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Flyover Development Risk Analysis: Review of The Construction Phase Efforts to Minimize Environmental Impact

Flyover Development Risk Analysis: Review of The Construction Phase Efforts to Minimize Environmental Impact

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Abstract. The increase of road segments are needed to overcome traffic congestion in Special Capital Region of Jakarta. Flyover is one of the efforts made to add road segments. The construction of flyovers will change the initial landscape and initial environmental tone. This change affects environmental, social, and economic conditions. All risks in construction activity must be managed to minimize their negative impact. Risks management starts with risk analysis by identification significant impact. This research aims to analyze the risks arising from the construction of flyovers. This analysis was carried out on the Becakayu flyover, which only began operating in 2017. Environmental risk is calculated based on parameters of opportunity, magnitude, level, frequency, and sensitivity of risks that may arise. Based on the results of the analysis, it was found that the construction of flyovers had a moderate risk to the environment during the construction phase. To minimize the risks that may arise, it is necessary to manage the risks that may arise through the construction process that meets the standards, the use of well-maintained equipment, the use of hazard signs, and the measurement of environmental quality during the construction phase.

1. Introduction

Traffic conditions in Jakarta are getting worse day by day. Growth in the number of motor vehicles amounts to 5.35% per year while the growth of roads is <2% per year [1]. In addition, 1,382, community live in Bodetabek (Bogor-Depok-Tangerang-Bekasi) who carry out activities Special Capital Region of Jakarta. This certainly adds to the burden of transportation needs in Special Capital Region of Jakarta. One of the efforts to overcome the imbalance conditions, it is necessary to increase the number of roads. Congestion occurs in the morning and evening. In the morning, where many communities who live in Bekasi and surrounding areas will go to work in Jakarta, and in the afternoon when the community will return home. Therefore Flyover is useful to reduce the accumulation of the vehicles volume at that time. The construction of flyovers is one solution to the addition of roads, because the availability of space for roads is now increasingly difficult and expensive, especially for big cities.

In the context of overcoming congestion problems, the construction of flyovers is difficult to avoid [2,3]. However, efforts should be made to avoid the negative impact on the physical condition of the environment due to the construction of flyover. If it is not managed, this negative impact can threaten human life as well [4].

To avoid the negative impacts of flyover construction, it is necessary to carry out development activities that refer to the principle of sustainable development [5]. Physical environmental conditions that must be examined as an impact of flyovers construction are air quality, water quality, land quality, and noise. Socioeconomic conditions affected by development are a decrease in the commercial value of land due to a decrease in income from business activities, increase disruption arising from the construction of flyovers, increase risk of accidents to communities around the construction site [6]. Therefore workers must commit to carrying out health and safety protocols. Workers must get skills training and understanding of work safety procedures, both related to equipment, materials, and working time so as not to work overtime, and workers' welfare must also be taken into account.

Various impacts that may arise due to the process and post-flyover construction need to be identified and the risk of these impacts needs to be assessed and anticipated. This research only analyzes the construction process, so that all impacts after the flyover function is not detected from this research. This research aims to identify and assess the risk of impacts that may arise due to the construction of flyovers, especially in the construction phase.

2. Method

The data used in this research were obtained based on observations, interviews with the parties road user, shop owner, the community around the project, as well as various reports related to the construction of the flyovers especially the Becakayu toll flyovers. Identification of risks that might arise was conducted by comparing the actual conditions on the ground with the ideal conditions to be achieved.

Risk value analysis was conducted by hierarchical analysis [8]. The Risk Value was calculated using the following formula:

$$Value\ Risk = \sum f\ x\ (S1 + S2) \quad (1)$$

Where: f = Risk frequency
S1 = Risk effect
S2 = Sensitivity value

Based on the formula above, the level of environmental risk can be concluded with the following classification [8]:

0–150 = Low risk, routine management procedures
151–300 = Moderate risk, requires high-level management attention
301–450 = High risk, requires detailed research and management.

