

# Local Road Maintenance Prioritization Literature Review

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**Abstract**—The quality of roads as public goods should be maintained and improved time to time. In order to put the available funds on the right roads for the optimal results, roads should be prioritized. This paper discussed how prioritization on road maintenance. The materials and method used are based on literature review. Discussion starts with the definition of local roads, the role of local road maintenance, and the definition of local road maintenance. The second part discuss the definition of prioritization, the objective of prioritization, and the roles of prioritization in road maintenance. The third part examines the common prioritization procedures conducted in planning process reflecting prioritization methods used in road maintenance prioritization. The fourth part discuss criteria in ranking alternatives which are single and multi criteria. The fifth part discuss the definition of actors, the roles of actors involved, the actors' attributes, and the types of actors in road maintenance prioritization process. According to the literature, there are four groups of prioritization methods based on procedure they conducted, and there are eight types of actors involved in prioritization process determined by the attributes such as power, legitimacy, and urgency they possess. The choice of method depends on where the roads to be prioritized are located.

**Index Terms** — Prioritization, Maintenance, Road, Local, Actors.

## I. INTRODUCTION

Infrastructure are facilities delivering public services in the area of public utilities (telecommunication, piped water supply, etc.), public works (roads, major dam, and canal works), and other transport sectors such as railways and port (World Bank, 1994 in Parkin and Sharma, 1999). Roads as one of transportation infrastructure are classified as public goods. It means that everyone has the same access to roads and should get the minimum level of accessibility.

Roads infrastructure has many economical and social benefits. Therefore, the quality of roads should be maintained and improved in order to ensure the public services are delivered well. The main problem faced in maintaining road quality is the available funds will be always not sufficient to maintain all roads. The solution is to maintain the most importance roads first. Selecting roads to be maintained is not an easy work since there are many parameters should be considered in order to optimize the results. In this case, the importance of roads can be identified and ranked through conducting the right prioritization. It will help the decision

makers in allocating the limited resources efficiently and effectively.

## II. LOCAL ROAD MAINTENANCE

This section will explain the definition of local roads, the role of local road maintenance, and the definition of local road maintenance. In managing roads, every country classifies the function of their roads differently in order to divide the competence of road management into different level of government. Based on OECD (1994), there are six most common classes based on the functional road classification: motorways, main roads (sometimes divided into two sub-classes I and II), collector roads, local roads, urban roads, and private roads. The term of local roads in this paper is roads that are managed by the local government. This paper is focused on local roads because nowadays Indonesia embraces decentralization policy in which the local government is the main actor in providing public services for local communities.

Furthermore, road is an important infrastructure in delivering public services since it can improve the economic and social accessibility. Therefore, there is a necessity for the optimal roads condition for the whole year. Activities aimed to maintain the optimal condition of the roads can be defined as local road maintenance. There are some definitions of road maintenance discussed on literature. For instance, Donnges et al. (2006) defined local road maintenance as integrated activities to maintain the structure of local roads in the minimum level of services throughout its design life. Another definition of local road maintenance is all works needed to maintain and to repair the local roads so that they can perform well and prevent the degradation caused by high demand after construction (NAASRA, 1978 in Alie, Asmawi 2006).

Based on those literatures, local road maintenance can be defined as all activities conducted on roads managed by local government, aimed to maintain and improve the roads quality in order to keep those roads serviceable. Since local roads is an important part of road network, it is important to maintain the roads in order to optimize the performance of road network in delivering public services.

## III. ROAD MAINTENANCE PRIORITIZATION

This section will explain the definition of prioritization, the objective of prioritization, and the roles of prioritization in road maintenance. The main obstacle in the development is a gap

between the amount of infrastructure funds needed and the amount of funds available. Moreover, along with the population increase, the human requirements for infrastructure in facilitating their activities aimed to meet their needs are also increasing. However, the resources owned by the government such as money and time are limited so that the number of infrastructure projects that can be conducted within certain period is restricted. It causes the need for maintaining roads will compete not only with other roads but also with other fields' projects that have the same role in public services. This situation in turns will create a selection process which will generate a list of candidate projects to be implemented. Project selection is not an easy process in decision making process since it should consider many criteria in identifying the best project (Ciutiene and Neverauskas, 2011). In general, project selection can be defined as a process to evaluate the criteria of different candidate projects for the purpose of funding and execution because in reality some criteria are more essential than others. This process involves prioritization process with certain prioritization method in identifying and assessing their usefulness and overall impacts (Flintsch and Bryant, 2006). Therefore, prioritization is involved from the beginning of decision making process.

