Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 227 (2016) 11 – 18
Procedia
Social and Behavioral Sciences

CITIES 2015 International Conference, Intelligent Planning Towards Smart Cities, CITIES 2015, 3-4 November 2015, Surabaya, Indonesia

Alternatives selection for sustainable transportation system in Kasongan City

Evan Buwana [a*], Hayati Sari Hasibuan [a], Chairil Abdini [b]

[a]*Environmental Science, Post Graduate Programme, University of Indonesia,Salemba Raya Rd.,Jakarta*
[b]*Ministry of State Secretaria of The Republic of Indonesia, Veteran Rd., Jakarta*

Abstract

Kasongan City is the district capital of Katingan which has 128.906 ha area.Since the first, community of Kasongan City have used Katingan river as a public transportation lines, but in recent years the development of road is increased significantly. It has give impact for growth of motorcycles that reached 91,9% in year 2013. Transportation sector contributes about 53.33% of the total CO_2 emissions produced per year. This paper discusses the most important criteria and choose the appropriate alternative to develop sustainable transportation systems in the Kasongan City using Analytical Hierarchy Process (AHP). Analysis result show the most appropriate alternative is optimize the integrated road—river transportation systems. Social acceptance become the main aspects that must be met in order to increase economic activity. Implementation of this alternative is realized by develop the integrated transit locations in Kasongan City, this program could increase public transport users and reducing CO2 emissions.

Peer-review under responsibility of the organizing committee of CITIES 2015

Keywords: Alternatives;Sustainability; Transportation; AHP.

* Corresponding author. Tel.: +62 8197991331; fax: +0-000-000-0000 .
E-mail address: buwana@live.com

Peer-review under responsibility of the organizing committee of CITIES 2015
doi:10.1016/j.sbspro.2016.06.037

1. Introduction

Regulation of The Minister of Transportation Number 49/2005 about National Transportation Systems explains that the integration between infrastructure and facilities of transportation is an important factor to support the provision of sustainable transportation services. Transportation plays a role to improve the economy by providing access for trading and services in various sectors (Wahidi, 2013). Transportation system has an influence on the population dynamics, urbanization, urban form, economic growth, and environmental quality (Sjafruddin, 2009).

Development of existing transportation systems in big cities such as Jakarta and Bandung proven to provide an economic positive contribution, but on the other hand it has not synergize with the availability of public transportation. Transportation problems arising because any gap betwen supply and demand, such as the unfulfilled of integrated transportation network. It make traffic flow increased, became a culture that thrives on community, this situatiuon make some people difficult to switch from private to public transportation. Sustainability transportation system should be developed in order to create the infrastructure optimization, support energy effeciency and support the renewable energy resources (Hasibuan, 2014).

Meanwhile, the transportation system in Kalimantan could not accelerate the regional economic development. The existing local potential was not supporting by integrated transportation system at the district level or as nodes around economy. Kalimantan highway development objectives is to provide access that can touch the entire district as a potential economic node region (MP3EI, 2011).

The development of river-based transportation system in Central Kalimantan is also noteworthy because Central Kalimanta has large rivers as their potential (Chandrawidjaja, 1998). River in Borneo such as Barito River and Katingan River used for trade activities, as a source of livelihood, conector district to another district, and also support other activities that affect to the social and cultural life (Sari, 2008). Sometimes, investors initiate the development of transportation infrastructure (e.a roads, bridges and pier) to linking business areas (MP3EI, 2011).

Kasongan as the capital city of Katingan Regent considered strategic because it is adjacent to the Capital City of Palangkaraya in Central Kalimantan. Kasongan city became the center of administrative development, trade and transport node and as well bypassed Katingan River that supports economic activities around Kasongan (RPJMD Katingan, 2013). Kasongan City population growth year 2012-2013 has increased to 2.4%. The population growth is much greater if compared from the previous years (BPS, 2014). The challenges of urban areas is to manage the growth in urban areas with a moderate way that can contribute to sustainable development in order to prevent the impact of carbon emissions and resource consumption in the transport sector (Hasibuan, 2014)

Bupati of Katingan Regent establish local policies to implement the Green City Development Program (P2KH) for Kota Kasongan in November 2014 ago. One of important variable in the Green City is the availability of Green Transportation System (BLH Katingan, 2014). Improved transportation systems in Katingan Regent, especially in the Kasongan City is one of the development missions of local government period 2013-2018. Base on medium-term development plan (RPJMD) of Katingan Regent year 2013, local Goverment have two strategies to achieve the mission. The first strategy is to optimize the road base transportations, while the second strategy is to optimize an integrated transportation system between road and river transportation. River transportation development program not explicitly mentioned in the document of RPJMD the Katingan Regency.

