Predicting of land logistics travel demand in Aceh Province Indonesia

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Abstract. In the process of planning a transportation system, it is important to predict transportation demand in the next few years. Predicting transportation demands for a wide area requires large resources including funding. Transport demand is usually done for the scope of the study area, such as formulating documents for the national transportation system, regional transportation system, local transportation system, and another similar one. One method of forecasting transportation demand is through transportation modeling. This paper is an analysis of land logistic transportation demand in Aceh Province Indonesia. Modeling is done based on data from the Origin-Destination survey of the movement of logistics in 2011, which has been calibrated to 2018. Finally, the prediction of the logistic movement is determined for land transportation mode in Aceh Province.

1. Introduction
Transportation is the activity of moving people or logistics from one place to another. Transportation infrastructure is one of the main infrastructures to improve the economy of a region [1]. Freight or logistics is also very important to support economic growth. Transportation has characteristics and attributes that show specific meaning and function. The main function is to connect humans with land use. Related to the transportation demand in a city and region, it is necessary to have good transportation planning to achieve efficiency and optimization of existing conditions [2].

Transportation of logistics in Aceh Province is still dominated by road transport, especially by trucking. The choice of shipping expedition logistics using truck mode is chosen by many freight forwarding service companies because it is not bound by time considering the delivery of logistics can be done at any time. Thus, truck transportation is the main choice of shipping logistics. More than 95% of the movement of logistics in Aceh Province uses road transportation modes [3]. Demand for land transportation for logistics can be seen based on the number of special vehicles in Aceh Province. Until now, the number of logistic vehicles in the form of 3,579 large trucks, while the types of small trucks are 24,489 units [4].

In the process of planning a transportation system, it is necessary to predict transportation demand in the next few years. Predict transportation demand in the next few years in a wide area requires large resources including funding. The scope of planning transportation systems is like the formulation of documents for the national transportation system, regional transportation system, local transportation system, and another similar one. One method of forecasting transportation demand is through transportation modeling [1]. In this paper, an analysis of the transportation demand for land logistics in the province is carried out, namely Aceh Province. Based on data from the Origin-Destination (O-D)
Matrix of the movement of logistics in 2011 that has been calibrated to 2018, projections of the distribution of trips in Aceh Province can be carried for land transport mode.

2. Transport demand modeling and predicting methods

Prediction of transport demand (traffic) is carried out through two approaches, namely the macro approach and the micro approach. The macro approach aims to obtain flows in general that enter or exit the study area and their influence on other parts of the network, while the micro approach aims to obtain micro-currents in the study area [1]. A four-stage transportation planning model will be used for the macro approach, because in addition to the ease of its ability to describe various interactions between the road transportation system and spatial planning in the study area.

Transport network data and zone system data are the main inputs in the four-stage transportation demand model. Transportation network data represents the supply and performance of transportation networks in the study area, while zone system data represents spatial characteristics in the study area and the socio-economic characteristics of the population in the spatial layout. The interaction between the two systems will be the main part analyzed in the four-stage transportation model.

Trip generation models (people and logistics) are a form of mathematical equations that represent the correlation between socioeconomic variables in the study area with the current reality of transportation or traffic (people/logistics), which can be obtained from National Origin-Destination (O-D) survey data. Based on the correlation of the relationship and predictions of the development of the region that is expected to occur, future travel demand can be predicted.

The trip generation model that is most often used in regional transportation studies is a multilinear regression analysis model, where travel demand (trip generation/attraction) as the dependent variable will be correlated with some socioeconomic data as independent variables, for example, population per zone, number office/trade / industrial floor area, and so on. The flow chart of the trip generation modeling process is presented in figure 1.

![Flowchart of Trip Generation and Prediction Process](image)

**Figure 1. Trip generation and prediction process.**

The trip distribution model is carried out to obtain the Origin-Destination (O-D) Matrix of the trip for every pair of zones in the study area. The trip data for each zone (trip end) has been obtained from the previous trip generation process. Preliminary data on O-D for the study area can be predicted based on population and employment data. This predicted data, then used as the base matrix (prior matrix) and are assumed to reflect travel patterns in the study area.

To get an O-D Matrix at year review, predictions are made according to the latest traffic data collected from the primary survey for road transportation modes. Furthermore, with the O-D data, this year the O-D prediction model was formed in the coming year with a Gravity or Furness model approach which is likely to be suitable for the condition of the study area.

