

# THE STUDY OF RAILWAYS INTERMODALITY AS ALTERNATIVES OF CPO TRANSPORTATION IN CENTRAL KALIMANTAN

**Noor Mahmudah**

Lecturer

Department of Civil Engineering

Faculty of Engineering

Universitas Muhammadiyah Yogyakarta

Jl. Lingkar Barat, Kasihan, Bantul 55183

Tel: (0274) 6497249

E-mail: [mahmudah@hotmail.com](mailto:mahmudah@hotmail.com)

**Danang Parikesit**

Professor

Dept. of Civil and Environmental Engineering

Faculty of Engineering

Universitas GadjahMada

Jl. Grafika No. 2 Yogyakarta 55281

Tel: (0274) 901075; Fax: (0274) 901075

E-mail: [dparikesit@ugm.ac.id](mailto:dparikesit@ugm.ac.id)

## Abstract

Several intermodal transportation models have been analyzed to convince the integration of spatial and transportation modeling by using the existing transportation infrastructures (such as road and river networks, ports, etc.). The modeling analysis of CPO transportation in Central Kalimantan Province using geographical information system (GIS) showed that intermodal transportation, especially combination of road-river networks, is the best alternative obtained from the models. In order to have a more robust model and to predict the likely effect of new transport infrastructures to the cost efficiency (in term of generalized cost), hence, it is required to analyze a future scenario. To do so, a case study of spatial and transportation modeling by integrating inter-modality concept between the existing transportation networks and planned railways in Central Kalimantan is also conducted by using ArcGIS. By considering all networks (road, river, railways, and intermodal networks), the reasonable minimum generalized cost (GC) to be applied in the field is a combination of road-rail-river networks.

**Keywords:** CPO, generalized costs, GIS, intermodal transportation, railways

## INTRODUCTION

Freight transportation has important role in regional and economic development, specifically to ensure the efficient movement and availability of materials/goods. To enhance the efficiency and quality of freight transportation, it is necessary to improve the overall cost effectiveness and function of transport operations and infrastructures. Nowadays, it is more and more realized that inter-modality may provide a key towards a better performing transport system (Kreutzberger *et al*, 2006) because of environmental concerns, reasons of efficiency and benefits of co-ordination of modes to cope with growing transportation flows (OECD, 1997 in Bontekoning, 2000; 2004).

Several studies concerning intermodal freight transportation have been conducted to analyze the integration of spatial and transportation modeling using the existing transportation infrastructures (i.e. road and river networks, general and special ports, etc.) to modeling CPO transportation in Central Kalimantan Province. The case studies of CPO transportation modeling in Central Kalimantan Province in the period of 2010 up to 2012 showed that generally intermodal transportation, especially combination of road-river networks is the best alternative obtained from the models and it is recommended to be applied in the real world (Mahmudah *et al*, 2010; 2011, 2012). In order to have a more robust model and to predict the likely effect of new transport infrastructures to the cost efficiency (in term of generalized cost), hence, it is required to analyze a future scenario.

To do so, a case study of spatial and transportation modeling by integrating inter-modality concept between the existing transportation infrastructures and planned (future) railways in Central Kalimantan is carried out (Mahmudah, 2014).

## METHODS

In this study, the model development is considered a planned railways network in Central Kalimantan. The data used in model development in the period of 2010 to 2013 are as presented in Table 1. Transportation infrastructures and CPO factories (formatted in geo-database) considered in spatial and transportation modelling are as shown in Table 2.

**Table 1** GIS (geo-database) utilized in model development

No.	Data	Format	Year
1	Palm plantation and attributes	Geo-database	2010, 2011, 2012
2	Road networks and attributes	Geo-database	2010, 2011, 2012
3	River networks and attributes	Geo-database	2010, 2011, 2012
4	River centerline	Geo-database	2010, 2011, 2012
5	General ports map	Geo-database	2010, 2011, 2012
6	Special ports map	Geo-database	2011, 2012
7	District map	Geo-database	2010, 2011, 2012
8	Sub district map	Geo-database	2010, 2011, 2012
9	Village map	Geo-database	2010, 2011, 2012
10	Land use map and attributes	Geo-database	2010, 2011, 2012
11	Railway and attributes (1A, 1B, 2, 3, 4A, 4B)	Geo-database	2012

