Strategy toward sustainable local road network infrastructure

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Abstract. With massive explosion of population, the urban inhabitants will rise up to 64% in 2050. This condition increases the pressure on the existing urban road infrastructure and requires substantial maintenance and often expansion of the inter/rural-urban as well as local road as mobility of people and goods upsurge extensively. The construction of these new network and maintenance of existing road infrastructures consumes huge natural resources which further might increase volume of waste and greenhouse gas emission. Currently, approximately 28% provincial road and 41% local (urban) road network in Indonesia are in unsatisfactory condition. There is obvious demand to improve regional road with minimum ecological impact despite limited amount of resources and budget. In achieving sustainable road network, local authorities require a strategy in tackling this complex, large-scale and interconnected problems. This study aims to formulate relevant strategy for local authorities – urban or inter rural-urban level within a province – in operation, maintenance and development of road network by applying strategic management principles. Rational decision model was used in strategy formulation in three consecutive steps: input stage, Matching stage, and Decision Stage. Rational decision model was also used in strategy establishment taking into account the Environmental Minister regulation and some important issues in the Department of public works employing sustainability concept. The strategy proposed is believed to be ecologically sound (environmentally friendly) while improving local road network quality.

1 Introduction

Civil infrastructure, especially road way, is a vital and essential for nation-development and economic growth. With massive explosion of population, the urban inhabitants will rise up to 64% in 2050. This condition puts the existing urban road infrastructure under pressure and requires substantial improvement of inter-urban as well as rural-urban road as the extensive mobility of people and goods upsurge.

The Directorate of Transportation of the Ministry of National Development Planning (BAPPENAS) reports that 28% of provincial road network and 41% of local road network are in unsatisfactory conditions. Further, the short design service life (10 years) even

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increased annualized life cycle coat. At the same time the road quality became deteriorated prematurely during its service life.

At the national level, however, the current Indonesian national road condition are quite well with 94% of it are in satisfactory.

Still, these are not the case for neither provincial nor local road network. Based on the 2014 transportation statistics, 171.295 km of 417.793 km of local road networks are in unsatisfactory conditions. It consumes a number of natural resources, increase waste volume, and require a massive human resources [1].

Therefore, a sound and sustainable planning, design, and construction approach is needed in road infrastructure development [2]. The sustainable concept is the crucial issue for the whole development activities, and even there is a growing demand to measure its implementation [3-6]. Applying sustainable construction via efficient contruction methods is appropriate strategy for project performance improvement [7]. In the strategic planning of the Ministry of Public Work and Housing, the sustainable development principle should be implemented in every building and infrastructure constructions. This principle harmonizes infrastructure and building constructions regarding environmental, climate, natural resources, economic, social and cultural aspects. Hence, such principles should be put into action in every building and infrastructure constructions including local road development.

2 Formulation of strategy

In general, the strategy is a method or plan chosen to bring about a desired future, such as achievement of a goal or solution to a problem [8]. Policy strategy is what government wants to change — its agenda, and the ways in which the agency will move to help it achieves this agenda. Strategy seems a good investment, provided it is done openly, and within acknowledged structures of accountability [9]. Strategic planning frameworks provide direction and justification for the flow of regularity and investment activity, which leads to changes in the location and form of development [10].

Rational Decision Model procedure as one of the comprehensive methods in formulating strategy has been suggested by David [11]. There are three stages to develop the procedure including input, matching, and decision. Each stage is shown in matrices which is consistent with the size and type of the organisation. Therefore, decision makers will be able to have an improvement in identifying, evaluating, and selecting the appropriate strategy.

Each of those three stages implies some necessary points to underline as stated in the following details. First, at the input stage, there are two kinds of matrix as Internal Factor Evaluation (IFE) and External Factor Evaluation (EFE) matrix. The IFE matrix is applied to acknowledge the internal factors of a company which are associated with the strengths and weaknesses that are considered necessary. Meanwhile, the EFE matrix is applied to evaluate the external factors of the company. We collect external data in analysing matters which relates to economic, social, cultural, demographic, environmental, political, governmental, law-related and technological issues and competition in markets where the company is located, among other relevant external data. Similarly, at the matching stage, we develop Strength Weakness Opportunities Threats (SWOT) matrix and Internal-External matrix (IE). The first step is to complete the SWOT items in the existing cells and then to develop alternative strategies with respect to the adjustment of internal to external factors.

