How to determine road maintenance priorities? An analysis using a probabilistic approach.

Anastasi H. Muda1, Priska G. Nahak1, Melchior Bria1, Deasy D.A.A Daud1,

1Department of Civil Engineering, State Polytechnic of Kupang, Adisucipto Street. PO. Box. 139 Penfui Kupang-NTT- Indonesia

Corresponding: melchibria@gmail.com

**Abstract**. The provision of a limited maintenance budget often causes maintenance not on target and tends to be wasteful. Treatment priority is one of the alternatives that have been carried out so far. This study describes a different approach in determining the maintenance program planning through a probabilistic approach, namely how big is the chance of the alternatives being included in the maintenance program. This study took samples of the Bakunase-Oenesu and Soe-Fatumnasi roads. The variables used are the pavement structure, average daily traffic, accessibility, economic benefits, time travel, and asphalt recycling technology. The binary logistic analysis shows that the condition of the pavement structure and average daily traffic are variables that have a significant effect on road maintenance. There is a greater chance of the Soe-Fatumnasi road section than Bakunase-Oenesu being involved in road maintenance. In making road maintenance decisions, policymakers need to pay attention to various factors to make their decisions right on target.

**Keywords** : Road Maintenance, Probabilistic Approach; Binary Logistic

1. Introduction

In road maintenance planning, there are difficulties in producing a predictive model for road conditions, mainly due to errors in the visual survey and a lack of knowledge of the essential factors affecting degradation [1]. If this continues to occur, it will affect the road's serviceability until it reaches its age economical and increases costs for road users [2, 3], including the impact on residents and the environment around the road [4]. On the one hand, road maintenance is closely related to budget availability, so it is necessary to carry out an appropriate condition assessment [5]. The road condition assessment includes the deterioration of the road condition and its sections, such as inspection of the pavement, road shoulders, drainage channels, and of course, subgrade [6, 7]. This condition implies the need for the right decision making in planning road maintenance [8].

To that end, various efforts have been made both technically and managerially. An example of a technical effort is to carry out routine maintenance periodically and in a managerial manner by conducting a priority analysis of road maintenance, which shows a significant government role in regulating it. However, the maintenance budget is often not followed by useful maintenance methods, so the budget is used in vain without producing a good construction [9].

Even though maintenance is the essential part of traffic management [10]. Therefore, in planning road maintenance, it is necessary to consider various aspects before making decisions, including the performance and strength of the pavement structure [11], traffic load, pavement age, road level, and non-technical aspects such as resources, disposition, and bureaucratic structure [12, 13]. Besides, due to limited natural and financial resources, handling critical roads needs to be done with a good strategy by relying on renewable materials and choosing the right maintenance method [9].

Thus, road maintenance is a matter of method and program planning related to data and budget. Many studies related to maintenance program planning have been conducted. These studies generally use a priority approach in planning road maintenance based on damage to the road structure using a multi-criteria analysis method [14 - 17].

This article presents a prioritization analysis based on the probability approach, namely the probability that a road section will be included in the maintenance program. Thus, the considerations that will be used in the analysis are not only on the structural aspects of roads but also on the economic value of roads and the application of green construction principles.

1. Method

The research location is in West Timor, East Nusa Tenggara Province. The roads sampled are the Bakunase-Oenesu Road in Kupang Regency and the Soe - Fatumnasi road in South Central Timor. The main concept of this research is to identify the opportunities for a road section to be included in the road maintenance program. The rationale is that in one budget year, the available maintenance funds are very limited, even far below what is needed. Therefore, to strengthen the related technical agencies' proposals, the planning approach with this probability concept can be used as a guide in proposing a particular road section. The considerations used to measure how much opportunity is accepted or not are based on three main criteria, namely the condition of the pavement structure (X1), average daily traffic (X2), accessibility (X3), economic benefits (X4), time travel (X5) and use of asphalt recycling technology (X6). The dependent variable is the maintenance of the Bakunase-Oenesu road and the maintenance of the Soe-Fatumnasi road.