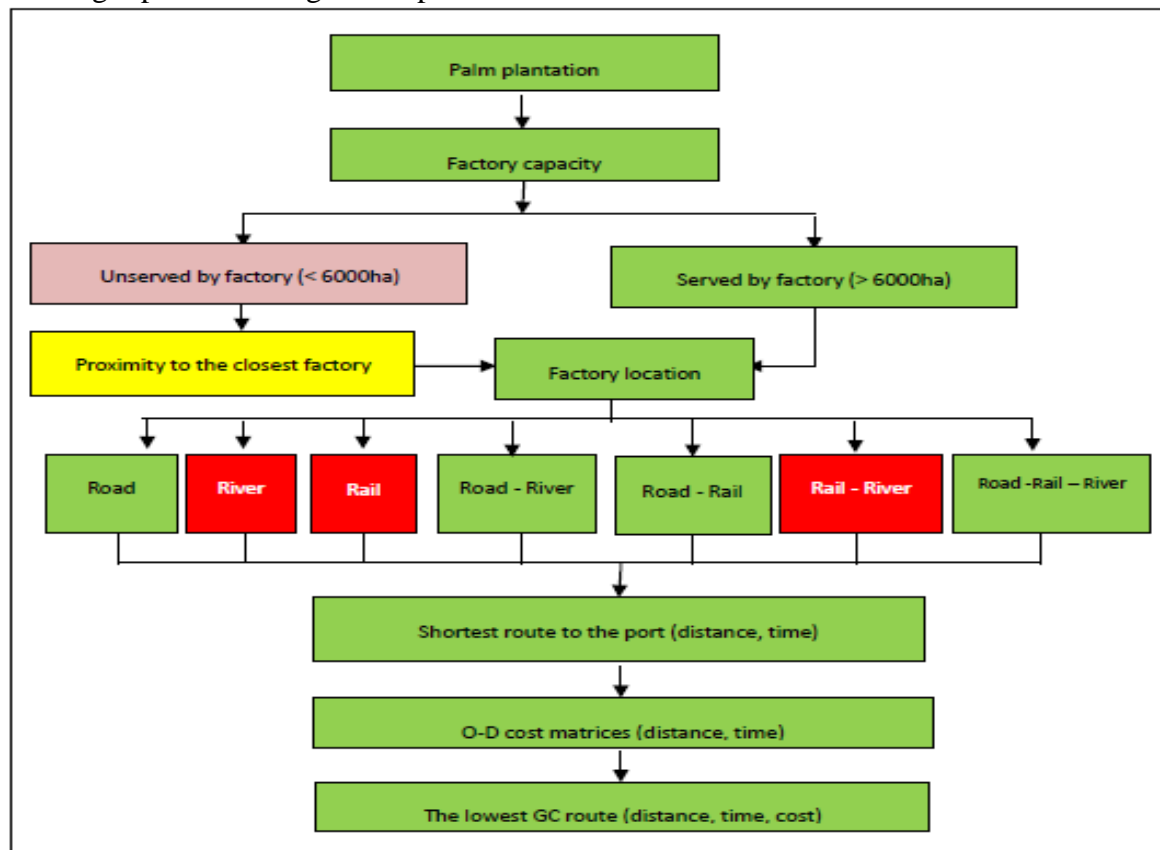
**Table 2** The infrastructures and CPO factories considered in the model

Transportation networks	Number of general port	Number of special port	Number of CPO factories
Road	2	11	281
River	2	11	281
Railways	2	11	281
Intermodal road-river	2	11	281
Intermodal road-rail (1A)	2	0	85
Intermodal rail-river (1A)	2	0	85
Intermodal road-rail river (1A)	2	0	85

The conceptual framework for model development by using network analysis of ArcGIS 10.1 is as illustrated in Figure 1. There are several stages considered in modeling intermodal transportation using ArcGIS 10.1 as follows:

- 1) Number of and location of CPO factories. The number of CPO factory is defined by assuming that one factory should have at least 6000 hectares of plantation (so called served by factory). In case the area of plantation is less than 6000, the owner (company) of this plantation cannot build his own CPO factory (namely un-served by factory) and this plantation is served by the closest factory. Each factory is assumed to be located in the center of plantation area, so every central point (centroid) of factories

can be located using ArcGIS software. These CPO factories are supposed to be the origin points of freight transportation simulated in the models.



**Figure 1** The conceptual framework for model development using ArcGIS  
(Source: Mahmudah, 2014)

- 2) Access of CPO factories. By using the closest facility of ArcGIS software, access of CPO factories to transportation networks (in term of distance) can be determined. Furthermore, these accesses are then classified as good (distance of 0 to 10 km), moderate (10 to 20 km), and bad (20-30 km);
- 3) The shortest route of CPO factories to the final destination (general ports). Utilizing network analysis of ArcGIS, the shortest path of each CPO factory (origin) to the port (destination)-in term of travel distance and time, using different transportation networks can be determined. Spatial mapping of shortest route for CPO factories to ports can also be plotted using ArcGIS. Due to river networks as well as railways and intermodal rail-river networks (as indicated in the red boxes of Figure 1), cannot be applied in the real world due to these transport networks need the road networks to deliver CPO to river or railways, so they do not take into consideration for the final decision of mode choice based on generalized cost (GC);
- 4) Origin-Destination matrices (so called O-D cost matrices). O-D cost matrices are the best O-D pair of each CPO factory to certain port by considering distance and time and are visualized as O-D line. The O-D cost matrices cannot present the route/path used for transporting commodity from origin to final destination. Nevertheless, the final result of O-D cost matrices and shortest route analysis are the same.