It is imperative use alternative strategies logically consistent with various internal aspects of the company, according to the external trends, which are realistic and practicable

(feasible). IE matrix is used to position Strategic Business Unit (SBU) of the company into a matrix which consists of nine cells, as shown in Figure 1. The IE matrix comprises two dimensions (i.e., a total score of the IFE matrix on the X-axis and total score of the EFE matrix on Y-axis). Therefore, by looking at the company's position in the nine of these cells, a conclusion can be drawn to formulate the strategy as follows: SBU which is located on cell I, II, or IV can be described as Grow and Build. A suitable strategy would be applied as an intensive strategy, such as market penetration, market development, and product development. We can select another strategy, such as integration strategy, or backward, forward and horizontal integration. SBU which is located in cell III, V or VII can be described as Hold or Maintain. A suitable strategy is market perpetration or product development. For SBU which is located on cell VI, VIII or IX, the right strategy to choose would be Harvest or Divesture.

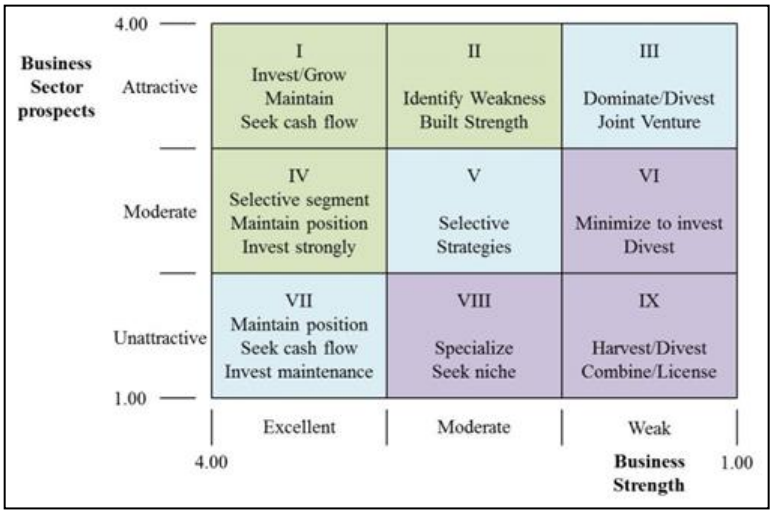

Fig. 1. Internal-External (IE) matrix [10]

The company which is able to control business in cell I will be the most successful company. Finally, at the decision stage, of the several alternatives available, Quantitative Strategic Planning Matrix (QSPM) is applied to select the best strategy. This technique provides an assessment of which strategy is the most appropriate. QSPM applies a matrix input from an external matrix, internal matrix, SWOT matrix and IE matrix. The highest Total Attractiveness Score (TAS) determines the strategy the contractors should apply.

In this study aims to formulate relevant strategy for local authorities-urban or inter rural-urban level within a province – in operation, maintenance and expansion of network by applying strategic management principles. Data were obtained through questionnaires and interviews. The participants of the research were road management, road planner, and road contractor in Central Java, Indonesia.

3 Result and discussion

3.1 SWOT factors

Prior to formulating a strategy toward sustainable local road network infrastructure, it is necessary to examine their current situation, condition, and SWOT (strength, weakness,

opportunity and threats). This was carried out through interviews and questionnaires representative respondents. The following section describes the result of the survey and the process of formulating strategies. Table 1 recapitulates the result of SWOT factors inventory.

Table 1. SWOT factors

Strength	Weakness
1. Road has a significant role in the spatial structure and formation. 2. Road is an important infrastructure in advancing the economic growth. 3. An alternative funding concept has continuously developed to overcome the lack of adequate funding. 4. The human resources quantity of Directorate General of Highways is relatively large. 5. Government's commitment to build and to develop road	1. The condition of local road network quality is relatively low. 2. The sustainability aspects in the life cycle of local road design, construction, operational, and maintenance is not put into consideration yet 3. The road prescribed design life is still short-term oriented, which is approximately 7-10 years. 4. The management of environmentally friendly road construction is not yet optimal. 5. The low quality of human resources of local road management.
Opportunity	**Threats**
1. The development in the road innovation and technology concerns the aspects of sustainability, safety, and quality improvement. 2. Provincial Road Improvement and Maintenance (PRIM) funding schemes for local road. 3. The road preservation funding scheme is implemented in accordance with Act Number 22 Year 2009 on Traffic and Road Transportation. 4. The existence of international cooperation in road construction such as IMG-GT, BIMP-EAGA, Asian Highway, and ASEAN Highway. 5. There is an existence of bureaucracy reform planned by government in embodying the good governance.	1. The population growth followed by the massive growth of motor vehicle. 2. The geologic geographic condition (volcanoes, faults, monsoon, etc) poses threats of natural disasters and high rainfall. 3. The delays in the arrangement of regulatory framework needed for innovative funding and road preservation. 4. The institutional unit related to local road development is not yet integrated in supporting the local target. 5. Government (Directorate General of Highways) has not yet owned an accurate and accountable database of local road as a basis in the appraisal for Local Government proposed program.

