ANALYSIS OF FLOOD MANAGEMENT STRATEGIES BASED ON INFRASTRUCTURE STRENGTHENING AND ENVIRONMENTAL CONSERVATION IN SOUTH KALIMANTAN

Aswin Rosadi
Master of Government Science,
Faculty of Social and Political Sciences,
Universitas Lambung Mangkurat, Indonesia,
2420421310013@mhs.ulm.ac.id;

Budi Kristanto
Master of Government Science,
Faculty of Social and Political Sciences,
Universitas Lambung Mangkurat, Indonesia,
budikristanto.fisip@ulm.ac.id;

ABSTRACT

Flooding in South Kalimantan has become increasingly severe due to deforestation, inadequate infrastructure, and urbanization. This study analyzes strategies to mitigate floods through infrastructure strengthening and environmental conservation. Using a mixed-methods approach, the research identifies deforestation as a primary driver of flood risk, reducing the land's water absorption capacity and worsening runoff. Urban areas, particularly Banjarmasin and Martapura, experience recurrent floods due to outdated drainage systems incapable of handling extreme rainfall exacerbated by climate change. Infrastructure improvements, such as modernized drainage systems, dams, and embankments, are crucial but must be supported by conservation efforts. Reforestation, river restoration, and sustainable watershed management significantly reduce flood risks by enhancing ecological resilience. Collaborative governance involving government agencies, local communities, and private sectors is essential to address resource limitations and improve flood preparedness. This integrated approach combines infrastructure development and ecosystem-based solutions to create sustainable, long-term flood mitigation strategies. By prioritizing environmental restoration, adaptive infrastructure, and multi-stakeholder collaboration, South Kalimantan can enhance its resilience against flood disasters.

Keywords: *Flood mitigation, infrastructure strengthening, environmental conservation, deforestation, South Kalimantan.*

A. INTRODUCTION

Flooding is one of the most frequent natural disaster phenomena in Indonesia, especially in areas with high rainfall and uncontrolled land use patterns (Suryani, 2019). South Kalimantan Province, located on the island of Borneo, has experienced a significant increase in the frequency and intensity of flooding over the past few decades. The impacts of these disasters include major economic and

social losses, as well as damage to infrastructure (Wijaya et al., 2020). For example, in 2021, South Kalimantan experienced the largest flood in the last five decades, affecting thousands of residents and causing serious damage to various critical infrastructures (Prasetyo & Mulyani, 2022).

Based on a report by the National Disaster Management Agency (*BNPB*, 2022), the high rate of deforestation is one of the main factors causing flooding in South Kalimantan. The function of forests as water retainers and absorbers has decreased significantly due to massive land conversion for plantations and settlements (Ridwan & Maulana, 2021). This decrease in forest area has reduced the soil's ability to absorb rainwater. Data from the Ministry of Environment and Forestry (KLHK, 2021) shows that South Kalimantan has lost around 1.9 million hectares of forest in the past decade, with more than 30% of the area degraded. This directly increases the risk of flooding, as degraded or lost forests are no longer able to reduce large amounts of stormwater runoff (Saputra & Gunawan, 2020).

This phenomenon is further influenced by climate change, which contributes to an increase in rainfall intensity. Based on an analysis conducted by the Meteorology, Climatology and Geophysics Agency (BMKG, 2022), tropical regions such as Indonesia are projected to face an increase in the number of days with extreme rainfall in the next few years, in line with global predictions regarding the impacts of climate change (Handoko et al., 2021). Research by Kumar and Wijaya (2019) revealed that heavy rainfall can worsen conditions in areas with significant environmental degradation, including South Kalimantan. The study confirmed that areas experiencing ecosystem degradation have a higher vulnerability to disasters such as flash floods and landslides.

In addition to environmental factors, rapid urbanization in South Kalimantan also plays a significant role in increasing flood risk. Cities such as Banjarmasin and Martapura have experienced rapid population growth, which has driven settlement expansion as well as infrastructure development. Based on data from the South Kalimantan Central Bureau of Statistics (BPS Kalsel, 2022), the urbanization rate in the region is recorded at 3.5% per year. However, this high rate of development is not matched by adequate spatial planning, especially in the management of drainage systems and the provision of water catchment areas (Rahman & Fitriani, 2021). Research by Abdullah (2020) revealed that cities with rapid urbanization development tend to have inadequate drainage systems, so that rainwater cannot be absorbed optimally, which then triggers puddles and large-scale floods.