Transportation program until year 2014 focus to establish the land base transportation infrastructure. Road length in the City Kasongan from 2008 to 2013 increased from 33.82 km length road becomes to 95.92 km. Evidently, roads and bridges construction encourage people to use private vehicles to transport activity because effeciency of travel time, The explosive growth of private vehicle users type of motorcycle that reached 86.58% of the total number of motor vehicles in 2013 (BPS, 2014). Consequently, exceeded of the transportation infrastructure carrying capacity and cause the congestion (Kuncoro, 2010). The implications of the use of private vehicles in Kasongan make the transportation sector became the largest contributor for CO_2 emissions, whereas according to Penalosa (2002).

'*Angkot*' and '*klotok*' as public transportation was decreasing due to the difficulty in obtaining income. Potential CO_2 emissions in the Kasongan City 2010 was 42,706.34 tons/year with the amount of emissions from motor vehicles reaches 22,772.17 ton/year whereas the portion of the land transportation infrastructure and building area is only 2% of the total Kasongan City area (Simarmata *et al*., 2014). This situation need to managed properly, because it potentially growing and cause congestion, discomfort and other problems (Suwarno, 2012). Therefore, this research aims to analyze appropriate alternative of sustainable transportation system to support activity in Kasongan City, with safety and comfortability at the present and the future. Efforts to develop the transportation system must consider to the three aspects of sustainable development: social, economic and environmental aspects (Aminah, 2007).

2. Methods

2.1 Research Methodology

This research using mix method approach. A scientific decision making method is needed to decide on which one is the most significative among sustainable criteria for transportation system in Kasongan City and, as a final result of this, selecting one is the best alternative among destinations under researched. If there are more than two criteria for decision-making, this kind is defined (Baldemira et al., 2013). For the solution of these problems, researcher used Analytic Hierarchy Process (AHP) as multicriteria decision-making problem.

2.2 Determine the Land use and Transportation Network

The first step is to gather information about land use, city form, and existing transportation pattern in Kasongan city according the literature review. The data is use to determine the form of vast changes, shapes, and transportation network that period 2003 until now. The instrument used is software ArcGIS 10.2.2. and Microsoft Excel.

2.3 Analytic Hierarchy Process (AHP)

We aim at solving the decision making problem about selecting the best alternative to be a strategy for implementing sustainable transportation system in Kasongan City. The problem is solved in three steps.

2.3.1 Create Hierarchy of relationships between variables

Base on data mentioned above and consideration of several experts serves as a basis information to create a hierarchy of relationships between variables. Hierarchy established using AHP method. Hierarchy made consists of four levels, the first level (top) is the goal, followed by aspects of sustainability at second level, the criteria from sustainability aspect on the third level, and at the last level (bottom) is the alternative direction to develop sustainable transportation system. The composition of the hierarchical structure that is used as shown in Figure 1.

2.3.2 Choosing Expert

The next stage is to create a form of weighting pairwise comparisons based on the hierarchy (Figure 1). Expert on Analytic Hierarchy Process (AHP) requires should not be taken by random. The expert must have knowledge or experience related to the environmental and transportation system in Kasongan City. The number of expert to resolve policy issues should more than one expert, but if we use too much expert were could lead to bias and difficulty to locate the source of inconsistent data to be corrected (Saaty and Ozdemir, 2015). Nine expert on this research involving representatives of the local government, the Regional Representatives Council, NGO and academicians. Set of documents containing of research framework, AHP pairwise comparisons form and information land use Kasongan City distributed and discussed with the expert via forum Group Discussion (FGD).

