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A Framework of image processing and machine learning utilization for flood disaster management

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ABSTRACT

Flood is one of the annual disasters in many places. It has not been well-managed yet both pre-disaster and post-disaster. Image processing and machine learning are commonly utilized for disaster management systems such as forecasting any potential flood by monitoring the water level in rivers and dams. However, it has a limited framework to be implemented as a strategic plan in flood management. Thus, this study aims to develop a framework for image processing and machine learning utilization for flood management. This study involves Padang, West Sumatera, Indonesia as a sample. It was conducted in three stages; 1) categorize the strategic plans and policies; 2) gather relevant literature; 3) analyze data. As findings, this study proposes a framework consisting of enhanced disaster preparedness, improved coping capacity, and completion of post-disaster reconstruction and rehabilitation. Involvement of the government, researchers and industry are mandatory. Government and researchers should collaborate to establish policies and regulations. Researchers should conduct studies with financial support from the industry. Meanwhile, the industry should be a public-private partnership with the government. In addition, the involvement of the private sector and the government are important factors that must exist to support research in this field.

Keywords: Flood disaster management; Image processing; machine learning; Padang city.

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1. INTRODUCTION

From January to December 2020, the National Disaster Management Agency (BNPB) reported 2,925 natural disasters, with 370 people killed. Up to 536 people were injured, and 39 people were missing. Floods account for 1,065 incidents in 2020, accounting for approximately 36% of all disasters. In 2021 (from January to August 2021), there were 1,805 hydrometeorological disasters, including 733 floods, 475 extreme weather events, 342 landslides, 205 forest and land fires, 23 earthquakes, 22 tidal waves and abrasions, and 5 droughts. Despite a statistical decline in the number of disasters, the magnitude of their effects has increased dramatically. According to the BNPB, there were 508 fatalities, 69 missing people, 12,881 injuries, and 5.8 million people evacuated or impacted. Furthermore, home damage increased by 660.67% between 2020 and 2021.

West Sumatra is one of Indonesia's most flood-prone provinces. Padang, West Sumatra's capital, is one of the cities hardest hit by flooding. Teluk Bayur Port, located in Padang, plays an important role in western Indonesia's international trade routes based on sea transportation. As a result, the Padang flood disaster could have far-reaching consequences not only for West Sumatra but also for international trade routes. Padang's lowlands, which are directly west of the Indian Ocean, have 16 minor rivers in addition to five larger ones. Padang has an average monthly rainfall of 414.63 mm, with 17 days of rain per month due to the tropical environment and constant rain. Padang's geomorphology includes coastal landforms in the west, alluvial

landforms in the middle, and volcanic hills in the east. As a result, nine of Padang's eleven sub-districts have different flood levels.

Through the Regional Disaster Management Agency (BPBD), the Padang City Government has developed a strategic plan document to address this situation. This document, which corresponds to the elected mayor's and deputy mayor's terms of office, is one of the regional planning documents required to guide the services of the Regional Disaster Management Agency in particular, and regional development in general, for the next five years. This paper serves as a resource for the government, community, corporate world, non-governmental organizations, international organizations, and stakeholders in disaster management.

Image processing and machine learning, for example, hold enormous promise for use in disaster management. The use of this technology can boost productivity and allow us to complete previously difficult tasks. Researchers from local and international universities, in particular, are critical to ensuring that this technology can be used. Numerous studies on disasters have been conducted, but limited research has been conducted on how image processing and machine learning are used in Padang City. Studies link to the strategic plan as the research framework are limited. Thus, the objective of this study is to develop a framework for image processing and machine learning utilization for flood management.

2. MATERIAL AND METHODS

The objectives of this paper are accomplished in three stages. First, categorize the strategic plan's strategies and policies. Based on the targeted objectives, there are three categories in this case: increasing disaster preparedness, increasing coping capacity, and realizing post-disaster rehabilitation and reconstruction. Second, relevant literature is gathered through the use of online search engines such as Springer, Google Scholar, Scopus, and Science Direct. When conducting the literature review search, specific keywords were used for this purpose. The paper under consideration is a paper review. Terms such as "flood" or "flood management techniques," as well as "image processing" and "machine learning," were used as keywords. Finally, the articles were filtered after they had been evaluated for relevance. This entailed reading and analyzing abstracts to determine the research's relevance. Based on strategic planning, the selected research articles were divided into three categories: Enhanced disaster preparedness, Improved coping ability and Completion of post-disaster reconstruction and rehabilitation.

