DEVELOPING PERFORMANCE INDICATORS FOR ROAD DEVELOPMENT IN INDONESIA

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Abstract: The road development in Indonesia has been focused only on the process of construction or physical provision. The attention still has not been given to the benefit and impact following the construction period. There has been no transparent evaluation standard to assess the performance of road development. This makes a comprehensive goal of road development is hard to be evaluated.

This paper reports the development of performance indicators currently carried out for road development in Indonesia. The identification of some potential indicators to be included was proposed. Criteria for selecting the most appropriate indicators were developed. Finally, the application of the selected performance indicators onto performance monitoring of provincial road developments was also reported.

Key Words: development, indicator, performance, road

1. INTRODUCTION

It is widely accepted that road development has a significant impact toward many aspect of life, such as economic, social, cultural, even state defence and security, and most importantly toward the quality of the environment and the quality of life. However, road development projects still focused on the process of physical provision or construction aspect only, in

which post-construction effects, such as benefit and impact of the road provision are still not evaluated proportionally.

With the increasing public awareness in which people and society become more critical toward government's responsibility in handling road development and its impact, it is therefore necessary to develop road performance indicators for performance monitoring purposes. These include measuring a project's progress toward explicit short and long-term objectives, and giving feedback on the results to decision-makers for improving road performance in the future.

This paper reports the development of performance indicators currently carried out as part of Government of Indonesia, Ministry of Settlement and Regional Infrastructure 's research effort in introducing road performance evaluation standard in Indonesia.

2. PREVIOUS STUDIES

2.1 Road Performance Indicators, World Bank (1996)

In developing the performance indicators from a project's objectives and components, it is required some understanding of the concept of the logical framework. The logical framework is a methodology for conceptualising projects and an analytic tool that has the power to communicate a complex project clearly and understandably on a single sheet of paper (Mosse & Sonteimer, 1996). It is a participatory planning tool whose power depends on how well it incorporates the full range of views of intended beneficiaries and others who have a stake in the project design. It is best used to help project designer and stakeholders:

- Set proper objectives
- Define indicators of success
- Identify key activity clusters (project components)
- Define critical assumptions on which the project is based
- Identify means of verifying projects accomplishments
- Define resources required for implementation

The logical framework can be used to help in developing tools for project implementation and evaluation. Knowing its advantages and limitations helps in assessing the value of the logical framework methodology at various points in the projects cycle, as shown in Figure 1.

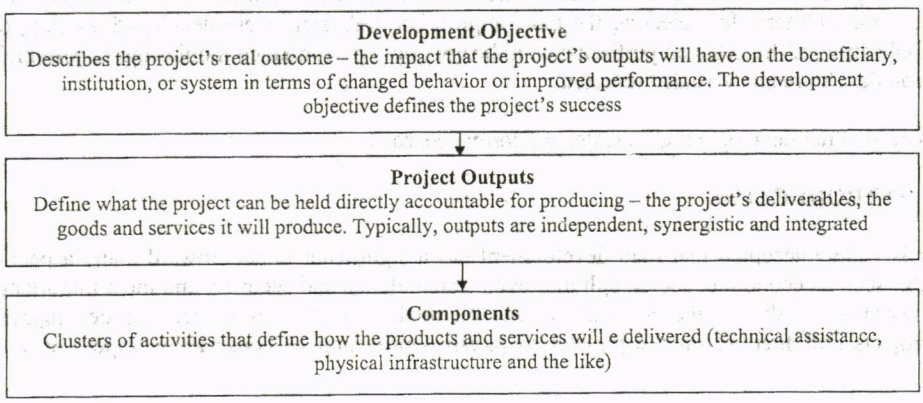
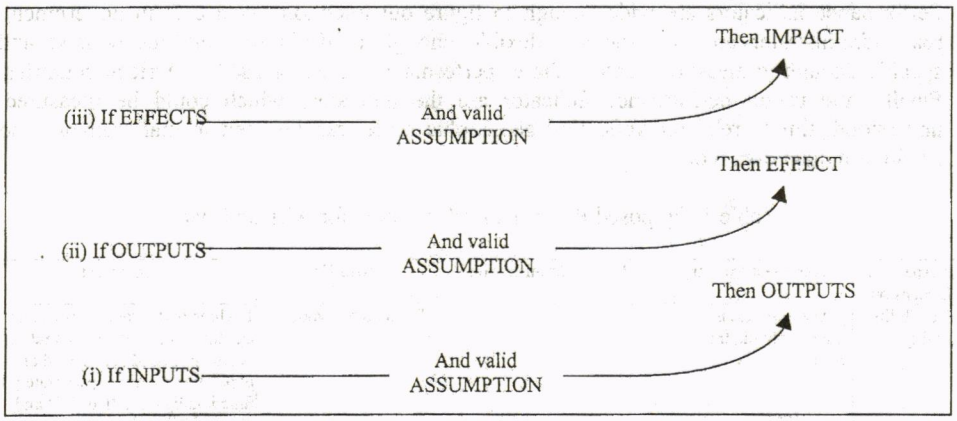