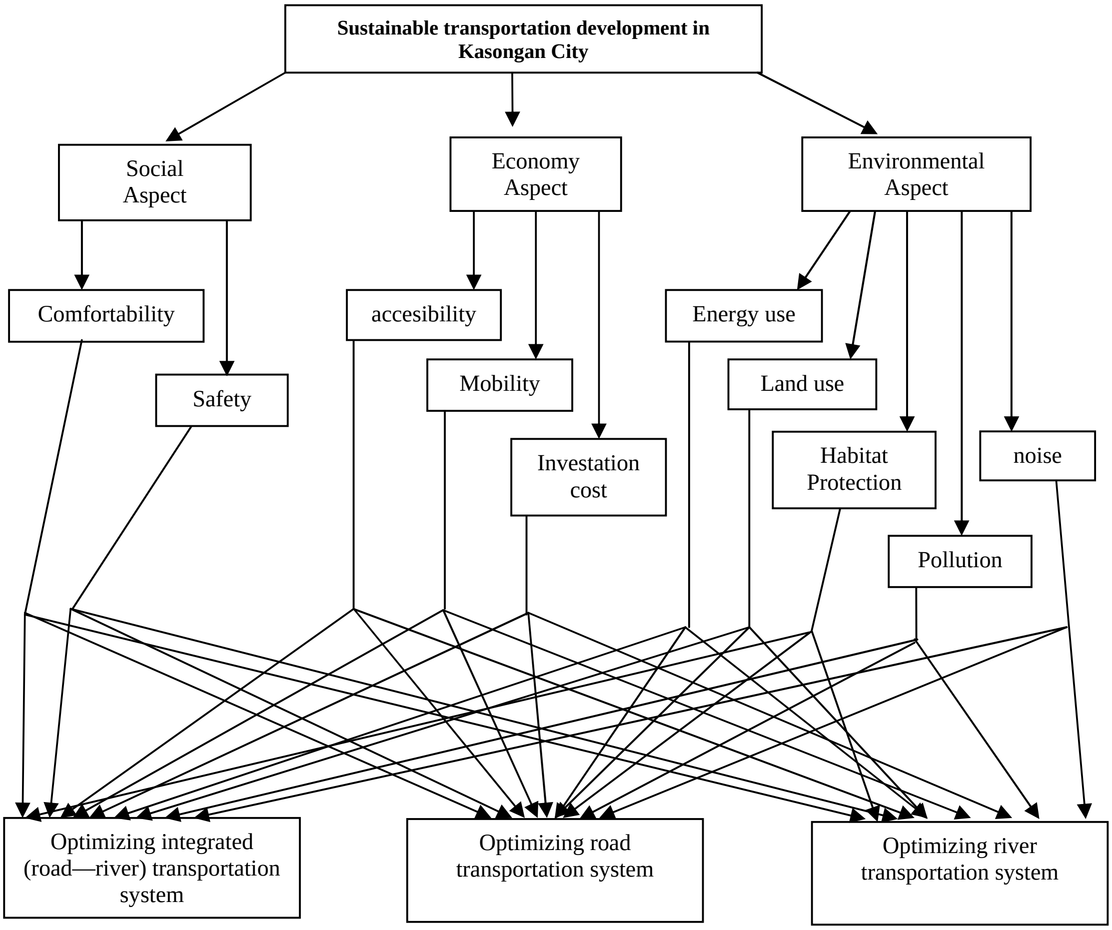

Fig. 1. Problem solving Hierarchy

2.3.3 AHP Pairwaise Comparison

We conducted interviews with each expert to get the weight of pairwise comparisons between all variables (such as the hierarchy that has been made). Weighting each expert proficiency level then tested the value of consistency, if the concistency value more than 0.1, we need to adjust or reconfirm to the expert for improvment. To get average value of the weight calculation (which is represents all expert) using geometric equations (Saaty, 2012) as in Equation 1.

$$\bar{a} = \sqrt[n]{(a_1 \times a_2 \times a_3 \cdots a_n)} \quad (1)$$

Where:

$\bar{a}$ = The average ratio of variables I and J

n = Number expert

a_n = expert pairwaise comparison value betwen variables *i* and *j*

These average weights calculated using SuperDecision 2.0. Data processing produces a number that indicates the dominance of each variable in a hierarchy that affect the implementation of sustainable transportation systems in City Kasongan. so that we can analyze:

a. The criteria most influential, on the implementation of a sustainable transportation system
b. The alternative chosen, as the focus in expanding the transportation system in the -kasongan city

2.4 Implementation from the Selected Alternatives

Data infrastructure and transportation facilities in Kasongan City and land use as guides in order to develop transportation system in line with the selected alternative. Some approaches are:
a. Analyzing the optimization of public transport
b. Create new of suitable transportation routes