- 5) Generalized cost (GC) is considered as the indicator of transportation performance. To determine GC, travel distance and time, which are obtained from shortest route analysis using ArcGIS, are then further calculated by employing equation 1 for various transportation networks. The GC of the same O-D pair with different transportation networks is compared. The lowest GC is chosen as the optimum one.

$$GC_{ij} = (TC_{ijm,r} + TT_{ijm,r} * V_oT) * W_{ijm,r} \quad (1)$$

Where

$GC_{ij}$  : generalized cost (Rp)

$TC_{ijm,r}$ : fare from  $i$  to  $j$  on link  $r$  for mode type  $m$  (Rp/T) incl. transfer cost

$V_oT$  : value of time (Rp/T/hour)

$TT_{ijm,r}$  : total travel time spent from  $i$  to  $j$  on link  $r$  for mode type  $m$  (hour)

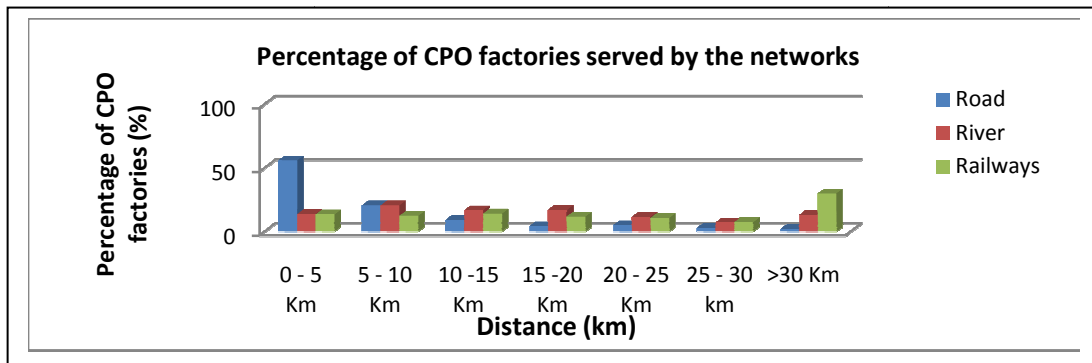
$W_{ijm,r}$  : weight of commodity transported from  $i$  to  $j$  on link  $r$  for mode type  $m$  (T)

Value of time (VoT) is weighted by considering the type of commodity. In this study, the FEMEX (*Fidelity Advisor Emerging Europe Middle East Fund*) standard, is used to determine the value of time. According to FEMEX (2003), the value of time for *bulk* commodity is 0,63 euro/ton/hour or equal to Rp 7.700/ton/hour (Mahmudah *et al*, 2012).

