PROSIDING SEMINAR NASIONAL & KONGRES MAKSI

2012

Akselerasi Inovasi Industri Kelapa Sawit

untuk Meningkatkan Daya Saing Global

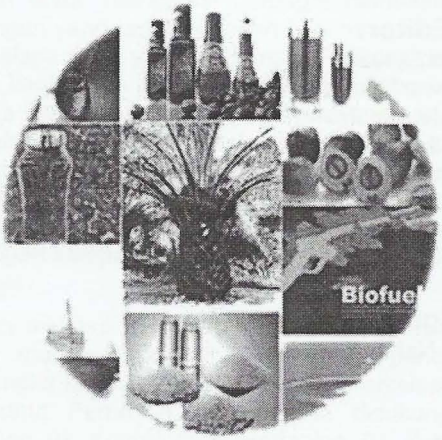
Editor:
Ani Suryani
Khaswar Syamsu
Dede Saputra
Kartika Sari Suparman
Iman Sulaeman
Yuli Sukmawati

ISBN
978-979-96096-9-4

MAKSI

PROSIDING SEMINAR NASIONAL DAN KONGRES MAKSI 2012

AKSELERASI INOVASI INDUSTRI KELAPA SAWIT UNTUK MENINGKATKAN DAYA SAING GLOBAL



Editor :

Ani Suryani
Khaswar Syamsu
Dede Saputra
Kartika Sari Suparman
Iman Sulaeman
Yuli Sukmawati

DISELENGGARAKAN OLEH :

MAKSI

INSTITUT PERTANIAN BOGOR

DIDUKUNG OLEH :

Bimoli. Kesempurnaan Minyak Goreng

Bakrie Sumatera Plantations

mandiri

Sampoerna Agro

PTPN 5

www.ptpn13.com

RISTEK

Kementerian Negara Badan Usaha Milik Negara

KEMENTERIAN PERINDUSTRIAN

GMSI

Api Lestari

2012

AKSELERASI INOVASI INDUSTRI KELAPA SAWIT UNTUK MENINGKATKAN DAYA SAING GLOBAL

Prosiding Seminar Nasional & Kongres MAKSI
Bogor, 26 Januari 2012

Editor:
Ani Suryani
Khaswar Syamsu
Dede Saputra
Kartika Sari Suparman
Iman Sulaeman
Yuli Sukmawati

Design Cover:
Nurwandi Nanda Cahyana

Diterbitkan oleh:
Masyarakat Perkelapa-Sawitan Indonesia (MAKSI)
Bogor-Indonesia, 2012

Perpustakaan Nasional: Katalog Dalam Terbitan
ISBN 978-979-96096-9-4

DAFTAR ISI

TRANSPORTATION NETWORK ANALYSIS TO SUPPORT PALM OIL BASED INDUSTRY DEVELOPMENT IN SUMATERA ECONOMIC CORRIDOR

Hermawan Prasetya[1], Taufik Djatna and Yandra Arkeman[2]

[1]Center for Assessment of Policies for Competitiveness Enhancement
National Agency for Assessment and Application of Technology, Jakarta, Indonesia
E-mail: hermawanprasetya@yahoo.co.id
[2]Department of Agroindustrial Technology
Bogor Agricultural University, Bogor, Indonesia
E-mail: taufikdjatna@ipb.ac.id and yandra@ipb.ac.id

ABSTRACT

Optimum transportation network would accelerate regional economic growth. The essence of development of economic corridor is how to enhance link among hub to key industry nodes and supporting infrastructure. The aim of this paper is to analyze transportation network to support Sumatera Economic Corridor (SEC) which contained of typology analysis, capacity analysis and optimization analysis of the network. Methods were employed respectively minimum spanning tree, maximum flow and goal programming. Conclusions of the research are (1) typology of network which was identified to support SEC development optimally, (2) the comparison between maximum flow and milling capacity were above 75 %. And (3) by added some goal to previous analysis, provided information that comparison between maximum flow and milling capacity was not difference significantly.

Keyword: Transportation Network, Palm Oil Based Industry and Economic Corridor

INTRODUCTION

Transportation network is an essential thing to support economic development in a region. Well planned transportation network would accelerate regional economic growth, because it addresses to handle continuing economic surge and traffic congestion (Kasikitwiwat and Chen 2005). In this context, transportation network planning was important subject in transportation planning and development (Babazadeh, Poorzahedy et al. 2011).

