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*by* Rina Kurniati

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# Revealing Cost and Benefit of Vegetative Approach to Mitigate Riverbank Landslide in Semarang Coastal Villages

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## Revealing Cost and Benefit of Vegetative Approach to Mitigate Riverbank Landslide in Semarang Coastal Villages

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**Abstract.** Landslide mitigation efforts through a vegetative approach have not been entrenched in the community, including in Semarang Coastal Villages. This condition happened due to several things, such as the lack of public understanding about the importance of reforesting river borders, the lack of understanding of reforestation, and the unclear benefits the community of river reforestation will receive. Although no specific approach can prevent landslides, the vegetative approach is one of the prevention strategies that tend to be easy to do and has a low cost. Therefore, the vegetative approach is a feasible strategy to be proposed, where the current government is also encouraging the application of this approach to prevent landslides as well as community empowerment. This study aims to identify the costs and benefits of implementing a vegetative approach to prevent landslides in the coastal area of Semarang City, knowing the socio-economic benefits the community may receive from the vegetative approach. It is hoped that it can increase community participation, especially among the local coastal people in Semarang City, which belong to the middle to lower economic community. The analytical method used is the cost-benefit analysis method by comparing the number of benefits and costs studied from the implementation process of the vegetative approach from beginning to maintenance. The data used in this study is secondary data such as existing land use, river border area, plant species, and population. The expected result is the feasibility of applying a vegetative approach in riverbank areas that compares the number of social and economic benefits and socio-economic costs. By knowing the feasibility, it can also be determined how the socio-economic capacity of the community to implement the approach.

**Keywords:** coastal area, feasibility analysis, landslides, vegetative approach

### 1. Introduction

Landslide can be interpreted as a form of erosion in which land transport occurs in a relatively short time in a vast number. Heavy rains cause it as one of the climate change impacts, which are created an increase in water content in the soil layer. Based on the Regional Disaster Management Agency (BPBD) of Semarang City (2020), the most significant percentage of disasters in Semarang City is landslides, which have 51% percentage. However, until 2021, erosion is still the city's most common disaster. It is recorded that there has been 146 landslide disaster throughout 2021 in Semarang City.

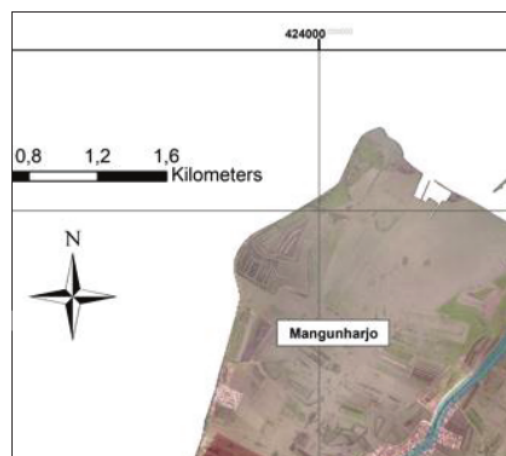
One of the locations that became the location of the landslide disaster was Mangkang Wetan Village as one of the coastal areas in Semarang, especially the area around the Beringin River, which crosses the two villages. The Beringin River border area has the potential to experience landslides caused by



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high water runoff from upstream, which causes erosion of river walls. Landslides at the study site are included in the type C landslide zone, which means they are on a low slope of 0-20%.



**Figure 1.** The Map of Research Area (Mangkang Wetan).

The threat of landslides in these locations is also related to frequent flooding where high water discharges erode the soil and landslides. In fact, based on BPBD (2021), in the last three years, landslides have always occurred in these two villages, causing material losses and loss of life. Water transportation routes are needed according to their capacity as part of the coastal area, an estuary, or downstream of water runoff from upstream areas. If it does not match, then what happens is the embankment breaks, then floods, and then landslides occur.

The implementation of disaster management in this city refers to Law No. 24 of 2007 concerning Disaster Management and Regional Regulation No. 13 of 2010 concerning Implementation of Management in Semarang City. These preventive efforts include several activities, including pre-disaster activities, emergency response, and rehabilitation. Landslide disaster management efforts in Semarang are handled by BPBD as referred to in Law No. 24 of 2007. BPPD Semarang City is divided into three fields in carrying out the duties and authorities of Semarang landslide disaster management, namely: (1) the field of prevention and preparedness, (2) the emergency sector and logistics, (3) the field of rehabilitation and reconstruction. Efforts to prevent and prepare for landslides by BPBD have not been able to minimize the risk of landslides that continue to occur in this city every year. The main obstacle is that the party who is the implementer, namely members of the disaster preparedness village (Kelurahan Siap Bencana) and The Disaster Tangguh Village (Kampung Tangguh Bencana), is not yet capable enough to carry out the landslide emergency response plan or the Contingency Plan by the BPBD. At the same time, the implementation of the Rekon focuses on the micro-level (kelurahan). The training held by the BPBD has not been carried out comprehensively.