According to a report by the South Kalimantan Regional Disaster Management Agency (BPBD), the capacity of the drainage system in urban areas of South Kalimantan is only able to drain about 50-60% of the water discharge during high rainfall, making flooding difficult to overcome (BPBD South Kalimantan, 2022). This problem is further exacerbated by the limited green open space that functions as a water catchment area. Based on a survey conducted by the Center for Environmental and Disaster Studies (2021), green open space in Banjarmasin City only covers 9% of the total area, far below the minimum standard of 30% recommended for large cities by the World Health

Organization (WHO, 2020).

To overcome the intensifying flood problem, various parties have sought mitigation measures. One example is the South Kalimantan Regional Disaster Management Agency (BPBD), which has been carrying out monitoring activities and providing early warnings to communities living in flood-prone areas, especially during the rainy season (BPBD South Kalimantan, 2022). However, despite the existence of various mitigation initiatives, their implementation faces a number of obstacles. One of the main challenges is the lack of coordination between relevant agencies. Sandra et al. (2023) revealed that the existence of sectoral egos among government agencies hampers synergy in flood management, resulting in less efficient resource allocation and mitigation efforts not being optimally integrated.

Lack of public awareness of flood risks is another factor that hinders the effectiveness of disaster management efforts in South Kalimantan. A survey conducted by the South Kalimantan Environment Agency (2022) revealed that only around 40% of residents in flood-prone areas have a basic understanding of mitigation measures. This finding emphasizes the importance of more intensive socialization and education programs to improve community preparedness for disaster threats. In addition, research by Lestari et al. (2021) shows that the level of community understanding of disaster risk significantly affects the speed and effectiveness of disaster management, especially in the aspects of risk reduction and flood response.

An ecosystem-based approach has been identified as one of the effective strategies in flood management. Handayani and Suryono (2021) explain that this approach includes various efforts, such as environmental conservation through reforestation and afforestation, as well as river ecosystem restoration and repair of damaged forest areas. Their results show that restoring river ecosystems can reduce flood risk by increasing water flow capacity and reducing sedimentation along river channels. Meanwhile, Zulkarnain et al. (2020) highlighted the importance of a community- based approach to flood mitigation, by actively involving communities in preserving the environment and participating in disaster risk management activities in their area.

In addition to an ecosystem-based approach, integrated spatial management and improved drainage infrastructure are important steps in reducing flood risk in South Kalimantan. Kusuma and Firmansyah (2022) emphasized the need for spatial planning that considers disaster risk. They recommended that local governments limit development in flood-prone areas and strengthen infrastructure such as drainage systems, dikes and canals. This research shows that implementing evidence-based strategies with adaptive spatial planning can significantly reduce the impact of flooding in the region.

At the policy level, cross-sector collaboration involving the government, community and private sector plays a strategic role in disaster management efforts. Based on the *Undang-Undang No. 24 Tahun 2007* on Disaster Management, the responsibility for disaster management in Indonesia is a shared responsibility, which emphasizes the importance of synergy between the central government, local governments, and non- governmental

institutions to create an effective and sustainable flood management strategy (BNPB, 2022). Research by Darmawan and Fitriana (2021) shows that cross-sector collaboration can improve efficiency and effectiveness in mitigation efforts, particularly through optimizing the provision of funds and utilization of available resources.

Sumber: Database Pengelolaan Data dan Informasi Bencana Indonesia (DIBI), diolah

The formulation of the problem in this study is to analyze how infrastructure conditions, particularly drainage systems, and deforestation levels affect the severity of flooding in South Kalimantan. In addition, this research also aims to identify effective strategies that can be applied in flood management, with a focus on strengthening infrastructure and environmental conservation as sustainable mitigation efforts in the region.

B. LITERATURE REVIEW

Deforestation, Climate Change and the Impact on Flood Risk

Flooding in tropical regions like Indonesia is influenced not only by high rainfall intensity, but also by major changes to the natural landscape. One environmental factor that increases flood risk is deforestation. Forests act as natural catchment areas that can absorb and retain rainwater. However, the high rate of deforestation in Indonesia, including in Kalimantan, has reduced the capacity of forests to manage water (Wijaya & Purwanto, 2018). Ridwan and Maulana (2021) noted that the conversion of forests into oil palm plantations in South Kalimantan has a significant impact on the reduction of water catchment areas, so that rainwater flows directly to the ground surface and triggers flash floods.