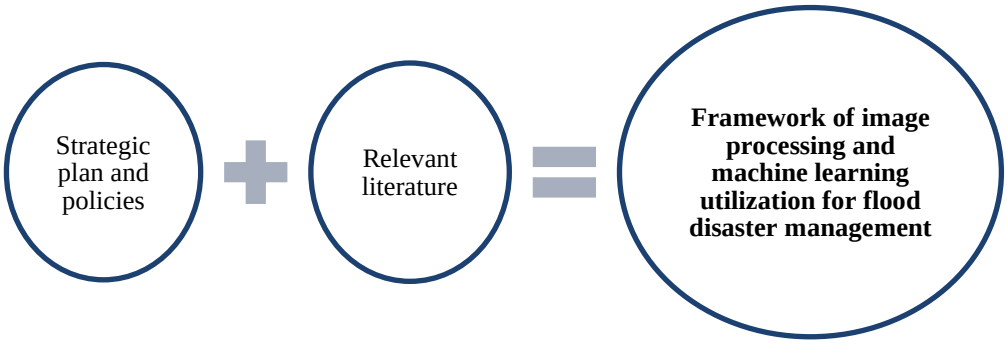

Figure 1: Research Framework

3. RESULTS AND DISCUSSION

Padang has 5 major rivers and 16 minor rivers in the lowlands, as well as being directly adjacent to the Indian Ocean to the west. Because of the tropical climate, rain falls almost all year. Padang City receives an average of 414.63 mm of rain per month, with an average of 17 rainy days per month. Padang's geomorphology consists of a mix of eastern volcanic hill landforms, central alluvial landforms, and western marine landforms. As a result, flood points of various characteristics can be found in nine of Padang City's eleven sub-districts. Padang's floods are classified into three types: puddle floods, flash floods, and tidal floods. A flash flood in the upper reaches of the river, on the other hand, is sufficient to cause a loss. This incident damaged agricultural and residential areas along the watershed and caused river abrasion. Table 1 shows the targets and policies developed to deal with the flood disaster.

Table 1: Flood disaster policies and objectives

No	Policy		Objectives
1	Enhanced disaster preparedness	1	Implementation of minimum service standards achievement
		2	Establishment of Tangguh Village
		3	Increased Participation of Government, Society, and Business in Disaster Management
		4	Improving evacuation infrastructure and facilities
		5	Development of disaster management policies
		6	Expand research collaboration with relevant parties
		7	Regularly expanding outreach
2	Improved coping ability	1	Increasing personnel capacity
		2	Improving Disaster Equipment and Supplies
		3	Improving Disaster Management by Increasing Personnel Preparedness
3	Completion of post-disaster reconstruction and rehabilitation	1	Improve disaster-prone areas monitoring
		2	Improving disaster response training and outreach
		3	Enhancing Post-Disaster Rehabilitation Activities
		4	Enhancing Post-Disaster Recovery Efforts

3.1 Image processing and machine learning opportunities based on Flood disaster policies

3.1.1 Enhanced Disaster Preparedness

Pre-disaster flood management techniques are linked to disaster preparedness. This section's image processing research focuses on data collection and processing techniques [1, 2, 3] as well as data interpretation related to water surface levels [4, 5, 6], water body location [6], morphological changes, and coastal dynamics [3]. The main challenges are expensive equipment, data collection requires professional UAVs capable of reaching extreme locations in extreme conditions, and data collection require large storage and adequate processing equipment. Furthermore, research and experts on existing equipment are scarce. This is directly related to the policy objectives of Strategic Plans 3, 4, and 6. In the field of machine learning, new research is focusing on improving machine learning models for flood prediction [7, 8, 10, 11, 12, 13, 14]. The application of machine learning models, like image processing, necessitates adequate equipment, particularly machines for data processing due to the large amount and size of data used. And, because the government is still unfamiliar with the topic of big data, this related investment necessitates appropriate recognition and education, given the large budget for its purchase and maintenance.

3.1.2 Improved Coping Ability

This section of the strategic plan focuses on increasing personnel and infrastructure capacity to deal with ongoing disasters. As a result, development related to flood monitoring and early warning, as well as development related to search and rescue, are required. Real-time flood mapping [15], surface water velocity [1, 9, 8, 16], water level detection [17, 18], flood debris detection [19, 15], structural damage assessment [20], and rainfall monitoring [21] can all be improved by combining image processing and machine learning. Furthermore, by using image processing and machine learning [3, 22] for search and rescue, it is possible to work faster and reach areas that are difficult for rescue teams to reach, as well as find safe rescue routes [8, 23].

