ISSN 2809-6339

ENVIRONMENTAL MANAGEMENT STRATEGY ON RIVERBANKS AS EROSION PREVENTION

Nurlita Pertiwi[1]
Mithen[2]
Nur Anny Suryaningsih Taufieq[3]

[1,2,3]Engineering Faculty, Universitas Negeri Makassar, Makassar, Indonesia

e-mail: nurlita.pertiwi@unm.ac.id

ABSTRACT

Riverbanks have an important role in maintaining river ecosystems. Erosion and sedimentation as the dynamics of watersheds determine the sustainability of river ecosystem functions. This study describes environmental management strategies on riverbanks to prevent erosion. The research method is descriptive quantitative. The location is three districts in South Sulawesi as managers of the Jeneberang River, Walanane River, and Saddang River. The primary data sources were 27 experts consisting of 21 government officials and six experts from higher education. The SWOT analysis method uses aspects of Strengths, Weaknesses, Opportunities, and Threats to find the strategy. The data analysis results indicate the development of green belts on the riverbanks with local vegetation maintenance. Therefore, the right strategy for achieving environmental quality on riverbanks is improving the quality of vegetation on riverbanks by strengthening the role of village institutions. Developing an education program to increase community knowledge, attitudes, and skills in local plant conservation on riverbanks is very important in planting and maintaining vegetation.

Keywords: Community, Village Institution, and Conservation

1) INTRODUCTION

Riverbank management protects the entire river ecosystem. The vegetation in this area can be wild plants or cultivated plants. The most important thing is that the selected plants can conserve water. Woody plants are a good choice in this protection program (Evette, Balique, Lavaine, Rey, & Prunier, 2012)(Schmitt, Schäffer, Koop, & Symmank, 2018)

However, the biggest challenges are cultivation and housing activities that cut down timber. Cultivating seasonal crops on riverbanks is very popular because of the fertility of the soil and the ease of obtaining water sources. In addition, communities are also built houses on the edge of the river embankment and pose the risk of landslides. This utilization condition causes surface erosion or the transfer of soil particles from land to river bodies (Seitz et al., 2015).

Surface erosion occurs in normal erosion or natural soil transport processes. This process takes place slowly but continuously. The transfer of these particles causes an increase in

sedimentation capacity in the river body. The volume of sediment that occurs due to normal erosion does not impact the physical form of the river. Furthermore, accelerated or surface erosion cases occur due to human activities on riverbanks (Montgomery, 2007). The displacement of large volumes of land occurs due to land use and settlements on the banks of rivers. This form of erosion is also commonly called a landslide if a riverbank collapses.

The government has made various efforts to protect the land from cliff erosion. Structural efforts are carried out by building concrete embankments or masonry, while non-structural efforts are planting vegetation by utilizing its roots as cliff reinforcement. In addition, many efforts to reduce the speed of river flow in flood assets are also carried out to protect riverbanks.

The erosion on riverbanks occurs in two stages of the process as follows. The first is the process of destroying the soil structure into smaller grains. This process occurs due to the impact energy of raindrops that hit the ground surface. The second is transporting soil grains by water at a lower level. Even on the river banks, the soil particles are transported to the bottom of the river. This process is known as sedimentation.

The process of erosion and sedimentation triggers the overflow of river water. The flow of river water displaces the banks of the river to the surrounding settlements. As a result, the community suffers heavy losses due to erosion and flooding. Riverbank management plays an important role in erosion and flood protection. The presence of tree and shrub vegetation along the riverbank has been shown to reduce surface erosion, and cliff erosion, the presence of bamboo plants contributes to maintaining slope stability and reduces the risk of landslides (Emberson, 2017)(Pertiwi, Rauf, & Lullulangi, 2021).