Research conducted by Abdullah and Handayani (2019) shows that forest destruction contributes to an increase in the volume of surface runoff due to a decrease in the soil's ability to absorb water. When deforestation reduces the soil's capacity to absorb water, rainwater that falls cannot be stored optimally in the soil. This phenomenon is further exacerbated by the topographic conditions of Kalimantan which has many low areas, which are vulnerable to inundation when river water discharge increases (Kusuma et al., 2020).

In addition to deforestation, global climate change also plays a role in increasing flood risk in the tropics. Studies from the Meteorology, Climatology and Geophysics Agency (BMKG, 2022) show that increasing global temperatures lead to more extreme and erratic rainfall patterns, worsening conditions in flood-

prone areas. Climate change lengthens and increases the intensity of the rainy season, which contributes to higher flood frequency in Kalimantan (Prasetyo, 2020). The combination of deforestation and climate change exacerbates conditions in South Kalimantan, which has a flood-prone topography, due to the loss of water-retaining forests and increased rainfall intensity. The decline in tropical forest area in Kalimantan also destabilizes microclimates that are important in reducing extreme rainfall and exacerbating flood impacts (Santoso & Rahmawati, 2019; Gunawan, 2021).

Drainage Infrastructure and Spatial Management in Flood Mitigation

Adequate drainage systems are essential in flood management, especially in urban areas. Drainage that is ineffective in conveying rainwater to sewers often leads to inundation and major flooding, as revealed by Suryani (2019) and Handoko & Setiawan (2020). Urban drainage must be designed to adapt to increased rainfall due to climate change, yet many Indonesian cities have outdated and inadequate drainage systems (Suryono, 2018). In South Kalimantan, rapid urbanization exacerbates this condition, with major cities such as Banjarmasin and Martapura having drainage systems that are unable to accommodate extreme rainfall (Rahman & Fitriani, 2021). Data from BPS South Kalimantan (2022) shows that only about 60% of drainage systems in major cities are in good condition, leading to frequent flooding of roads and settlements.

Good spatial management is crucial in flood mitigation, as expressed by Abdullah et al. (2020), who noted that spatial policies that pay little attention to disaster risk lead to development in flood-prone areas and divert water catchment areas into settlements or shopping centers. This increases the risk of flooding as water cannot be properly absorbed into the soil. Kusuma and Firmansyah (2022) recommend limiting development in low-lying areas and using technology to monitor the development of urban areas. Research by Yusuf et al. (2019) also emphasized the importance of flood risk- based spatial planning, such as zoning flood- prone areas, as well as the need for river rehabilitation to prevent sedimentation that reduces water flow capacity.

Policy Approach and Community Empowerment in Flood Mitigation

Flooding in South Kalimantan requires an integrated policy approach involving the government, community, and private sector. Law No. 24 of 2007 emphasizes disaster management as a shared responsibility (BNPB, 2022), and cross-sector collaboration is key to effective flood mitigation (Darmawan & Fitriana, 2021). Research by Lestari et al. (2021) shows that community involvement in mitigation efforts, such as reforestation and repairing waterways, increases understanding and preparedness for flood risks. Supriyadi (2020) added that community-based programs, such as volunteer groups or evacuation simulations, can strengthen mitigation. Kusuma and Maulida (2022) also emphasize the importance of community participation in spatial planning and flood mitigation policies, with community empowerment creating more disaster-resilient communities. Flood management in South Kalimantan requires evidence-based policies that can identify flood-prone areas and design appropriate mitigation strategies. Zulkarnain et al. (2020) proposed the use of spatial

data and geographic information systems (GIS) to monitor flood patterns, water flow, and the condition of drainage infrastructure. Factors such as deforestation, climate change, and urbanization without disaster risk-based spatial planning exacerbate flooding conditions, especially in areas with low topography and inadequate drainage. In addition, cross-sector collaboration and community empowerment also play an important role in flood mitigation, as actively engaged communities can strengthen resilience to disasters. With an integrated approach that involves all stakeholders and considers environmental aspects, infrastructure and evidence-based policies, flood management can be more effective and sustainable.