3. Result and Discussion

3.1. Description of Becakayu Flyover

The Becakayu flyover was built in 2015 with a length of 21.04 km that stretches from the DI Panjaitan-Casablanca road to Jalan Raya Genda Agung Bekasi Timur, Bekasi City. The flyover construction is divided into two sections, namely section I Kasablanka-Jakasampurna stretching 11.8 kilometers and section II stretching 9.2 kilometers from Jakasampurna-Jalan Raya Genda Agung, East Bekasi. The flyover construction passes through several villages, namely Cipinang Melayu, Jetibening, Jakasampurna, Bintarajaya, Durenjaya and Rawatembaga. The Becakyu Flyover was built on the banks of the Kalimalang river and used part of the Kalimalang road, so that part of the buildings along the Kalimalang, both on the left and right sides, were affected by the eviction. This causes many plants along the Kalimalang road section to be felled and the relocation of various buildings along the Kalimalang road. In terms of space, the construction of the Becakayu Flyover has made significant changes.

3.2. Risks in construction activity

Risk in a project is a measure of the opportunities and consequences of not achieving predetermined project targets [9]. In analyzing the risk factors that occur, is based on the result of observations and includes stakeholders and experts. Risk analysis is based on 3 impact parameters including economic, environmental, and social [10]. Meanwhile, other research related to risk analysis in construction activities is more dominant in risk analysis researches on worker safety. As the results of measurements, various risks are identified as a result of flyovers construction during the construction phase. Risks are categorized into 3 parts, namely risks to the physical environment which include groundwater and air, economic risks which include the household economy and the economy of the affected area, social risks which include comfort, safety, and aesthetics. Risk assessment of construction activities can help decision-makers identify major impact factors and make friendly construction plans for environmental, social, and economic in the early stages of construction. The impact of construction activities on road infrastructure development activities varies greatly. This depends on the construction technique and the material construction used. Analysis of the impacts distribution and the level of impact will help to determine the steps to be taken as well as the utilization of existing resources and energy [11]. Possible risks can be seen in Table 1.

Table 1. Risk identification of flyover construction in the construction phase

Environmental, Social, and Economic Components	Effect of Constructing Flyover in the Construction Phase
Environmental Aspect	
Land use [12][13]	Exist
Flora [14]	Exist
Fauna [14]	None
Air quality [14–16]	Exist
Surface water quality [14]	Exist
Groundwater quantity [17]	None
Flood [18]	Exist
Soil structure [19]	Exist
Noise [15]	Exist
Social Aspect	
Public health level [20]	None
Public comfort level [20]	Exist
Total population [21]	None
Public culture/habits [21]	None
Environmental aesthetics [14]	Exist
Economic Aspect	
Business opportunities [22,23]	Exist
Transportation costs [14]	None
Type of business [22]	None
Congestion [15]	Exist
Criminality	None
Traffic accident [24]	Exist

Based on the identification results of risk types that may arise, risks in the construction phase and physical aspects of the environment are more than economic and social aspects [25]. Potential risks will be differ different in post-construction conditions because the activities carried out are different. This is because the construction phase is the beginning of changes in the landscape, and the use of various heavy equipment that can cause emissions and noise. As a result of landscape changes, besides having an impact on the physical environment itself, it will also have an impact on the type of activity and use

of space around the construction site. Meanwhile, the use of heavy equipment in addition to having an impact on the physical environment also has an impact on the levels of comfort and environmental aesthetics.

Analysis of environmental risks was carried out by 3 methods, namely qualitative analysis, semi-quantitative analysis, and significant environmental analysis [26]. In this research, the risk analysis was conducted qualitatively and semi-quantitatively. An environmental risk analysis was carried out to estimate the risk opportunity of activity and the magnitude of the impact that might occur.

Quantitative analysis was conducted by combining the risk opportunity value (Table 2) with the magnitude of the risk that might arise (Table 3). The risk level from the results of qualitative analysis can be seen in Table 4.

Table 2. Risk opportunity matrix for the construction phase flyover construction.

