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AN EVALUATION OF ROAD NETWORK PERFORMANCE IN INDONESIA

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Abstract: There is a disparity of development achievement in East Region of Indonesia, which has been left behind from West Region. To reach more optimum welfare development supported by high performance road, a good practice of fair evaluation is needed. This study evaluates the effectivity of road network in twelve provinces located in Sumatra, Kalimantan, and Sulawesi islands from 1999 to 2002. The study used four indicators, namely road performance, road availability, traffic load, and road services. Analysis presents a significant difference for each road indicators among provinces, and the road index is just an average of the four indicators in each province and each year. The result shows there is a specific pattern of outputs (road index) and outcomes (Gross Regional Domestic Product, GRDP) for each island. As well expected that provinces with high road performance index correlate with high output and outcome, it is shown in this study that there are some provinces with high road index but produce either low outcome or low output and outcome.

Key Words: Effectivity, road network, road performance, road availability, traffic load, and road services

1. INTRODUCTION

The success and progress of human society depends on physical infrastructure for distributing resources and essential services to the public. The quality and efficiency of this infrastructure affects quality of life, the health of the social system, and the continuity of economic and business activity. A nation's economic strength is reflected in its infrastructure asset. The history of economic and social system walks parallel with infrastructure development. Demands on infrastructure and related services increase as people expect a higher quality of life and public services. But, more importantly, good infrastructure facilitates a higher quality of life (Hudson, et.al., 1997).

Infrastructure development is, however, a long-term issue, which has an important attribute the long gestation period of infrastructure project. As a result, decisions on investment in infrastructure require a long-term perspective. Furthermore, there is no clear-cut method of allocating public funds among the various infrastructure sectors (Akatsuka&Yoshida, 1999). This has led public authorities and national planners to believe that it is needed a kind of method to allocate the limited resources to achieve the national objectives, especially transportatoin aspect.

The objective of road transport services is to form a traffic and road transport in safe, secure, fast, fluent, order and regular, comfort and efficient, integrated with others mode, reachable by all land region, and support fair distribution, development and stability to drive, to motor, and to support national development with reachable cost by community. According to that objective, it is needed a performance evaluation which considering accessibility distribution, safety, efficiency, effectivity, reachable cost, and integrity with others transport system. The evaluation has a goal to value the level of service of existing road network. The evaluation result will be used to estimate and build the strategy of road network rehabilitation and development. The evaluation has a role in developing sustainable transportation system, which has a meaning as a sustainable system for individual/community, economy, and environment.

Road network development program starts with giving an input, in a kind of investment (money and human resources), then resulting an output, in a kind of physical road infrastructure. The using of this infrastructure makes an outcome, in a kind of traffic interaction in that road network. The effectivity and efficiency of this road creates an impact to the environment and community. The step and series of activity in road network development shown in Figure 1 and its definitions explained in Table 1.

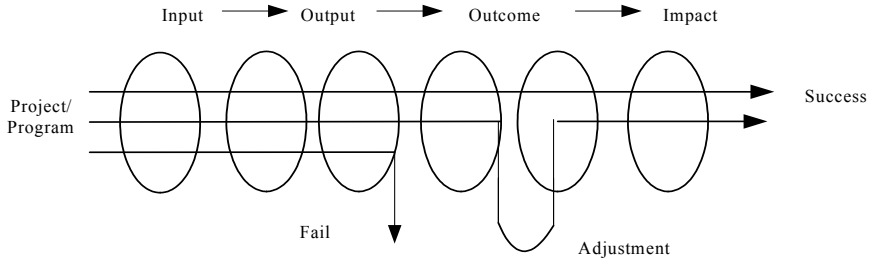


Figure 1. Schematic Diagram the Progress of a Project (Dickey, 1984)

Table 1. Several Definition in Road Network System Services (Menneg. PU, 2000)

Terms	Definition
Input	Resources used to handle road network development project
Output	Reached of physical road network development objectives/goals
Outcome	Reached of mission and policy of road network development, regional infrastructure integrity as a result of road network development activity
Benefit	Reached of national development objectives, and sharing value of road network as a support to social and economic aspect
Impact	Result of road network development to community and regional welfare

The objective of this study is to evaluate the effectivity of road network in twelve provinces located in Sumatra, Kalimantan, and Sulawesi islands. The effectivity will be expressed by several indicators, road index, and its correlation with economic parameter and budget available. The work in this study covers a literature study, collection of data and related regulation, indicator development, and evaluation of road network performance.

2. PERFORMANCE INDICATORS

Effectivity is defined as an ability of an object to fulfill a kind of objective, which does not just measure in benefit and cost only, but it is measured in the ability to fulfill several objectives. The road services are effective when all stakeholders in road development receive the benefit from it. To measure the effectiveness of road infrastructure, it is needed a series of indicator, which will give a measurement about how the elements of the system interact agree with the objectives. The characteristic of indicators are 1)covers all project phases, 2)gives a needed information to monitor all project phase, 3)gives a clear information to all stakeholders, especially the policy maker, 4) objective and measurable, and 5)not too much in number.

2.1 Performance Indicators

There are several approaches to evaluate road network performance as shown in Table 2. The data needed in performance evaluation shown in Figure 2. The source of data can be grouped in two, namely actual data and estimated data.

Table 2. The Approach of Performance Evaluation of Regional Road Network

Aspect	Approach	
	Micro	Macro
Point of view	Network as a system of road and traffic interaction	Network as a part of infrastructure system
Evaluation concept	Network as a media of traffic flow	Network as a primary regional economic infrastructure
Evaluation indicator	Traffic flow, VCR, system operating cost	*Input, output, outcome, benefit, impact*
Efficiency	Minimum travel cost in system	Ratio of *input* and *output*
Effectivity	Road capacity utility level	Level of road network objective fulfillment

In developing road performance indicators to measure the infrastructure effectivity, it must be defined firstly the parameter. In this evaluation, road network system is divided in four steps as shown in Figure 3. The definition of the parameters can be formulated as:

1. Efficiency and productivity = output / input
2. Effectiveness = output / outcome
3. Sustainability = impact or benefit / output

Input indicator is a fund spent for road handling, which can be presented by APBN (national budget), APBD I (provincial budget), or APBD II (city/municipal budget). Output indicator is explained by length of road, outcome indicators are presented by number of vehicle using road in a range to time (veh-km/year), and impacts are presented by several measurements like number of carbon monooxide (ton/year). The data for the output of the road handling is a road length developed and rehabilitated and the outcome data used is road network performance, presented by average speed and vehicle operating cost in those road networks.

