0:100 (priority on operational aspect is 0 and priority on sustainability is 100) indicates that the program arrangement purely takes into account the sustainability aspect as a single aspect. Conversely, the ratio of 100:0 indicates that the arrangement purely considers the operational aspect without looking at the sustainability aspect. The straight lines indicate the government viewpoint, while dot lines indicate the company viewpoint.

Gradient of lines in Figure 1 varies, and it indicates the sensitivity of each program on changes in the priority level of the operational aspect and sustainability aspect.
The differences on the opinion between the City Government and industries occur because these stakeholders have different interests and goals. The city government concerns more on the development of the city, while industries concerns more on their business. Because of this difference, to get the best program based on the combined interests of both City Government and industries, it is used the following model:

$$Z_j = (\delta \times Y_j^1) + (\gamma \times Y_j^2) \quad \forall j$$  \hspace{1cm} (2)

Where:

- $Z_j$ = Weight of combined interests of operational and sustainability aspects according to the City Government and industries for program $-j$
- $Y_j^1$ = Combined importance weight of program $-j$ based on the viewpoint of City Government
- $Y_j^2$ = Combined importance weight of program $-j$ based on the viewpoint of industries
- $\delta$ = Interest weight of the City Government
- $\gamma$ = Interest weight of the Industries

Using equation (2), it can be calculated weight of the combined interests of operational and sustainability aspects based on the interests of both the City Government and industries simultaneously for each proposed program. It involves parameters $\delta$ and $\gamma$ that representing interest weights of both stakeholders. In an extreme case at which the program arrangement is aimed to consider only the interest of city government, $\gamma$ could be set as zero. The consequence of this option is the arrangement of proposed programs may benefit the industries at least.

To take a final decision related to priority program, it is used the following approach: □ Operational and Sustainability Ratio

To get the best arrangement of the programs, it is taken operational ratio ranging from 40%-60% and the sustainability ratio from 40%-60%. This ranges is considered to represent the two aspects quite proportionally.

□ The City Government and Industries Interest Weight

For the best decision, it is used the interest weight of industries ranged from 0%-30% and the interest weight of the City Government ranged from 70%-100%. This justification is considered to be the rational one given that the major determinant of program development is the city government. Hence, the bigger interest weight is given to the city government.

Furthermore, the analysis is performed with the tool of quadrant diagram. Weights and ranks of the programs are mapped on a diagram consisting of four (4) quadrants as follows: Quadrant I is a quadrant with high rank and high weight, quadrant II is a quadrant with high rank but low weight, quadrant III is a quadrant with high weight but low rank, quadrant IV is a quadrant with low weight and rank. This analysis is performed to determine the final decision on the order of the proposed programs. Based on the scatter of the programs in the quadrant in Figure 4, it can be seen that the program distribution is accumulated in quadrant I, III and IV. The order of the proposed programs is determined by choosing the program that dominates each program cluster. For example, the highest weight and the highest rank program in the program in the quadrant I is the green vehicle program since it dominates the most top right cluster significantly. It means that for various interest ratios of operational and sustainability aspects, and for various interest ratios of the city government and industries, the program of green vehicles is considered as a program which needs to be prioritized.

Based on the distribution, then the arrangement of the programs can be made as follows: the programs belonging to priority I (quadrant I), are Green vehicles, Access/Zone Restriction, Freight Terminal; programs belonging to priority II (Quadrant III) are Consolidated Shipment and Night Delivery; and programs belonging to priority III (Quadrant IV), are Distribution Center and parking arrangements.

Figure 4 Matrix of Combined Weight and Ranks of Operational and Sustainability Aspects based on various Ratios of the City Government and Industries
IV. CONCLUSION

Based on analysis that have been performed, it can be concluded that the issue of sustainable freight transport in Depok city needs attention from both the city government and industries. Moreover, in the development of programs related to sustainable transport, operational aspect and sustainability aspect are possible to be considered simultaneously to obtain more optimal results in terms of the implementation and impacts on the city. Although the city government has a major role in the planning of urban freight transport system, the viewpoints of the industries are also important to be counted given that naturally both of them have different interests. The programs that combine these two interests are expected to provide better impacts on the sustainability of the city. The proposed program arrangement for Depok city need to be studied further in detail for their implementation. The concept of the development of these programs can be applied to other areas, involving programs that may be different.

REFERENCES