Risk	Opportunity Level	Description
		Environmental Aspect
Land-use change	C[c]	Some of the Becakayu flyover construction is above the Kalimalang, but it uses community land around the object to replace the road used for piles. Local people sell their land because their comfort is disturbed, so the change in function due to the activity is likely to be moderate.
Decreased amount of flora	A[a]	Decreased amount of flora (plants) due to the felling of trees around the project area.
Decreased air quality	A[a]	Decreased air quality due to soil excavation thereby increasing dust and emissions from machinery and heavy vehicles used.
Decreased surface water quality	B[b]	The decrease in surface water quality occurs due to the process of installing piles/excavations that use water to soften the excavated soil so that the discharge often enters the surface water, in this case, Kalimalang or the closest drainage channel.
Increased flood/inundation	B[b]	Flood/inundation occurs due to the presence of solids or rocks that enter the drainage channel so that it can close the water inlet.
Change/disturbance to the soil structure	C[c]	Disruption to the soil structure occurs due to the installation of foundations and bridge piles.
Increased noise	A[a]	Increased noises due to the operation of heavy equipment and the pile erection process and the sound of motor vehicles experiencing congestion
		Social Aspect
Public comfort level	A[a]	The public comfort level decreases due to the influence of decreased air quality, noise, and congestion
Reduced environmental aesthetics	C[c]	Reduced environmental aesthetics due to the work process that produces a lot of soil piles
		Economic Aspect
Decreased business opportunities	A[a]	The decrease in business opportunities occurs because the road that is traversed in the construction phase is very dense and uncomfortable so many parties/consumers avoid the flyovers construction area.

Risk	Opportunity Level	Description
Increased congestion	A[a]	Increased congestion occurs because the road when construction is cut off by the work area so that its capacity is reduced.
Increased traffic accidents	E[e]	Increased traffic accidents occur because a lot of lands is scattered on the road, the surface of the road is damaged and the density increases so that the chance of falling or other accidents increases.

[a]Certainly happen [b]Most likely [c] Medium probability
[d] Low probability [e]Rarely

Table 3. Risk magnitude matrix for flyover construction in the construction phase

Risk	Opportunity Level	Description
		Environmental Aspect
Land Use Change	2[b]	The effect is small because the land affected by the project is largely unused and has not changed from its original function, because the conditions of congestion and discomfort do not increase community interest in investing land in the area.
Decreased amount of flora	3[c]	The effect of a decrease in the amount of flora is due to the development process, trees in the project area are cut down because it is feared to disrupt the development process and at the time of operation.
Decreased air quality	4[d]	The decline in air quality is of a large category due to the dust generated and emissions released by heavy equipment and motor vehicles, especially when congestion is very high, and project work is carried out 24 hours.
Decreased surface water quality	3[c]	The decline in surface water quality is of a moderate category because the construction work process that uses water is not continuous, but the discharge can increase sedimentation in receiving water bodies and have an impact on the capacity of the canal and the quality of PDAM (water utility company) raw water.
Increased flood/inundation	3[c]	Increased opportunities for flood/inundation in the medium category because as a result of the reduction in water catchment areas, decreased channel capacity due to increased sediment from runoffs and closed/change in drainage channels.
Change/disturbance to the soil structure	2[b]	Changes/disturbances to the soil structure are of a small category because the installation of the pile is carried out by referring to the SOP, with a certified operator.
Noise increase	3[c]	The increased noise is in the medium category because the development process is carried out over a long and continuous period, so the impact received is also relatively significant.
		Social Aspect
Public comfort level	4[d]	A decrease in the comfort level is categorized as a big because of the many direct impacts received by the community, such as noise, congestion, decreased air quality. In addition, the construction period runs long enough so that the recovery process on the community is also long.
Reduced environmental aesthetics	2[b]	The aesthetic reduction is of a small category because the aesthetic impact can be overcome by closing the construction area with a good banner.

Risk	Opportunity Level	Description
		Economic Aspect
Decreased business opportunities	2[b]	The decrease in business opportunities is small because the impact of the community can make temporary/permanent changes to the types of businesses that are following the conditions of the roads around and can maximize the types of online businesses that do not rely on the physical building and business location.
Increased congestion	4[d]	The increase in congestion is a big category because of congestion that occurs in a long and continuous area, causing waste in fuel use, increasing noise, increasing vehicle emissions, reducing the economic value of the region, and increasing community stress.
Increased traffic accidents	2[b]	The increase in traffic accidents is small because it can be overcome by installing signs—especially in accident-prone areas.