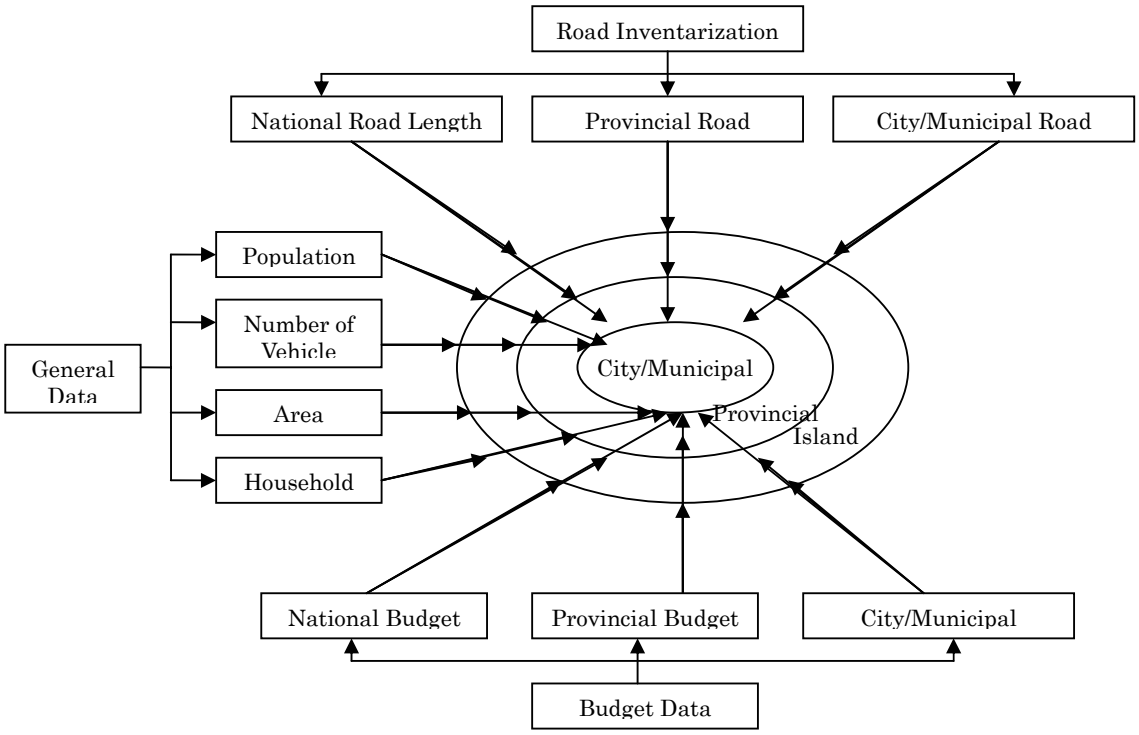


Figure 2. Data for Road Operation and Maintenance Evaluation Program
(Ministry of Settlement and Regional Infrastructure, 2004)

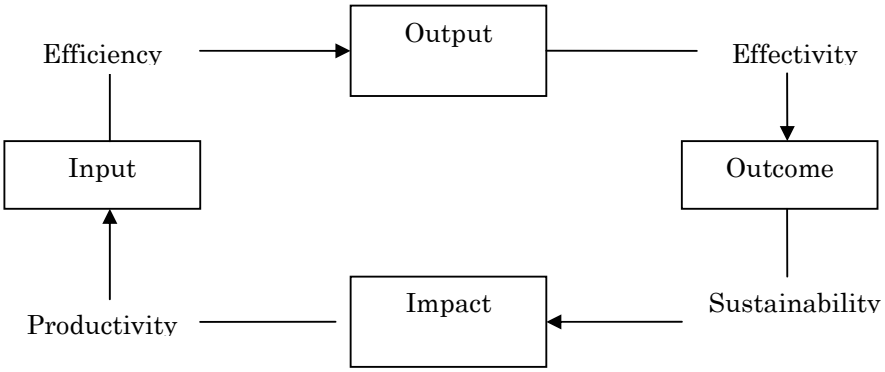


Figure 3. Project Cycle (Soedarmadji, 2000)

The measurement of road network's performance can be divided by its level, namely for provincial level and city/municipal level. Indicators for provincial level are road availability, road network performance, traffic load, and road network serviceability. Indicators for city/municipal level are road network availability, road network performance, and road network serviceability (Ministry of Settlement and Regional Infrastructure, 2004).

2.2 Road Indexes

In evaluating the road performance, it is needed a kind of measurement to represent the condition of the road. This analysis will apply road index (indeks prasarana jalan). This index is a relative representation about the road performance according to the others performance. This index can be applied in provincial and city/municipal level. The index can be calculated with variation of weight for every aspect. Ministry of Settlement and Regional Infrastructure (2004) used weight for road availability, road performance, traffic load, and road serviceability are 2, 3, 2, and 2, respectively.