C. RESEARCH METHODS

An appropriate research method to assess the influence of infrastructure and deforestation on flood severity in South Kalimantan and its mitigation strategies is mixed-methods. This approach combines quantitative and qualitative analysis, using numerical data to measure flood severity and contextual data to understand causal factors and mitigation measures. In the quantitative stage, primary data was obtained through field surveys on drainage capacity, deforestation and rainfall, while secondary data was analyzed to examine the relationship between deforestation, infrastructure condition and flood frequency. Statistical analysis was used to identify correlations between these variables.

The qualitative phase focused on in- depth interviews with relevant parties, such as government officials, BPBDs, affected communities, and environmental organizations, to explore local perspectives on the causes of flooding and the effectiveness of mitigation strategies. Field observations were conducted to examine the condition of infrastructure and areas affected by deforestation. Qualitative data was analyzed using thematic analysis, while quantitative data used descriptive statistics. The combined results of these two approaches allow researchers to provide recommendations for data-driven and contextualized flood management strategies, as well as mitigation policies that are more effective and appropriate to the geographical, social, and environmental conditions in South Kalimantan.

D. RESULTS AND DISCUSSION

Effect of Deforestation on Flood Severity

The quantitative data analysis conducted shows that deforestation in South Kalimantan has a significant impact on flood severity. In the last ten years, the region has lost nearly 1.9 million hectares of forest, with more than 30% of it degraded. This process of forest loss has a direct impact on the diminishing capacity of groundwater recharge. Without adequate vegetation to absorb rainwater, the soil becomes more vulnerable to runoff, which increases the intensity of flooding. This decrease in forest cover causes rainwater to be poorly absorbed, and flow directly to the surface, increasing the potential for flash floods.

Interviews with officials from South Kalimantan's Regional Disaster Management Agency (BPBD) also confirmed that areas experiencing severe

deforestation tend to be hit more frequently by major floods, especially during the rainy season. This is closely related to nature's reduced capacity to absorb rainwater that runs off the surface more quickly, increasing the likelihood of widespread inundation. The interviews illustrate that deforestation exacerbates conditions on the ground, where areas that once absorbed water effectively are now unable to withstand high water flows, leading to more frequent and damaging floods.

In the statistical analysis, a strong relationship was found between the level of deforestation and the frequency and intensity of flooding in the South Kalimantan region. Areas that have lost more forest tend to experience more frequent and more severe flooding compared to areas that still have better forest cover. The degradation of soil quality due to the loss of water-retaining vegetation exacerbates this condition, as bare soil is unable to absorb rainwater effectively. In addition, the topography of South Kalimantan, which is mostly lowland, makes the region more vulnerable to water logging. Under these conditions, South Kalimantan is more prone to inundation during heavy rainfall, increasing its vulnerability to flooding.

The Role of Drainage Infrastructure in Flood Mitigation

The condition of drainage infrastructure in South Kalimantan, especially in major cities such as Banjarmasin and Martapura, shows a major problem in handling extreme rainfall events that occur regularly. Based on field observations, most of the drainage systems in these cities are outdated and cannot accommodate high water discharge. Most of the drainage channels can only accommodate about 50- 60% of the water discharge that occurs during heavy rainfall, resulting in water overflowing and inundating major roads and residential areas. This increases the risk of flooding, as water cannot be channeled quickly and efficiently to the sewer or river.

The field survey conducted also showed that inadequate drainage leads to frequent puddles on main roads and in densely populated areas. These puddles hamper community mobility and often damage existing infrastructure, such as roads and bridges, further exacerbating the impact of flooding. This shows that the inability of drainage to drain water properly can worsen the impact of floods, especially in densely populated urban areas.

In addition to the drainage problem itself, interviews with local communities and city infrastructure managers revealed that rapid urbanization in South Kalimantan has exacerbated this condition. Many urbanized areas do not have enough green open spaces, which function as water catchment areas. This lack of green open space reduces the city's capacity to cope with waterlogging during the rainy season. As a result, these cities are increasingly vulnerable to flooding, as there is not enough space to absorb rainwater and reduce the impact of surface runoff.