[a]Influence is insignificant
[b]Small effect
[c]Medium influence
[d]Big influence
[e]Disaster

Table 4. Risk level matrix for flyover construction in the construction phase

Risk	Opportunity	Magnitude Value	Risk Value
	Environmental Aspect		
Land Use Change	C	2	Low
Decreased amount of flora	A	3	High
Decreased air quality	A	4	High
Decreased surface water quality	B	3	Medium
Increased flood/inundation	B	3	Medium
Change/disturbance to the soil structure	C	2	Low
Increased noise	A	3	High
	Social Aspect		
Public comfort level	A	4	High
Reduced environmental aesthetics	C	2	Low
	Economic Aspect		
Decreased business opportunities	A	2	Low
Increased congestion	A	4	High
Increased traffic accidents	E	2	Low

Based on the results of qualitative risk analysis, the results are obtained that the high risk due to the construction of flyovers in the construction phase is a decrease in air quality, noise levels, comfort levels of the community, and increased congestion. Other research that strengthen the results of this research were conducted by [27] states that the dominant environmental risks arising from construction activities include air, soil, water, and noise pollution. These impacts need to be a concern for development implementers and the local government so as not to ignore standardized work procedures, use of well-maintained equipment/machinery and carry out continuous monitoring and control efforts at least every 6 months.

The semi-quantitative analysis was carried out to assess the total risk of the flyover construction activities. Assessments are based on elements of the frequency of occurrence (Table 5), the magnitude value (Table 4), and sensitivity (Table 6) of the risks that arise. The rating of each element can be seen in Tables 3, 5, 6, and 7.

Table 5. Matrix frequency of impact occurrence of construction phase flyover construction

Risk	Frequency	Description
		Environmental Aspect
Land Use Change	1[a]	The average community adjusts the function of the building to their land, rarely the community who at the time of construction sell the land they own or convert it.
Decreased amount of flora	5[e]	Reduction in the amount of flora is very common because before entering the construction stage land clearing is carried out, at this stage trees in the project area are cut down so that it is not dangerous and does not interfere.
Decreased air quality	5[e]	Decreased air quality in the construction phase is very common, especially in increasing concentrations of dust, CO_2, and CO.
Decreased surface water quality	3[c]	The decrease in surface water quality is medium/moderate, because significant impacts only occur in the rainy season, while in the dry season the impact can be minimized.
Increased flood/inundation	3[c]	Increased opportunities for flooding have moderate/medium frequency because the impacts are significant only during the rainy season and are local.
Change/disturbance to the soil structure	2[b]	Changes/disruptions to the soil structure have a small frequency because the construction process is carried out following SOP, certified operators, and standardized equipment.
Increased noise	5[e]	Increased noise has a very frequent frequency due to increased congestion and construction work that lasts 24 hours in a very long duration.
		Social Aspect
Public comfort level	5[e]	Decrease in the level of comfort has a frequency very often occurs because construction activities carried out 24 hours in long duration and considerable impact.
Reduced environmental aesthetics	2[b]	The aesthetic decline has a low frequency because the construction process is conducted neatly and covers the construction area.
		Economic Aspect
Decreased business opportunities	3[c]	The decrease in business opportunities has medium/medium frequency due to the very dense access conditions that reduce the interest of the community in carrying out activities around the construction site
Increased congestion	5[e]	Increased congestion has a frequency very often because roads around the project are significantly reduced and road surface conditions are very poor, so vehicle speed decreases and road capacity is reduced

Risk	Frequency	Description
Increased traffic accidents	2[b]	Increased traffic accidents have a small frequency because signs have been installed in accident-prone areas.

[a]A possibility not to occur [b]Small [c]Medium/Moderate
[d]It often happens [e]Very often happens

Table 6. Sensitivity value matrix

Risk	Sensitivity Value	Description
		Environmental Aspect
Land Use Change	3	Land-use change is a regional/local concern
Decreased amount of flora	4	Decreased amount of flora is a national concern
Decreased air quality	4	Decreased air quality is a national concern
Decreased surface water quality	3	Decreased surface water quality is a regional/local concern
Increased flood/inundation	3	Increased flood/inundation is a regional/local concern
Changes/disturbances to the soil structure	1	Changes/disturbances to the soil structure are not a concern of the community
Increased noise	3	Increased noise is a regional/local concern
		Social Aspect
Public comfort level	3	Decreased level of comfort is a regional/local concern
Reduced environmental aesthetics	1	The reduced environmental aesthetics are not a concern of the community
		Economic Aspect
Decreased business opportunities	3	Decreased business opportunities are a local/regional concern
Increased congestion	3	Increased congestion is becoming a local/regional concern
Increased traffic accidents	1	Increased traffic accidents are not a concern of the community