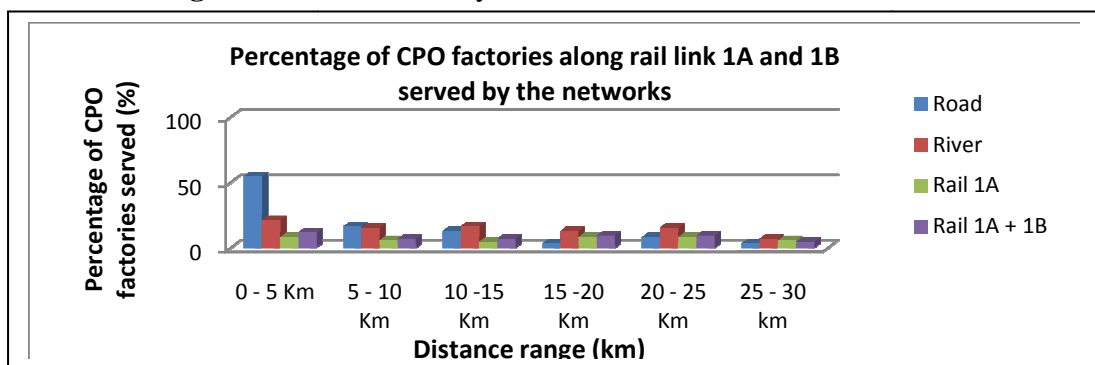
## RESULTS AND DISCUSSIONS

- 1) Model development. In model development, there are some analysis conducted among other: closest facilities to analyze the access, shortest route analysis to calculate the shortest distance and time of each factory to certain port, O-D cost matrices to determine the best O-D pair (CPO factory-port) using specific transport networks, and to calculate generalized costs based on travel distance and time obtained from shortest route analysis. More specifically, there are two types of generalized cost analyzed. Firstly, generalized cost by considering all CPO factories by employing 2 general ports (Bagendang and Bumiharjo) with 3 transportation networks (road, river, and inter-modal road-river networks). This model fits with the real condition in Central Kalimantan Province. Secondly, generalized cost by considering CPO factories located along railways link 1A and 1B. The second model attempts to predict future transportation system by including the planned railways as a transportation network beside road and river. The new general ports located in Bangkuang and Lupak Dalam are also considered in the second developed model instead of Bagendang and Bumiharjo ports. The analysis results of spatial and transportation modeling using ArcGIS 10.1 are as illustrated in Appendix 1 and 2 respectively.
- 2) Accessibility of CPO factories. By utilizing ArcGIS software, it is known that there are 281 CPO factories located in Central Kalimantan Province that have access to road, river, and railways. However, only a few of those factories (around 85 CPO factories) are located along the railways link 1A and 1B and have access to road, river, and railways as well. The accessibility of CPO factories to all networks considered in the model (road, river, and railways) is classified by considering the distance range. Most of the factories have good access to road networks, that is in less than 5 km distance range, followed by river networks and, last one, by railways. However, when the distance range is increased (5 to 30 km), river network is better than road and railways. Only considering factories located along railways link 1A and 1B (around 85), most of them have good access (less than 10 km) to road networks. Meanwhile,

river network still has a chance to compete to other networks when the distance range is between 10 and 30 km (see Figure 2 and 3).



**Figure 2** The accessibility of all CPO factories to the networks



**Figure 3** Accessibility of CPO factories along railways link 1A and 1B

- 3) Generalized cost (GC) by considering all CPO factories. The shortest route analysis using ArcGIS can produce the shortest distance and time needed for transporting CPO from factory (origin) to the selected port (destination). Employing equation 1, the generalized cost (GC) of each O-D matrices, which is for transporting CPO from factory to port using road, river, and intermodal road-river networks can be predicted. When the three GC of different networks are compared, the cheapest GC is obtained from using uni-modal river networks, followed by intermodal road-river networks, and uni-modal road networks as the most expensive one. However, the river network is still facing the longest travel time due to long haul distance.
- 4) Generalized cost (GC) by considering CPO factories along rail link 1A and 1B. The GC for transporting CPO from factory to port using road, river, railways, intermodal road-river, intermodal road-rail, intermodal rail-river, and intermodal road-rail-river are then also predicted (see Appendix 3). If all GC of various networks are compared, the cheapest GC is again obtained by using uni-modal river networks and then followed by intermodal road-rail-river network. However, uni-modal river networks as well as railways and intermodal rail-river networks cannot be applied in the real world due to these transport networks need the road networks to deliver CPO to river or railways. Therefore intermodal road-rail-river is the best option to have optimum generalized cost.

The comparison of all generalized costs using different transportation networks is as illustrated in Figure 4 below. Overall, intermodal network of road-rail-river is offering the good option with the lowest generalized cost. Transportation cost considered in calculation of generalized costs has included the costs of labour and the operation and maintenance of vehicles and containers, as well as the costs of roadways, storage facilities, and terminals required to support the transfer (handling) of goods. To apply the intermodal networks like road-rail-river, the big challenge to be considered are the provision of proper and adequate intermodal transfer (i.e. CPO storage in port and rail station) and the transfer (handling) cost, including transfer penalty, that should be calculated in more detail.

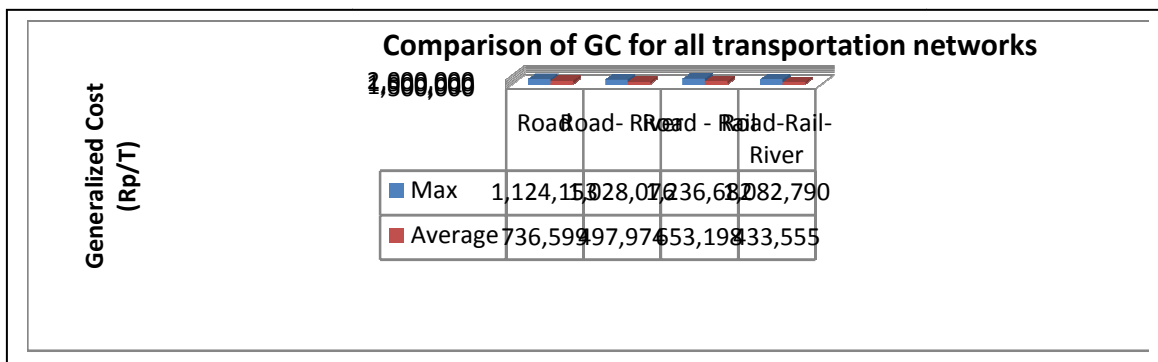


Figure 4 Comparison of generalized cost for all transportation networks

## CONCLUSIONS

In order to have a more robust model and to predict the likely effect of new transport infrastructures to mode transportation choice (in term of generalized cost), it is required to analyse a future scenario. To do so, a case study of modeling spatial and transportation by integrating inter-modality concept between the existing networks (road and river) and planned (future) railways in Central Kalimantan is carried-out. The developed model is considered the planned railways and includes an analysis of access of CPO factories to road, river, and railways (link 1A, 1B, 2, 3, 4A, and 4B) and shortest route of road, river, and railways for link 1A and 1B using generalized cost (GC) as an efficiency indicator.