The importance of strengthening drainage infrastructure that is adaptive to climate change is increasingly urgent to reduce flood risk in South Kalimantan. Given the increasing volume of water due to extreme rainfall and climate change, the development of more modern drainage infrastructure based on disaster risk analysis is crucial. One approach that is needed is the

construction of larger and more efficient drainage channels, which can accommodate higher volumes of water. In addition, research and planning related to the use of advanced technologies, such as artificial intelligence (AI) to predict water flow patterns and the use of geographic information systems (GIS) to map flood- prone areas, will greatly assist in designing and improving drainage capacity. With the utilization of these technologies, drainage systems can be more effective in facing the evolving challenges of climate change.

The flood control infrastructure that has been developed in South Kalimantan, such as dams, embankments and drainage systems, is an important first step in flood mitigation. However, as urbanization increases and rainfall patterns change, there is a need to increase the capacity and adaptation of this infrastructure. Dams and embankments play a role in controlling the flow of rivers and retaining the volume of water that can cause flooding, while drainage systems serve to efficiently convey storm water to sewers. However, the construction and development of such infrastructure must be complemented with the latest technologies, such as GIS and AI, to increase its effectiveness and resilience in the face of increasingly unpredictable climate change.

Some key findings related to infrastructure strengthening are as follows:

1. Riam Kanan Dam in Banjar Regency

   A dam built to control the water discharge from the Martapura river plays a very important role in flood mitigation, especially during the rainy season. Designed to contain and regulate the flow of water from the frequently overflowing river, the dam aims to reduce the impact of flooding in downstream areas, including major cities such as Banjarbaru and Banjarmasin. With better control of water discharge, the dam can prevent major floods that often damage infrastructure and settlements. This provides significant protection for people living in areas that were previously vulnerable to flooding.

   While these dams are effective in reducing flood risk in general, their capacity is often insufficient when rainfall exceeds 3,000 mm/year, which is often the case due to climate change phenomena. When extreme rainfall occurs over a short period of time, the volume of water that must be handled exceeds the dam's capacity, which can lead to more severe overflows and flooding. Climate change phenomena that increase rainfall intensity unexpectedly add to the challenges in the management of these dams, requiring capacity building and adaptation to anticipate more extreme changes in weather patterns in the future.

2. Martapura River Embankment

   The construction of embankments along several river segments in South Kalimantan is one of the important steps in flood mitigation. These embankments are designed to protect residential areas from river water runoff that often occurs during the rainy season. The levees are expected to reduce the negative impacts of flooding, such as infrastructure damage and property loss. The embankment also serves as a barrier that helps to retain water, maintain settlement stability and increase the sense of security for residents

living in flood-prone areas.

The main challenge in these levee construction projects lies in the high cost of maintenance and reliance on limited local resources. Many constructed embankments suffer damage due to a lack of regular maintenance, rendering them unable to function optimally in the long term. This damage is often caused by factors such as erosion, lack of funds for repairs, and limited expertise and equipment available in the area. Therefore, a more structured and sustainable care and maintenance of levees is urgently needed to ensure their effectiveness in reducing flood risks.

3. Urban Drainage Systems in Banjarmasin and Banjarbaru

   The drainage systems in the cities of Banjarmasin and Banjarbaru have undergone significant improvements through projects supported by the local government. These improvements include widening drainage channels and installing water pumps in low areas prone to flooding. The widening of drainage channels aims to increase water flow capacity, while water pumps help drain water trapped in lower areas during heavy rainfall. These measures are expected to reduce waterlogging and reduce the risk of frequent flooding in both cities.

While improvements have been made, a number of obstacles still hamper the effectiveness of the drainage systems in both cities. One of the main problems found is rapid sedimentation in the drainage channels. This is caused by poor waste management, which causes debris such as soil, garbage, and wastewater to collect in the drainage channels. The accumulated sedimentation reduces the capacity of the drainage to drain water smoothly, resulting in standing water that causes flooding. Therefore, better waste management and regular maintenance of the drainage system are necessary to address this problem.

While infrastructure upgrades in South Kalimantan have provided significant benefits in reducing flood risk, their effectiveness is often hampered by limited technical capacity and lack of optimal maintenance. Existing infrastructure, despite improvements, is often unable to cope with increasing water volumes due to climate change and rapid urbanization. An increase in more extreme rainfall and the development of denser urban areas mean that existing infrastructure becomes less effective at containing water. Therefore, a renewal of more adaptive infrastructure capacity, including more modern drainage systems and better resource management, is required to meet these challenges in a sustainable manner.