The government has not yet optimally responded to this in line with the increasing number of yearly landslides. The role of the community in disaster mitigation is critical. So far, landslide prevention efforts have been more technical in nature with a top-down approach so that community involvement is relatively low. Therefore, one approach to prevent landslides that the government is pushing is a vegetative approach. This approach not only aims to mitigate landslides but also empowers the community, where the community plays a key role in its implementation. The vegetative approach is considered an option in participatory and local landslide disaster management efforts.

Currently, vegetation as a Natural Based Solution, well known as NBS, is increasingly being used for erosion. The utilization of vegetation in landslide prevention efforts and drainage control has been implemented for centuries however its popularity has increased in the last few decades [1].

The vegetative approach is an alternative to post-flood and landslide disaster management which is considered more comprehensive and conserves the landscape, and can educate the public because it can be done directly by the community. In this area, most people are elementary school graduates who focus more on fulfilling the economy and do not understand the need for environmental conservation. Although the vegetative approach is carried out in stages and takes longer, this approach is considered more sustainable in maintaining natural functions while empowering local communities. Based on [2], The implementation of the vegetative approach was identified as having positive and negative effects. The positive effects that arise from the implementation of this approach are the strength of the soil increases due to roots and binding of soil layers, (ii) the pore water pressure is reduced due to plant's uptake and canopy cover, while the negative effect that may arise is vegetation may destabilize slopes in connection with strong winds (this is valid only for trees). Even though this vegetative approach has been used successfully for erosion protection in Europe, there are still some challenges that arise, such as the tools available at present are not sufficient to demonstrate properly.

In addition, the use of vegetation as a viable and effective measure in erosion risk mitigation management needs to be documented and more quantifiable. The effect of vegetation is complex and varies with time, soil type, and atmospheric conditions. One implementation of the vegetative approach is through the use of vetiver. Many studies all over the world have shown that vetiver as a hedge is the ideal plant to conserve soil and rehabilitate eroded land [1]. Vetiver grass has having fibrous roots reported to reach depths up to 3 m is very popular in slope stabilization. It is a low cost approach and environmentfriendly method for erosion control [3]. In Indonesia, vetiver grass technology as an effort to overcome landslides has only been known since 2007. In fact, planting vetiver as a form of vegetative approach is a disaster mitigation technology that is low-cost, practical, easy to manage and very effective in controlling erosion and land rehabilitation. In addition, vetiver also has economic value so that it can be a resource in empowering local communities. This is in line with the results of the Sendai Declaration Disaster Risk Reduction as so-called natural-based solutions. This approach is an effort to reduce disaster risk while at the same time contributing to the restoration, protection, and sustainable management of ecosystems, which in turn provides benefits for the surrounding communities, both local communities and the environment. President Joko Widodo also ordered local governments to apply a vegetative approach in the form of planting vetiver in landslide-prone areas (Setkab, 2020).

Based on the description above, to overcome landslides at the research locations, further studies are needed to analyze socio-economic feasibility (Cost-Benefit Analysis) so that comprehensive benefits can be known, especially for local communities as the most affected parties. CBA is considered as an approach commonly used in decision making, one of which is in disaster management efforts [4]. This is in line with [5], whereas CBA is a proper approach for the assessment of the economic efficiency of Disaster Risk Reduction measures. In contrast to the identification and specification process as the initial stage of the pre-project appraisal stage, CBA is able to scenario the potential of a project from different perspective [6]. Therefore, by knowing the economic feasibility of a vegetative approach to reduce disaster risk in the form of landslides, it is hoped that the community at the two research locations will play a more optimal role.

## 2. Data and Method

This research is closely related to quantitative data representing conditions in the field. The author uses economic feasibility analysis through the benefit-cost ratio method by using quantitative data obtained from secondary surveys to answer the stated objectives. This method was a useful predictive tool to appraise the landslide disaster management measures.