Transportation network analysis is part of transportation supply model (Cascetta 2009). Related to design problem, there were three group variables which should be considered in transportation supply design, i.e.: network topology, network performance and prices and fares. Also, discussion about transportation network, should be talked about transportation network capacity which it is important in transportation planning or design (Kasikitwiwat and Chen 2005).

Corridor economic development was a development concept in some urban scale which adopted by Government of Indonesia to develop wider areas. There were six economic corridor areas which covered nearly all of region of Republic of Indonesia. The corridor economic was built by hub and nodes in corridor area. It is assumed that there were six guiding principles define successful corridor area, i.e.: (1) Corridor to connect at least two hubs, (2) Corridor to link hubs with rural areas, (3) Corridor to connect hubs over land (or bridge), (4) Corridor to connect to mega hubs where feasible, (5) Avoid lengthy and highly heterogeneous corridors and (6) Corridors to link hubs to key industry nodes and supporting infrastructure (Anonymous 2010). Based on these assumptions, it could be inferred that transportation network analysis and design was an important key to ensure the successfully of economic corridor development.

This paper will present transportation network analysis in corridor economic area. The analysis contained of typology analysis, capacity analysis and optimization analysis of the

network. The results of analysis were expected to give recommendations in masterplan of acceleration and spreading of development of Indonesia Economic 2011 -2025, which determined three main strategies, i.e.: Indonesia economic corridor development, strengthening of national connectivity and acceleration of technology capabilities (Anonymous 2011).

Sumatera economic corridor was chosen as area of work, because it was highest growth of economic corridor among six economic corridors in Indonesia. The corridor is constructed by seven linking hub and five proposed location of specific economic zones. Based on Gross Regional Domestic Product 2008, there were three biggest economic sectors, i.e.: manufacturing, mining, and agricultural. Three commodities will be focused to develop in this corridor, i.e.: palm oil, rubber and coal. In 2006, contribution of Sumatera on area of palm oil plantation in national level was 73 %, and on palm oil production was 80 % (Anonymous 2010).

Several researchers were conducted researches on transportation network analysis and design. A detailed network analysis using Geographic Information Systems was conducted to better understand and increase efficiency in delivery of harvested round wood on West Virginia' roadways (Harouff, Grushecky et al. 2007). The concepts of ultimate capacity and practical capacity are applied to the transportation problem to relax the limitation of the reserve capacity concept, therefore the concepts can yield information regarding the spatial distribution of the demand pattern (Kasikitwiwat and Chen 2005). Network optimization study employed the heuristic of particle swarm optimization (PSO) (Babazadeh, Poorzahedy et al. 2011). The result of study shows that PSO capability can be compared with HACO (Hybrid Ant Colony Optimization).

In this paper, network analysis would use several methods to explain typology of network, capacity of network and optimization. Methods will used to describe them respectively Minimum Spanning Tree (MSPT), Maximum Flow and Goal Programming. Sensitive analysis was conducted to explore variation of network analysis result over years, because it would be exercised to formulate recommendation into the masterplan 2011-2025. Geographic Information System (GIS) and Microsoft Excel softwares were employed to perform these analyses.

METHODOLOGY

Framework

This research was started by reviewing of Masterplan of Sumatera economic corridor development. One of output of this reviewing was identification of district/municipalities which there were predicted as hinterland areas of Sumatera Economic, corridor hub areas or outlet areas. Based on identification of these areas, two Origin Destination (OD) matrixes were formulated as basis to next analyses. Relations among areas were estimated by Minimum Spanning Tree (MST) and Shortest Path analysis. Geographic Information system (GIS) was implemented to conduct these analyses in formulation two OD matrixes, i.e.: matrix of distance and matrix of flow.

The next step was analysis network capacity and network optimization. These analyses used two matrixes which produced in previous step. Maximum flow and goal programming were implemented to analyze capacity and optimum of network respectively. Some iterations of analysis were done, due to dynamic change of flow of good in time horizon of masterplan. Sensitivity analysis was implemented to explore change of capacity and optimum network over years.

Formulation of recommendation was final step of this research. The recommendation would comprise of some network aspect, such as optimum network should be developed, addition of industrial capacity in certain year and development of port scenario. The framework of this research was presented in Figure 1.