Therefore, to assist the process of analysis, the equation use to determine the amount of CO_2 emissions resulting from energy use of fuels in the transport sector, as follows:

$$CO_2 Emmission = \sum_i (A_i \times EmmissionFactorCO_2 \times t) \quad (2)$$

Where :
Emission Factor CO_2 = 0,002598 ton/litre (Simarmata, 2014)
$\boldsymbol{A_i}$ = Total Fuel Consumption of each type of vehicle (liter)
t = Time (1 year equal with 365 days multiples with operating hour)
i = Vehicle type

Total Fuel Consumption of each type of vehicle (A_i) calculated using the following equation:

$$A_i = B \times C \times \overline{LHR} \quad (3)$$

Description:
S = Distance from the origin to destination (km)
LHR = average daily traffic volume (vehicle unit per hour)
C = Distance traveled using one unit of fuel (km/liter)

3. Result and Discussions

3.1 Transportation and Land Spatial of Kasongan City

Local Government expanding city spacious became 128,906.8 hectares in 2015 or 1478.6% greater than spacious of Kasongan City in 2009 as show in Figure 2. Increasing of Kasongan City area also affected to the number of transportation infrastructure in Kasongan City territory.
Tabel 1 show road length increases into 228%. Spatially, the length of Katingan River in Kasongan City are 110.6 km, whereas previously in 2009 only 15.46 km. Katingan river longitudinally in the middle of Kasongan City with quiet streams. This situation is good for transportation activities. Settlements area and economic centers that connected with Katingan River are Pendahara and Petak Bahandang, while Hampalit and Bukit Batu just connected by the road network.