Through this method, identification, measurement, and comparison of the benefits and costs of the vegetative approach project as one of the landslide prevention efforts to create efficiency. The data used in the form of secondary data include:

1. Data on landslides 2020.
2. Social impact of landslides.
3. The economic impact of landslides.



4. Cost of procurement and maintenance of vetiver plants.
5. Benefits of Vetiver Grass Technology in several Asian countries

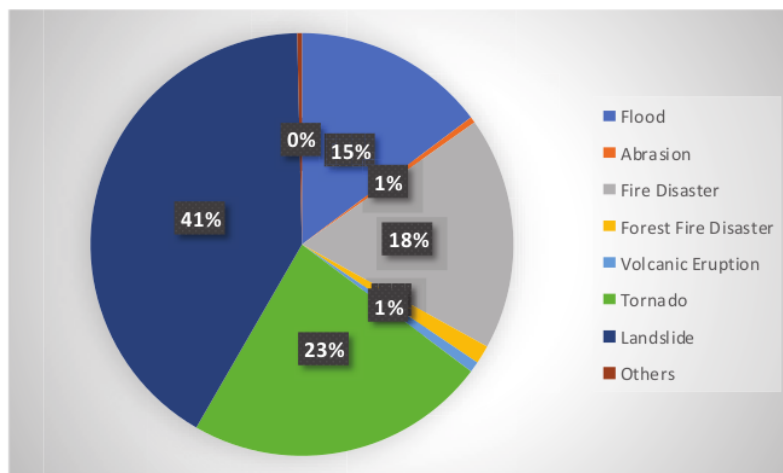
### Cost Benefit Analysis

Benefit Cost Ratio is a comparison between benefits and costs that have been adjusted to the present value. Disaster costs are increasing, both in terms of real needs and allocations [4], so that through a vegetative approach is expected to reduce losses caused by landslides. A comparison of the benefits and costs of implementing a vegetative approach is known by using the method of cost and benefit analysis. Based on [7] it founds that most of the studies illustrates higher benefits of disaster risk reduction measures compared to the costs incurred.

## 3. Discussion

### 3.1. Landslide Disaster (Semarang City)

Semarang city, the capital of Central Java province, has various potential for natural disasters, and the most common disasters in the last five years are landslides. As a coastal city exposed to the impact of climate change, one of which is very high rainfall and typology, the city of Semarang faces frequent erosion problems that impact losses of belongings and even human life. Based on the 2016-2020 Central Java Province Disaster Risk Study Document, Semarang City is an area that has a high level of potential danger for landslides. According to BPBD Semarang City, landslides were the most common disaster in Semarang City in 2020.



**Figure 2.** Semarang City Disaster in Percentage.  
(BPBD Semarang City,2020)

Based on the BPBD (2022) report, for the past five years, landslides have dominated all-natural disasters in the city of Semarang. Based on the table above, almost 50% of all natural disasters in the city of Semarang are landslides. Landslides occur not only in hilly areas (southern and left of Semarang) where the slope is >15% but also in coastal areas. Landslides that occur in this city are included in the category of "shallow landslides," which occur on river banks. The landslide was caused by large-scale flooding due to the high rain intensity, so it impacted the livelihood system of the local community. This disaster was also influenced by the conversion of land functions on the Beringin River border in the form of settlements and rice fields. This encourages silting up to the narrowing of the Beringin Hilir river. Hence when the intensity of rain is high, the volume of water in the Beringin Hulu watershed causes runoff water that flows the downstream, and the Beringin river cannot be accommodated enough.

This condition caused river bank erosion or landslide. In addition, the downstream location of the river is on the north coast of Semarang City. Based on the spatial analysis shown in Figure 4, the slope levels are 0 – 2% and 2 – 15%, but in the area around the banyan river the slope is dominated by 0 – 2%, so the Banyan river elevation can be said to be close to sea level elevation.

However, currently referring to the 2016-2020 RPJMD document for Semarang City, there has been no special effort in handling shallow landslides. The coastal area of Semarang, which is prone to landslides is Mangkang Wetan Village. Every year, the embankment of the Beringin River that flows in this village often breaks (landslides), causing flooding to reach the residents' settlements.