Figure 1. Point of View of the Logical Framework

The resulting indicators measure project accomplishment relative to project objectives. Results are measured at the level determined by a project's objectives. Based on logical framework approach, the indicators should be defined starting with the impact and outcome indicators (and working backward to the input indicators). These, however, require an extensive database of road network condition and its traffic performance for imputing before indicators can be established. As data collection and database provision are expensive, it is necessary to justify the number of indicators to be included, but sufficient, so that costs for data gathering were effectively utilised.

Government of Indonesia as part of World Bank research project has compiled Road Performance Indicator (1996), especially for national and provincial roads. A set of cause and effect relationship between three related aspects, viz. input → *output*, *output* → *outcome*, *outcome* → impact, has been adapted (ADB, 1992). This framework is illustrated in Figure 2.



Source: Asian Development Bank, 1992

Figure 2. Logical Framework of a Project

This logical framework is also assuming some hierarchical target in a project. There is no number of level limitation, however, there is often found some difficulties in managing more than 4-hierarchy level. In the framework, World Bank used indicators specified in 3-target level, input in project activity, output from project activity, and outcome and impact. For World Bank needs, input and *output* directly correspondence to project management, whilst *outcome* and impact correspond with the project goal and objectives. At the end, the project has to show the target (quantified objective) which related to the realisation of the national development goal as a whole.

Performance indicator should be designed within this logical framework. The framework development is started by project goal and reflecting the relationship of activities hierarchical as well as expected *output and outcome* for each project components. The activities carried out and the results obtained in lower level target would become an input to obtain the results in higher level, institutional level, sectors programs or even national level. Indicator definition in each level refers to the final target or the highest level.

Within this study, 18 aspects of objective and 67 indicators were proposed. It was understood that this is the most complete list of indicators, but operationally it is very complex, difficult in terms of database provision and backup.

2.2 Road Sector Performance Indicators in African Countries (World Bank)

This study was started from the public awareness toward the responsibility of road administrator to deliver better road service and system performance. Apart from the effort made in some countries, there is no clear measurement or standard evaluation comparison for road performance indicator.

List of possible and feasible performance indicators could be very long, therefore it has to be classified. This classification represents the fundamental role of transportation through the 7 aspects of objective, viz. mobility, accessibility, safety, environment, equity, energy preservation and economic development, and with 20 indicators. These set of objectives and indicators were cross-viewed from 3 perspectives, government, road administrator, and user/society.

Performance indicators are wide enough to figure out intention essence from government, road administrator and user/society; flexible enough in different countries context and specific enough to measure. Table 1 shows performance indicator used in African countries. Finally, the useful performance indicator are the indicators which could be measured, understood, timely relevant, reflecting geographic scale, can be used in management, and useful as a diagnoses tools.

Table 1. Proposed Performance Indicators for African Roads

Perspective Dimension	Government Ministry	Road Administration	Road User	Comments
Accessibility Mobility	1. Average road user cost (car, truck, trailer truck)		2. Road Network	1. Three part: producer price, tax and tariff for road administration 2. Km/sq. km of arable land or population by region; separately for functionally classified (FC) and community roads.
Safety	3. Accident risk: fatality and injury accidents/veh-km		4.Unprotected road user risk	3. No. of fatalities and injuries 4. Nonmotorized fatalities and injuries
Environment		5. Environmental Policy or Program		5. Yes or No; elaboration required (e.g. phasing in of non-leaded fuel; treatment of polluting vehicles; etc.)
Equity Community		6. Percentage of population within 10 km of a classified road	7. Processes in place for customer/road user feedback	6. Or within 2 hrs. walking time. 7. Yes or No; a method to obtain information of social benefits and costs.
	8. Rolling multi-year program for construction, maintenance, and operations 9. Percent completion of annual work program	10. Data bank for FC roads 11. PMS system distribution of funds by region, functional class, and for prioritizing and rehabilitation and maintenance actions		8. Yes or No; elaboration required 9. By program (construction/ maint./oper.) 10. Yes, or no: elaboration required on data collection methods and updating. 11. Yes or No; elaboration of principles
Perspective Dimension	Government Ministry	Road Administration	Road User	Comments
Program Delivery		12. Forecast values of road costs vs. the actual costs 13. Percent of work done by direct labor and parastatals	14. Percent of gravel roads formed twice or more times a year	12. By FC and program (construction, maintenance, operations). 13. A measure of competition
Program Performance	15. Value of assets	16. Paved road roughness (IRI) 17. Bearing capacity/deflection 18. Thickness of gravel surface 19. Defective bridge deck area	20. No . road closings and road closing days	15-17. By FC 18. Gravel roads only 20. Percent links and percent time closed by FC
Final Conditions	Possible descriptors are: (1) population (urban/rural); (2) GDP; (3) vehicle fleet by type; (4) fleet without emission control; (5) current road administration budget by program ; (6) veh and ton km of travel and traffic volumes by FC (weighted by link length); (7) modal split for passenger and freight (all road modes); (8) congestion: weighted road-km with Volume/Capacity >1 by FC			