Mode choice model is generally not established in this study, given its review in the city and the influence of modes other than roads can be ignored. In the subsequent analysis process, other modes
other than roads will be seen qualitatively and quantitatively through the determined performance magnitude.

**Trip assignment model** also called route choice model will be done by using the software. Origin-destination Matrix will be distributed to the road network. The structure step of the trip assignment model is shown in figure 2.

![Trip Distribution Model](image)

**Figure 2.** Trip distribution model and prediction process.

**Trip Zone Modeling.** The division of trip zones established at the location of activities is a zone with internal and external analysis units. The study area is divided into 23 internal zones and 13 external zones. The zone of internal movement between the center of activity consists of the activity center of each district/city while the external zone consists of the nodes of movement of the seaport. For more details about zones can be seen in figure 3 and related to table 1.

3. **Results and discussion**

3.1. **Network system modelling**

The developed road network system is pursued according to the level of development demand for multimodal transportation. In planning this multimodal transportation, the road network that is used as modeling is a road network with primary functions or a road network that connects activity centers. Based on the existing base map, a road network model was created at the location of the activity. The road networks in this plan are several roads that connect between zones of movement, both internal and external trips. In this road network modeling, there were 446 review links spread across 36 zones. By considering the possible impacts, the road network system model is formed to include the national and provincial roads in Aceh Province. The attribute data on this road network system consists of road length, basic capacity, speeds, and travel time. The road networks system can be seen in figure 4.
Figure 3. Zones in the studied area.

Table 1. The name of the internal and external zone.

| No | Internal Zone               | No | External Zone               | Note                                                                 |
|----|-----------------------------|----|----------------------------|----------------------------------------------------------------------|
| 1  | Kab. Aceh Barat             | 1  | Eks. Pel. Ferry Meulaboh    | The ports that are actively carrying out logistic loading activities at the Ports of Pel. Lhokseumawe, Kuala Langsa, Ulee Lheue, Krueng Geukuh, and Malahayati |
| 2  | Kab. Aceh Barat Daya        | 2  | Eks. Pel. Ferry Susoh       |                                                                      |
| 3  | Kab. Aceh Besar             | 3  | Eks. Pel. Krueng Geukuh     |                                                                      |
| 4  | Kab. Aceh Jaya              | 4  | Eks. Pel. Kuala Langsa      |                                                                      |
| 5  | Kab. Aceh Selatan           | 5  | Eks. Pel. Lhoknga           |                                                                      |
| 6  | Kab. Aceh Singkil           | 6  | Eks. Pel. Lhokseumawe       |                                                                      |
| 7  | Kab. Aceh Tamiang           | 7  | Eks. Pel. Malahayati        |                                                                      |
| 8  | Kab. Aceh Tengah            | 8  | Eks. Pel. Sabang            |                                                                      |
| 9  | Kab. Aceh Tenggara          | 9  | Eks. Pel. Sigli             |                                                                      |
| 10 | Kab. Aceh Timur             | 10 | Eks. Pel. Sinabang          |                                                                      |
| 11 | Kab. Aceh Utara             | 11 | Eks. Pel. Singkel           |                                                                      |
| 12 | Kab. Bener Meriah           | 12 | Eks. Pel. Tapak Tuan        |                                                                      |
| 13 | Kab. Bireuen                | 13 | Eks. Pel. Ulee Lheue        |                                                                      |
| 14 | Kab. Gayo Luces             |    |                            |                                                                      |
| 15 | Kab. Nagan Raya             |    |                            |                                                                      |
| 16 | Kab. Pidie                  |    |                            |                                                                      |
| 17 | Kab. Pidie Jaya             |    |                            |                                                                      |
| 18 | Kab. Semeulue               |    |                            |                                                                      |
| 19 | Kota Banda Aceh             |    |                            |                                                                      |
| 20 | Kota Langsa                 |    |                            |                                                                      |
| 21 | Kota Lhokseumawe            |    |                            |                                                                      |
| 22 | Kota Sabang                 |    |                            |                                                                      |
| 23 | Kota Subulussalam           |    |                            |                                                                      |
3.2. Trip generation modelling

To determine the number of trips in the future at the location of the activity, the current model of logistic movement is determined in advance. Production and attraction trip number at the activity site using the 2011-year Origin-Destination (O-D) matrix data that has been calibrated to 2018 by using vehicle growth rates and linear regeneration methods. The results of trip generation modeling of logistic based on O-D Matrix can be seen in table 2 and table 3. Table 2 shows the trip generation of the internal zone and table 3 shows that the trip generation of the external zone.