The data obtained from spatial and transportation modeling using network analysis of ArcGIS 10.1 are: a) number of and location of CPO factories; b) location of transfer point; c) access of CPO factories; d) shortest route of CPO factories to the final destination (general ports); e) Origin-Destination matrices (so called O-D cost matrices); and f) Generalized cost (GC) that is considered as the indicator of transportation performance.

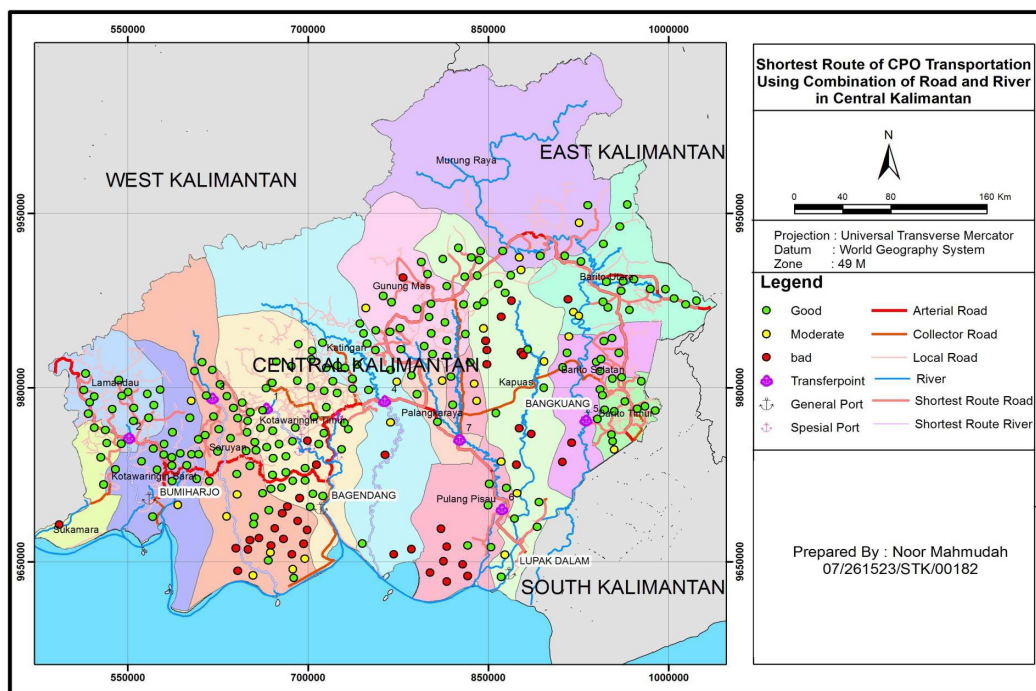
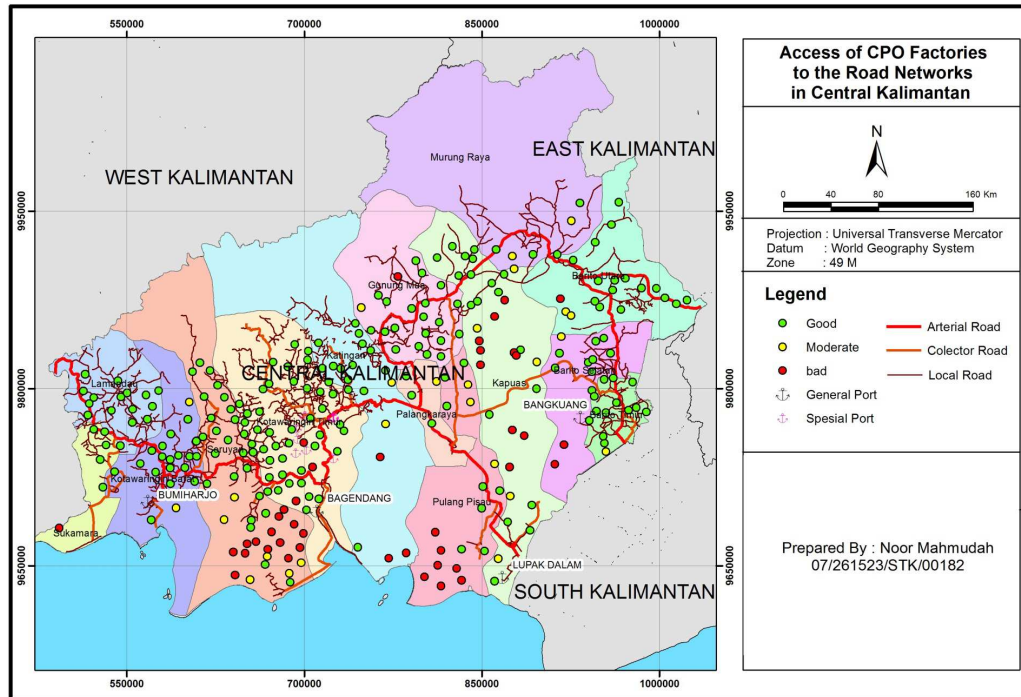
By considering all networks (road, river, railways, and intermodal networks), the reasonable minimum generalized cost (GC) to be applied in the field is a combination of road-rail-river networks. To apply the intermodal networks like road-rail-river, the big challenge to be considered are the provision of proper and adequate intermodal transfer (i.e. CPO storage in port and rail station) and the transfer (handling) cost, including transfer penalty, that should be calculated in more detail.