The approach used to obtain the value of the three criteria above is quantitative subjective; that is, the respondent makes an assessment based on the information they have on the choices through a distributed questionnaire. Therefore, respondents in this study know the problems, are involved in road maintenance activities and are responsible for road maintenance problems, including budgeting. In short, the respondents are policymakers related to road maintenance. In this study, we determined that the number of respondents was 150 from technical agencies at the provincial and district levels.

The analytical method used to determine the probability of road maintenance is binary logistic. Because the questionnaire questions are qualitative, each response is given a certain nominal scale, as in Table 1.

**Table 1**. Variables and scales used

|  |  |  |
| --- | --- | --- |
| No. | Variable | Response |
| 1 | The pavement structure (X1) | (0) slightly damaged; (1) moderate; (2) heavily damaged |
| 2 | Average daily traffic (X2) | (0) low; (1) moderate; (2) high |
| 3 | Accessibility  | (0) low; (1) moderate; (2) high |
| 4 | Economic Benefits | (0) low; (1) moderate; (2) high |
| 5 | Travel time | (0) slow; (1) moderate; (2) normal |
| 6 | Application of recycling technology | (0) is not urgen; (1) importand and urgen |
| 7 | Maintenance of roads | (0) not yet feasible; (1) feasible |

Based on the variables above, the following model can be formed:

The basic form of binary logistics:

From this basic form, then used as a binary logistic equation model tested in this study are:

β0 is a constant; βi is the regression coefficient of each variable; Xi is the independent variable. P is the probability that the road will be included in the maintenance program; (1-P) is the chance that the road will not be included in the maintenance program.

The model evaluation includes: (1) goodness of fit test concerning the level of significance 0.05; (2) simultaneous variable effect test based on the chi-square significance value; (3) the test of determination using the Negelkerke R-square criteria; and (4) the significance test of the variables in the equation. Because two dependent variables are being compared, each road section's analysis is carried out separately for the Bakunase-Oenesu and Soe-Fatumnasi roads.

1. Result

First, to assess the goodness of fit of the model, the terms used are the chi-square significance value. Table 1 shows that the two models meet the goodness of fit requirements where the chi-square value of the Hosmer and Lemeshow test is more than 0.05. These results indicate that the model can be used to predict the observations made.

**Table 2**. Result of model test

|  |  |  |  |
| --- | --- | --- | --- |
| Model | The goodness of fit test | Model simultaneous test | Determination test |
| Y1: Maintenance of Bakunase-Oenesu road | 1. The chi-square significance value 0.211 > α = 0.05
2. The percentage on the classification test is 80.2%.
 | The chi-square significance value on the omnimbus test is 0.000 < α = 0.05 | The Negelkerke R-square value is 0.406 |
| Y2: Maintenance of Soe-Fatumnasi road | 1. The chi-square significance value 0.912 > α = 0.05
2. The percentage of the classification test is 81.7%.
 | The chi-square significance value on the omnimbus test is 0.000 < α = 0.05. | Nilai Negelkerke R-square sebesar 0.564 |

Second, the simultaneous test results based on the omnimbus test (Table 1) show that the chi-square value significance level is less than 0.05 in both models. These test results indicate that all the variables that make up the model (X1 - X6) have a simultaneous influence on road maintenance. In other words, it can be said that at least one of the variables in the model has a significant effect on road maintenance.

Third, from Table 2, it can also be seen that the negelkerke R-square value of the two models is far above 0.05. These results prove that the independent variable can explain the dependent variable's variability by 40.6% in the Y1 model and 56.4% in the Y2 model.