Road indicator involves in this evaluation are:

a. Road availability; a ratio between total road lengths with area width. Road availability has a unit km/km^2.
b. Road performance; a ratio between lengths of road in stable condition with total road length. Road performance has no unit or km/km.
c. Traffic load; a ratio between total lengths of road with number of vehicle (pcu). This indicator has a unit km/pcu.
d. Road serviceability; a ratio between total lengths of road with number of population in that region. The unit of this index is km/people.
e. Road index; a combination of four ratios, which can be calculated in several conditions according to its weight for each ratio. The formula is shown in Eq. (1).

$$IPJ = \frac{\text{Ppr(ktj)xW}_{(ktj)} + \text{Ppr(knj)xW}_{(knj)} + \text{Ppr(bln)xW}_{(bln)} + \text{Ppr(pyp)xW}_{(pyp)}}{4} \quad (1)$$

with IPJ is road index, Ppr $_{(ktj)}$ is proportion of road availability, Ppr $_{(knj)}$ is proportion of road performance, Ppr $_{(bln)}$ is proportion of traffic load, Ppr $_{(pyp)}$ is proportion or road serviceability, $W_{(ktj)}$ is weight for road availability, $W_{(knj)}$ is weight for road performance, $W_{(bln)}$ is weight for traffic load, and $W_{(pyp)}$ is weight for road serviceability.

3. INDONESIAN GENERAL DATA

The objects of study consist of twelve provinces in three islands, namely Sumatra, Kalimantan, and Sulawesi. These islands are selected to figure out the comparison of condition in the west, central, and east regions in Indonesia. The statistical data for each province in study area are shown in Table 3. Four provinces in each island investigated were selected in this study, and each province has vary in the number of cities/municipals.

To explain the condition of road network in those provinces, several indicators are explored. Those indicators are shown in Figure 4, 5, 6, and 7, which are road availability, road performance, traffic load, and road services, respectively. Figure 4 shows that almost all provinces have no change in road availability during 1999-2002. It was the result of two conditions, firstly there was no addition of road length, and secondly there was bigger addition in width of area with small addition of new road development. According to ANOVA results, there is no significant difference among years (p-value=0.455), but there is significant difference among provinces (p-value=1.72x10^{-6}).

Table 3. Statistical Data for Each Province in Study Area

Province	Capital	Area (km^2)	Number of City/Municipal	Specific Allocation Fund (DAK) (10^9 Rupiah)	Fiscal Index
		Sumatra			
North Sumatra	Medan	71.680	23	4,8	0,99
West Sumatra	Padang	42.503	16	4,7	0,36
Jambi	Jambi	56.436	10	7,4	0,22
Riau	Pekanbaru	94.800	17	-	2,40
		Kalimantan			
West Kalimantan	Pontianak	146.807	10	8,6	0,41
Center Kalimantan	Palangkaraya	171.558	14	6,9	0,30
East Kalimantan	Samarinda	200.395	13	-	2,54
South Kalimantan	Banjarmasin	38.424	13	5,7	0,41
		Sulawesi			
North Sulawesi	Menado	15.272	8	6,70	0,21
Center Sulawesi	Palu	61.550	9	7,20	0,13
South Sulawesi	Ujung Pandang	62.362	28	3,40	0,53
South East Sulawesi	Kendari	38.140	7	7,90	0,12

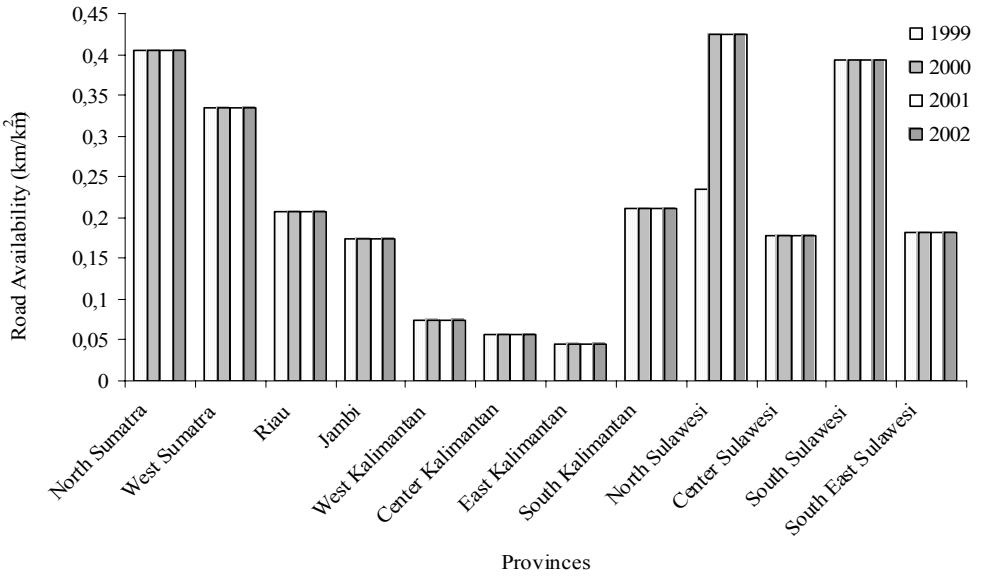


Figure 4. Road Availability for Twelve Provinces in Indonesia

Figure 5 shows the comparison of road performance in twelve provinces. The road performance is calculated by divided length of road in stable condition by total road length in those provinces. Almost all provinces have variation road performance condition during 1999-2002. ANOVA result shows that there is no significant difference of road performance among times (p-value=0.4299), but there is significant difference among provinces (p-value=0.098704).