### 3.2. *Landslide Disaster Impact in Mangkang Wetan*

Trends around the world indicate that large numbers of people are migrating to big cities and coastal areas. Since 2000, more than 50% of the world's population live in cities, where 50% of them live in the coastal areas IPCC (2019) on [8] estimated that 680 million people currently live in the low-lying coastal zone and projected this number to reach more than one billion by 2050. As the largest archipelagic country in the world with the second-longest coastline in the world, it is not surprising that the progress of urban development in Indonesia cannot be separated from coastal cities. Coastal cities are the forefront of the fight against climate change, which risks the livelihoods of hundreds of local people that rely on natural resources for their daily needs. Hence, these areas are highly vulnerable to climate change and tend to face the impact of climate change in a variety of ways. The driven climate change impacts might be more exacerbated by other induced pressures due to the urban development pressure.

Coastal areas tend to have more complex impacts due to the climate change because these areas are more vulnerable than inland areas. Therefore Semarang, as the capital of Central Java Province and as a coastal city faces big challenges in adapting to climate change. The changes of weather cycle triggers flooding in coastal areas and it caused landslides disaster in downstream areas. The area that often occurs in disasters is Mangkang Wetan Village, which the Beringin Watershed crosses. At the end of 2020, the Sungai Beringin watershed increased by up to 70 cm, resulting in landslides around the river embankment. Landslides caused by river flooding are influenced by the high intensity of rain, a form of climate change. The embankment, which is partly in the form of a concrete foundation, cannot accommodate the high water discharge of the Beringin Watershed, causing shallow landslides around it. The impact of this disaster is that there have been fatalities since 2010, either dead, injured, or missing. The total estimated loss suffered by the community due to flooding during the rainy season of October 2017 – February 2018 is Rp. 481,578,517.00.

### 3.3. *Vetiver Grass Technology Project Feasibility Identification in Mangkang Wetan*

Vetiver System prevents soil erosion, preserves rain water, stabilizes earth, beautifies landscapes, purifies wastewater, keeps away pests, and stabilizes slopes. Based on [9], Vetiver grass technology is part of a green infrastructure approach that is sustainable, low-cost, and for reducing the risk of flooding. Vetiver and its parts have been widely developed for other uses, namely as a building material, animal feed, landscaping, ornamental plants, mulch, compost, veneer, fiberboard, ash for concrete work, and insecticide. The grass is also brought in to remove heavy metals from industrial waste, leachate from garbage, and participate in various industrial and commercial products.

This approach was introduced by the World Bank for soil and water in India in the 1980s and then developed in various countries based on their respective interests and functions. In disaster mitigation, it combines the deep root system and thick growth of the vetiver hedges so it will protect the banks of rivers and streams under flood conditions. Its deep roots prevent it from being washed away, while its thick top growth reduces flow velocity and its erosive power. Countries that have successfully implemented this approach are Australia and several Asian countries such as Malaysia, Philippines, China, and Vietnam [10].

In Indonesia, vetiver has been used for at least 200 years and is cultivated as an essential oil. However, since 2000, Ekoturin's East Bali Poverty Project (EBPP) Foundation has introduced Vetiver

Grass Technology as an effective means of preventing erosion and landslides. This technology continues to develop until now as a simple, organic, highly effective, and environmentally sustainable approach to soil conservation. So in this study, the authors conducted a feasibility study of the vetiver planting program to overcome landslides through the Benefit-Cost method.

The feasibility aspect only compares the costs and benefits that may be received. The approach is economical and aims to see the benefits and costs arising in the vetiver planting project as a disaster risk reduction effort, especially for the community as the affected party. The main aspect to be considered in this analysis is the Risk analysis aspect. The risk analysis results in a baseline estimate of the risk of the exposed population, assets, and the environment. This is the basis for analyzing the benefits of risk management. The risk analysis needs to be done with regard to the risk management measures to be identified in the later stage of the analysis, i.e., potential area affected and benefits due to risk management measures.

Benefit-Cost Identification Analyze.

- *Benefit*

Planting vetiver roots at the research site has the main objective of mitigating floods and landslides as a soil stabilizer. Planting vetiver as a disaster mitigation effort is widely used in various countries because of the great potential for reducing runoff and soil loss, in which the vetiver strips significantly hold back soil from the field. [11, p.]. Vetiver has been used as a disaster mitigation approach in Kalimantan and other parts of Indonesia.