Soil erosion on riverbanks can cause sedimentation in river bodies so that siltation occurs. The result is a flood or puddle on the riverbank. Erosion that is not controlled indicates a decline in river quality. Therefore, riverbank management is important because it causes a lot of loss of land and crop yields. In Indonesia, the collective management of natural resources requires local government regulations. The regulation is formed based on a strategic reference that accommodates all interests and follows the government's potential and resources. Therefore, this study discusses riverbank management strategies to prevent erosion. SWOT analysis based on all stakeholders' strengths, weaknesses, opportunities, and threats related to river management used in strategy formulation.

2) METHODS

The research team compiled a questionnaire involving three environmental experts. The three experts have research experience in three watersheds: the Walanae watershed, the Jeneberang watershed, and the Saddang watershed. Therefore, the resulting questionnaire can be declared valid. The resulting questionnaire includes statements following field conditions and measures four categories, namely strengths, weaknesses, challenges, and opportunities. Respondents were given the option to sort the statements by giving the highest score to the most important statement.

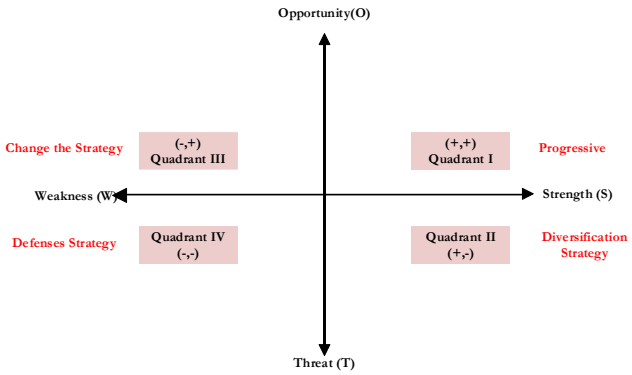
Primary data sources were 27 experts consisting of 21 government officials and six experts from higher education. Informants are people who are considered to have sufficient knowledge about riverbank management. Informants who work as local government officials have tasks that focus on riverbank management, such as the Public Works Service, the Environment Service, and the Agriculture Service. Furthermore, seven informants are environmental experts who have research experience in three watersheds. Table 1 describes the distribution of informants and their affiliations.

Tabel 1. Information Distribution Based on Their Afiliation

Affilition	Data Source
Local Governmnet of Enrekang Regency	6
Local Governmnet of Gowa Regency	6
Local Governmnet of Soppeng Regency	5
Provincial Government	4
University	6
Total	27

Informants were given a questionnaire to determine the significant value, weight, and score for each strategy that had been determined. Furthermore, informants' answers were averaged and included as material for analysis. The SWOT analysis begins with the next calculation by accumulating internal factors with the method of combining strengths and weaknesses as an IFAS analysis. In contrast, the accumulation of external factors is referred to as EFAS analysis (Sarsby, 2016). Strategy determination is carried out using the quadrant method presented in Figure 1.

Figure 1. Quadrant of SWOT Analysis



3) RESULTS

The river management policy strategy aims to achieve a sustainable river ecosystem with community participation in the protection of vegetation on its banks. This policy direction is considered to accommodate economic (land productivity and community assets), social (fair), and environmental (sustainable) interests. This strategy also aims to reduce the risk of surface erosion and cliff erosion that causes damage to river ecosystems.

Analysis of the Strength of Riverbank Management in Preventing Erosion

Strength is the potential possessed by the community or regional government related to riverbank management. This strength can be seen from the activities carried out in the past and supporting these conservation efforts. The results of the formulation of internal strengths found three strategies, namely: 1) The existence of protective plants on the banks of the river, 2) The existence of green open space that functions as a greenbelt in the upstream and middle areas, 3) There is a public trust to maintain vegetation along the riverbank.

In Indonesia, vegetation along riverbanks is mostly overgrown by endemic plants such as bamboo, banyan, tamarind (Hastari & Gumiri, 2021; Pertiwi & Taufieq, 2019). This plant has the potential to protect the physical quality of the river. Communities around the river have a local culture to maintain the vegetation with various considerations, such as using plants for daily needs or meeting the needs of local traditional events.