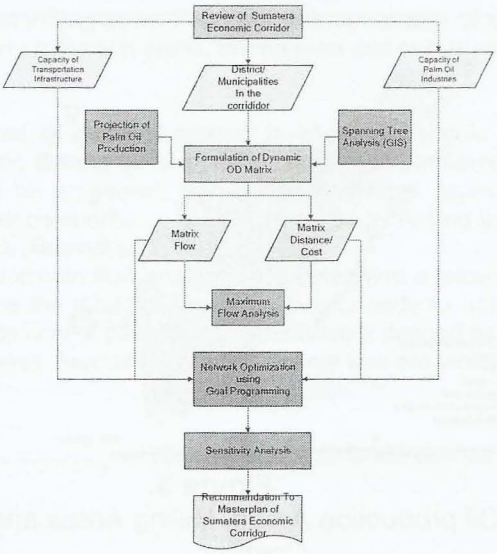


Figure 1.
Framework of Research

Minimum Spanning Tree

Minimum spanning tree was chosen to analyze network, because all districts in Sumatera corridor should be connected with certain milling area or refinery area. Palm oil production in all districts should be processed less than 8 hours for harvest time, to avoid their quality decreasing. Minimum spanning tree identified spanning tree with the minimum of length less than or equal to the length of every other spanning tree (Ravindran 2009). The objective of minimum spanning tree is to select a minimum total cost set of links. In masterplan context, minimum total cost represented minimum investation in transportation sector which should be allocated by government or private companies.

In this research, transportation networks were designed to connect among production areas, milling areas and port areas. 36 districts/municipalities were selected to represent three types of areas (27 districts represented palm oil production areas, 5 districts milling areas, and 4 district port area). Network ink between palm oil production areas, milling area and port area was represented palm oil value chain. The value chain and distribution of these districts in Sumatera corridor was offered in Figure 2 and Figure 3.

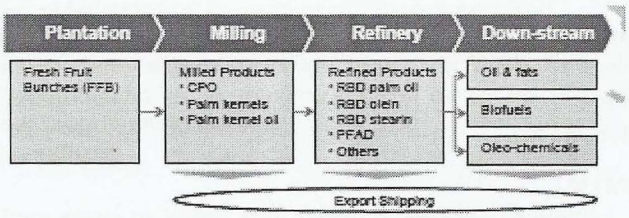


Figure 2.
Palm Oil Value Chain

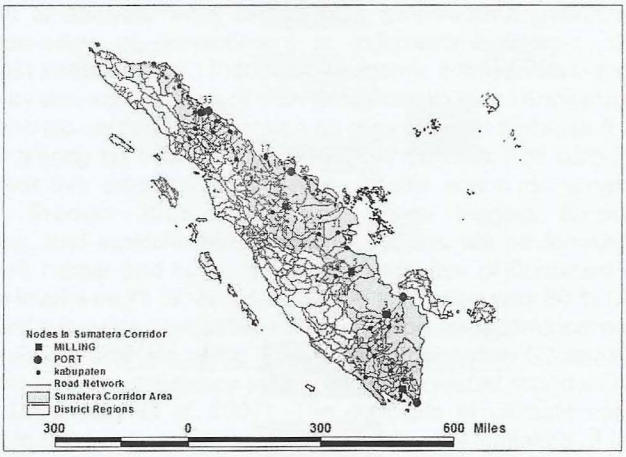


Figure 3.
Distribution of Palm Oil production Areas, Milling Areas and Ports in Sumatera Corridor

Figure 2. Show 4 steps of palm oil processing. Initial step is palm oil harvesting in plantation areas, then it is milled to produce CPO and kernel oil in certain milling areas. Transport time from harvesting to milling process should be less than 8 hours, if time more than the one, quality of CPO/kernel oil would decrease and significantly. After that, CPO/kernel oil would be exported or processed to produce various products. In the study, supply chain of oil would be focused on harvesting to CPO production only.

Figure 3, show distribution of nodes and current road network of SEC which would be utilized as basic data of network analysis. Industrial capacity per year was utilized in the analysis without conversion, and port capacity and port handling capability should be converted into capacity per day (assumed time operation of port is 20 hour per day), before they were employed in network analysis.

Formula of minimum spanning tree was presented below:

$$Minimum \sum_{(i,j)\in A} c_{ij}x_{ij}$$

Subject to $\sum_{(i,j)\in A} X_{ij} = |N| - 1$

$$\sum_{(i,j)\in A(S)} X_{ij} = |S| - 1 \qquad S \subseteq N$$

$$X_{ij} \in \{0,1\} \qquad (i,j) \in A$$

Where:

c_{ij} = transport cost from i to j

x_{ij} = arc or segment i to j

N = total number of Nodes

S = set of Nodes which they induced selected arc

Based on minimum spanning tree analysis, transportation networks in Sumatera corridor would be split into 4 networks. Splitting networks were done to distribute flow of palm oil product to 4 ports in Sumatera corridor. It was assumed, each districts would conveyed their product to

be processed into nearest milling area. Each network comprised of some path network which connected among palm oil production areas, milling area and port area.