2.3 Road Performance Indicators: US Federal Highway Administration (FHWA)

Performance plan proposed by FHWA as part of the President's Fiscal Year 2001 budget. It was a continuation of FHWA FY 1998 Strategic Plan. This plan defines annual performance target and their indicator used to measure a progress made to achieve the goal. Surprisingly in the USA, only a limited number of aspect and subsequent indicators were proposed. The strategic goal of FHWA with the indicators is listed in Table 2.

Table 2. FHWA Road Performance Indicator (2000)

Performance	Strategic goal	Performance goal	Performance indicators
Safety	Continually improve highway safety	Reduce the rate of highway-related fatalities and injuries	Rate of highway-related fatalities per 100 million vehicle miles traveled (VMT)
Mobility	Continually improve the public's access to activities, goods, and services through preservation, improvement and expansion of the highway transportation system and the enhancement of its operations, efficiency, and intermodal connections	Increase the percentage of kilometers (miles) on the national highway system that meet owner - agency managed pavement performance for acceptable ride quality IRI ≤2,68 m/km (170 in/mi)	Percent of kilometers (miles) on the national highway system that meet pavement performance standards for acceptable ride quality IRI ≤2,68 m/km (170 in/mi)
Productivity	Continuously improve the economic efficiency of the Nation's transportation system to enhance national position in the global economy	Reduce the cost of highway freight per ton-kilometer	Cost of highway freight per ton-kilometer
Human and Natural Environment	Protect and enhance the natural environment and communities affected by highway transportation	Increase public satisfaction with highway systems and highway projects as a beneficial part of their community	Percent community satisfaction with the Nation's highway contribution to meeting community goals
National Security	Improve the Nation's national defense mobility	Improve access between key military installations (including power projection and power support platforms) and the air or seaport point of embarkation	The indicators will be developed

Source: http://www.fhwa.dot.gov/policy/pp2k01.htm

2.4 Study Package D7, Directorate General Bina Marga, Government of Indonesia

In late 1999 a study was initiated to develop road performance indicators, and was reported in March 2000. In this study, performance indicators were viewed from government, road user and non-user perspectives categorized under aspects or criteria such as productivity, effectiveness, mobility, environment, etc. The list of indicators may be suggested different for each location, depending on the social, cultural and economic condition in each region.

At least 15 aspects of objectives and 18 indicators representing road service delivery were proposed, seemingly to be based and simplified from World Bank (1996) list of indicators. It was recommended that those indicators should further be refined and subsequent works should be focused for data collection methodology and provision.

From road manager point of view, important aspects to be included generally similar for each regional area under study such as on asset and their values. It was perceived that the financial and economic aspects are not the main goal, as the availability of fund is considered to be the central government obligation to provide.

From road user point of view, the proposed performance indicator is perceived important and also not significantly different from area to area under study. However, the method or formula used to provide the data should be further developed, so that the total road assessment could fulfill its goal. The road performance indicator viewed by non-user has similarity with those viewed by government, this would be double counted although different weight could be introduced for each, for instance, indicators related to land value estimation.

3. DEVELOPMENT OF ROAD PERFORMANCE INDICATOR

To obtain an understanding and the same perception about development project, the approach of logical framework were adapted, which consists of input, output, outcome, benefit and impact. Based on this approach as well as from literature review Table 3 gives a long list of proposed indicators considered to be the most suitable for Indonesian condition.

Table 3. Long List of Proposed Road Performance Indicator

	Aspect/Criteria/ Dimension	Indicators
Input	Productivity	Road Development Expenses
		Road Maintenance Expenses
	Financial	Regional Government Expenses for Road
	Institutional	Contract Expenses for Road Development
	Structure	Program Ownership Structure Based on Decentralization Level
Output	Asset	Artery Road Length Collector Road Length Local Road Length
Output	Effectiveness Asset Preservation	Road Pavement Preservation
		Bridge Preservation
		Pavement Asset Condition (good)
		Bridge Asset Condition (good)
		Road Quality (IRI)
Outcome	Production Effectiveness	Traffic Volume
		Volume Capacity Ratio
	Mobility	Travel Time (average speed)
	Defense (and Security)	National Defense (Accessibility to the military installation – average distance to the primary network system)
Benefit	Program Effectiveness	Program Benefit
		Vehicle Operating Cost Index
	Level of Risk	Fatalities Risk
	Resources Cost	Fuel Consumption
Impact	Environment	Noise Pollution Air Pollution
	Economic	Land Value (real) land taxed value (mortgage) GRDP GRDP Growth

3.1 Comparing the Proposed Indicator with the Previous Studies

The comparison of proposed indicators with the previous studies, especially the Package D7 of Bina Marga, can be seen in Table 4. Remarks and the existence of the corresponding indicator was also commented.