Environmental Conservation as a Flood Mitigation Strategy

An environmental conservation-based approach is one of the effective strategies in reducing flood risks, especially in disaster- prone areas such as South Kalimantan. Data from the South Kalimantan BPBD and the Ministry of Environment and Forestry (MoEF) show that reforestation and re- greening of degraded areas plays an important role in reducing the volume of water runoff. This reforestation process improves the soil's ability to absorb water, reduces erosion, and improves overall soil quality. Restored forests can serve as effective water barriers, preventing excess runoff that can lead to flooding.

One form of conservation implemented in South Kalimantan is a river ecosystem restoration program that focuses on restoring forest areas along river courses. This program has been proven to retain water longer, reducing the potential for flooding during the rainy season. In addition, forest restoration in watersheds also plays a role in preventing excessive sedimentation that can reduce the capacity of waterways and cause flooding more quickly. With healthier forests, river ecosystems are able to function more optimally in regulating water flow and maintaining environmental balance, which in turn reduces the risk of flooding in downstream areas.

Community-based forest management is also an important approach to disaster mitigation in flood-prone areas. Interviews with environmental experts revealed that forest management involving local communities has many benefits, one of which is increasing community awareness and participation in preserving the environment. Afforestation programs involving local communities help create a sense of responsibility for the sustainability of forests and natural resources. This not only has an impact on improving environmental capacity, but also on community economic empowerment through activities based on the sustainable use of natural resources.

South Kalimantan's environmental conservation approach also focuses on ecosystem-based mitigation, which includes watershed management, critical land rehabilitation and peat swamp forest restoration. More integrated watershed management helps maintain water quality, prevent erosion, and reduce the risk of flooding that often occurs due to forest destruction. Critical land rehabilitation and peat swamp forest restoration also serve to restore the ecological function of damaged land, thereby restoring the soil's ability to absorb water and increasing resilience to natural disasters, including floods. This ecosystem-based approach not only improves environmental conditions, but also provides long-term benefits for communities that depend on these natural resources.

Some key findings related to environmental conservation are:

1. Barito Watershed Management

   The Barito watershed is one of the largest watersheds in South Kalimantan, covering most of the flood-prone areas. To reduce the risk of flooding, the reforestation program in the Barito watershed is focused on planting trees on critical land, with the aim of increasing soil absorption of rainwater. This program is expected to improve soil quality and reduce surface runoff that often causes flooding in downstream areas.

   However, reforestation efforts in the Barito watershed are hampered by ongoing deforestation, mainly due to land conversion for oil palm plantations and open-pit mining. This deforestation reduces the soil's capacity to absorb water, causing increased water flow into rivers and exacerbating flood risks. This deforestation threatens the effectiveness of reforestation programs and makes the area even more vulnerable to flood disasters.

2. Peat Swamp Forest Restoration

   The peat swamp forests in South Kalimantan, particularly in the Aluh-Aluh area, have suffered severe damage due to land conversion for agriculture, which has reduced the ecological function of these areas as

water buffers. This damage has contributed to increased surface water runoff and exacerbated the risk of flooding in the region. In response, restoration efforts are being carried out using peat rewetting techniques to restore water storage capacity and reduce runoff flowing into rivers.

Although these peat restoration efforts have yielded positive results, full recovery is a lengthy process due to the high level of degradation. Peat rewetting helps improve ecosystem conditions, but the structural and functional recovery of severely damaged peat requires sustained attention. The time needed to achieve optimal results involves gradual changes in enhancing water retention capacity in the affected areas.

3. Critical Land Rehabilitation

   In areas with sloping topography, such as the Meratus Mountains, rehabilitation is carried out by building terraces to reduce soil erosion as well as planting endemic trees to improve soil structure and increase water absorption. This program has proven successful in reducing soil erosion and surface water flow, which in turn reduces the risk of flooding and environmental damage. However, implementation is often constrained by limited available funds and a lack of effective coordination among relevant agencies, which hinders the smooth implementation and long-term maintenance of the program.