[a]Not a community concern [b] A group concern [c]A regional/local concern
[d]A national concern [e]An international concern

Table 7. Risk magnitude matrix for flyover construction in the construction phase

Risk	Frequency (f)	Influence (S1)	Sensitivity (S2)	Risk Value (S1+S2)	Fx
		Environmental Aspect			
Land Use Change	1	2	3	5	
Decreased amount of flora	5	3	4	35	
Decreased air quality	5	4	4	40	
Decreased surface water quality	3	3	3	18	

Risk	Frequency (f)	Influence (S1)	Sensitivity (S2)	Risk Value (S1+S2)	Fx
Increased flood/inundation	3	3	3	18	
Changes/disturbances to the soil structure	2	2	1	6	
Increased noise	5	3	3	30	
Social Aspect					
Public comfort level	5	4	3	35	
Reduced environmental aesthetics	2	2	1	6	
Economic Aspect					
Decreased business opportunities	3	2	3	15	
Increased congestion	5	4	3	35	
Increased traffic accidents	2	2	1	6	
TOTAL RISK				249[b]	

[a]0–150 = Low risk, routine management procedures
[b]151–300 = Moderate risk, requires high-level management attention
[c]301–450 = High risk, requires detailed research and management

Based on the results of semi-quantitative risk analysis, it shows that overall aspects of both environmental, social, and economic risks pose a moderate risk due to the construction of flyovers in the construction phase. This risk assessment shows that it requires high-level management attention in the construction phase of the flyover construction. Factors causing this condition are the use of heavy equipment, the project is carried out in a fairly long area and connects Special Capital Region of Jakarta with the dense city of Bekasi, close to residential areas and commercial buildings and is carried out over a long time with a continuous workable system. This is in line with the results of research conducted by [28]. Therefore, to avoid the risk of negative impacts, the work process following the Standard Operating Procedure (SOP) of construction is carried out by a trained and certified workforce, especially for heavy equipment operators, the use of well-maintained equipment, and monitoring and control of environmental quality. Based on the results of the assessment of respondents' answers to the research sample questionnaire, it shows that there is a positive correlation between occupational health and safety knowledge (OSH) with employee behavior. There is a positive correlation between OSH knowledge, the use of personal protective equipment, and the use of infrastructure in the workplace. The level of risk understanding has a positive effect on behaving safely [29]. In the perspective of the project, the party who has the greatest risk in the construction of road infrastructure is the contractor. This is because the contractor is responsible for the use of various heavy equipment in construction work [30]. Failure in the use of heavy equipment will adversely affect the ecological, social and economic environment. This is in line with the environmental risks for road infrastructure development activities, such as what happened in the construction of the Becakayu flyover. Other research in China and Australia show that the risks of construction activity arising are categorized into 2, namely (a) risks to internal of the project such as completion time, costs, construction quality, and safety; (b) risks to external of the project such as the preservation of the health environment and the comfort of the community. This study also suggests maximizing the planning and management of construction activities so that the project runs safely, efficiently, and with quality [31]. The following steps are recommended to reduce the possibility of environmental and communal impacts: (a) Provision of flyovers for pedestrians; (b) Flush water

frequently at the construction stage to reduce dust; (c) Solid waste landfill and wastewater disposal in permitted locations; (d) Stop construction work activities during peak traffic flow (e) Manage traffic flow and install traffic symbols such as traffic signals, road markings, street lighting and protecting road users; (f) Move shade trees or plan to plant new trees as compensation for pruning trees in the work area; (g) Rehabilitate damaged utility facilities as soon as possible due to flyover work.

4. Conclusion

The results of a qualitative risk analysis indicate that there are several components from environmental, social, and economic aspects that have a high risk due to the construction of flyovers during the construction phase. These components are a decrease in air quality, noise levels, a decrease in the amount of flora, a level of public comfort, and increased congestion. Meanwhile, the components that have the risk of impact are land-use changes, changes in structure/disturbance to the land, a decrease in environmental aesthetics, and an increase in the number of traffic accidents. The effect of flyover construction on the construction phase on humans and the surrounding environment shows a moderate risk. This is because the scope and area of the project are large and are on a strategic road and involve the use of heavy equipment and the implementation of the project which is quite long and carried out continuously

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