Table 4. Comparison of Proposed Indicator with Previous Studies

Groups Interested	Assessment Aspect	Assessment Parameter	Dimension	Previous Study *)	Proposed	Remark
Providers	Productivity	Expenditure	Development, maintenance, operational (Rp)	√	√	
		Work Saving	Development, maintenance, operational (Rp/year)	√		Eliminated due to double counting with the expenditure parameter
	Effectiveness Asset Preservation	Standard of Preservation	Pavement-length km, % no. of bridge/length	√	√	
		Asset Condition	Pavement-length km, % no. of bridge/length	√	√	
		Road Quality	% road length with IRI < 6m/km compared to the road length		√	Added because can be assessed directly
	Program Effectiveness	Program Benefit	Total NPV total and average per km	√	√	
	Facility Production Effectiveness Cost Effectiveness	Production from Facility Provision	Production (kg)/yr each km or km^2 road, Rp/yr/km or km^2	√	√	The unit is changed to veh.km/year, passenger.km/year, ton.km/year and % road length with VCR > 0.85
		The change of road quality vs volume and expended cost	(m/km)/pcu-Rp)	√		Eliminated because it has been considered in preservation asset effectiveness aspect
	Land Value	Land Value	Real value, land taxed value (Mortgage)	√		Eliminated because has been calculated by non-user
	Institutional	Contract Expenses	Rp, % total	√	√	Unit is changed to be % total road expense
Regula-tors	Asset	Road Length	km (based on road class)	√	√	Dimension is added by function and road status
	Financial	Road Expenditure	% government expenditure involved	√	√	Dimension is changed to % expenditure relative to the total regional budget
	Defense and Security	Accessibility to the Military Installation – average distance – to the primary network system	Road Km		√	Added due to road's defense and security function
	Structure	Ownership program structure based on decentralization level	% road program managed by regional government	√	√	
Users	Mobility	Travel time	Sample from every road class	√	√	Dimension is changed to km/hour
	Risk Level	Fatalities Risk	Fatalities/million veh.-km	√	√	
	User cost	Average vehicle operating cost	Average VOC	√		Dimension is changed to be Rp/km and added with passenger travel cost (Rp/km/passenger) and goods travel cost (Rp/km/ton)
	Resources cost	Fuel consumption	Liter/vehicle yearly	√	√	
Non-user	Land value	Land value	land taxed value (mortgage)	√	√	
	Environment	Pollution	Noise pollution (dB), emission rate (ton/year)	√	√	
	Economic	Gross Regional Domestic Product	Rp		√	Added because GRDP has correlation with road development
		GRDP growth	%		√	Added because GRDP has correlation with road development

*) Road Performance Indicators, Study Package D7, Bina Marga, March 2000.

There are some difficulties in distinguishing between *output* and *outcome from one project, or between outcome* and *impact*. Therefore, it has to consider indicator typology as a logical framework in formulating the goal or the target of the project: *input of activity gives an* output, which contribute toward *outcome* benefit and impact. This aspect should be presented by each indicator. Impact indicator is very difficult to be obtained and measured, due to the time lag between project implementation and its impact realisation. The assessment from interview data is one of the methods, which quite successfully used to obtain the data qualitatively. Survey on "before and after" project implementation is also a good method to collect a comprehensive impact data. However, time and budget constraint makes this method does not practical to monitor regular projects. Moreover, the final indicator selected should also consider the data availability, as availability of data is an important part in project performance assessment.

3.2 Type of Data Required

From the long list indicator, the next discussion is moved to the type of data and the procedure to obtain the value of each indicator. In general, the type of data required can be categorised into 2 groups, actual data and estimation data. Actual data is the data that has been available and ready to be used without any further analysis. This kind of data is related to the input and output data, such as government expenses for road development, road distance, etc. Meanwhile, Estimation data is the data that is derived from a calculation of basic data, which can also be the actual data) and has a lot of relation with the data beside the input data.

The calculation is carried out, especially, to obtain the indicators related to the utilisation of transportation system, such as operation speed, travel time and travel distance, vehicle operating cost and environment affect which as directly related to the air pollution.