Environmental conservation approaches have a more significant long-term impact in preventing flooding. However, they require strong commitment from local governments, communities and the private sector to address challenges such as deforestation and land degradation. From the analysis conducted, it is clear that these two approaches cannot stand alone. The combination of the two provides more effective results in flood management. Important findings related to synergies are:

a. Watershed Management Based on Infrastructure and Ecosystems

   An example of synergy can be observed in the construction of small reservoirs (check dams) in the upstream Barito watershed, combined with reforestation of the surrounding water catchment areas. This approach helps reduce surface runoff while simultaneously increasing water storage capacity.

b. Integration of Urban Drainage and Green Spaces

   In urban areas such as Banjarmasin, the reorganization of drainage systems is often accompanied by the development of city parks that function as water infiltration areas. However, this project remains limited to a small scale and needs to be expanded to cover more regions.

c. Zoning Policies for Flood-Prone Areas

   Local governments have designated zoning for flood-prone areas and prohibited construction in these areas. However, violations of this policy frequently occur due to weak enforcement. Synergy between infrastructure strengthening and environmental conservation must be prioritized in flood mitigation policies. This requires a cross-sectoral approach and strong coordination between the government, communities, and the private sector.

Cross-Sector Collaboration in Flood Mitigation

This study also found that cross-sector collaboration between the government, communities, and the private sector is key to improving the effectiveness of flood mitigation efforts. Based on interviews with various stakeholders, there are still coordination challenges among institutions that slow the implementation of mitigation programs. Although the South Kalimantan Regional Disaster Management Agency (BPBD) has undertaken monitoring and early warning efforts, coordination with other institutions such as the Ministry of Environment and Forestry (KLHK) and local governments is often poorly integrated. This results in limitations in resource allocation and inefficiencies in disaster management.

However, successful examples of cross-sector collaboration were also identified, such as initiatives involving local governments, environmental NGOs, and the private sector in the development of green infrastructure. These programs have successfully created more sustainable solutions by leveraging technology and local knowledge, such as vegetation-based rainwater harvesting systems that not only prevent flooding but also enhance urban environmental quality.

E. CLOSING

Conclusion

Flood mitigation in South Kalimantan requires an integrated approach with a focus on strengthening infrastructure and environmental conservation. This study identifies deforestation as a primary factor in the increased flood risk, making ecosystem restoration and reforestation of degraded forest areas a priority in mitigation efforts. Additionally, inadequate urban drainage infrastructure must be upgraded using modern technologies, such as GIS mapping and artificial intelligence, to address extreme rainfall caused by climate change. Ecosystem-based approaches, such as river rehabilitation and community involvement in conservation, have proven effective in reducing flood risk and strengthening disaster resilience.

Flood mitigation strategies must involve cross-sector collaboration between the government, communities, and the private sector to ensure mitigation policies are implemented effectively and efficiently. Synergy among relevant institutions will support forest restoration, enhance drainage capacity, and implement sustainable ecosystem-based solutions. Through these efforts, South Kalimantan can build a more resilient system to manage floods while strengthening the region's social and economic resilience.

Recommendations

1. Enhance collaboration among relevant institutions in the planning and implementation of flood mitigation strategies.
2. Integrate environmental conservation into spatial planning policies and infrastructure development.
3. Encourage active community participation in natural resource management and disaster mitigation.
4. Develop water management plans based on technology and data to address the increasing frequency of extreme weather caused by climate change.

REFERENCES

Abdullah, R., & Handayani, S. (2019). *Deforestation and flood risks in tropical regions: A case study of South Kalimantan*. Environmental Research Journal, 25(3), 215-230.

Abdullah, T., et al. (2020). *Urban spatial planning and its impact on flood mitigation*. Journal of Urban Planning and Development, 146(5), 409-421.

Aria, M., & Cuccurullo, C. (2017). *Bibliometrix: An R-tool for comprehensive science mapping analysis*. Journal of Informetrics, 11(4), 959-975.

Badan Meteorologi, Klimatologi, dan Geofisika (BMKG). (2022). *Climate change and its impacts on Indonesian flood events*. BMKG Publications.

Badan Nasional Penanggulangan Bencana (BNPB). (2022). *Annual disaster report: Flood events in Indonesia*. BNPB Publications.

BPBD Kalimantan Selatan. (2022). *Flood risk management in South Kalimantan: Report and analysis*. BPBD Kalimantan Selatan.

Damanhuri, E. (2019). *Mitigasi Banjir di Kalimantan Selatan: Pendekatan Infrastruktur dan Konservasi Lingkungan*. Jurnal Geografi, 13(2), 45-58.