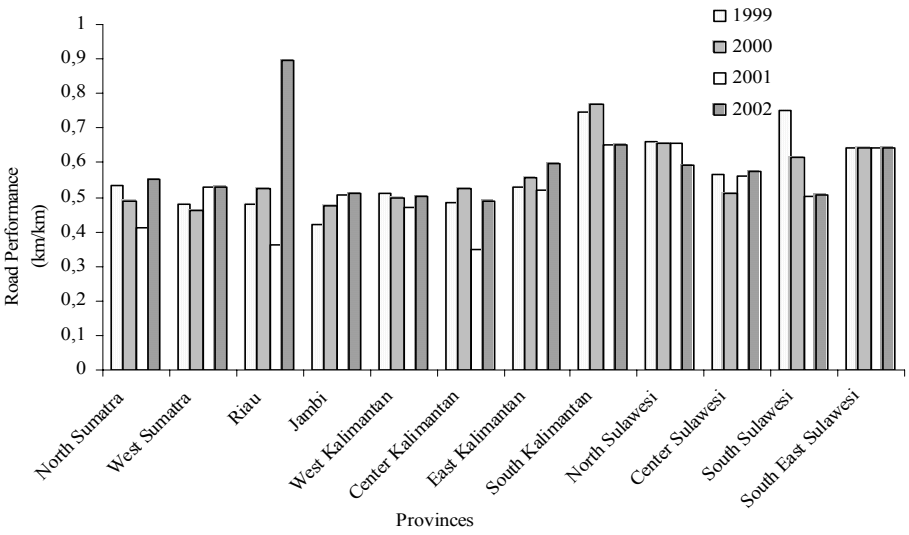


Figure 5. Road Performance for Twelve Provinces in Indonesia

Traffic load condition among provinces is shown in Figure 6. The data shows that Center Kalimantan and South East Sulawesi relatively have the highest traffic load among others. The traffic load is an indicator to show ratio of road length and number of vehicle in each provinces. Statistical analysis result shows that there is significant differences of traffic load among provinces (p-value=1.016×10^{-10}) and years (p-value=3.33×10^{-08}).

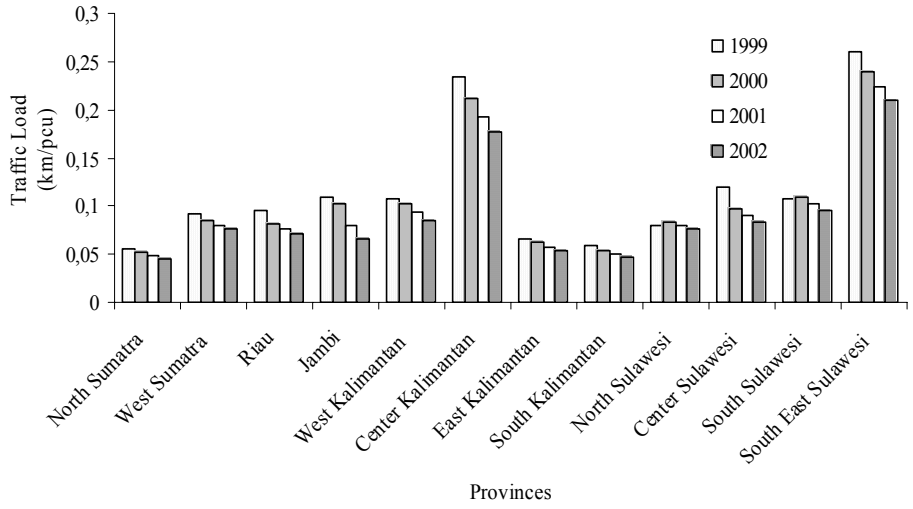


Figure 6. Traffic Load for Twelve Provinces in Indonesia

Figure 7 expresses the condition of road service in the object studied area. The road service has a unit kilometer per people, which means the length of road available for each people in each province. The figure shows the variation of road service condition in each island. ANOVA result shows that there is significant difference of road service among provinces (p-value=3.7×10^{-5}) and years (p-value=0.0415).

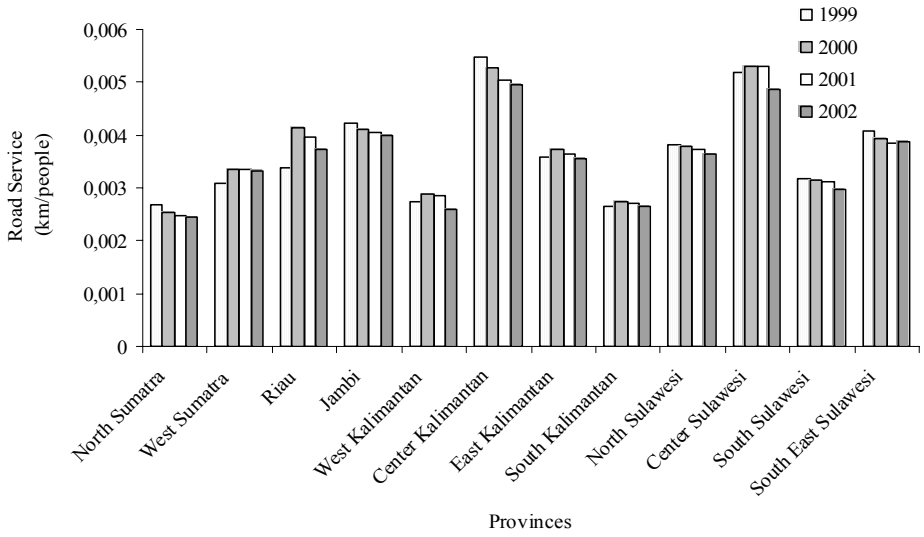


Figure 7. Road Service for Twelve Provinces in Indonesia

Another important element of road performance evaluation is fund allocation and economics parameter. There are several fund allocation to finance road development in each province, namely APBN (national budget), DAK (specific allocation fund), and APBD (regional budget). The economic parameters will figure the economic condition of community and GRDP (Gross Regional Domestic Product) is used in this paper. Table 4 shows the National Budget for road sector and GRDP for each province and Figure 8 shows the relation graphically.

Table 4. Road Sector National Budget and GRDP

Province	Road Sector National Budget Fund for national road (10^9 Rupiah)				GRDP (10^{12} Rupiah)			
	1999	2000	2001	2002	1999	2000	2001	2002
Sumatra Utara	48,29	45,8	60,8	126,8	22,7	23,8	24,8	25,8
Sumatra Barat	33,65	35,3	138,9	73,5	7,6	7,9	8,1	8,4
Jambi	39,34	62,93	41,1	123,9	3,2	3,4	3,5	3,7
Riau	9,63	22,02	136,7	142,1	20,3	21,6	22,5	23,7
West Kalimantan	23,54	30,7	31,81	76,43	7,1	7,3	7,4	7,5
Center Kalimantan	12,07	34,93	65,81	114,85	4	4,1	4,2	4,3
East Kalimantan	40,19	40,14	321,37	343,9	21,5	22,4	23,3	24,2
South Kalimantan	28,37	22,87	33,32	90,74	6,2	6,4	6,7	6,9
North Sulawesi	47,76	29,69	63,95	155,08	3,91	3,22	3,36	3
Center Sulawesi	56,55	61,73	22,07	87,9	2,28	2,38	2,51	2,49
South Sulawesi	49,21	45,43	29,39	142,82	9,63	10,101	10,62	11,1
South East Sulawesi	42,82	58,83	50,57	103,34	1,59	1,67	1,77	1,85