Each corresponding data can be obtained from the source listed below,

- Regional Income and Budget Plan (Regional Planning Board));
- Integrated Road Management System /IRMS data (Directorate General of Highway);
- Estimated data (from spreadsheet)

3.3 Data Compilation and Database Provision

There are three possible sources of data: primary (real measurement or survey), secondary sources and estimated. It is highly desirable to obtain all the related data from real primary measurement in the field. However not all of the output (operational benefit) data can be gathered from a real survey, as effect of road investment (input) will take sometime to be materialized. Therefore much of the benefit data were preferably estimated from a procedure as proposed herein.

The estimated data is provided through a procedure shown in Figure 3. The most basic or actual data used are from IRMS data.

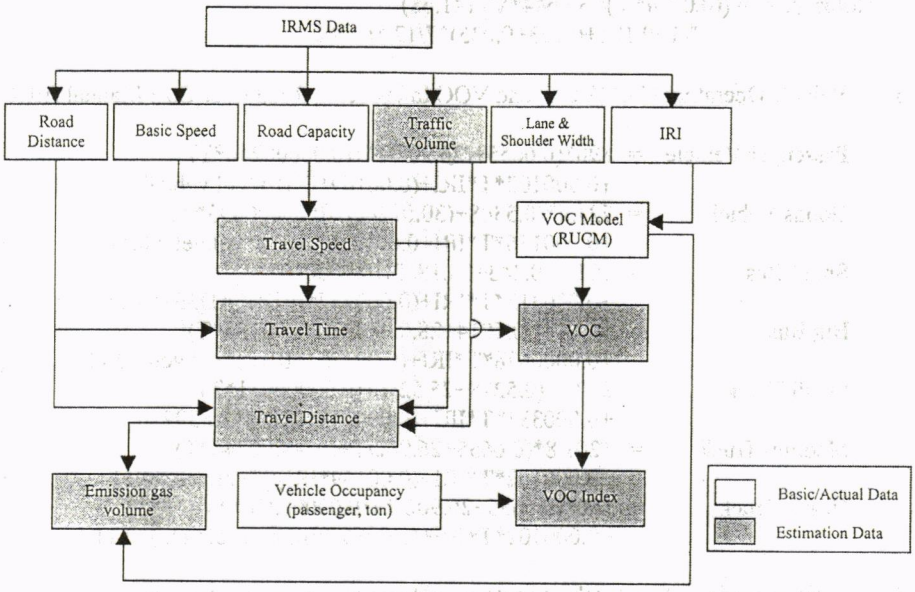


Figure 3. Procedure for Estimated data provision

Meanwhile, formulas used in the calculation are listed below,

1. Travel Speed (V – km/hour)
   V = *free flow speed* x 0,5 x (1 + (1 – (volume/eff. capacity)))^{0,5},
   for volume < eff. capacity (1)
   V = *free flow speed* x 0,5, for volume ≥ eff. Capacity (2)

2. Travel Time (T - second)
   T = Road length / (travel speed x 3600) (3)

3. Travel Distance (L_{trip} – veh.km/year; passenger.km/year; ton.km/year)
   $$L_{trip} = \left(\sum_{i=1}^{n} volume_i * road\ length_i \right) / (0{,}11 * 365) \quad (4)$$

4. Travel Time (T_{trip} – veh.hour/year; passenger.hour/year; ton.hour/year)
   $$T_{trip} = \left(\sum_{i=1}^{n} (volume_i * V_i) / 3600 \right) / (0{,}11 * 365) \quad (5)$$

5. Fuel Consumption using PT Jasa Marga's VOC Model (1996)

   $$Car = ((0.0284*V)^2 - 3.0644*V + 141.68) * (1+0.121+0.253+0.035) / 1000 \quad (6)$$

   $$Bus\ \&\ Truck = 2.26533*((0.0284*V)^2-3.0644*V+141.68) * (1+0.121+0.253+0.035)/1000 \quad (7)$$

$$\text{Motorcycle} = ((0.0284*V)^2-3.0644*V+141.68) *(1+0.121+0.253+0.035)*7/12.5/1000 \quad (8)$$