Fourth is a partial effect test to see the effect of each variable. Table 3 describes the probability model of Bakunase-Oenesu road maintenance, where two variables partially have a significant effect, namely variables X1 and X2, because the significance value is <0.05. Variable X1, which is positive, indicates that the greater the pavement structure's damage, the greater the chance for the Bakunase-Oenesu road section to be included in the road maintenance program. The magnitude of this opportunity, seen from the odds ratio, is 8,425 times higher than if the damage does not increase. Likewise, with average daily traffic, the higher the average daily traffic, the opportunity to be included in the road maintenance program for 1,923 times higher than if the average daily traffic did not increase.

**Table 3**. Result of Y1 Model: maintenance of the Bakunase-Oenesu road

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | β | S.E. | Wald | Df | Sig. | Exp(β) |
| X1 | 2.131 | .561 | 14.430 | 1 | .000 | 8.425 |
| X2 | .654 | .290 | 5.097 | 1 | .024 | 1.923 |
| X3 | .150 | .309 | .235 | 1 | .628 | 1.162 |
| X4 | .126 | .304 | .172 | 1 | .678 | 1.134 |
| X5 | .096 | .407 | .056 | 1 | .814 | 1.101 |
| X6 | .439 | .449 | .955 | 1 | .328 | 1.551 |
| Constant | -4.385 | 1.354 | 10.496 | 1 | .001 | .012 |

In contrast to the Y1 model, as in Table 4, it can be seen that the magnitude of the influence of the X1 variable on the Y2 model is positive by 20,980 times greater than if the road section does not experience additional damage. For variable X2, it also has a positive effect with an odds ratio of 2.475 times greater than if the average daily traffic does not increase.

**Table 4**. Result of Y2 model: maintenance of Soe-Fatumnasi road

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | B | S.E. | Wald | df | Sig. | Exp (β) |
| X1 | 3.044 | .702 | 18.811 | 1 | .000 | 20.980 |
| X2 | .906 | .340 | 7.093 | 1 | .008 | 2.475 |
| X3 | .291 | .353 | .680 | 1 | .410 | 1.338 |
| X4 | .597 | .385 | 2.407 | 1 | .121 | 1.817 |
| X5 | .797 | .489 | 2.663 | 1 | .103 | 2.220 |
| X6 | -.442 | .457 | .934 | 1 | .334 | .643 |
| Constant | -6.161 | 1.714 | 12.917 | 1 | .000 | .002 |

1. **Discussion**

The analysis results show that in the Y1 and Y2 models, the variables that have a significant effect are the condition of the pavement structure and average daily traffic. These results confirm the general trend that has occurred so far that pavement conditions are the main basis for making road maintenance decisions [11, 12]. It means that policymakers have not fully developed various criteria in assessing the feasibility of a road section being included in the maintenance program. Economic benefits and accessibility have not yet received attention. It becomes a serious problem when faced with choices when many roads are in the same condition, and it won't be easy to make decisions. In this study, two roads were assessed as having a strategic role as a route to a tourist area. On the Soe-Fatumnasi road, apart from providing access to tourist areas, it is also the only access from the interior to urban areas. However, this study shows that the large probability of this road segment compared to Bakunase-Oenesu is only affected by pavement damage and average daily traffic. Thus, policymakers need to determine the direction of the maintenance program to pay attention to various criteria so that the decisions taken are the best of several alternatives. Besides, sustainability issues need to be considered, for example, by rewiring asphalt pavements [18] in maintenance work.

However, in this study, our assumption of respondents is that they fully understand the road maintenance and condition of the two sample roads. This assumption certainly contains weaknesses because respondents may not understand about road maintenance and the two roads' condition. Moreover, data collection was carried out by distributing questionnaires so that there was no dialogue when filling out the questionnaire. Therefore, the data obtained may not fully reflect the actual conditions.

1. **Conclusion**

Determining road maintenance priorities based on a probability approach using this logistic regression model results in a different assessment form compared to priority determination based on ranking or weight. In this logistic regression, it is seen how likely it is for a road section to be included in the road maintenance program. The benchmark is the amount of opportunity from an alternative. This method would be more appropriate if applied to planning at the first level based on this opportunity criteria.

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