Table 5 shows correlation coefficient value between National Budget and GRDP for each province in year 1999, 2000, 2001, and 2002. The correlation coefficient explains

relationship between input and outcome parameter. Table 5 shows that all provinces in Kalimantan and Sumatra relatively have positive and higher correlation value. The cofficient of correlation of National Budget and GRDP for all provinces in each year is shown in the last row. The values show that there is negative value for 1999 and 2000, and positive value for 2001 and 2002.

Table 5. Coefficient of Correlation for National Budget for Road Sector and GRDP

Provinces	Sumatra Utara	Sumatra Barat	Jambi	Riau	West Kalimantan	Center Kalimantan	East Kalimantan	South Kalimantan	North Sulawesi	Center Sulawesi	South Sulawesi	South East Sulawesi
Island		Sumatra				Kalimantan				Sulawesi		
all years data	0.84	0.53	0.81	0.90	0.78	0.99	0.91	0.79	-0.58	-0.13	0.66	0.81

years	1999	2000	2001	2002
all provinces	-0,13	-0,31	0,61	0,56

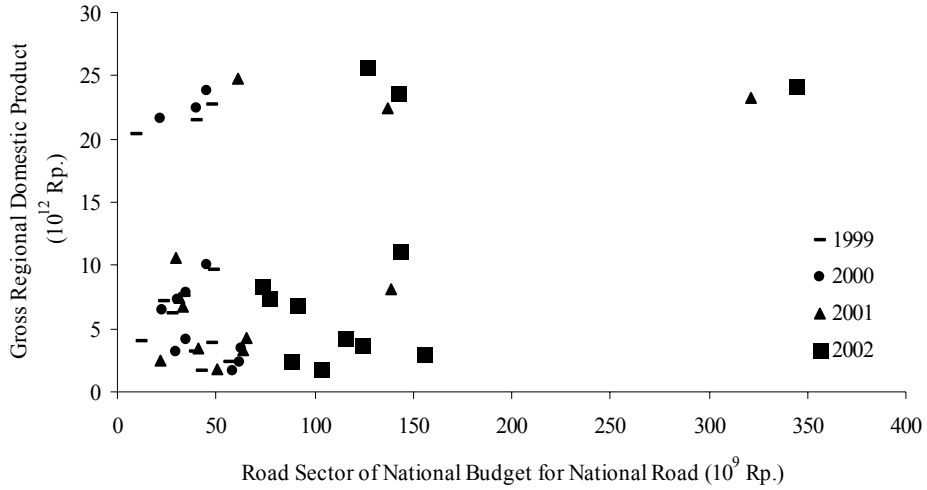


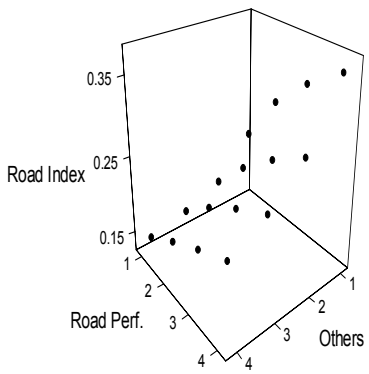
Figure 8. The Relation between National Budget and Gross Regional Domestic Product

4. DATA ANALYSIS

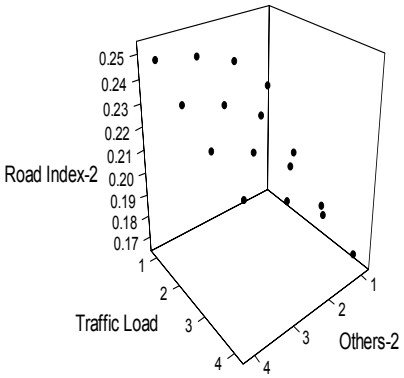
From four indicators as shown in Figure 4, 5, 6, and 7, then road index for each province can be calculated. Road indexes can be calculated using same or different weight for each indicator, which the weight range is from 1 to 4. To draw the effect of the weight used, the sensitivity analysis is conducted. Figure 9 shows the sensitivity of road index value according to the variation weight of road indicator. The figure shows the typical pattern among traffic load, road availability, and road service, except for road performance. This difference pattern happens because the road performance value is the biggest among

others indicators, so when the weight is increase, the road index will increase too. The three indicators have smaller value and give small difference to total, so when its weight higher and the summation of weight higher, the road index will smaller.

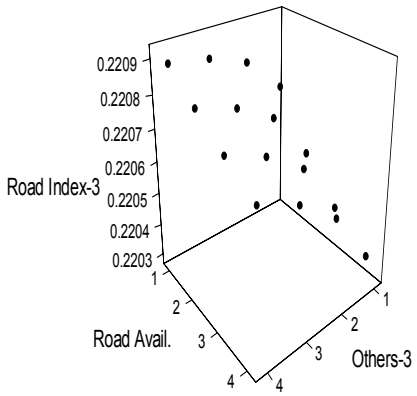
To analyse the difference among the road index with indicator's weight variance, the analysis of variance (ANOVA) is conducted. The result shows that there is no significant difference among indicator's weight variance (p-value = 0.65768). It means that there is no difference using different weight or same weight for each indicator, so further analysis applies same weight for each indicator. It means the road index is just an average of four road indicators.