The researcher's search at the research location found that bamboo plants grew spread on the banks of the river. The root, stem, and leaf systems of bamboo have the potential for surface erosion. The strength bamboo root system and intertwined with each other strengthen the soil structure, resulting in minimizing cliff erosion. In addition, a tight root system can withstand water runoff or, in other words, reduce surface runoff. The dense leaves and twig system bamboo support the soil conservation. Bamboo leaves reduce the kinetic energy of rain falling to the ground. Low energy can reduce soil particles that trigger surface erosion. The series of bamboo plant systems is important because it reduces surface erosion and cliff erosion (Nath & Das, 2011; Zhou, Hua, Tong, & YE, 2004).

Other woody plants with large canopies also contribute to erosion prevention. Several research results show that the larger the canopy area in a landscape reduces the volume of runoff water on the surface (Mosley, 1982). In addition, the ability of roots and stems to absorb water also supports the ability of water conservation in vegetation.

Green open space that functions as a greenbelt is still available in river areas, especially upstream and middle areas. This is due to the low level of community access to manage the land. These two aspects are the main supporters of riverbank management activities. Some research results also show that the community maintains the plants along the river because of their function as medicinal plants and plants to support daily activities. Another reason that develops in the community is that some trees are guarded and must not be cut down because they have mystical powers.

Analysis of the Weakness of Riverbank Management in Preventing Erosion

Weaknesses are elements that hinder all efforts that hinder riverbank management. These internal elements have been considered the cause of the lack of riverbank management in preventing erosion. The assessment of strategic factors regarding the weakness of environmental conditions that hinder the potential of riverbanks consists of three, namely: 1) Cultivation activities on the banks of the river, 2) The growth of residential areas on the banks of rivers in urban areas, 3) River material mining activities.

Cultivation activities also mark community activities in utilizing riverbanks. The existence of rice fields and gardens on the river banks is a trigger for erosion. Several references reveal that intensive tillage causes an increase in surface erosion. In addition, agricultural cultivation on land with a high slope has a great risk of erosion. This risk will increase if the riverbanks originally covered with vegetation are cut down into rice fields. The water absorption level in the land is reduced and facilitates drainage.

Settlements located on the riverbanks generally do not have a good wastewater network system. As a result, waste is directly dumped into the ground and allowed to flow into the river. The volume of liquid waste is quite large and continues to cause an increase in surface runoff. This condition increases the risk of riverbank erosion.

The potential for river materials such as sand and gravel is the target of miners (Lagasse, Simons, & Winkley, 1980). Mining activities with various means of transportation cause changes in river flow. This activity also eliminates tree and shrub vegetation along the river. As a result, surface erosion occurs more quickly.

Analysis of Riverbank Management Opportunities for Erosion Prevention

Opportunity is an external element that drives all riverbank management efforts. The results of the opportunity analysis found three strategies, namely: 1) Priority for the use of village funds which regulates the existence of an environmental care program, 2) The role of community

institutions in providing education to encourage environmental attitudes and behavior 3) Provision of perennial plant seeds for planting on riverbanks.

Central government regulations on strengthening village institutions provide the authority to regulate development funding. In recent years, the issue of community empowerment in government programs has become a priority (Colby, 1997). The Law of the Republic of Indonesia Number 6 of 2014 concerning Villages mandates the role of the community in village development, including river management as an important resource for people in rural areas. Furthermore, the Regulation of the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration Number 13 of 2020 concerning Priorities for the Use of Village Funds regulates the existence of villages that care about the environment. This mandate is an opportunity for the village government to program Non-Structural River Management activities to achieve the title of an environmentally caring village. One of the regulations is an environmentally friendly village category which is a form of performance. Villages that show good performance will receive awards and funding from the central government. The village government can activate community participation in riverbank maintenance with this regulation.