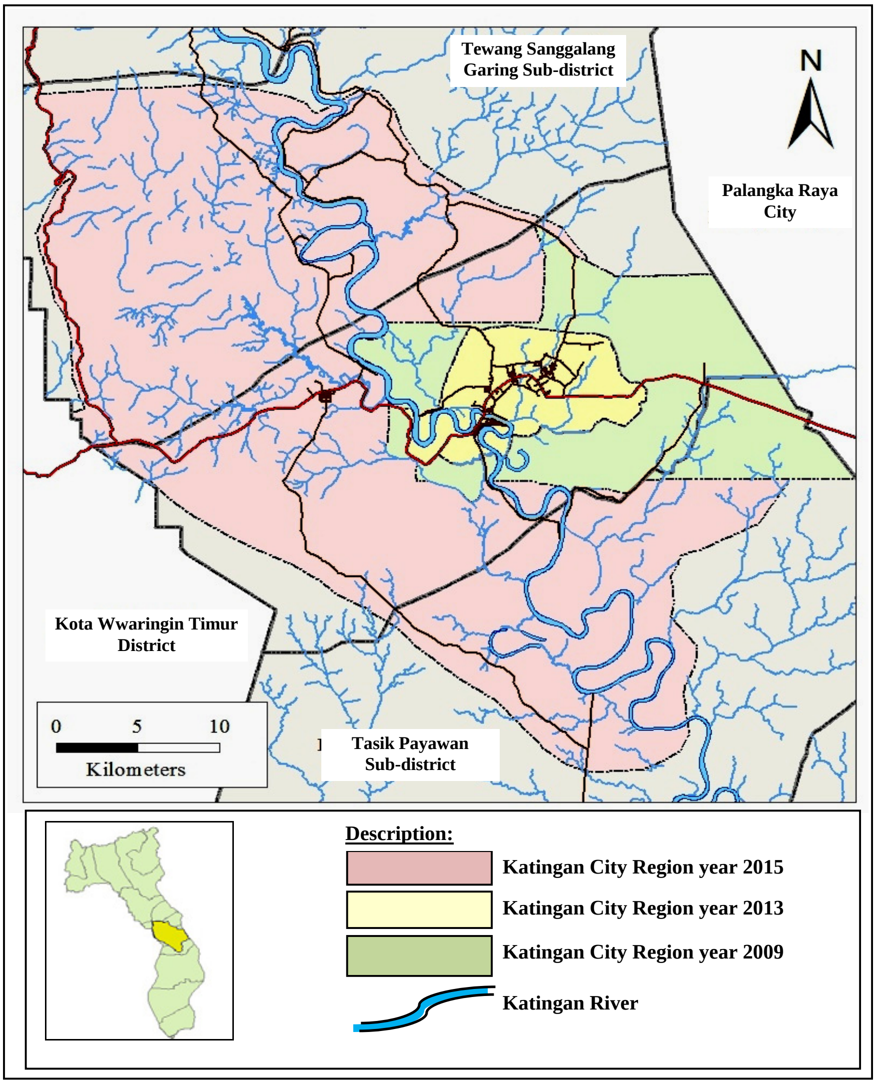

Fig.2. Kasongan City Territory Expansion

The results show the number of vehicles in Kasongan City increased to 4,018 units from 1,139 units in 2010, with 91.9% are motorcycles type. Meanwhile number of cars or minibus only 149 units. This shows people tend to use private vehicles than using public transportation. Minibus with 12 passengers namelly ‘*angkot*’ is existing public transportation that serve Kasongan—Hampalit with 6—7 vehicles per day.

Tabel 1. Kasongan City Land and Transportation Properties

City Properties	Year 2009	Year 2013	Year 2015
City area	8.166 Ha	31.044 Ha (3,9 times larger)	128.906,8 Ha (14 times larger)
Total Roads length	43,7 km	81,5 km	228,9 km
Number of roads segment	43	50	104
Total Katingan river length	15,46 km	36,5 km	110,6 km

Pier (at riverside)	1	1	3

3.2 Sustainable Transportation System Criteria

The result from AHP show level of safety as priority criteria from the social aspect to support sustainable transportation system in Kasongan City, while based on the economic aspect the priority criteria is level of accesibility. Meanwhile, based on the environmental aspect priority criteria is land use pattern. Safety has the greatest weights (0,281) in social aspect criteria, followed by comfortability criteria (0,169) and accessibility (0,168) in economy aspect, meanwhile consideration existing land use criteria (0,059) is the most affecting in environmental aspect. Therefore, to develop sustainable transportation system in the Kasongan City, infrastructure and transportation facilities should be socially acceptable. It was realized by providing good transportation facilities and linking potential areas in Kasongan City.

3.3 Appropriate Alternative to Develop Sustainable Transportation System

Base on three alternatives from AHP models, the analysis results show in Table 2 show that optimization of an integrated road-river transportation system is appropriate alternative. This alternative focuses on connectivity between road and river transportation system. Regarding this alternative and the dominant criteria, some approaches that could be implemented to create a sustainable transportation system in Kasongan City is:

a. Develop an integrated transit site which serve and connecting between road and river transportation network by expanding Kasongan port function in order to be transit hub entire available transportation modes.
b. Enhance the public transportation routes and types, as far as possible in accordance with the existing transport lines. Therefore, public transport could used in the interest of community activities, the community economy is also increasing and it could reduce the use of private vehicles especially motorcycles.

Table 2. AHP Result for Sustainable Transportation Alternatives

Alternatives	Weightness
Optimize the Land Base Transporation	0,3571
Optimize River Base Transporation	0,2347
Optimize the Integrated Road-River Transporation	0,4082

Optimization of Public Transportation could be started with optimize public transportation in Kasongan—Hampalit route as show in Table 3 which can guarantee deemed to have met the following criteria: safety, comfortability, assurance a vehicle accessibility on a route which does have recognized by Kasongan community. Daily traffic average per hour (LHR) for motorcycles is 361 units and for passenger car unit (PSU) is 71 units per hour in 2014 (Statistical Bureau of Katingan District, 2014).

Table 3. Public Transportation Optimizing for Kasongan—Hampalit Route

Remark	Optimize Recomendation	BaU Condition
Number of round-trip per hour	5 units round-trip per hour	6-7 units round-trip per day
Waiting and Operating Time	Every 12 min, operating hour: 06.00—20.00 WIB	Depending on driver judgement, operating hour: 07.00—13.00 WIB
Shelter/stop area	Added 6 stops	without definitive stop area
Number of passengers	Maximum 12 passengers	More than 12 pasasengers

From calculation using formula 3, fuel estimation for motorcycles is 135.38 l/hour and for passenger car unit (PSU) is 76.07 l/h. CO_2 emissions from each type vehicles per year obtained using formula 2 where CO_2 emmission for motorcycles is 1,797.21 t/year and passenger car unit (PSU) is 1,009,89 t/year. Total CO_2 emissions in Business as Usual (BaU) condition are 2,807.1 t/year. While in optimize recommendation, addition of public transportation (angkot) CO_2 emissions using the same formula is 71,12 t/year, but if the public transportation can affect at least 6—12 bikers (50%—100% angkot passengers) then CO_2 emission could be reduced become 119.48—238.96 t/year . Which means the potential reduction of CO_2 emissions by optimizing the management of public transportation might achieve 4.26%—8.51% from BaU condition.