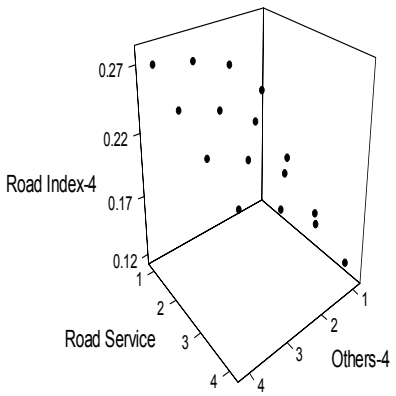
a) Road Performance's Weight Variation



b) Traffic Load's Weight Variation



c) Road Availability's Weight Variation



d) Road Service's Weight Variation

Figure 9. Sensitivity Analysis of Road Indicator's Weight to Road Index

The relation between road index and GRDP expresses the effectivity, which means a region has an effective road network when can create high outcome. In this paper the outcome of road development will be expressed by GRDP. Figure 10 shows the

relationship between road index and GRDP for all provinces from 1999 to 2002. The other aspect which can be drawn from road index is the efficiency of road network. This efficiency is studied by make a relationship between Road Index and National Budget for all provinces from 1999 to 2002 as shown in Figure 11.

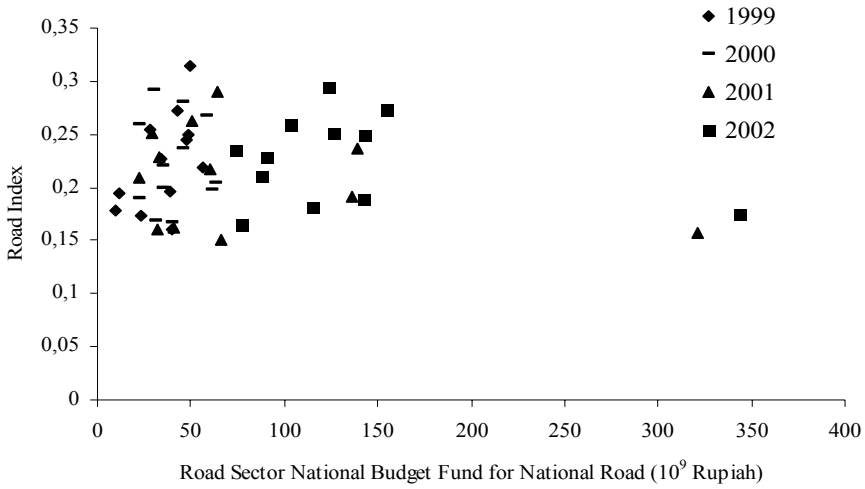


Figure 10. The Relation of Road Sector of National Budget with Road Index

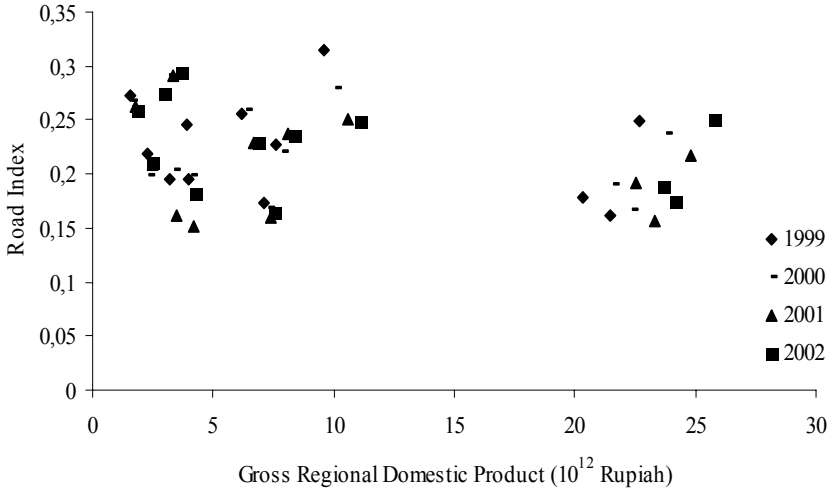


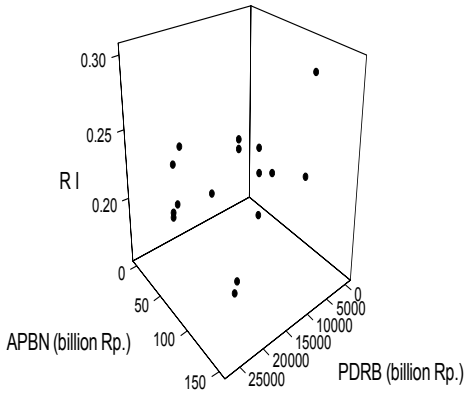
Figure 11. The Relation of Road Index and GRDP

The pattern of the relationship among road index, GRDP, and National Budget for road sector is presented in Figure 12. The figure shows that each province has its own pattern and looks different one to another. To explore more consicely, it is build a model to study the relation of GRDP as a dependent variable and several independent variables, namely four road indicator and amount of money used (National Budget for road sector). The models are explained in Table 6 and consist of four models according to the region from 1999 to 2002. It can be compared the relation of economic development of one provinces according to the road condition in those area.

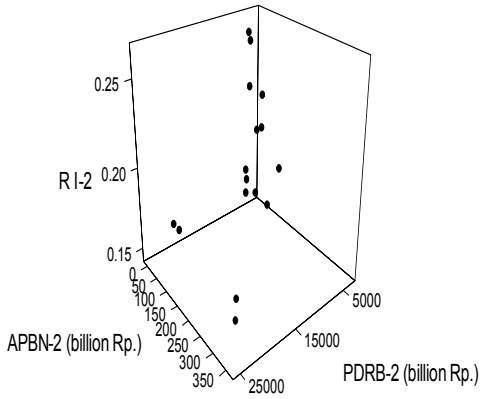
Table 6. Models to Predict GRDP from Road Indicators and Road Budget Data