In general, prioritization can be seen implicitly when making choices. Priority is interpreted by Gilb and Maier (2005) as relative right of a requirement to the utilization of limited (or scarce) resources. Botta and Bahill (2007) defined prioritization as a negotiation process in achieving tradeoff among different stakeholders with different interests. Furthermore, Agarwal et al. (2004) argued that prioritization is an analysis process to rank the best alternatives of candidate projects based on several factors in order to make the use of limited resources as optimal as possible. According to that definition, it can be said that prioritization in road maintenance is a significant initial step of road management to rank roads to be maintained.

The objective in conducting prioritization is to evaluate the identified projects and to rank them in order of importance (Trigueros, 2008). Through conducting the right prioritization, the decision makers will be capable in deciding which alternatives should be implemented and which one should be eliminated, utilizing the funds effectively and wisely, reducing risks, selecting the highest priority alternative, reducing discussion time, and identifying the high priority alternatives (Botta and Bahill). Therefore, the prioritization process determines the efficiency in conducting project.

In the case of road maintenance, the available resources cannot match with the requirements of roads that need to be maintained. Realizing that there are some roads that have more significant impacts than the others, Shen and Spedding (1998) argued that prioritization process can be a solution for the lack of funds through conducting the assessment and setting the priorities for planned maintenance works. In this case, the decision makers can maintain the most significant roads through assessing the roads based on certain standards in order to utilize the limited resources for the optimal results. Recall to those benefits of road maintenance prioritization, it is important

to formulate and practice the right road maintenance prioritization.

#### IV. ROAD MAINTENANCE PRIORITIZATION METHODS

This section will examine the common prioritization procedures conducted in planning process reflecting prioritization methods used in road maintenance prioritization. There are many literatures discuss prioritization methods used in infrastructure planning process. Every prioritization method has different procedures reflected by some sequential steps in ranking a set of alternatives. Normally, there are four common steps used in prioritization process (Trigueros) as explain bellow.

1. Choose criteria for evaluating projects. It is important to apply the same range of criteria scales for all criteria (Botta and Bahill). They also suggested some value of criteria/criteria scales. The scales can be low, medium, high; optional, conditional, and essential; nice-to-have, goal, highly desired, and must achieve; and numeric (e.g. 0 to 10)
2. Generate performance measures to compute project compliance to those criteria. In valuing criteria, basically almost all the selection processes are performed in a subjective manner (Vanier et al., 2006) since there is a close linkage between the criteria and the objective of planning process (Hudson et al., 1997).
3. Combine scores for each performance measure in some way.
4. Rank the project in order of importance.

Every method cannot be applied for every case and place because there will be different considerations and situation faced. Hassab-alla (2001), for example, mentions that prioritization based on defective indices which mostly consider rainfall, freeze and thaw cannot be applied in places with a low rain fall rates. Furthermore, Robinson et al. (1998) explain that the prioritization process that covers the small scale area will need a simpler method because there is less possibility of conflicting interests. The methods are varied from the simple one to the complex one. It can be seen in the six classes of prioritization methods proposed by Hudson et al.: simple subjective ranking based on judgments; ranking based on parameters; ranking based on parameters with economic analysis; optimization by mathematical programming model for year-by-year basis; near optimization using a marginal cost-effectiveness approach; and comprehensive optimization by mathematical programming model. In my view, those six methods can be simplified into four group of methods because the last three methods is similar. In identifying methods used in prioritization process, this thesis will use the four groups of prioritization method extracted from methods proposed by Hudson et al.; simple subjective ranking; ranking based on parameters with scoring and/or weighting; ranking based on parameters with economic analysis; and optimization.

1. Simple subjective ranking this method just relies on the judgments and experiences of decision makers and can be

conducted by using matrix and decision tree. For instance, Haas et al. (1994) in Agarwal et al. said that this method is a traditional method in which the choices of roads are based on the experiences and subjective judgments of road engineers. Thus, it can be conducted very quickly. Other researchers, Meyer and Miller (2001) stated that subjective ranking involves a subjective assessment of how each project is related to goal achievement by determining cost-effectiveness measures of "high, medium, and low". In this case, there is no analytical tool used in selecting the roads to be maintained. Therefore, the priorities resulted tends to be bias and inconsistency, far from optimal. Mak (1973) in Trigueros emphasized that the use of this method can cause the selection process vulnerable to personal engineering biases, lack of comprehension, lack of consistency and transparency, and become unmanageable. Furthermore, National Cooperative Highway research Program (1978) in Trigueros stated that the use of this method also will create political bias. These flaws generate the requirement for the new prioritization methods that promote objectivity, rationality and defensibility (Trigueros). It reveals the clear sequence steps, the transparency of the data, criteria, and performance measures used (Turochy and Willis, 2006 in Trigueros). This new prioritization method is developed time to time and will be further elaborated in the following sections.