4. Conclusions

Suitable Program accordance with the sustainable transportation system is create an integrated transit systems. The main activities from this program is to develop the connectivity of all public transportation betwen road and river based. The program put forward a sense of safety and comfortability while using public transportation as a social advantage, providing accessibility and better mobility as an economic advantage. The program is also advantageous, when viewed from the the environmental aspects, as it may reduce CO_2 emissions. Appropriate program to reduce CO_2 is optimizing using angkot as existing public transportation, where add more round-trip operasional and *angkot* route would be from integrated transit area (at Kasongan) to Hampalit district. Potensial reduction of CO_2 emissions by optimizing the management of public transportation might achieve 4.26%—8.51% from *Bisnis as Usual* condition.

Acknowledgements

Acknowledgements for Government of Katingan Regency and *experts* who involved in this research.

References

_____. (2011). Masterplan for the Acceleration and Expansion of Indonesian Economic Development (MP3EI) 2011-2025. Jakarta, Coordinator Ministry of Economy.

Aminah, S. (2007). Public Transportation and Accessibility Urban Communities. *Masyarakat Journal of society, culture and politics*, 20, (pp 31-45).

Baldemira, E., Kayab, F., & Sahin, T. K. (2013). A Management Strategy within Sustainable City Context: Cittaslow *Procedia - Social and Behavioral Sciences (pp 75 – 84)* . Published by Elsevier Ltd

Chandrawidjaja, R. (1998). Mainland Waters Navigation. Engineering Faculty. Lambung Mangkurat University. Banjarmasin.

Conservation for Borneo and The Implementation of Green City in Kasongan. Environment Agency of Katingan District.,Palangka Raya: 6 pp. http://katingan.lingkunganhidup.net/index.php/public/info/detail/berita/6. 12 Januari 2015, pk. 20.00 WIB.

Hasibuan, S. H., Tresna P. S., Raldi Koestoer, Setyo Moersidik. (2014). The Role of Transit Oriented Development in constructing urban environment sustainability, the case of Jabodetabek, Indonesia. *Procedia Environmental Sciences*; 20; (pp 622–631).

Hasibuan, S. H.(2014) *Spatial Planning and Sustainable Transport for Sustainable Urban Models (Concept Development Study of Transit Oriented Development in Jabodetabek)*. Jakarta: Universitas Indonesia;.

Kuncoro A. H. W. (2010). *Study of Mixed Transportation Mode in Bogor in Baranangsiang Terminal,* Depok: Fakultas Teknik Universitas Indonesia;

Medium Term Development Plans of Katingan Regency Year 2013—2018. (2013). Government of Katingan District.

Penalosa, E. (2002). *The Role of Transport in Urban Development Policy*. Eschborn, German: GTZ GmBH;.

Statistical Bureau of Katingan District (BPS). (2014). *Statistical Report of Katingan District Year 2013.* Kasongan.

Saaty T. L., Ozdemir M. S. (2015). How Many Judges Should There Be In A Group, *Annal of Data Science Journal*, 1-3, (pp 359-368). New York Springer.

Saaty T. L., Vargas, L. G. (2012). *Models, Methods, Concepts and Aplication of Analityc Hierarchy Process*. New York, Springer.

Sari, R. P. (2008). Shifting movement of the Martapura River Transportation in Banjarmasin. Semarang, Diponegoro University. Graduate Program

Simarmata, H. A., Dimastanto, A., Kalsuma, D. & Santoso S. I. (2014). Institutional Barriers of Low Carbon Development Planning in Indonesian Small Cities. *Low Carbon Economy Journal*, 5; (pp 105-116).

Sjafruddin, A. (2009). Development of Transport Infrastructure for Supporting Sustainable Development Based Sciences. ITB, Bandung. 11 pp. http://www.opi.lipi.go.id/data/1228964432/data/-13086710321319703573.makalah.pdf. October 16, 2014, pk. 3:02 pm

Suwarno. (2012). Livelihoods pattern changes related to Hinterland Public Perception and Education. *Economia Journal*. 8, (pp164-180). Palangkaraya University.

Wahidi, R. (2013). *Portrait of Roads and Bridges Infrastructure Development in Indonesia*. Bogor: Eternal Press.