Risk analysis on implementation of road maintenance project with STEPLE method in Badung, Bali

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Abstract. In the implementation of the road maintenance project always risks arise. These risks have an impact on stakeholders related to the execution of the project, the community of road users and the surrounding environment. These risks need to be studied, managed, and assessed as a risk-mitigation effort for stakeholders. As the case study is the district road maintenance project, in Badung regency of Bali. Descriptive method used in the study. Identification of variable risk used STEPLE (Social, Technology, Economy, Politics, Legal, and Environment) method. The factors STEPLE is identified through literature review and brainstorming, then used as a questionnaire instrument. Respondents are experts involved in road maintenance projects in Badung regency. Risk assessment uses a risk assessment matrix. The results of the study found 36 risks. These risks are identified as dominant from the Technical variable that is 13 risks. Risk assessment found is 6 risks classified as unacceptable, and 30 risk classified as undesirable.

1 Introduction

Economic activity in Badung Regency is very high compared to regencies and cities in Bali Province. The road network infrastructure in Badung Regency is also a connecting road/connector for one regency with other regencies, for example with Tabanan Regency, Gianyar Regency, and Denpasar City. Due to the economic life cycle during operation, this road infrastructure has decreased service levels due to damage to the road structure. To keep the damage level from getting worse, and to improve road services, this road infrastructure needs maintenance. However, during the construction period, it often causes negative impacts/risks on stakeholders and the surrounding environment [1-5].

Regency is a tourism area and the high social, religious negative impact or risk needs mitigation efforts. However, before mitigation efforts are carried out, it is necessary to identify the dominant risk factors in the implementation of this road maintenance project. Until now, the dominant risks during the maintenance period of roads specifically in the district roads in Badung Regency have not been studied in advance, so it needs to be investigated. Method analysis of risk, especially at the risk identification stage that is developing at this time, and related to stakeholders is a Political, Economic, Social,
Environment, Legal or known as PESTLE analysis [6-8]. This PESTLE method will be used in risk identification in this study. This is based on the suitability of the case studies studied which fulfill the political, economic, social, environmental, and legal aspects.

2 Methodology

Descriptive method was used in this study [9, 10]. The execution period of the Road maintenance project in Bandung Regency was used as a study case. The research framework analysis is shown in Fig. 1.

![Analytical framework](image)

**Fig.1.** Analytical framework.

2.1 Risk identification

Factors are identified from Political, Economic, Social, Technological, Legal, and Environment (PESTLE) [8]. PESTLE method is frequently written by PESTEL [7]. PESTLE factors can be described as follows [6-8]:

1. Political factors. Political factors that show impacts such as political parties, various policies, and routines that directly bear on business operations. If a particular country faces a crisis or war situation, then sudden decisions taken by political parties may have an impact on business.

2. Economic factors. Economic risk factors include changes in inflation rates, interest rates, monopoly trade, international competitiveness, commodity costs, taxation regimes, global financial stability, and changes in foreign exchange rates.

3. Social factors. Social factors such as demography and culture. Demographic features such as age, gender, and occupational level also affect social factors.
4. Technology factors. Technological factors influence operations in organizations. The usage of innovative technology increases the productivity and efficiency of the company’s operation.

5. Legal factors. Legal factors explain the impact of legal philosophies and legal practices that organizations require to adopt.

6. Environment factors. Environmental, ecological factors such as the influence of climate and geographical factors on the organization.

2.2 Respondents

The respondent's determination method used nonprobability purposive sampling, based on expert judgment. The respondent's criteria were found based on the expertise possessed by the respondents regarding the care of the district road.

2.3 Frequency and consequences scale measurement

The scale used to measure the level of assessment of respondents is a Likert scale in the form of an ordinal scale that shows the level/ranking of responses from respondents to the risks identified and does not indicate how much distance (interval) between levels of one another [9, 10].

| Table 1. Level and frequency scale (Likelihood).  |
|-----------------------------------------------|
| **Frequency level** | **Scale** |
| Very often | 5 |
| Often | 4 |
| Sometimes | 3 |
| Rarely | 2 |
| Very rare | 1 |

| Table 2. Consequences and levels.  |
|----------------------------------|
| **Level of consequences** | **Scale** |
| Very large/catastrophic | 5 |
| Large/critical | 4 |
| Medium/serious | 3 |
| Small/marginal | 2 |
| Very small/negligible | 1 |