2. Ranking based on parameters with scoring and/or weighting This method is also simple, easy to use, and quick but the results may be far from optimal (Hudson). In the field of road maintenance, Haas et al. in Agarwal et al. argued that there are some priority assessment schemes in developing priority rating scores according to certain numerical composite index such as defects rating index, pavement condition index, maintenance need index, rate, priority, and fuzzy condition index. However, most of those schemes focus only on the pavement condition. It causes the prioritization results are far from optimal. For that reason, the other methods using multi criteria become popular. For example, there are also some approaches that combine those indexes such as unique sum approach, utility theory, Delphi method, factorial rating method, and fuzzy set theory. Shen and Spedding argued that ranking based on multi criteria can minimize the subjective elements that are predominant in the decision making process for planned maintenance, and can increase the transparency of the prioritization process which eventually will improve public accountability. Therefore, prioritization that based on parameters is better than prioritization based on parameter.
3. Ranking based on parameters with economic analysis According to Zimmerman in Agarwal et al., this method is the most well-known method in prioritization process because this method is reasonably simple. The decision making tools that can be used in this method are benefit/cost ratio, life cycle cost analysis, or cost-effectiveness. In practice, it transforms all maintenance factors to equivalent monetary values, and then uses an

economic index to evaluate the alternative projects so that it should be closer to optimal (Haas et al., in Agarwal et al.,). However, it is difficult to measure all relevant impacts of a project in money terms (Hudson et al., 1997). Thus, this method needs a thorough analysis.

4. Optimization Haas et al. in Agarwal et al. explained that this method is quite complex and often be the most time-consuming method. On the other hand, it has the advantage of producing the most optimal decision in which it maximizes the benefits and minimizes the costs (Hudson et al.). Besides that, the optimization technique considers both time (current and future) and space (entire network). To accomplish this, road sections are categorized into different condition categories based on factors such as pavement condition and traffic volume. The proportion of road network in each of the condition category at different time period reflects the performance of road network over time. The objectives of the optimization technique are maximization of performance standards, and minimization of costs and the deficient portion of the network. The required components to accomplish these objectives are the selection of a functional criteria, performance variables, road classes, and condition categories; the specification of maintenance alternatives; and the development of the mathematical model. There are three components of the mathematical representation in this technique: decision variables, objective function, and constraints. (Peng and Ouyang, 2010). In line with the development of science, optimization has been developed through the time. Along with the development of this method, optimization can be divided into three groups: a. optimization by mathematical programming model for year-by-year basis. This method is less simple and may be close to optimal, but the effects of timing are not considered, b. near-optimization using a marginal cost-effectiveness approach. This method is reasonably simple, and it is close to optimal results, and c. comprehensive optimization by mathematical programming model, taking into account the effects of 'which', 'what', and 'when'.

The sequential steps of procedures which implicitly show prioritization methods used are depended on the decision maker's considerations. Therefore, every method conducted by different actors tends to represent the different sequential steps.

#### IV. ROAD MAINTENANCE PRIORITIZATION CRITERIA

The final output of prioritization is a ranking of projects so that prioritization can be defined as the preference ranking of projects (Vanier et al., 2006). In this case, projects with the worst score will have the highest priority. One essential step in ranking the alternatives is assessing the criteria. Regarding to the criteria, Vanier et al. divided the existing prioritization techniques into two groups: single criteria prioritization technique and multi criteria prioritization technique.

1. Single criteria prioritization technique is a prioritization technique which only considers one criterion. This method

is conflicting because every technique with different criterion can produce different ranking (Vanier et al.). For example, the prioritization based on the age of road maintenance will generate the different ranking with prioritization based on road condition. Sharaf and Mandeel (1998) also found the different output when they assessed the alternatives based on lowest life cycle cost, highest traffic, and highest benefit/cost ratio.

2. Multi criteria prioritization technique is a prioritization technique that assesses several criteria. This method potentially gives the better result than the single criteria prioritization technique because it is more comprehensive in addressing the issues. In choosing the most suitable prioritization technique, it is important to look at the situation faced. For instance, if there are many conflicting interests among stakeholders, Nijkamp et al. (1998) in Tsamboulas (2007) proposed to use multi criteria analysis rather than single criteria analysis.