**Table 2** Generating internal zone of logistic in activity locations in 2018 (tons/year).

| No | Internal Zone | Trip Production | Trip Attraction |
|----|---------------|-----------------|-----------------|
| 1  | Aceh Selatan  | 1,526,554       | 1,521,277       |
| 2  | Aceh Tenggara| 1,050,573       | 997,261         |
| 3  | Aceh Timur   | 4,963,349       | 4,428,763       |
| 4  | Aceh Tengah  | 4,149,464       | 3,682,232       |
| 5  | Aceh Barat   | 2,993,889       | 3,158,994       |
| 6  | Aceh Besar   | 1,580,270       | 1,765,923       |
| 7  | Pidie        | 3,877,621       | 3,622,706       |
| 8  | Aceh Utara   | 5,003,986       | 5,002,193       |
| 9  | Simeulue     | 459,193         | 492,081         |
| 10 | Aceh Singkil | 380,728         | 404,656         |
| 11 | Bireun       | 4,205,993       | 4,125,737       |
Table 3 Generating external zone trips of logistic in activity locations in 2018 (tons/year).

| No | External Zone                  | Trip Generation | Note                                      |
|----|--------------------------------|-----------------|-------------------------------------------|
|    |                               | Trip Production |                                           |
|    |                               | Trip Attraction |                                           |
| 1  | Eks. Pel. Ferry Susoh          | -               |                                           |
| 2  | Eks. Pel. Lhoknga              | -               |                                           |
| 3  | Eks. Pel. Sigli                | -               |                                           |
| 4  | Eks. Pel. Sinabang             | -               |                                           |
| 5  | Eks. Pel. Tapak Tuan           | -               |                                           |
| 6  | Eks. Pel. Sabang               | 25,228          | 49,775                                    |
| 7  | Eks. Pel. Ferry Meulaboh       | -               |                                           |
| 8  | Eks. Pel. Krueng Geukuh        | -               |                                           |
| 9  | Eks. Pel. Kuala Langsa         | 6               | 20,661                                    |
| 10 | Eks. Pel. Lhokseumawe          | 257,544         | 873,336                                   |
| 11 | Eks. Pel. Malahayati           | 1,338,065       | 979,856                                   |
| 12 | Eks. Pel. Singkil             | -               |                                           |
| 13 | Eks. Pel. Ulee Lheue           | -               |                                           |

3.3. Trip distribution modelling

Trips distribution describes the pattern of travel from the origin and to a destination zone. Analysis of trip distribution is made based on the results of data processing from the destination between the movement zones that have been adjusted to the center of activity. Modeling the trip distribution of people and logistics in the current conditions uses the gravity model method. This model takes into account the magnitude of accessibility between movement zones. The higher the accessibility, the greater the movement between the zones. The results of modeling the movement distribution with the gravity model method are mentioned in Table 4 as an example. Predictions of road network loading had been completed for 2023, 2028, 2033 and 2038. Based on Table 4 on can be seen briefly that the number of movements of the O-D matrix in the location of the activity, it can be seen that the movement patterns are mostly still towards the activity centers (provincial and district capitals cities). Most of the trips go to Banda Aceh, Lhokseumawe City, Meulaboh, Pidie, East Aceh and North Aceh). While the high movement to the seaport transportation nodes (Sinabang, Sigli, Singkil, Ulee Lheue, Krueng Geukuh, and ferry ports is still relatively low).

