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,

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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.

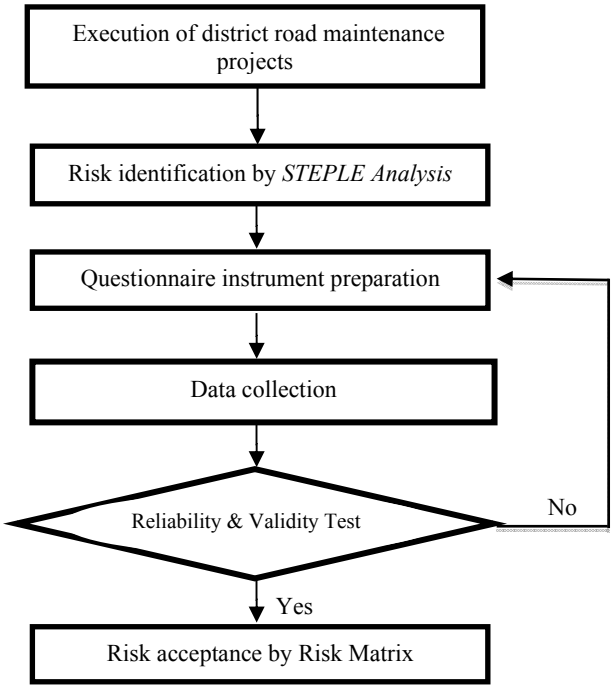

Fig.1. Analytical framework.

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/catastropic	5
Large/critical	4
Medium/serious	3
Smal/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].

Table 3. Risk acceptance scale.

Acceptance of risk	Risk acceptance scale (X)
Unacceptable	$X \geq 15$
Undesirable	$5 \leq X < 15$
Acceptable	$3 \leq X < 5$
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.

Table 4. Identified risks.

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)**	Eco
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

No	Risks	Code
D	**Political Risk (P)**	Pol
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
E	**Environmental Risk (E)**	Env
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
F	**Legal risk (L)**	Leg
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.

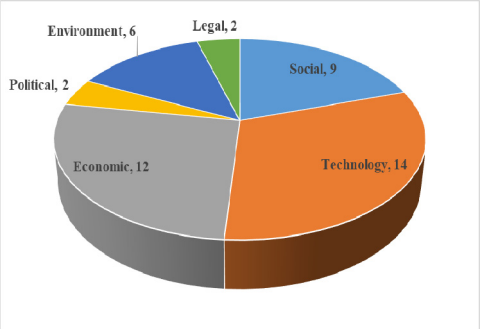

Fig. 2. Identified risks (45 risks) by STEPLE method.

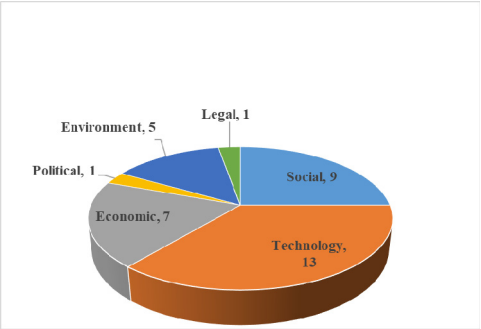

Fig. 3. Valid risks (36 risks) resulting from validity and reliability tests.

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).

Table 6. Risk matrix.

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)	(2)	(3)	(4)	(5)	(6) = (4)*(5)	(7)
	predetermined 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	Tech10	4	3	12	Undesirable
19	Failure to obtain planning details with available time	Tech11	4	4	16	Unacceptable
20	Inadequate geological data and existing field surveys	Tech12	3	4	12	Undesirable
21	Lack of heavy equipment	Tech13	3	4	12	Undesirable
22	Incompatibility between work volume in the contract and field conditions	Tech14	3	4	12	Undesirable
C	**Economic Risk (E)**	**Eco**				
23	Market unpredictable risk	Eco2	3	4	12	Undesirable
24	Unexpected price increases for materials	Eco4	3	4	12	Undesirable
25	Late payment of the terms of the owner to the contractor	Eco5	2	4	8	Undesirable
26	The main contractor cannot pay To subcontractor	Eco7	3	4	12	Undesirable
27	Increased operating costs	Eco8	3	3	9	Undesirable
28	Short-term costs that cannot be resolved to minimize long-term costs	Eco11	4	4	16	Unacceptable
29	Problems arise during the warranty period	Eco12	3	3	9	Undesirable
D	**Political Risk (P)**	**Pol**				
30	The rejection of certain mass organizations for the benefit of their group	Pol2	3	4	12	Undesirable
E	**Environmental Risk (E).**	**Env**				
31	The influence of a bad community environment, as a result of the project	Env1	3	4	12	Undesirable

No	Risks	Code	Mode (F)	Mode (C)	Matrix Value	Category
(1)	(2)	(3)	(4)	(5)	(6) = (4)*(5)	(7)
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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