For the respect of effectiveness and efficiency, not all proposed criteria will be considered in prioritization process. The criteria chosen are based on the level of importance decided by planners. Furthermore, the criteria used for assessing the alternatives in every prioritization method used can be single criteria or multi criteria, based on the situation and issued faced. For example, Vanier et al. argued that decision makers in road maintenance should decide the alternatives based on several criteria such as type of maintenance interventions, overall network performance, risk and reliability, life cycle costs, desired levels of service, budgetary constraints, construction costs, social and costs.

In another case, Flintsch and Bryant (2006) claimed that the prioritization methods are usually used in selecting projects in order to evaluate the attributes of different candidate projects for the purpose of funding and implementation, economic impacts, and timing parameters. According to their research, there are several criteria considered in selecting projects: available budgets, engineering parameters, public demands, project significance, agency costs/benefits, usage of project, environmental considerations, geographic distribution of projects/funds, user costs/benefits, distribution among asset types, ease/difficulty of implementation, and proximity of project to major urban areas. Li and Sinha (2004) added other criteria such as the effect of certainty, risk, and uncertainty. Based on many literature discussing prioritization criteria, criteria that commonly used in road maintenance prioritization are regional goals and objectives, technical such as road condition, traffic volume, and other performance variables, political, financial, social, economical, legal, environmental, risk, and intangible factors.

## V. ACTORS INVOLVED IN THE PRIORITIZATION

This section will discuss the definition of actors, the roles of actors involved, the actors' attributes, and the types of actors in road maintenance prioritization process. Actors can be defined as any group or individual who (can) affect or is affected by the achievement of the organization's objectives or

actions (Freeman, 1984; Jones, 1995; Kreiner & Bhambri, 1988 in Mitchell et al., 1997).

In decision making process, actors have their own role which is closely related to their salience. The key success of actors' involvements is the integrity and capability of actors involved. Moreover, the extent of actors' involvement in decision making process will influence the final decision. For that reason, it requires a good understanding of actors involved in decision making process include prioritization. Technically, actors take an important part in the prioritization process. It can be seen when a planning team selects the criteria that need to be considered. This team is consisted of the representatives of all relevant actors who are affected by and/or influence the decision making process. Then, the team weights each criterion and applies to every candidate project. After that, the team can calculate the scores, and finally rank all alternatives. Furthermore, when a prioritization will be started, the leader of the team can identify and select the actors that will be involved.

Furthermore, Ward (2001) suggested involving the diverse actors in transport planning process. The reason for his suggestion is the involvement of various actors who represent the different interests in planning process will reveal the diversity of problem definitions and innovations which will be beneficial in calculating the level of importance of alternatives. Therefore, the prioritization becomes more representative in accommodating all actors' interests. For example, based on World Bank document discussing rural road maintenance (Ward, 2001) actors involved in prioritization are focused on various government agencies, commercial interests, and local communities. This best practice states that local participation is very important since they have the most updated data as they use the roads daily.

Moreover, Schroeder argued that the centralized decision making which is often ignoring local preferences will lead to a less efficient outcome and their willingness to participate. Besides that, in this system the higher level of government set the guidelines. Furthermore, Ward stated that the involvement of diverse actors does not make the planning process become expensive and inconclusive. However, the effort to involve the diverse actors is not easy since it is related to the current power structure that constraint the involvement of diverse actors. For that reason, it is important to identify the type of actors involved based on their roles in road maintenance prioritization so that there will be recommendations proposed related to actors involved in order to improve the prioritization practices.

Mitchell et al. (1997) proposed three attributes (power, legitimacy, and urgency) in identifying the different classes of actors, as explained below.

1. Power is a relationship among social actors in which one social actor, A, can get another social actor, B, to do something that B would not otherwise done (Dahl, 1957; Pfeffer, 1981; Weber, 1947 in Mitchell et al.). Actor who has power is one who has the (potential) ability to impose their will on a given relationship through coercive, utilitarian, or normative means (Etzioni, 1964 in Parent and Deephouse, 2007).

2. Legitimacy is a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions (Suchman, 1995; Weber, 1947 in Mitchell et al.). It can be attained in the level of individual, organizational, and societal (Wood, 1991 in Mitchell et al.).
3. Urgency is the degree to which actor claims to call for immediate attention based on time sensitivity. Furthermore, it is the degree to which managerial delay in attending to the claim or relationship is unacceptable to the actor. It also can be defined as the importance of claim or relationship for actor (Mitchell et al.).