3.4. Trip assignment modelling

The modeling of road network assignment was used as the equilibrium method. The state of equilibrium is assumed that the traffic flow will stand itself in the road network in such a way that no one driver will be able to reduce their travel cost by changing to another route. In other words, in equilibrium conditions, all selected routes have the same costs, while non-selected routes have the same or greater costs.
Table 4 The result of trip distribution modeling for the 2023 year as an example (tons/year) (1/2).

| The Name of Zone | Kab. Acch. Singkil | Kab. Acch. Tanah | Kab. Acch. Tengah | Kab. Acch. Tenggara | Kab. Acch. Tinaur | Kab. Acch. Bireuen | Kab. Acch. Langsa | Kab. Acch. Kuala Koha | Kab. Acch. Langkat | Kab. Acch. Sabang | Kab. Acch. Sabang | Kab. Acch. Sabang | Kab. Acch. Sabang | Kab. Acch. Sabang |
|------------------|-------------------|-----------------|-------------------|-------------------|-----------------|------------------|-----------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Eks. Pel. Ferry Mubalghi | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Ferry Sukasada | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Krueng Lebah | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Krueng | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Lhokseumawe | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Bahr | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Langsa | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Lhokseumawe | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Kab. Acch. Bireuen | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Kab. Acch. Langsung | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Kab. Acch. Kuala Lhokseumawe | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Table 4 The result of trip distribution modeling for the 2023 year as an example (tons/year) (2/2).

| The Name of Zone | Kab. Acch. Singkil | Kab. Acch. Tanah | Kab. Acch. Tengah | Kab. Acch. Tenggara | Kab. Acch. Tinaur | Kab. Acch. Bireuen | Kab. Acch. Langsa | Kab. Acch. Kuala Koha | Kab. Acch. Langkat | Kab. Acch. Sabang | Kab. Acch. Sabang | Kab. Acch. Sabang | Kab. Acch. Sabang | Kab. Acch. Sabang |
|------------------|-------------------|-----------------|-------------------|-------------------|-----------------|------------------|-----------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Eks. Pel. Ferry Mubalghi | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Ferry Sukasada | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Krueng Lebah | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Krueng | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Lhokseumawe | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Bahr | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Langsa | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Eks. Pel. Kuala Lhokseumawe | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Kab. Acch. Bireuen | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Kab. Acch. Langsung | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Kab. Acch. Kuala Lhokseumawe | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

3.5. Forecasting roads loading
Forecasting road network loading due to the movement of goods in Aceh Province is obtained from the modeling of road loading using the equilibrium (balance) method. Modeling predictions for road loading were carried out in 2023, 2028, 2033, and 2038. Changes in road network load due to the travel logistics in Aceh Province can be seen in figure 5.
Forecasting road network loading due to the movement of logistics in Aceh Province is obtained from the modeling of road network assignment using the equilibrium (balance) method. Modeling predictions for road network assignments were carried out for 2023, 2028, 2033, and 2038 year of prediction. The changes in travel demand at road network assignment due to travel of logistics in Aceh Province can be seen in figure 5.

The pattern of distribution of goods movement in Aceh Province from 2018 until the end of the planning year did not experience much change, this is because the center of movement (transportation node) did not change much. The change that occurred was an increase in the amount of logistic distribution. As a result of the increasing number of goods distributions, the traffic load on the road network has also increased. The development of road network loading in Aceh Province can be seen in the following sequential figure 5.

As seen at that picture that the road load due to the travel of logistics in Aceh Province is increasing in the eastern lane section. At the end of the planning year (2038) the logistic vehicle load in the eastern, middle, and western lanes is higher than any other road network. This means that the road network running parallel from south to north or opposite direction must be the focus of attention to facilitate logistics transportation to and from port outlets. Thus, the road routes that connect between the regional development cities must be the next focus to support the main lines that have been mentioned.

![Figure 5](image_url)

**Figure 5.** The traffic condition in the ratio of road volume to capacity at prediction years.

4. Conclusions
Based on the steps that have been done to predict the transport demand of logistic and the prediction of road performance, several points can be concluded and suggested, are:
1. Logistic travel demand at basic and prediction year can be determined by modeling techniques using data of origin and destination survey, socio-economic, socio-economic growth rates, transportation networks, road traffic by using four-steps modeling methods.

2. Analysis of travel distribution shows the potential path of Origin - Destination that can be the focus of attention in handling both the starting point and destination and on the path.

3. In the predicted years, the logistic movement in the east lane of Aceh will be more congested. For this reason, on the eastern lane, it is necessary to immediately construct a new transportation modal such as the railway and toll roads.

4. Similar studies with this study at the same location need to be carried out for air and sea transportation needs.

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