3.2 SWOT matrix

SWOT factor analyses were then followed by developing of SWOT matrix. After filling SWOT items in the existing cells, the process of alternative strategy development took into account the appropriateness of internal factors (strength and weakness) and external factors (opportunity and threat). The S-O analysis was conducted in this part. This was to analyse how the strengths can be used to benefit the advantage provided by the opportunities. While W-O analysis was conducted to how the weakness can be coped with the existing opportunities. The S-T analysis was performed to study how the strengths can be used to overcome or minimalize the existing threats. Finally, the W-T analysis was carried out to analyse how the weakness can be solved to minimalize the threats. The alternative strategy

produced should be realistic and implementable. The result of analysis is presented in Table 2.

Table 2. SWOT matrix

	STRENGTH S1. Government's commitment to build and to develop road S2. An alternative funding concept has continuously developed to overcome the lack of adequate funding S3. Road is an important infrastructure in advancing the economic growth. S4. The human resources quantity of Directorate General of Highways is relatively large. S5. Road has a significant role in the spatial structure and formation	**WEAKNESS** W1. The condition of local road network quality is relatively low. W2. The sustainability aspects in the life cycle of local road design, construction, operational, and maintenance is not put into consideration yet W3. The road prescribed design life is still short-term oriented, which is approximately 7-10 years. W4. The management of environmentally friendly road construction is not yet optimal. W5. The low quality of human resources of local road management.
OPPORTUNITY O1. The development in the road innovation and technology concerns the aspects of sustainability, safety, and quality improvement. O2. Provincial Road Improvement and Maintenance (PRIM) funding schemes towards local road. O3. The road preservation funding scheme is implemented in accordance with Act Number 22 Year 2009 on Traffic and Road Transportation. O4. The existence of international cooperation in road construction such as IMG-GT, BIMP-EAGA, Asian Highway, and ASEAN Highway. O5. There is an existence of bureaucracy reform planned by government in embodying the good governance.	**S-O Strategy** 1. Building a stable transportation connectivity concerning aspects of sustainability, safety, and quality improvement in order to support and encourage the local economic development. (S1,S3,O1) 2. Establishing international cooperation in the road construction in order to improve the quality of road. (S1,S2, O4) 3. Improving the human resources competence and conducting capacity building to embody good governance.(S4,O5) 4. Maximizing the PRIM funding schemes to build and to develop local road. (S2, O2)	**W-O Strategy** 1. Improving the quality of local road network by applying PRIM funding schemes and preservation funding schemes. (W1,O2,O3) 2. Implementing performance based pavement design taking into account sustainability, safety, and quality. (W3,O1) 3. Implementing environmentally friendly roads management by using innovative and sustainable technology. (W4,O1)
THREATS T1. The population growth followed by the massive growth of motor vehicle.	**S-T Strategy** 1. Developing concept and regulatory framework towards innovative funding	**W-T Strategy** 1. Improving the quality of local road network supported by related

T2. The geologic geographic condition (volcanoes, faults, monsoon, etc.) poses threats of natural disasters and high rainfall. T3. The delays in the arrangement of regulatory framework needed for innovative funding and road preservation. T4. The institutional unit related to local road development is not yet integrated in supporting the local target. T5. Government (Directorate General of Highways) has not yet owned an accurate and accountable database of local road as a measurement in the appraisal of Local Government proposed program.	and road preservation. (S2, T3) 2. Optimizing human resources quantity in the Directorate General of Highways in strenghtening accurate and accountable local road database government's commitment in constructing and developing roads. (S4,T5) 3. Building road network connectivity supported by the support of government's commitment and institutional unit of road development in order to attain local development target and to advance the economic growth. (S1,T4)	institutional unit in order to attain the local development target. (W1,T4) 2. Managing environmentally friendly road by integrating sustainability in the whole life cycle and local road maintenance aiming at minimizing from natural disaster and high rainfall. (W3,T2) 3. Creating local road accurate and accountable database and human resources capacity by conducting trainings. (W5,T5)

3.3 QSP matrix

Following the SWOT matrix analysis, several alternative strategies were found. These alternative strategies were formulated. These alternative strategies were then reformulated in Table 3. Alternative 1, 2, 3, and 4 - is S-O, W-O, S-T, and W-T strategy, respectively.