In their research, Parent and Deephouse found that the more attributes belong to certain actors, the more important their roles in the planning process. Besides that, they rank those attributes in which power in the first place as an influence attribute, followed by urgency, and then legitimacy. Mitchell et al. established eight types of actors based on various combinations of those three attributes: dormant actor, discretionary actor, demanding actor, dominant actor, dangerous actor, dependent actor, definitive actor, and non-actor. As illustrated in Figure 1, dormant actor, discretionary actor, and demanding actor are actors that only possess one attribute. Dominant actor is actor that possesses power and legitimacy. Dangerous actor is actor that possesses power and urgency. Dependent actor is actor that possesses legitimacy and urgency. Definitive actor is actor that possesses power, legitimacy and urgency. Non actor is actor that possesses no attribute.

From Table 1, it can be seen that there are diverse name of actors. In this case, there are some researchers who already classified those actors. For instance, Ward classified actors into planners, politicians, monitoring organizations, and business. Taschner and Fiedler (2009) divide actors into four general groups: government/authorities, businesses/operators, communities/local neighborhoods, and others. In this thesis, those actors will be classified into nine groups: authorities, technical agency of local government, non technical agency of local government, higher level of government, politicians, communities, funding donor, business, and others.

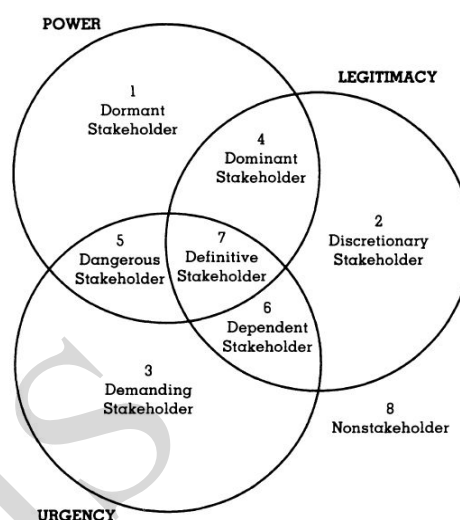


Fig 1. Types of Stakeholders (source: Parent and Deephouse)

Table I: Diverse Actors

Sources	Power	Legitimacy	Urgency
Nick Osborne (1995)	- Local politicians - Community	- Local politicians - Planners - Other technical experts	- Planners - Community
Hassab-alla (2001)	- Road administration (public authorities) - Political actors or legislative - Donor-funded road maintenance projects	- Road administration (public authorities) - Political actors or legislative - Contractors and consultants	- Road users - Road engineering industry - Contractors and consultants - Road administration (public authorities)
King (1978)	Individuals that have various claims on the organization (stock holders)	Individuals that have various claims on the organization (regulators)	Individuals that have a stake in the way the organization is operated (e.g. managers, employees, vendors, customers, etc.)
Wiegiers (1999)	- The project manager	- Development representatives	- Key customer representatives
Omdoff (2003)	- Transportation decision makers - The general public	- Transportation decision makers	- Businesses affected - The general public - Transportation decision makers

Based on the above explanation, actors listed in Table 1 can be classified into eight types described in Figure 1. Dormant actors: donor-funded road maintenance projects, the project manager; discretionary actors: technical expert except planners, development representatives; demanding actors: road users (key customer representatives), road engineering industry, businesses affected; dominant actors: political actors or legislative (local politicians); dangerous actors: community (the general public); dependent actors: planners, contractor or consultant; definitive actors: road administration (public authorities), transportation decision makers; and none actors: none.

They also can be grouped into four groups: latent actors: donor funded road maintenance projects, the project manager, technical expert except planners, development representatives, road users (key customer representatives), road engineering industry, and businesses affected; expectant actors: political actors or legislative (local politicians), community (the general public), planners, and contractor or consultant; definitive actors: road administration (public authorities), and transportation decision makers; and non-actors: none.

## VI. CONCLUSION

The prioritization is a crucial part in local roads maintenance because it helps the decision makers in allocating the resources in maintaining local roads efficiently and

effectively so that roads can be kept in their optimal condition. Given the importance of prioritization, it is important to identify methods used, criteria considered, and actors involved.

According to the literature, there are four groups of prioritization methods based on procedure they conducted, and there are eight types of actors involved in prioritization process determined by the attributes (power, legitimacy, and urgency) they possess. The four classes of prioritization methods are simple subjective ranking; ranking based on parameters with scoring and/or weighting; ranking based on parameters with economic analysis; and optimization. The criteria used in assessing the alternatives can be single criteria and multi criteria. Furthermore, the eight types of actors are dormant actor, discretionary actor, demanding actor, dominant actor, dangerous actor, dependent actor, definitive actor, and non actor.

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