## ACKNOWLEDGEMENTS

My sincere appreciation is addressed to Prof. Dr. Ir. Siti Malkhamah, M.Sc., and Prof. Ir. Sigit Priyanto, M.Sc., Ph.D. from Universitas Gadjah Mada and Dr. Ir. M.H.P. (Mark) Zuidgeest from University of Twente, for their guidance, support, encouragement, and constructive criticism during conducting the research.

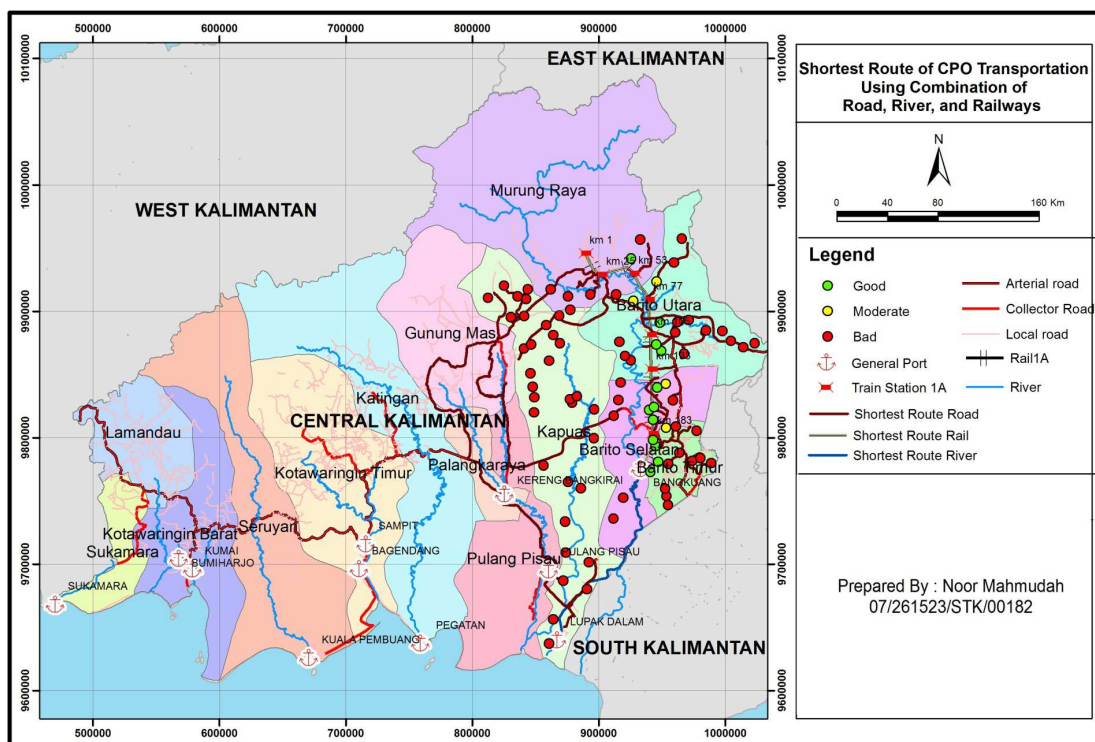
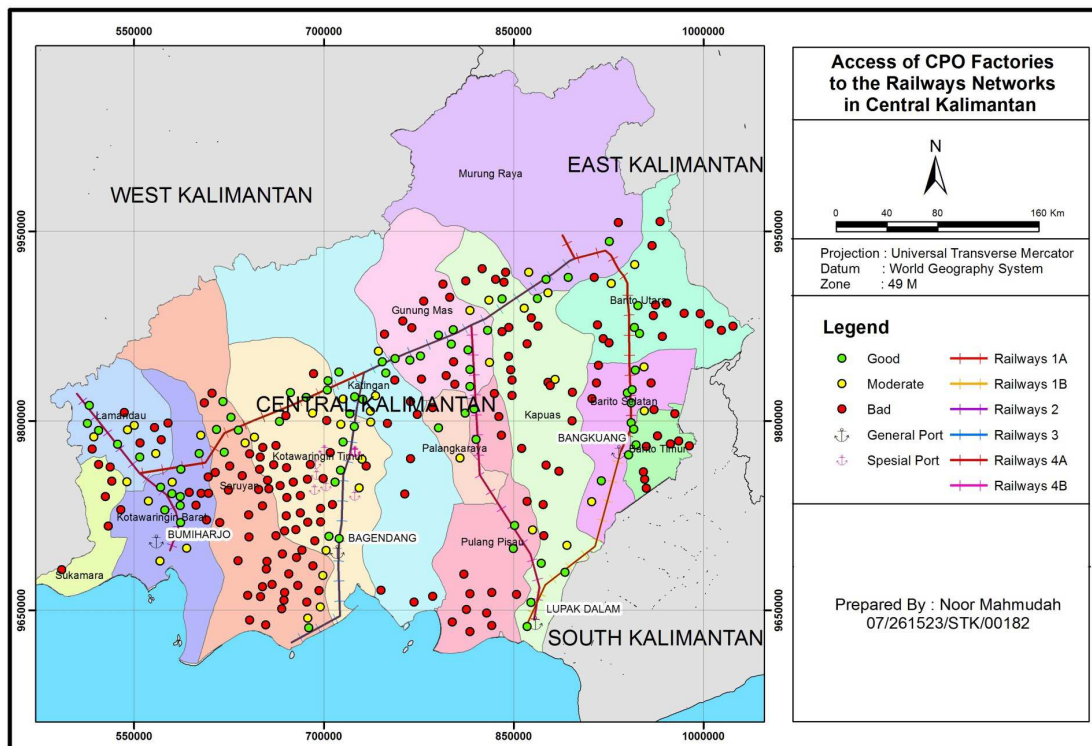
## REFERENCES