Table 3. Alternative strategies

Alternative	Strategy
1	- Creating a stable transportation connectivity concerning aspects of sustainability, safety, and quality improvement and maximizing the PRIM funding schemes in order to support and encourage the local economic development. - Establishing international cooperation in the road construction and improving the human resources competence by conducting several trainings in order to embody good governance.
2	- Managing and improving the quality of local road network by sustainability in the whole life cycle supported by PRIM funding schemes. - Implementing performance based design and managing environmentally friendly and safer roads by using and sustainable technology.
3	- Optimizing human resources quantity in the Directorate General of Highways in strengthening accurate and accountable local road database supported by the government's commitment in constructing and developing roads. - Building road networks connectivity supported by the government's commitment and institutional unit of road development to attain local development target and to advance economic growth.
4	- Managing environmentally friendly road by sustainability in the whole life cycle and minimizing the natural disaster and high rainfall. - Creating accurate and accountable local road database and building human resources by conducting trainings

Of some alternative strategies, the best strategy can be chosen by using quantitative strategic planning matrix (QSPM). This technique assesses the best strategy out of several alternatives. Based on the existing key factors to identify previous factors. The best strategy formulated by means of the QSPM is presented in Table 4.

Table 4. QSP matrix

Key factors	weight	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS
S1	0,20	2	0.40	1	0,20	2	0,40	1	0,20
S2	0,15	3	0.45	3	0,45	3	0,45	1	0,15
S3	0,02	3	0.06	1	0,02	3	0,06	1	0,02
S4	0,01	3	0.03	1	0,01	3	0,03	1	0,01
S5	0,01	2	0.02	2	0,02	1	0,01	1	0,01
W1	0,27	2	0.54	4	1,08	1	0,27	4	1,08
W2	0,20	1	0.20	4	0,80	1	0,20	4	0,80
W3	0,10	1	0.10	3	0,30	1	0,10	3	0,30
W4	0,02	2	0.04	3	0,06	1	0,02	3	0,06
W5	0,02	1	0.02	1	0,02	1	0,02	1	0,02
O1	0,26	4	1.04	3	0,78	1	0,26	1	0,26
O2	0,20	4	0.80	4	0,80	1	0,20	1	0,20
O3	0,12	3	0.36	2	0,24	1	0,12	1	0,12
O4	0,11	3	0.33	4	0,44	1	0,11	1	0,11
O5	0,06	3	0.18	2	0,12	1	0,06	1	0,06
T1	0,17	1	0.17	1	0,17	2	0,34	2	0,34
T2	0,03	1	0.06	1	0,03	2	0,06	3	0,09
T3	0,02	2	0.04	1	0,02	4	0,08	2	0,04
T4	0,01	2	0.02	1	0,01	4	0,04	3	0,03
T5	0,02	1	0.02	1	0,02	3	0,06	4	0,08
Total score			4,85		5,59		2,89		3,98

From QSPM matrix calculation, it is obvious that alternative 2 is the most attractive strategy. However, by looking at a relatively small score difference, alternative 1 namely S-O strategy is also a quite interesting strategy. Hence, combining these two alternative strategies is promising. It may be deployed to increase local road quality by maximising PRIM funding scheme and to manage environmentally friendly and safer-local road by integrating sustainability aspects in design, construction, maintenance, and rehabilitation (whole life cycle). These strategies are in accordance with the policies and targets of local road development of Directorate General for Road Network, Ministry of Public Works and Housing Strategic Planning 2015-2019, which among others are the increasing of basic infrastructure availability; the expansion of PRIM pilot project; the satisfactory condition of provincial roads by 75%, and the satisfactory condition of local roads by 65%.

4 Conclusion

The appropriate strategy toward sustainable local road network infrastructure were the management of local road and improving the quality of local road network by concerning aspects of sustainability in the stages of design, construction, maintenance by applying PRIM funding schemes, the management of environmentally friendly roads with the long-term pavement design and with road innovation and technology.

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