Maximum Flow

It was expected that all palm oil product in all district should be transported to milling areas, to be processed and then to be shipped in certain port. In solving this expected, network capacity analysis should be employed. Knowledge of overall capacity of the network might provide an advantage over competitor. It can be achieved by finding the maximum flow that can be shipped on the network (Ravindran 2009).

The objective of maximum flow analysis is to determine a feasible pattern of flow through the network that maximize the total flow from the supply node to destination node (Ravindran 2009). In this research, districts of palm oil production were defined as supply nodes and milling districts as destination nodes. Formula of Maximum flow was presented below.

Maximize $\sum_{i=1}^{n} a_i p_i$

Subject to $\sum_{i=1}^{n} m_i$

Where:

a_i = harvest area of palm oil in area i at selected year

p_i = productivity of palm oil in area i at selected year

m_i = milling industry capacity which area i transported product to

There were some assumptions which would be used to predict palm oil production (Manurung 2001). These assumptions were:

- Palm oil plant productivity was 20-29 ton/hectare,
- Palm oil plat started to produce at year 4th,
- Maximum production of palm oil at Year 10th until Year 18th,
- Declaining production start Year 19th and at Year 25th palm oil become not productive more,
- Maximum level of extraction is 24% and minimum level of extraction is 5 %

Goal Programming

The last network analysis in this research was optimization network analysis, which would use goal programming method. Goal programming is a variation of linear programming considering more than one objective (goals) in the objective function. The method falls under the class of methods that use completely prespecified preference of the decision maker in solving the Multi Criteria Mathematical Programming (Ravindran 2009).

In formulation of goal programming equations for this research, it is need to be identified initial linear programming and some objectives (goals) in order of their importance. The objective of initial programming is to maximize palm oil to be processed and shipped. Limitations of the linear programming were:

a. Capacity of milling industry
b. Port capacity
c. Transport Time from estate to milling area should be less than 8 hours,

Some goals should be added to this model in order of their importance were described below:

1. Transport time in longest path in each transport network should be less than 8 hours,
2. Total flow of palm oil from estate to milling area should be less than milling capacity,

3. Total shipped of CPO from milling area should be less than port capacity,
4. Average shipped CPO per day should be less than port handling capability.

Based on initial linear programming and some goals which should be achieved, goal programming formula was described below.

Minimize $P_1 d_1^-, P_2 d_2^-, P_3 d_3^-, P_4 d_4^-$

Subject to
$$\sum_{i=1}^{n} \frac{x_{ij}}{v} + d_1^- - d_1^+ = 8$$
$$\sum_{i=1}^{n} a_i . p_i + d_2^- - d_2^+ = I$$
$$\sum_{i=1}^{n} (a_i . p_i) r + d_3^- - d_3^+ = Pc$$
$$\sum_{i=1}^{n} \frac{a_i . p_i}{365} + d_4^- + d_4^+ = Ph$$
$$a_i, p_i, v, d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+, d_4^-, d_4^+ \geq 0$$

Where:

P = priorities of goal,
d = deviation of certain goal variable,
x_{ij} = segment of network i to j,
v = average of velocity over the segment of road (it is assumed 40 km per hour),
a_i = harvest area of palm oil in area i,
p_i = productivity of palm oil in area i,
r = rendement (0.24)
I = certain milling industry capacity,
Pc = certain port capacity,
Ph = certain port handling capability.

RESULT AND DISCUSSION

Short Description on Sumatera Economic Corridor

Vision of Sumatera Economic Corridor (SEC) development is to accomplish this area as center of agricultural production, agricultural processing area and national energy resources area. Target of the corridor development is to multiply Gross Regional Domestic Product (GDRP) 3.4 times in 2030 with annually economic growth 6.3 %. There are three commodities should be focus as economic prime movers in this area, palm oil, rubber and coal (Anonymous 2011).

In development SEC supporting, it was identified some key infrastructures such as port, railway or road network, power generation and milling/refinery industry capacity. Four ports in SEC area were determined as outlet for all products in this area. Also, it was set up tracing of Trans-Sumatera road network and railway network which planned to serve CPO transportation in Riau Province. To support energy demand for SEC development, it was planned to utilize coal through mine-mouth and processing plant development in South Sumatera Province. It is assumed that milling industries were located in hub areas (capital city of each province).

therefore palm oil production would be transported to milling areas (capital cities of each provinces). In this research, data on capacity of ports and milling industries are important to conduct some network analysis; data on capacity were presented in Table 1.