6. Vehicle Operating Cost (VOC) and VOC Index using Road User Cost Manual (RUCM)

$$\text{Passenger Vehicle} = 890*(0.6655+(26.902/T)+(0.00000246*T)^2 +0.000102*T*IRI+(0.00169*IRI)^2)*\text{vol.veh.}*0.11 \quad (9)$$

$$\text{Goods Vehicle} = 721.4*(0.5348+(30.022/T)+(0.00000893*T)^2 +0.000136*T*IRI+0.001216*IRI)^2)*\text{vol.veh.}*0.11 \quad (10)$$

$$\text{Small Bus} = 1033*(0.443+33.18/T+(0.0000101*T)^2 +0.000312*T*IRI+(0.000757*IRI)^2)*AD397*0.11 \quad (11)$$

$$\text{Big Bus} = 1493.7*(0.5014+28.039/T+(0.0000185*T)^2 +0.0000678*T*IRI+(0.001734*IRI)^2)*\text{vol.veh.}*0.11 \quad (12)$$

$$\text{Small Truck} = 880.6*(0.5278+25.52/T+(0.00000931*T)^2 +0.000333*T*IRI+(0.000743*IRI)^2)*AF397*0.11 \quad (13)$$

$$\text{Medium Truck} = 1201.8*(0.6655+26.902/T+(0.00000246*T)^2 +0.000102*T*IRI+(0.00169*IRI)^2)*\text{vol.veh.}*0.11 \quad (14)$$

$$\text{Heavy Truck} = 890*(0.6655+26.902/T+(0.00000246*T)^2 +0.000102*T*IRI+(0.00169*IRI)^2)*(\text{vol.veh.})*0.11 \quad (15)$$

7. Emissions of car, bus, truck and motorcycle can be calculated using formula:

$$CO = 195{,}05 * 0{,}9 * \text{fuel consumption} * \text{vol. veh.} \quad (16)$$

$$NOx = 21{,}35 * 0{,}9 * \text{fuel consumption} * \text{vol. veh.} \quad (17)$$

$$HC = 18{,}51 * 0{,}9 * \text{fuel consumption} * \text{vol. veh.} \quad (18)$$

$$CO_2 = 2.597 * 0{,}9 * \text{fuel consumption} * \text{vol. veh.} \quad (19)$$

4. THE FORMULATION OF THE INDICATORS

In this stage, an in depth analysis was carried out toward performance indicator choices developed before (*long list indicator*). The steps of analysis are shown in Figure 4.

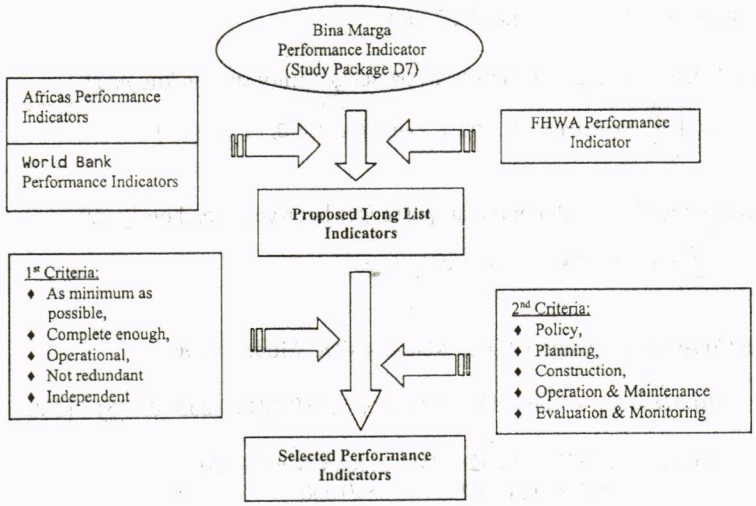


Figure 4. Formulation of Road Performance Indicators

4.1 Long List Selection: Step 1

Having evaluated the long list using criteria in stage I, the proposed indicator can be seen in Table 5.

Table 5. Indicator Selection Based on the Easiness of Data Provision

	Aspect / Criteria / Dimension	Indicators	Level of Difficulty			
			West Sumatera	Special District of Yogyakarta	Central Kalimantan	West Nusa Tenggara
Input	Productivity	Road Development Expenses	****	****	****	****
		Road Maintenance Expenses	****	****	****	****
	Financial	Regional Government Expenses for Road	****	****	**	****
	Institutional	Contract Expenses for Road Development	****	****	****	****
	Structure	Program Ownership Structure Based on Decentralization Level	****	****	****	****
Output	Asset	Artery Road Length	****	****	****	****
		Collector Road Length	****	****	****	****
		Local Road Length	*	*	*	*
	Effectiveness Asset Preservation	Road Pavement Preservation	**	**	**	**
		Bridge Preservation	**	**	**	**
		Pavement Asset Condition (good)	**	**	**	**
		Bridge Asset Condition (good)	**	**	**	**
		Road Quality (IRI)	****	****	****	****
Outcome	Production Effectiveness	Traffic Volume	****	****	****	****
		Volume Capacity Ratio	****	****	****	****
	Mobility	Travel Time (average speed)	****	****	****	****
	Defense (and Security)	National Defense (Accessibility to the military installation – average distance to the primary network system)	*	*	*	*
Benefit	Program Effectiveness	Program Benefit	*	*	*	*
		Vehicle Operating Cost Index	****	****	****	****
	Level of Risk	Fatalities Risk	**	**	**	**
	Resources Cost	Fuel Consumption	****	****	****	****
Impact	Environment	Noise Pollution	*	*	*	*
		Air Pollution	****	****	****	****
	Economic	Land Value (real)	*	*	*	*
		land taxed value (mortgage)	****	****	****	****
		GRDP	****	****	****	****
		GRDP Growth	****	****	****	****

**** = Fully available
*** = Available for the most
** = Not much available
* = Rare

From Table 5, it can be seen that the indicators with (*) is the least preferred data provision in almost all study area.