The Likert scale generally uses a rating of five rating, namely, strongly agree (5), agree (4), uncertain (3), disagree (2), and strongly disagree (1) where this scale can be used to indicate the level/ranking of responses from respondents to identify risks. The frequency and consequence measurement scale is presented in Table 1 and 2 [10, 11].
2.4 Risk matrix

The risk acceptability level is extended out a risk matrix analysis. The value of risk from the risk matrix is the result of the multiplication of the tendency (likelihood) with consequences. The outcomes of the risk matrix are categorized in the degree of risk acceptance as in Table 3 [12].

| Acceptance of risk | Risk acceptance scale (X) |
|--------------------|---------------------------|
| Unacceptable       | X ≥ 15                    |
| Undesirable        | 5 ≤ X <15                 |
| Acceptable         | 3 ≤ X <5                  |
| Negligible         | X < 3                     |

3 Results and discussion

3.1 Risk identification

The identified risks associated with project risks are from some previous researchers such as Wideman (1992), Shen (2001), Fisk (1997), Al-Bahar [13,14], and brainstorming found 45 risks. These risks found in groups based on the STEPLE category can be seen in Table 4. The number of respondents in the study was determined by the purposive sampling method as many as 24 respondents.

| No | Risks                                                                 | Code |
|----|-----------------------------------------------------------------------|------|
| A  | Social Risk (S)                                                       | Soc  |
| 1  | Delays due to labor holidays                                         | Soc1 |
| 2  | There are traditional ceremonies around the project                  | Soc2 |
| 3  | Lack of good coordination in the project                             | Soc3 |
| 4  | Labor strike when the task is going                                  | Soc4 |
| 5  | Quality work that is not good because of an incompetent workforce    | Soc5 |
| 6  | Destruction of tools, materials and facilities occurred by irresponsible parties | Soc6 |
| 7  | There was sabotage of equipment                                      | Soc7 |
| 8  | Lack of awareness of project workers on work safety and security     | Soc8 |
| 9  | Accidents that occur in locations that cause injury                  | Soc9 |
| B  | Technical Risk (T)                                                   | Tech |
| 10 | Colonization is not appropriate according to a predetermined schedule | Tech1 |
| No | Risks                                                                 | Code |
|----|----------------------------------------------------------------------|------|
| 11 | Life cycle of plan that is not suitable                              | Tech2|
| 12 | Damage to results due to poor working methods                        | Tech3|
| 13 | Field measurements to find locations, spots, lines and heights are not according to design starts late | Tech4|
| 14 | Task starting delay                                                  | Tech5|
| 15 | Delay in the arrival of material                                     | Tech6|
| 16 | Maximum machine and operational poor efficiency                      | Tech7|
| 17 | Use of materials that are less efficient so that they harm contractors | Tech8|
| 18 | Test samples of materials that are not in accordance with established quality standards | Tech9|
| 19 | Congestion around the project thus hampering the arrival of material  | Tech10|
| 20 | Failure to obtain planning details with available time               | Tech11|
| 21 | Inadequate geological data and existing field surveys                | Tech12|
| 22 | Lack of heavy equipment                                              | Tech13|
| 23 | Incompatibility between work volume in the contract and field conditions | Tech14|
|    | **C Economic Risk (E)**                                              |      |
| 24 | Claims from outside of competition                                   | Eco1 |
| 25 | Market unpredictable risk                                            | Eco2 |
| 26 | The occurrence of inflation during project implementation affects material prices | Eco3 |
| 27 | Unexpected price increases for materials                             | Eco4 |
| 28 | Late payment of the terms of the owner to the contractor             | Eco5 |
| 29 | Workers' demands for pay gains that do not match standard wages      | Eco6 |
| 30 | The main contractor cannot pay To subcontractor                      | Eco7 |
| 31 | Increased operating costs                                           | Eco8 |
| 32 | Late payment by contractors for material suppliers                   | Eco9 |
| 33 | Work progress is delayed because the contractor lacks funds to cover the operational costs of the project | Eco10|
| 34 | Short-term costs that cannot be resolved to minimize long-term costs | Eco11|
| 35 | Problems arise during the warranty period                             | Eco12|
### Political Risk (P)

| No | Risks                                                                 | Code |
|----|----------------------------------------------------------------------|------|
| 36 | Lack of coordination between relevant agencies in decision making that can affect project work | Pol1 |
| 37 | The rejection of certain mass organizations for the benefit of their group | Pol2 |