From Table 1 present data on milling and port capacity in SEC which would be utilized as limitation both in maximum flow and goal programming analysis.

Table 1.
Capacity of Milling Industries and Port in Sumatera Economic Corridor

No.	Province	Milling Industry Capacity		Port Capacity	
		I (TBS/Hour)	CPO (ton/year)	Pc (ton/hour)	Ph (ton/hour)
1.	North Sumatera /Belawan Port	3,030	3,222,046	11.000	55
2.	Riau Dumai Port	5,645	3,366,378	5.000	53
3.	Jambi	1.0503	859,035	-	-
4.	South Sumatera/ Tanjung AA *)	2,410	1,084,019	5,000	53
5.	Lampung/ Panjang Port	125	210,941	92,850	97.5

*) Capacity of Tanjung Ai-Api was assumed same to Dumai Port
Sources: processed from various sources

Minimum Spanning Tree

GIS software was implemented to identify shortest path among districts in SEC area. The software has capability to calculate length of roads which they connected among district. By using this software, identification of shortest path among district could be conducted in short time. In this research, shortest road distance represented minimum transport cost, because it was assumed, transport cost per length of road is uniform in all areas. Result of minimum spanning tree was presented in Figure 4.

Figure 4 show result of minimum spanning tree analysis which was supported by using GIS software. The analysis identified current shortest road networks which connected all of the nodes. Furthermore, in fashioning network analysis more simple, the network was split into four sub networks, which break based on shortest path to milling areas. The sub networks are Medan sub network, Riau sub network, Palembang sub network and Lampung sub network. In next analysis, the sub network would be smallest unit of analysis. Some assumptions on sub networks in SEC were presented in Table 2.

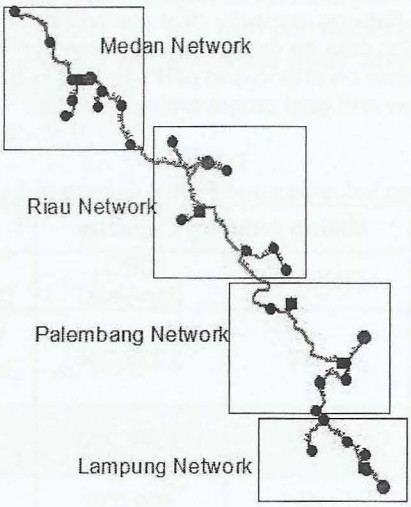


Figure 4.
Minimum Spanning Tree of SEC using GIS Software

Table 2.
Some Assumptions on Sub Network in SEC

Sub Network	Nodes	Milling Area	Port	Longest Path	Travel Time Above 8
Medan	9	Medan	Belawan	240	0
Riau	7	Riau	Dumai	370	1
Palembang	6	Palembang	Tanjung Api	230	0
Lampung	5	Lampung	Panjang	280	0

Source: analysis result

Maximum Flow Analysis

Maximum flow analysis was directed to calculate optimum capacity of the sub networks. Several data were collected to support the analysis, i.e.: harvest area of palm oil, palm oil productivity, and length of path. Several variables were computed using previous data, such as amount of flow of palm oil, transport time (assumed average of velocity is 40 Km per hour), and longest transportation time from node to milling area. Because flow of palm oil was calculate by production between harvest area and productivity, therefore harvest area was assumed as unfixed variable and the others were fixed.

The goal of the analysis is to determine maximum harvest area in each node (districts/municipalities) which would affect to maximum flow of palm oil. Two constraints were defined, i.e.: total flow of palm oil should less than milling industry capacity and longest transport time should less than 8 hours. The calculations were employed solver in Microsoft Excel. Results of calculations in each sub network were presented below.

Table. 3
Calculation of Maximum Flow in SEC

Sub Network	Maximum Flow	Milling capacity	%
Medan	3,116,558.7	3,222,046	97%
Riau	3,144,001.17	3,366,378	93%
Palembang	925,648.20	1,084,109	85%
Lampung	157,418.89	210,491.00	75%

Sources: analysis result

Tables 3 show a result of maximum flow analysis. From this table, the ratios between maximum flow and milling capacity were above to 75 %. The ratio in Medan and Riau sub network were above oh 90 %, therefore it was said combination of harvest area in two sub network were nearly optimum, if compared to milling capacity. In response to estate area growth, milling capacity should be increased in short time.