The strength of social institutions in several regions in Indonesia is an important issue in community empowerment. The role of community institutions to provide education to their members effectively encourages environmental attitudes and behavior in rural communities. The development of community roles should begin with an educational program about the importance of real conservation on riverbanks. Various models of community empowerment have been applied to get riverbank conditions that are maintained. Furthermore, the Ministry of Environment and Forestry has distributed thousands of perennial plant seeds to support riverbank conservation.

Analysis Of Riverbank Management Threats in Preventing Erosion

Threats are elements that hinder all efforts to support riverbank management. This element comes from outside parties, the community and local government, and other external potentials. The threat analysis results found three strategies: 1) Licensing for building material mining business 2) Environmental and spatial management policies 3) Sectoral River management programs.

The researchers' search on three strategic rivers found mining activities in the river. This activity is an effort to meet the needs of building materials. However, the facts show that mining activities cause river channel displacements, making it difficult for the government to regulate the pattern of Non-Structural River Management. These activities are mostly managed by entrepreneurs who do not live in the river area. The condition is even worse than the entrepreneur has obtained a legal mining permit from the government.

The environmental management policy is realized by Law No. 32 of 2009 concerning Environmental Protection and Management and Law No. 26 of 2007 concerning Spatial Planning. These policies are national and are not implemented optimally. Several strategies that refer to the policy have made river border areas a cultivation area. As a result, the local government does not have the legal power to regulate the community's conservation in the riverbank area.

In addition, riverbank management policies are generally sectoral(Nurhidayah & McIlgorm, 2019). Natural resources management is dominated by efforts to utilize riverbanks for the economic benefit of the community.

Alternative Strategy

Based on the identification of the strategic environment above, several alternative non-structural river management strategies can be formulated as follows:

The first strategy is S-O (using strengths by taking advantage of opportunities). The potential

of riverbank vegetation can be maintained with the village government's efforts to achieve the title of an environmentally caring village. This strategy can be achieved by stimulating local governments to achieve this predicate. In addition, community institutions must also be able to educate the community in maintaining vegetation on riverbanks or participate in planting protective plants to conserve water and land. The strategy is chosen for the utilization of strengths and opportunities in the provision of non-structural river management facilities and infrastructure in the form of providing land, seeds, and plant maintenance costs.

Secondly is W-O (overcoming weaknesses by taking advantage of opportunities). The people's habit of carrying out cultivation activities on the river banks causes the cutting of trees. This is based on the belief that these trees can reduce land productivity. This weakness can be anticipated by the village government's efforts to achieve the title of an environmentally caring village. This strategy must, of course, be encouraged through environmental instruments or providing incentives to communities who wish to participate in the Non-Structural River Management program. The choice of the right strategy is to socialize the Environmental Care Village program that encourages community empowerment in Non-Structural River management.

In addition, the potential of community institutions needs to be directed to provide education for those who manage land intensively on riverbanks. With this education, the community will realize the importance of non-structural river management efforts to protect their land assets. The strategy chosen in overcoming weaknesses by taking advantage of opportunities is to develop the capacity of community institutions to educate their members to be involved in protecting river quality.

Thirdly is S-T (using force to deal with threats). The existence of vegetation on the river banks, which is a characteristic of Non-Structural River Management, can be used as a zoning boundary for river material mining. With the maintenance of the vegetation, mining activities that damage the left and right sides of the river can be limited. Therefore, the strategy chosen in utilizing strengths and overcoming threats is limiting river material mining zoning through the application of riverbank greenbelts.

Fourth is W-T (minimize weaknesses to overcome threats). A green belt can overcome the negative impact of intensive cultivation on riverbanks. Optimal application of river border policies will be a barrier to the risk of expanding the mining area, which is a threat from non-structural river management. Therefore, the strategy of optimizing riverbank policies is an option to minimize weaknesses and overcome threats

Swot Analysis

Identification of the internal and external strategic environment is carried out by IFAS and EFAS analysis. The results of the two analyses are presented in table 2 and table 3.