### Environmental Risk (E)

| No | Risks                                                                 | Code |
|----|----------------------------------------------------------------------|------|
| 38 | The influence of a bad community environment, as a result of the project | Env1 |
| 39 | Difficult access to entry for heavy equipment to be used during project implementation due to congestion | Env2 |
| 40 | Disruption of smooth work due to the high level of traffic density around the project site | Env3 |
| 41 | Project delays due to weather (rain, wind)                           | Env4 |
| 42 | Damage due to natural disasters: storms, floods, and earthquakes     | Env5 |
| 43 | Unexpected soil conditions                                          | Env6 |

### Legal Risk (L)

| No | Risks                                                                 | Code |
|----|----------------------------------------------------------------------|------|
| 44 | Changes in legislation                                              | Leg1 |
| 45 | Lawsuit from within and from outside                                 | Leg2 |

There were 9 factors of invalid risk identified from validity and reliability test found as in Table 5.

**Table 5.** Invalid risks resulting from validity and reliability testing.

| No | Risks                                                                 | Code   | Note  |
|----|----------------------------------------------------------------------|--------|-------|
| 1  | Maximum machine and operational poor efficiency                      | Tech7  | Invalid |
| 2  | Claims from outside of competition                                   | Eco1   | Invalid |
| 3  | The occurrence of inflation during project implementation affects material prices | Eco3   | Invalid |
| 4  | Workers' demands for pay gains that do not match standard wages      | Eco6   | Invalid |
| 5  | Late payment by contractors for material suppliers                   | Eco9   | Invalid |
| 6  | Work progress is delayed because the contractor lacks funds to cover the operational costs of the project | Eco10  | Invalid |
| 7  | Lack of coordination between relevant agencies in decision making that can affect project work | Pol1   | Invalid |
| 8  | Unexpected soil conditions Unexpected soil conditions                | Env6   | Invalid |
| 9  | Changes in legislation                                              | Leg1   | Invalid |
Invalid risks as in Table 5 are not included in the subsequent analysis. The risks that are further calculated are 36 risks, can be seen in Table Table 6 column (2). The number of each risk identified based on the STEPLE category is presented in Fig. 2. While the valid number of each category is presented in Fig. 3.

Fig. 2. Identified risks (45 risks) by STEPLE method.

Fig. 3. Valid risks (36 risks) resulting from validity and reliability tests.

### 3.2 Results of risk assessment

The tabulation of data from the survey results for the perception of frequency (F) can be seen in Table 6 column (4), for consequences can be seen in Table 6 column (5). The results of the assessment matrix can be seen in Table 6 column (6).