Goal Programming Analysis

Objective of the analysis was to calculate minimum deviation of several determining goals. Four goals were determined and added to this analysis. These goals related to transport time, flow of palm oil compared with milling capacity, port capacity and port handling capability. The result of analysis was presented in Table 4.

Table 4.
Goal Programming for Each Sub Network in SEC

Goals	Deviation		Goal	Constraint	%
	d+	d-		Total	
Medan Sub Network					
Flow of Palm Oil	-	0.000001	3,222,046	3,089,941	95.9%
Transport Time	0.000825	-	8	7.4	91.9%
Port Capacity	0.003543	0.023289	96,360,000	754,755.3	0.8%
Port Handling	0.000000	0.000239	1,100	2,067.8	188.0%
Riau Sub Network					
Flow of Palm Oil	0.000000	0.025000	3366378	3143578.96	93.4%
Transport Time	0.000000	0.001967	8	9.2	114.4%
Port Capacity	-	-	43,800,000	755,851.93	1.7%
Port Handling	0.000000	0.002792	1,060	2,070.83	195.4%
Palembang Sub Network					
Flow of Palm Oil	0.022437	0.053373	1,084,109	928,904	85.7%
Transport Time	0.038452	0.036639	8	5.9	73.1%
Port Capacity	0.053830	0.056716	43,800,000	210,451	0.5%
Port Handling	0.045140	0.056298	1,060	577	54.4%
Lampung Sub Network					
Flow of Palm Oil	0.050898	0.045509	210,491.0	152,791.3	72.6%
Transport Time	0.024145	0.006321	8	7.0	87.2%
Port Capacity	-	0.025295	813366000	32,910.92	0.0%
Port Handling	-	-	1950	90.17	4.6%

Sources: analysis result

Table 4 shows calculation result in four sub networks. Some ratio between constraint and goal were above 100 %. Transport time in Riau sub network was 114.4 %, it was mean that in certain path, transport time more than 8 hours, and therefore it was possible decreasing in palm oil quality. Also some ports have handling capability under average CPO production per day, therefore it was predicted CPO accumulation in port at certain day.

If it was compared between Table 3 and 4, there was no difference on ratio milling capacity and maximum flow significantly, therefore said that adding some goals in the calculation in SEC did not affect in the ratio.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on previous network analysis, it could be inferred some conclusions. The conclusions are:

1. Minimum spanning tree analysis using GIS software could be identified an typology of network which expected to support SEC development optimally,
2. Maximum flow analysis show comparison between maximum flow and milling capacity were above 75 %.
3. By added some goal previous analysis, called goal programming, provided information that comparison between maximum flow and milling capacity was not difference significantly.

Recommendation

1. Certain network path which produced by minimum spanning tree, recommended to support SEC development as guidance to develop road network.
2. Milling industry should be reallocated in optimum location to reduce transport time in Riau sub net work.
3. Increasing of port handling capability in Medan and Riau sub network to reduce possible CPO accumulation in certain day.

BIBLIOGRAPH

Anonymous (2010). "Indonesia Economic Development Corridors : Eastern Sumatera North West Java Economic Development Corridor Master Plan." Executive Summary of Indonesia Economic Development Corridors Masterplan.

Anonymous(2011)."Masterplan Percepatan dan perluasanpembangunan Ekonomi Indonesia2011 -2025 " Kementerian Koordinator BidangPerekonomian–BAPPENAS, 27 Januari2011.

Babazadeh, A., H. Poorzahedy, et al. (2011). "Application of particle swarm optimization to transportation network design problem." Journal of King Saud University – Science (2011) xxx, xxx–xxx.

Cascetta, E. (2009). Transportation Systems Analysis. New York, Springer.

Harouff, S. E., S. T. Grushecky, et al. (2007). "West Virginia Forest Industry Transportation Network Analysis Using GIS." Proceedings of the 16th Central Hardwoods Forest Conference.

Kasikitwiwat, P. and A. Chen (2005). "Analysis Of Transportation Network Capacity Related To Different System Capacity Concepts." Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 1439 - 1454, 2005.

Manurung, E. G. T. (2001). "Analisis Valuasi Ekonomi Investasi Perkebunan Kelapa Sawit di Indonesia." Environmental Policy and Institutional Strengthening IQC-PCE-I-806-96-00002-00.

Ravindran, A. R., Ed. (2009). Operation Research Methodologies. New York, CRC Press Taylor & Francis Group.