3.1.3 Completion of Post-Disaster Reconstruction and Rehabilitation

They are related to the rehabilitation and reconstruction of disaster-affected areas for post-disaster flood management techniques. The four policies stipulated are related to disaster-prone areas monitoring, training and socialization, post-disaster rehabilitation, and reconstruction. Image processing and machine learning combined can be used to monitor flood-prone areas. Landmark recognition from aerial images [24], real-time assessment of flood-affected areas [6], flood mapping [25], and an assessment system [26] are all examples of research. Because the city of Padang has different geomorphological conditions with different types of floods,

it is necessary to consider needs based on flood location criteria in order to be able to apply research related to these themes.

3.2 Proposed strategy for implementing image processing and machine learning

To implement image processing and machine learning for disaster management, the involvement of the government, universities and industry is required.

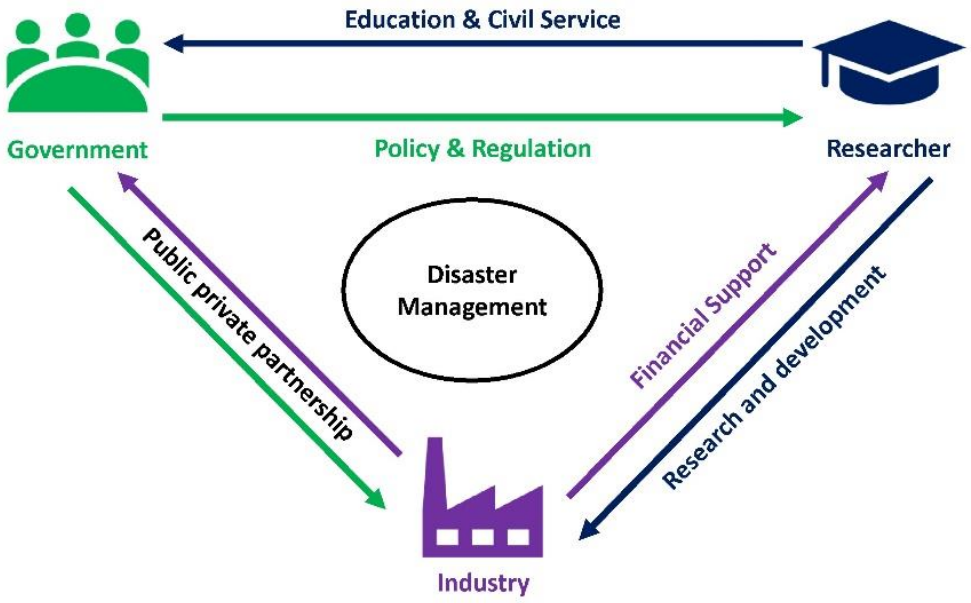

Figure 2: Strategy for implementing image processing and machine learning in disaster management

The Indonesian government has established policies related to cooperation between the government and the private sector in accelerating infrastructure development and improving social services in Indonesia. The implementation of this policy goes through three stages: planning, preparation, and transactions. At the planning stage, disaster management aspects need to be considered. Because the losses incurred due to disasters are very large and repeated every year, especially floods. So measurable planning is needed by the government and the private sector so that the actions taken are effective and on target.

Higher education is an institution that focuses on conducting research. Padang has 54 universities. Some are suitable for research related to disaster management such as Universitas Negeri Padang, Universitas Andalas, Universitas Negeri Islam, and Politeknik Negeri Padang. However, research related to image processing and machine learning for disaster management requires large capital, especially in supporting data collection that covers large areas and difficult terrain. In addition, to support this research, it is mandatory to have a device that is quite expensive and maintainable. On the other hand, the private sector requires innovation as a necessity for sustainability. Links and matches between universities and the private sector can occur through the research and development industry being handed over to the universities, and the industry providing infrastructure support and appropriate funding. The results of the research are also used by the government. Universities provide education and civil service based on applied research. So that the government gets the benefits of research directly and measurably. But for this, the government needs to provide good policies and regulations that facilitate the application of science and technology.

4. CONCLUSION

Flood is a disaster that always occurs every year in the city of Padang. There are many research opportunities that can be carried out. Research must consider the strategic plan that has been set by the Padang city government. In this paper, research opportunities that can and need to be carried out are described, especially applied research that can be done directly and quickly in flood disaster management. In addition, multi-disciplinary research needs to be carried out because the impact of the flood disaster is very large.

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DECLARATIONS

Author contribution

Fazrol Rozi, Indri Rahmayuni, Fitri Nova and Ardi Syawaldipa- Original Draft, Writing, Investigation, Resources, Visualization. Primawati and B.Batara: -Review & Editing, Conceptualization, Formal analysis, Investigation, Supervision.

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Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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