Darmawan, H., & Fitriana, S. (2021). *Cross- sectoral collaboration in flood mitigation in Indonesia*. Disaster Management and Response, 14(2), 189-202.

Gunawan, D. (2021). *The role of tropical forests in stabilizing local climate and water regulation*. Journal of Environmental Management, 92(7), 55-66.

Handoko, D., & Setiawan, T. (2020). *Challenges in urban drainage management and flood control*. Water Resources Management, 34(9), 1983-1995.

Handoko, P., & Setiawan, T. (2020). *Adapting urban drainage systems to extreme weather events*. International Journal of Hydrology, 45(5), 612-627.

Handayani, L., & Suryono, M. (2021). *Ecosystem-based approaches to flood risk reduction in Indonesia*. Journal of Disaster Studies, 32(6), 153-165.

Kusuma, F., & Firmansyah, W. (2022). *The importance of spatial planning in flood-prone areas*. Regional Environmental Change, 19(4), 93-104.

Kusuma, I., et al. (2020). *Topographical influences on flood vulnerability in Kalimantan*. Hydrological Sciences Journal, 62(8), 1243-1260.

Kumar, V., & Wijaya, K. (2019). *Impact of climate change on rainfall and flood risk in Southeast Asia*. Asian Climate Journal, 16(5), 443-458.

Kurniawan, R., & Lestari, Y. (2021). *Community involvement in flood disaster preparedness in Indonesia*. International Journal of Disaster Risk Reduction, 31, 101-114.

Lestari, Y., et al. (2021). *The effectiveness of community-based flood risk management*. Journal of Environmental Planning and Management, 64(1), 55-73.

Maulana, A., & Ridwan, H. (2021). *Deforestation impacts and flood risk management in Kalimantan*. Indonesian Journal of Environmental

Studies, 18(3), 322-337.
Prasetyo, D. (2020). *Changing rainfall patterns and flood risk in Indonesia*. Meteorological and Climatological Science, 17(2), 78-92.
Prasetyo, D., & Mulyani, T. (2022). *Severe flood events and urban response in South Kalimantan*. Journal of Environmental Hazards, 26(2), 312-327.
Rahman, H., & Fitriani, S. (2021). *The impact of urbanization on flood risk in South Kalimantan*. Urban and Regional Planning Review, 18(2), 215-230.
Ridwan, H., & Maulana, A. (2021). *Effects of deforestation on flood severity in Southeast Asia*. Environmental Science Journal, 19(3), 120-138.
Santoso, E., & Rahmawati, N. (2019). *Deforestation and its impact on water catchment areas in Indonesia*. Asian Water Journal, 14(1), 34-49.
Saputra, S., & Gunawan, D. (2020). *Forest degradation and flood vulnerability in tropical regions*. Ecological Management Journal, 45(8), 237-252.
Siahaan, M. T., & Simatupang, M. (2020). *Peran Pengelolaan DAS dalam Mitigasi Banjir di Kalimantan Selatan*. Jurnal Lingkungan, 22(3), 120-130.
Supriyadi, B. (2020). *Community programs for flood preparedness in Indonesia*. Journal of Disaster Resilience, 23(4), 67-82.
Suryani, D. (2019). *Urban flood management and drainage challenges*. Journal of Environmental Planning, 22(5), 100-115.
Suryono, B. (2018). *Upgrading urban drainage to prevent floods*. Hydrology and Water Management, 13(6), 85-98.
Supriyadi, D., & Maulida, A. (2022). *Flood risk mitigation through community empowerment*. Journal of Community Studies, 29(3), 45-60.
WHO. (2020). *Urban green spaces and their role in flood mitigation*. World Health Organization Publications.
Wijaya, R., & Purwanto, S. (2018). *Forest loss and flood risk: A comprehensive review*. Environmental Reviews, 26(4), 285-301.
Winarno, T., & Setiawan, Y. (2018). *Pengelolaan Infrastruktur Perkotaan untuk Penanggulangan Banjir di Kalimantan Selatan*. Jurnal Perencanaan Wilayah, 15(1), 10-23.
Yusuf, A., et al. (2019). *Risk-based spatial planning for flood-prone areas*. Land Use Policy, 78, 202-216.