Table 2. IFAS Analysis of Riverbank Management

No.	Strategic Factor	Significance Level	Weight	Rating	Score
1	The existence of protective plants on the banks of the river	3	0.20	3	0.60
2	The existence of green open space that functions as a greenbelt in the upstream and middle areas	2	0.13	4	0.53
3	There is a public trust to maintain vegetation along the riverbank	2	0.13	3.5	0.47

Strength Total					1.60
4	Cultivation activities on the banks of the river	3	0.20	2	0.40
5	The growth of residential areas on the banks of rivers in urban areas	3	0.20	2.5	0.50
6	River material mining activities	2	0.13	2.5	0.33
Weakness Total					1.23
IFAS Score					0.37

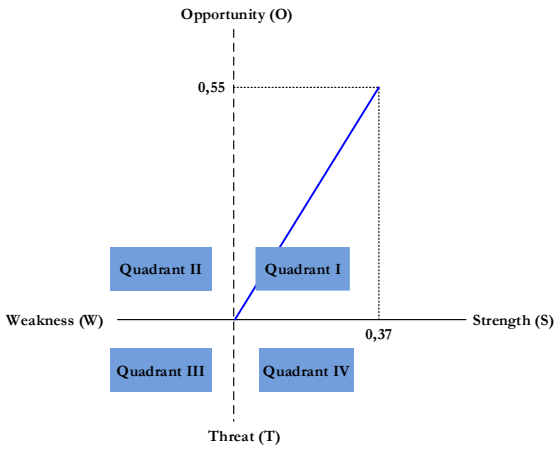
The value of strength in the SWOT result is greater than the value of weakness. These results indicate that the potential for vegetation along the riverbank is in good condition. Furthermore, the EFAS results show that the opportunity value is higher than the threat value. Opportunities for riverbank management can be optimized, so that threats can be reduced.

Tabel 3. EFAS Analysis of Riverbank Management

No.	Strategic Factor	Significance Level	Weight	Rating	Score
1	Priority for the use of village funds which regulates the existence of an environmental care program	3	0.18	4	0.71
2	The role of community institutions in providing education to encourage environmental attitudes and behavior	3	0.18	3	0.53
3	Provision of perennial plant seeds for planting on riverbanks	2	0.12	3	0.35
Opportunity Total					1.59
4	Licensing for building material mining business	3	0.18	2.9	0.51
5	Environmental and spatial management policies	3	0.18	1	0.18
6	Sectoral river management programs	3	0.18	2	0.35
Threat Total					1.04
EFAS SCORE					0.55

Determination of policy positions based on the difference in Strength-Weakness and the difference in Opportunity-Threats is illustrated in the following quadrant analysis:

Figure 2 Quadrant of Startegy



The results of the quadrant analysis indicate that the presence of vegetation on the riverbanks as a green belt must be maintained. Local governments and communities have the opportunity to develop vegetation maintenance on riverbanks to prevent erosion. The right strategy is to optimize the village government to educate the community to participate in this program. The target of achievement is the concern of the whole community so that the criteria for village care for the environment are achieved. In addition, the assistance of plant seeds is also an important part of improving the quality of riverbanks.

4) DISCUSSION

The old paradigm of river management, which focuses on the work of cliff protection structures, should be shifted to the development of greenbelts on riverbanks with the maintenance of local vegetation. Implementation of the Non-Structural River Management strategy can be achieved with the knowledge and attitude of the community environment to participate in the maintenance of vegetation and river protection. In previous studies, the author has developed the four - M Model as a guide for community institutions in educating the community (Pertiwi & Taufieq, 2020).

As part of water resource management, riverbank management can be realized by identifying the community's needs and the government as stakeholders (Colby, 1997). A river basin strategy that views this ecosystem from upstream to downstream is important to address the risk of erosion, landslides, and flood disasters. In addition, these resources are also very important in supporting food security and various needs of people's lives.