Predictor	SUMATRA		KALIMANTAN		SULAWESI		12 PROVINCES	
	Coef.	T	Coef.	T	Coef.	T	Coef.	T
Constant	84829	1.31	6460	1.45	43246	3.65*	36833	4.70*
Road Performance	-29244	-1.18	15059	1.71	-19308	-2.13	-26627	-2.87*
Traffic Load	-227260	-0.96	-173968	-8.60*	-27124	-1.88	-44748	-2.18*
Road Availability	-52139	-0.66	-84162	-6.25*	-8869	-0.77	-4020	-0.48
Road Service	-7298418	-0.57	6033458	5.44*	-4905430	-3.38*	-2574321	-1.86
Natioanl Budget	19.06	0.25	0.081	0.01	-23.37	-1.56	35.42	2.39*
R-Sq		31.1%		96.5%		77.4%		43.7%
R-Sq (adj)		0.0%		94.7%		66.2%		37.1%

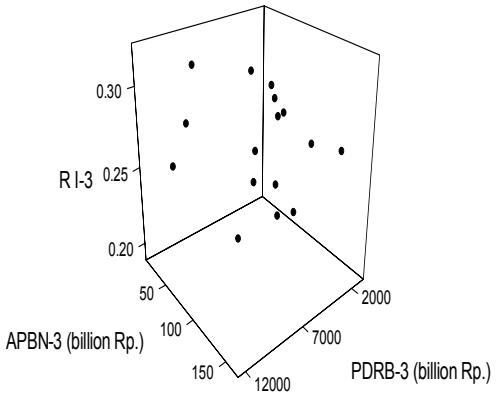
Note: * means significant in 5% level of significant



a) Sumatra



b) Kalimantan



c) Sulawesi

Figure 12. Relationship among Road Index, National Budget, and GRDP for each Province

Further analysis to figure the condition of road network effectivity is done by plotting the data as shown in Figure 13, 14, and 15 for Sumatra, Kalimantan, and Sulawesi islands respectively. In each graph there are vertical lines as an average of GRDP for each year (1999-2002) and horizontal lines as an average of Road Index in each year. The dots in the figure show the value of Road index related with its GRDP for each province in each island for specific years. The vertical and horizontal line divides four region or quadrant as shown in Table 7. The ideal condition is that the province which has a high Road Index also has a high GRDP. It means the provinces have an effective road network.

Table 7. Four Conditions from GRDP and Road Index Relations

	Road Index below an average	Road Index above an average
GRDP above an average	2nd quadrant	3rd quadrant
GRDP below an average	1st quadrant	4th quadrant

Figure 13 shows that Sumatra provinces have an increasing average of GRDP from 1999 to 2002, but the average of Road Index moves up and down dynamically. Form 1999 to 2002 the provinces of Riau and West Sumatra always have GRDP below the average, while North Sumatra and Jambi has higher GRDP than average. The interesting fact is that each provinces post in one quadrant differently, like Jambi always in 4th quadrant and North Sumatra always in 3rd quadrant. Riau in year 2002 experiences increasing in Road Index without high increasing of GRDP, which result Riau moves form 1st quadrant to 2nd quadrant. It shows that there is an improvement in road aspect but still can not directly produce higher GRDP.

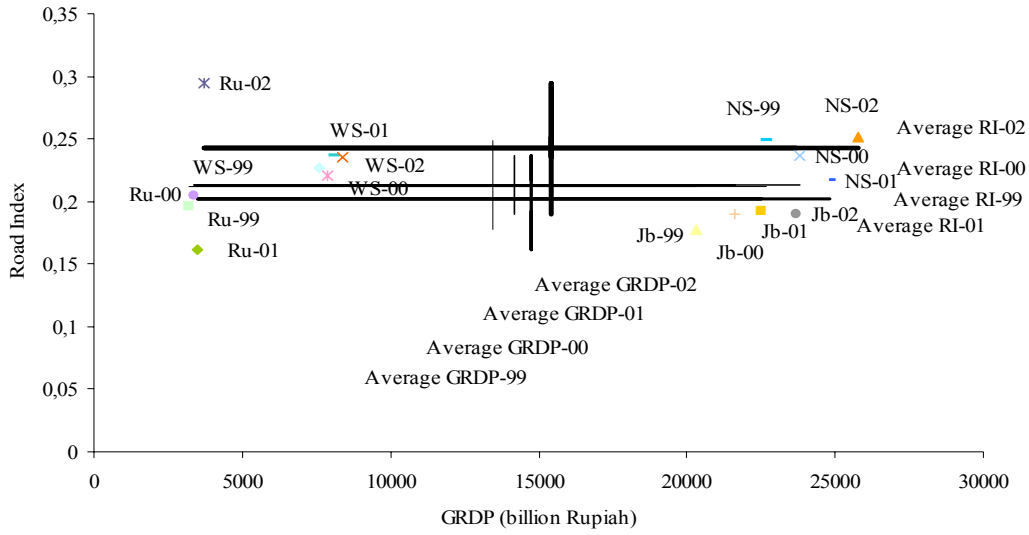


Figure 13. Relationship between Road Index and GRDP in Sumatra Island

The condition of effectivity of Road Network in Kalimantan is shown in Figure 14. The average of GRDP always growing from 1999 to 2002, but the Road Index shows relatively decreasing average. The province of East Kalimantan posts in 4th quadrant from 1999 to 2002, while the rest of three provinces stay in 1st and 2nd quadrant. It means East Kalimantan has higher GRDP than average with lower road index than average and

the rest three provinces in Kalimantan produces lower GRDP than East Kalimantan. It is also interesting to study the decreasing of Road Index in Central, South, and West Kalimantan, while Central Kalimantan experiences slight movement from 2nd to 1st quadrant.