- Bontekoning, Y, M, Macharis, C, and Trip, J, J, 2004, Is a new applied transportation research field emerging?—A review of intermodal rail-truck freight transport literature, *Transportation Research Part A* 38 (2004), pages 1–34
- Bontekoning, Y, M, 2000, *A jump forward in intermodal freight transport: are hub-terminals an alternative for shunting?* TRAIL Research School, Delft
- Kreutzberger, E, Macharis, C, and Woxenius, J, 2006a, Intermodal versus unimodal road freight transport, in *Towards Better Performing Transport Networks*, Routledge, Oxon, pages 17 – 42
- Mahmudah, N., 2014, *The Development of Methodology for Regional Transportation Planning: Freight Transportation Model in Central Kalimantan, Indonesia*, Dissertation, Graduate Program of Civil Engineering Faculty of Engineering Universitas Gadjah Mada, Yogyakarta (unpublished)
- Mahmudah, N., Parikesit, D., Malkhamah S., Priyanto, S, 2012, Study of Regional Transportation for CPO in Central Kalimantan, *Proceedings of the 15th International Symposium FSTPT*, 23 - 24 November 2012, Bekasi
- Mahmudah, N., Parikesit, D., Malkhamah S., Priyanto, S, 2011, Pengembangan Metodologi Transportasi Barang Regional, *Jurnal Transportasi Vol. 11 No. 3, December 2011*, pages 173-182
- Mahmudah, N., Parikesit, D., Malkhamah S., Priyanto, S, 2011, Pengembangan Metodologi Transportasi Barang Regional, *Proceedings of the 14th International Symposium FSTPT*, 11 – 12 November 2011, Pekanbaru
- Mahmudah, N., Parikesit, D., Malkhamah S., Priyanto, S., Zuidgeest, M, 2011, Modeling Freight Transportation for Crude Palm Oil in Central Kalimantan, *Proceeding of the 3<sup>rd</sup> International Conferences of European Asian Civil Engineering Forum (EACEF) 2011*, 20-22 September 2011, Universitas Atma Jaya, Yogyakarta, pages 49-54
- Mahmudah, N, 2011, *Pemodelan Transportasi Barang Regional untuk Crude Palm Oil (CPO) di Kalimantan Tengah, Indonesia*, Final Report of Dissertation Grant FY 2011, Institute for Research and Community Service (LPPM) Universitas Gadjah Mada, Yogyakarta (unpublished)
- Mahmudah, N., Parikesit, D., Malkhamah S., Priyanto, S, 2010, Regional Freight Transportation Model for Crude Palm Oil (CPO) in Central Kalimantan, *Jurnal Transportasi Vol 10 No. 3, December 2010*, pages 213-224
- Mahmudah, N., Parikesit, D., Malkhamah S., Priyanto, S., Zuidgeest, M, 2010, Regional Freight Transportation Planning: An Overview of Developing Methodology, *Proceeding of Malaysian Universities Transportation Research Forum and Conferences 2010 (MUTRFC2010)*, 21 December 2010, Universiti Tenaga Nasional, Putrajaya, Malaysia, pages 99-116