Bojonegoro is one of the areas that has implemented vetiver planting as slope stability in 2009, and this project has succeeded optimally in ensuring the stability of the slopes of the oil field in Bojonegoro, East Java. Apart from being an approach to landslide disaster mitigation, planting vetiver is also beneficial in controlling pollution and conserving soil and water. Planting vetiver has proven successful as a sustainable solution in controlling water pollution in the Citarum watershed in 2007 [12]. Furthermore, there are indirect benefits that are expected to occur from the vetiver planting project. The main indirect benefit is the reduction of economic losses due to yearly landslides. Planting vetiver as a soil stabilizer, especially in the Beringin watershed, is expected to withstand the currents during the rainy season, which is the main cause of landslides, where the local community bears the economic loss reaches more than Rp. 400,000,000, - (BPBD, 2020). Based on [13], Mangkang Wetan is the village with the highest poverty rate in the Tugu District, where most local people work as farm laborers, so vetiver planting is expected to provide economic benefits through the development of vetiver-based local products that can compete with similar products from other areas. Vetiver can be used as a raw material for essential oil with a high selling value, as well as various handicraft products such as mats, baskets, and other household products. Therefore, in the long term, it is expected to increase the Mangkang Wetan area's competitiveness and community engagement and relationships.

- *Cost*

The process of implementing the vetiver root planting project at the Beringin watershed requires a cost factor that must be met, and the main thing is the cost of financing the vetiver planting project, which consists of providing land, purchasing vetiver seeds, paying the wages of project implementers and in the long term requiring the cost of monitoring this project.

However, based on the maintenance of vetiver, it is quite easy and inexpensive so that it does not burden the community as the leading actor. Furthermore, if viewed from an economic point of view, this project has the potential to provide economic benefits for the communities involved through the development of local products that the subsequent cost is the cost of capital for developing local products made from vetiver but based on [14] the production cost of essential oil products made from essential oils is smaller than the profit obtained from these products. The following cost is the cost of empowering local communities who will be involved in the process of implementing this project which can be obtained from government and NGO funding. This project also requires the community to adapt and give time to get involved in planting vetiver in their neighborhood.



Direct		Indirect	
Tangible	Intangible	Tangible	Intangible
Vetiver as Soil Stabilizer	Communities as planning subjects involved throughout the vetiver planting project process	Reduced losses from annual landslides	Increasing regional competitiveness
Vetiver as a soil moisture enhancer	Vetiver Grass increasing the value and skills of local people as regional assets	Improving water quality and reducing pollutant levels	increased community engagement and relationships
Vetiver as pest deterrent	Residents are able to use the river for non-consumption needs	Increasing the income of local residents involved	
Vetiver Grass System as a regional asset		Increased regional income	
Direct		Indirect	
Tangible	Intangible	Tangible	Intangible
Financing in vetiver planting projects	Local Community Adaptation	Biaya monitoring keberlanjutan proyek	Regional development based on local economy
Financing for local community empowerment		Biaya pengembangan produk lokal berbahan baku vetiver	

High  
Low

**Figure 3.** Cost and Benefit Identification.

(Research Analysis 2022 according to relevant studies: [9][15][15] [16])

The results of the above analysis show that there are intangible and tangible benefits as well as costs, and both are tangible and intangible. This shows that the costs incurred in the form of economic expenditure will produce a much more significant impact on tangible, intangible, and direct or indirect benefits. The impact of the vetiver planting project in the long term will not only play a role in disaster risk reduction, which routinely occurs every year and creates material and non-material losses to local communities. However, it will also play a role in developing the area's competitiveness, which is currently a densely populated settlement, through product development of local volatile ingredients made from vetiver. This analysis is expected to be able to provide an overview of the impact of disaster risk reduction efforts through a vegetative approach for local communities and is also expected to be a model for similar cases in other areas.

#### 4. Conclusion

It concludes that the vetiver planting project is one of the effective approaches to mitigating landslides that regularly occur in Mangkangwetan Village as an area passed by the Beringin watershed. Implementing the Vetiver Grass System to mitigate landslides has been carried out in various countries, especially on the Asian continent.

According to the result analysis, the leading cause of landslides at the research area is the very heavy river currents and river bodies and embankments that are not able to withstand the heavy river as a form of rainfall with very high intensity. This condition happened as a result of climate change. The Vetiver Grass System functions as a soil stabilizer to withstand very heavy river currents, especially during the rainy season.

Besides reducing the risk of annual landslides at the research site and reducing the economic loss borne by residents, planting vetiver indirectly in the long term has the potential to improve the quality of life of local communities. Local communities quality of life improvement through water and soil conservation as well as the development of vetiver-based local products involving local communities as the subject of planning.

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