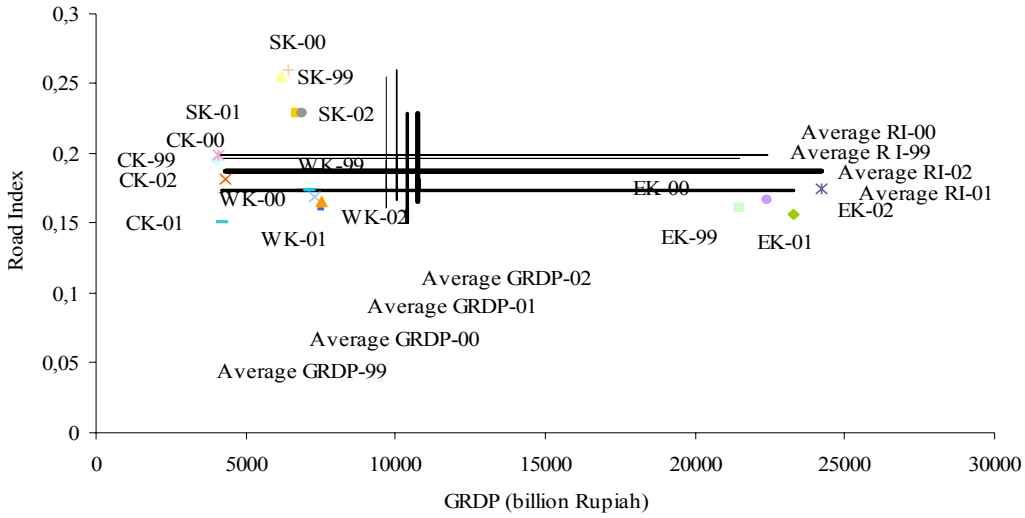


Figure 14. Relationship between Road Index and GRDP in Kalimantan Island

Figure 15 shows the relationship between Road Index and GRDP in Sulawesi Island. Comparing to Sumatra and Kalimantan, Sulawesi did not show big changes in GRDP and in Road Index, which is shown in proximate average of GRDP lines and also proximate average of Road Index lines. This picture shows that Sulawesi experienced rather statically condition related to road condition and GRDP. Only South Sulawesi has a position in 3rd quadrant, higher GRDP than average, and higher Road Index than average, while Central Sulawesi always has a position in 1st quadrant with below GRDP than average and below Road Index than average. North and South-East Sulawesi showed the fluctuation condition even not dramatical.

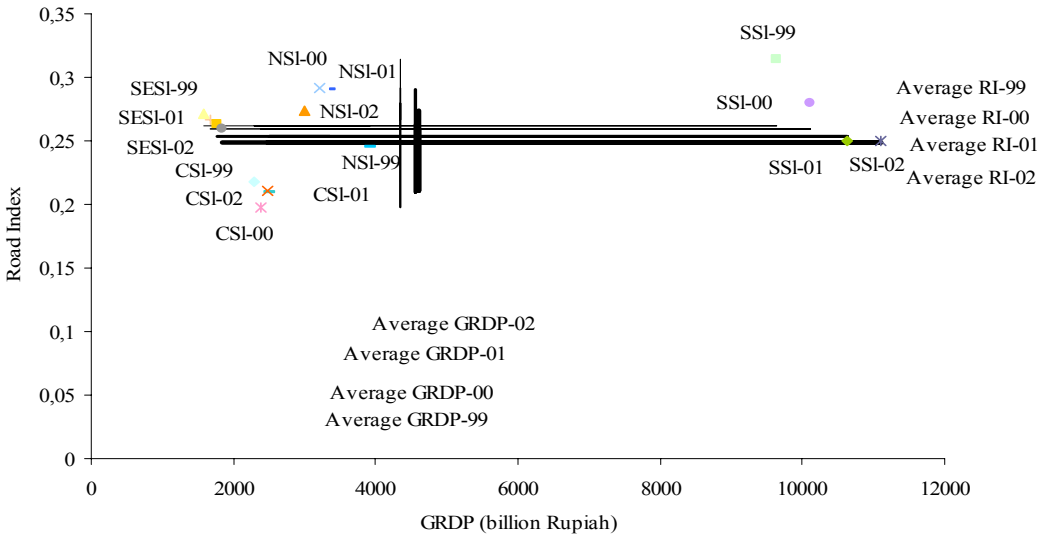


Figure 15. Relationship between Road Index and GRDP in Sulawesi Island

5. CONCLUSIONS

Based on the analysis to the data of road network in twelve provinces located in Sumatra, Kalimantan, and Sulawesi islands, it can be studied the performance of its road network. The road performance studied using four indicators, namely road performance, road availability, traffic load, and road services. Those indicators in each provinces calculated using aggregate data in provincial level from 1999 to 2002. Using statistical analysis, it can be drawn a conclusion about each road indicators that there is significant difference among provinces. The analysis also shows that there is no significant difference for each road indicators among times, which is represented by year.

Based on the four indicators, the road index can be calculated. The road index is simply the composition of the road indicators with its weight. According to the analysis, there is no significant different using different weight for each indicator in producing road index. It means the road index is just the average of the four indicators in each province and each year.

The performance evaluation conducted in this research has a concern to study the effectivity of road network in each province and national level. The effectivity measurement is expressed by the relation of road condition (output) and GRDP (outcome). Each island (in this research each island is represented by four provinces) has specific pattern of output and outcome relations. The relation can be expanded by employ input variabel, which also produces specific relations. The data from twelve provinces in four years is further applied to build a model between outcome and output, which has a coefficient of determination 0.437.

Further analysis is conducted to study the effectivity condition of each province in each year by comparing to the average of island aggregation. This analysis can show four effectivity conditions for each province, which expresses in four quadrant. Each quadrant relates to a specific condition of its GRDP and its road index, which is compared to the yearly average of GRDP and average of road index. Ideally the provinces with high road index (output) will produce high GRDP (outcome), and it is hoped that each provinces has an increasing road index and increasing Gross Regional Domestic Product.

The analysis shows that there is a slight increasing outcome from 1999 to 2002 in the study area, but there is fluctuation in output condition from 1999 to 2002. The provinces with high road index not always creates high outcome (GRDP), but there are many provinces with low road index and low GRDP. The analysis can be used to make a prioritization of budget allocation to accelerate the increasing of GRDP (outcome) by allocating resources in road network development.

Further study is needed to build a more comprehensive model to explain the input, output, outcome, and impact. The study needed is especially in dis-aggregate area, like city or municipal level. The short term benefit of the study is an application in practical use to allocate the limited budget, while the long term benefit is to study the relationship of road network performance evaluation with economic development in case of Indonesia.

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