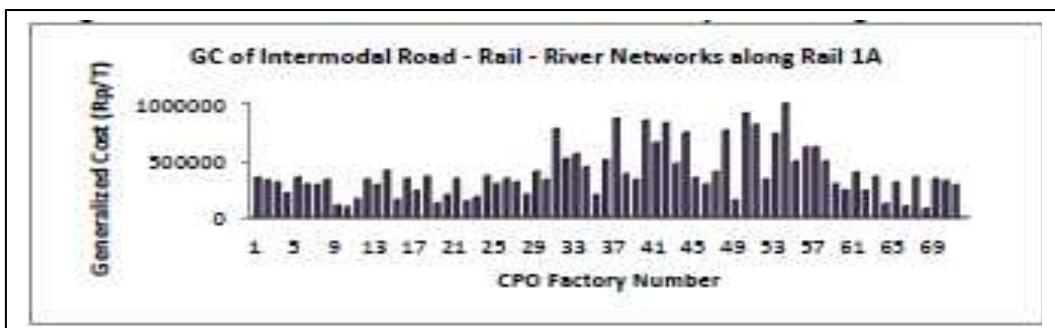
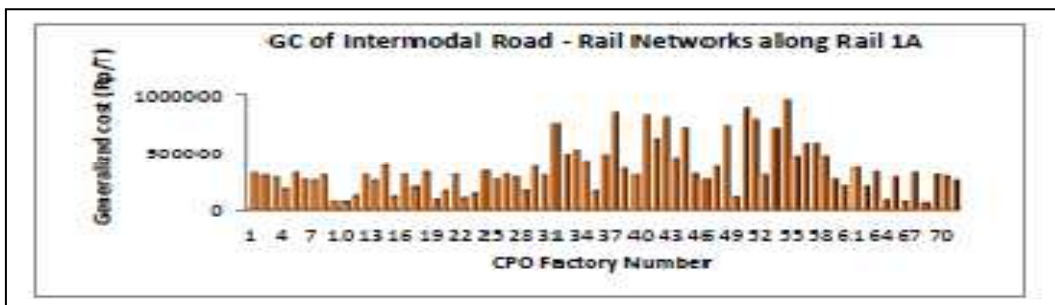
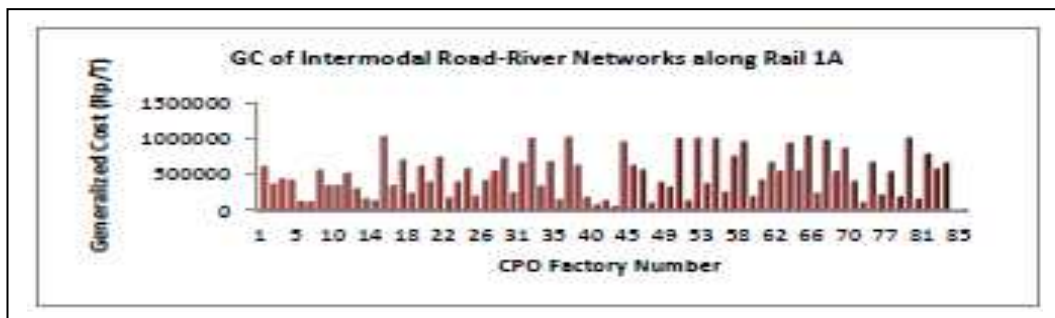
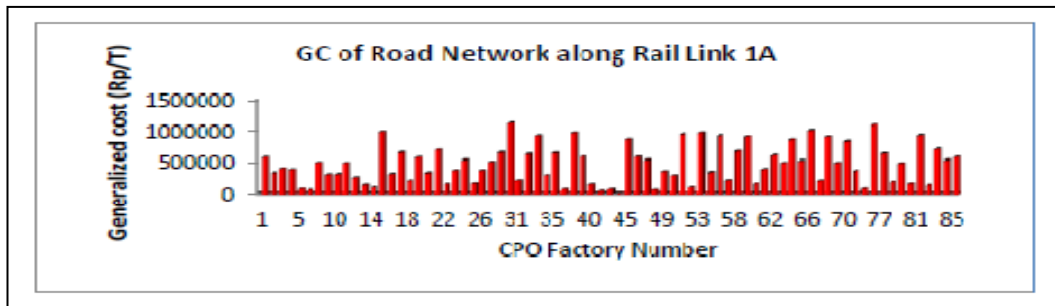


**Appendix 1** The results of spatial and transportation modeling using ArcGIS  
(Source: Mahmudah, 2014)





Appendix 2 The results of spatial and transportation modeling using ArcGIS  
(Source: Mahmudah, 2014)



**Appendix 3** Generalized cost(GC) of unimodal and intermodal transportation networks by considering 85 factories(Source: Mahmudah, 2014)