4.2 Long List Selection: Step 2

Based on the purpose of indicator, the proposed indicators can be seen on Table 6.

Table 6 Indicators selection based on their usage

Indicators	Unit	The Use of Indicators			
		Strategic Planning	Construction	Operation & maintenance	Monitoring & Evaluation
Development Expenses & Rehabilitation	Rp.	X	X		X
Maintenance Expenses	Rp.	X		X	X
Government Expenses for Road	% to the Regional Government Budget Planning	X	X		X
Road Development Expenses based on Contract	Rp.	X	X		X
	% road expenses	X	X	X	X
Program Ownership Structure Based on Decentralization Level	% km road program managed by regional government to the total km	X		X	X
Arterial Road Length	Km	X	X	X	X
Collector Road Length	Km	X	X	X	X
Road Pavement Preservation	% - km	X		X	X
Bridge Preservation	% - number of bridge	X		X	X
Pavement Asset Condition (good)	% - km road with IRI < 6 m/km	X		X	X
Bridge Asset Condition (good)	% - no. of bridge	X		X	X
Production (traffic volume)	veh-km/year	X		X	X
	Passenger-km/year	X			X
	ton-km/year	X			X
Production (Volume Capacity Ratio)	% km > 0,85	X		X	X
Travel time (average speed)	km/hour	X		X	X
VOC index	Rp/km	X		X	X
Passenger travel cost	Rp/km/passenger	X			X
Goods travel cost	Rp/km/ton	X			X
Fatalities Risk	Fatalities/million veh-km	X		X	X
Fuel Consumption	Liter/year	X			X
Noise Pollution	DB	X			X
Air Pollution	Nox, Sox, particulates	X			X
Economic	GRDP	X			
	Economic growth	X			

Those indicators, either from stage I and II, are still possible to be reduced or added, depending on local characteristic needs.

4.3 Developing Evaluation System

The next step is dealing with evaluation mechanism to know how these indicators assessed to determine performance condition. There are some methods, which could be used to evaluate this. First, the indicator values can be directly compared with the standard values. Then their results could be categorised into poor, fair or good based on the comparison made before. The difficulties in this method are unavailability of standard values for some indicators. However, this standard could be developed and determined later.

Secondly, the evaluation can be made by assessing efficiency, effectiveness and sustainability objectives. Efficiency is measured by comparing input to output. Whilst effectiveness is comparison of output to outcome and sustainability is measured from comparison of outcome to impact. Illustration of this relationship is shown in Figure 5.

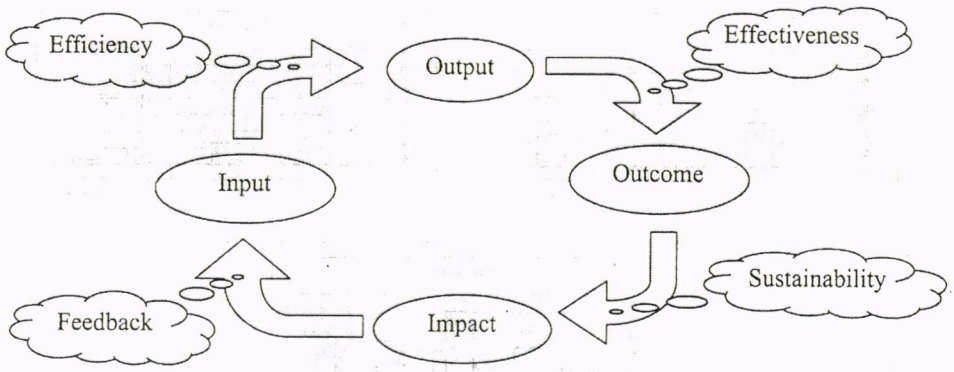


Figure 5. Cycle of Input-Output-Outcome-Impact

The formula to calculate those aspect or objectives is as follows:

$$\frac{\text{Output}}{\text{Input}} \longrightarrow \text{Efficiency and Productivity}$$

$$\frac{\text{Outcome}}{\text{Output}} \longrightarrow \text{Effectiveness}$$

$$\frac{\text{Impact}}{\text{Outcome}} \longrightarrow \text{Sustainability}$$

The next calculation is dealing with the determination of single indicators represent each group (i.e input, output, outcome, or impact). In this study it was determined as follows:

- Input is represented by indicator expenditures - (Rp)
- Output is represented by indicator road length - (km)
- Outcome is represented by indicator production (i.e traffic volume) – (veh.-km/year)
- Impact is represented by indicator air pollution CO – (ton/year)

Figure 6 illustrates the estimation of efficiency, effectiveness and sustainability of each province graphically. Having estimates those aspects, assessment can be carried out by calculating Common Indicator (CI). CI is a single indicator represents performance of road and can be calculated using a formula as follows:

$$CI = \{(W_p \times \text{efficiency}) + (W_e \times \text{effectiveness}) + (W_s \times \text{sustainability})\} \times c$$

where:
W_p, W_e, W_s = weight of efficiency, effectiveness and sustainability respectively
c = constant

Figure 7 illustrate an example of CI calculation for each province, by assuming weight of efficiency, effectiveness and sustainability are 0,3, 0,5 and 0,2 respectively. In this case, Province of DI Yogyakarta have highest CI compared with the other provinces. This indicate that road development projects in DI Jogyakarta is considered as perform better relatively compared with other provinces.

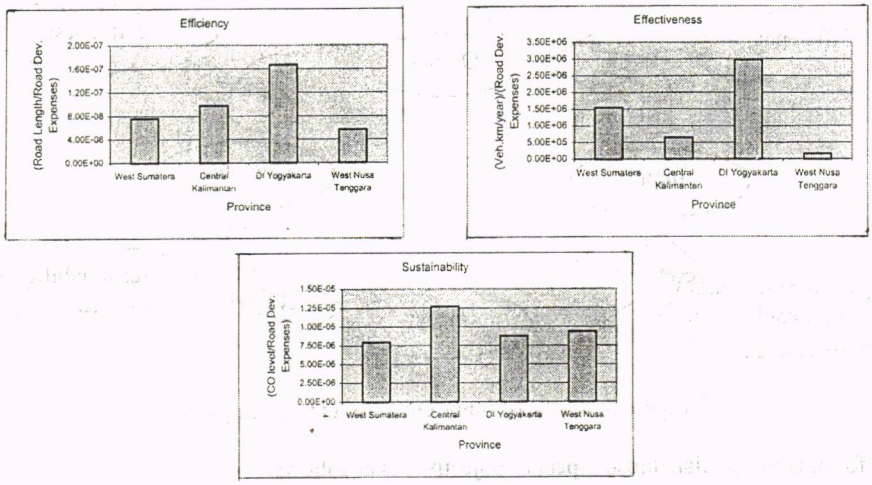


Figure 6. Estimation of Efficiency, Effectiveness and Sustainability Objectives

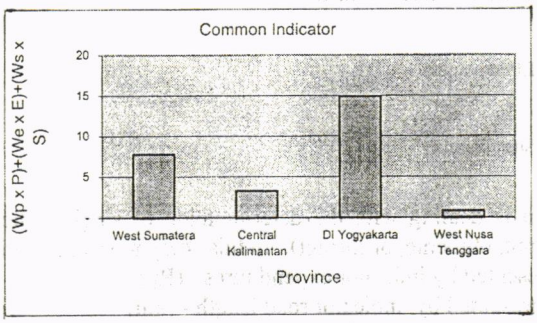


Figure 7. CI Value for Each Province Case Studies

Furthermore, the evaluation mechanism is also possible to be carried out by using different weight for each indicator. In this case, the weighing could be formulated using many techniques, such as through aspiration survey of stakeholders, etc. The final process of the evaluation could be carried out using Multi-Criteria Analysis, which was widely used technique nowadays in the evaluation field.

5. CONCLUSIONS AND RECOMMENDATION

From the study, it was concluded that:

1. Not all road performance indicators resulted from previous studies could be applied. Some of them have to be changed and modified or replaced for some reasons, among

others, if it was double counted on other indicators or if it was a complicated unit to be measured.

2. Two criteria were used to select the most appropriate indicators, i.e. :
   a. Related to individual indicator characteristic, viz. minimum, complete, practical/operational, not redundant and should be independent
   b. Related with its use, i.e. Policy, Planning, Construction, Operation and Maintenance, Evaluation and Monitoring

3. Assessment on performance indicator can be made based on efficiency, effectiveness and sustainability objectives. Calculating common indicator (CI), developed in this study can provide a representative single performance indicator. From the case study, it was revealed that DI Yogyakarta has a relatively better performance compared to other area.

It is worth noting that the final standard performance indicator to be used in other areas should be tested prior to its use. More case studies are required to ensure the proposed performance indicators are consistent and transferable applied onto other areas.

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