| No | Risks | Code | Mode (F) | Mode (C) | Matrix Value | Category |
|----|-------|------|----------|----------|--------------|----------|
| (1) | (2)   | (3)  | (4)      | (5)      | (6) = (4)*(5)| (7)      |
| A Social Risk (S) Soc | 1 Delays due to labor holidays | Soc1 | 3 | 4 | 12 | Undesirable |
|   | 2 There are traditional ceremonies around the project | Soc2 | 3 | 3 | 9 | Undesirable |
|   | 3 Lack of good coordination in the project | Soc3 | 3 | 4 | 12 | Undesirable |
|   | 4 Labor strike when the task is going | Soc4 | 4 | 3 | 12 | Undesirable |
|   | 5 Quality work that is not good because of an incompetent workforce | Soc5 | 3 | 3 | 9 | Undesirable |
|   | 6 Destruction of tools, materials and facilities occurred by irresponsible parties | Soc6 | 4 | 4 | 16 | Unacceptable |
|   | 7 There was sabotage of equipment | Soc7 | 3 | 4 | 12 | Undesirable |
|   | 8 Lack of awareness of project workers on work safety and security | Soc8 | 3 | 4 | 12 | Undesirable |
|   | 9 Accidents that occur in locations that cause injury | Soc9 | 4 | 4 | 16 | Unacceptable |
| B Technical Risk (T) Tech | 10 Colonization is not appropriate according to a | Tech1 | 2 | 4 | 8 | Undesirable |
| No | Risks                                                                 | Code | Mode (F) | Mode (C) | Matrix Value | Category      |
|----|----------------------------------------------------------------------|------|----------|----------|--------------|---------------|
| (1) | determined schedule                                                  |      |          |          |              |               |
| 11  | Life cycle of plan that is not suitable                              | Tech2 | 3        | 4        | 12           | Undesirable   |
| 12  | Damage to results due to poor working methods                        | Tech3 | 3        | 3        | 9            | Undesirable   |
| 13  | Field measurements to find locations, spots, lines and heights are not according to design starts late | Tech4 | 4        | 4        | 16           | Unacceptable  |
| 14  | Task starting delay                                                  | Tech5 | 3        | 5        | 15           | Unacceptable  |
| 15  | Delay in the arrival of material                                     | Tech6 | 2        | 3        | 6            | Undesirable   |
| 16  | Use of materials that are less efficient so that they harm contractors | Tech8 | 3        | 4        | 12           | Undesirable   |
| 17  | Test samples of materials that are not in accordance with established quality standards | Tech9 | 3        | 4        | 12           | Undesirable   |
| 18  | Congestion around the project thus hampering the arrival of material  | Tech1 | 4        | 3        | 12           | Undesirable   |
| 19  | Failure to obtain planning details with available time               | Tech1| 4        | 4        | 16           | Unacceptable  |
| 20  | Inadequate geological data and existing field surveys               | Tech1| 3        | 4        | 12           | Undesirable   |
| 21  | Lack of heavy equipment                                             | Tech1| 3        | 4        | 12           | Undesirable   |
| 22  | Incompatibility between work volume in the contract and field conditions | Tech1| 3        | 4        | 12           | Undesirable   |
| 23  | Economic Risk (E)                                                   | Eco  |          |          |              |               |
| 24  | Market unpredictable risk                                           | Eco2 | 3        | 4        | 12           | Undesirable   |
| 25  | Unexpected price increases for materials                             | Eco4 | 3        | 4        | 12           | Undesirable   |
| 26  | Late payment of the terms of the owner to the contractor             | Eco5 | 2        | 4        | 8            | Undesirable   |
| 27  | The main contractor cannot pay To subcontractor                      | Eco7 | 3        | 4        | 12           | Undesirable   |
| 28  | Increased operating costs                                           | Eco8 | 3        | 3        | 9            | Undesirable   |
| 29  | Short-term costs that cannot be resolved to minimize long-term costs | Eco11| 4        | 4        | 16           | Unacceptable  |
| 30  | Problems arise during the warranty period                            | Eco12| 3        | 3        | 9            | Undesirable   |
| 31  | Environmental Risk (E)                                               | Env  |          |          |              |               |
| 32  | The influence of a bad community environment, as a result of the project | Env1 | 3        | 4        | 12           | Undesirable   |

C: Economic Risk (E)

D: Political Risk (P)

E: Environmental Risk (E)
No | Risks                                                                 | Code | Mode (F) | Mode (C) | Matrix Value | Category |
---|----------------------------------------------------------------------|------|----------|----------|--------------|----------|
(1) |                                                                      |      |          |          |              |          |
32 | Difficult access to entry for heavy equipment to be used during project implementation due to congestion | Env2  | 3        | 3        | 9            | Undesirable |
33 | Disruption of smooth work due to the high level of traffic density around the project site | Env3  | 3        | 4        | 12           | Undesirable |
34 | Project delays due to weather (rain, wind)                            | Env4  | 2        | 4        | 8            | Undesirable |
35 | Damage due to natural disasters: storms, floods, and earthquakes      | Env5  | 3        | 4        | 12           | Undesirable |

F Legal risk (L) | Leg                        |
36 | Lawsuit from within and from outside                                | Leg2  | 4        | 3        | 12           | Undesirable |
34 | Project delays due to weather (rain, wind)                          | Env4  | 2        | 4        | 8            | Undesirable |
35 | Damage due to natural disasters: storms, floods, and earthquakes     | Env5  | 3        | 4        | 12           | Undesirable |
36 | Lawsuit from within and from outside                                | Leg2  | 4        | 3        | 12           | Undesirable |

The results of the risk matrix founded 6 unacceptable and 30 undesirable risk. This risk is categorized as major risk requiring mitigation actions.

4 Conclusions

The risks identified during the execution of District road maintenance projects in Badung regency, Bali was found to be 36 risks. These six risks were found in the unacceptable category, such as the social risk that is equipment damage occurred, workplace accidents: technical risks that are results of field measurements were not according to plan, starting late implementation, getting picture details, economic risks that are limited short-term costs. The unacceptable risk is carried out in advance mitigation efforts such as planning costs, time, security, and safety.

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