5) CONCLUSION

The strategy for achieving the environmental quality on riverbanks is improving the quality of vegetation on riverbanks by strengthening the role of village institutions. Developing an education program to increase community knowledge, attitudes, and skills in local plant conservation on riverbanks is very important in planting and maintaining vegetation.

REFERENCES

Colby, I. C. (1997). Transforming human services organizations through empowerment of neighbors. *Journal of Community Practice*, *4*(2), 1–12. Taylor & Francis.

Emberson, R. (2017). Deforestation: Accelerating riverbank erosion. *Nature Geoscience*, *10*(5), 328. Nature Publishing Group.

Evette, A., Balique, C., Lavaine, C., Rey, F., & Prunier, P. (2012). Using ecological and biogeographical features to produce a typology of the plant species used in bioengineering for riverbank protection in Europe. *River Research and Applications*, *28*(10), 1830–1842. Wiley Online Library.

Hastari, B., & Gumiri, S. (2021). Diversity of riparian plants of black water ecosystem in the Sebangau River of Central Kalimantan Indonesian. *IOP Conference Series: Earth and Environmental Science* (Vol. 744, p. 12040). IOP Publishing.

Lagasse, P. F., Simons, D. B., & Winkley, B. R. (1980). Impact of gravel mining on river system stability. *Journal of the Waterway, Port, Coastal and Ocean Division*, *106*(3), 389–404. American Society of Civil Engineers.

Montgomery, D. R. (2007). Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(33), 13268–13272.

Mosley, M. P. (1982). The effect of a New Zealand beech forest canopy on the kinetic energy of water drops and on surface erosion. *Earth Surface Processes and Landforms*, *7*(2), 103–107. Wiley Online Library.

Nath, A. J., & Das, A. K. (2011). Decomposition dynamics of three priority bamboo species of homegardens in Barak Valley, Northeast India. *Tropical Ecology*, *52*(3), 325–330. Cambridge.

Nurhidayah, L., & McIlgorm, A. (2019). Coastal adaptation laws and the social justice of policies to address sea level rise: An Indonesian insight. *Ocean & coastal management*, *171*, 11–18. Elsevier.

Pertiwi, N., Rauf, B., & Lullulangi, M. (2021). Analysis of Riverbank Stability Due to Bamboo Vegetation in Walanae River, South Sulawesi, Indonesia. *Journal of Ecological Engineering*, *22*(9), 176–184. Polskie Towarzystwo Inzynierii Ekologicznej.

Pertiwi, N., & Taufieq, N. A. S. (2019). The Diversity of Riparian Trees Vegetation at Around The Lawo River, South Sulawesi, Indonesia. *Journal of Physics: Conference Series* (Vol. 1244, p. 12008). IOP Publishing.

Pertiwi, N., & Taufieq, N. A. S. (2020). Four-M Model for Bamboo Conservation in Riverbanks Management (Case Study in Communities of Soppeng Regency South Sulawesi Indonesia). *3rd International Conference on Education, Science, and Technology (ICEST 2019)* (pp. 40–44). Atlantis Press.

Sarsby, A. (2016). *SWOT analysis*. Lulu. com.

Schmitt, K., Schäffer, M., Koop, J., & Symmank, L. (2018). River bank stabilisation by bioengineering: potentials for ecological diversity. *Journal of Applied Water Engineering and Research*, *6*(4), 262–273. Taylor & Francis.

Seitz, S., Goebes, P., Zumstein, P., Assmann, T., Kühn, P., Niklaus, P. A., Schuldt, A., et al. (2015). The influence of leaf litter diversity and soil fauna on initial soil erosion in subtropical forests. *Earth Surface Processes and Landforms*, *40*(11), 1439–1447. Wiley Online Library.

Zhou, W., Hua, X., Tong, X., & YE, H. (2004). Preliminary Study on Water and Soil Erosion at Bamboo Stand. *Journal of Zhejiang Forestry Science and Technology*, *24*, 20–23.