River Risk Management: Case Study of Padang City-West Sumatera Province

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Abstract: ***Water and water resources are useful for meeting basic needs for human life. The number of physical changes in river areas and watersheds has increased pressure on water resources. Three main issues of water resources, there are too much, too little and too dirty. Those become problems that threaten the sustainability of the quality and quantity of water resources. Water resources in West Sumatra Province are abundant with a total of 254 rivers that flow into the east and west coasts of Sumatra and four large lakes. West Sumatra Province is also an area that has potential disasters such as earthquakes, tsunamis, volcanic eruptions, floods, landslides, hurricanes, and tidal waves. Flood control infrastructure in several rivers has been built, and one of them is in the BatangKuranjiriver in Padang City. After the September 2009 earthquake, the city's offices, such as the Padang Mayor's Office, have been moved to the upper reaches area of the Batang Maransi watershed (second order of Batang Kuranjiriver). This movement is changing land use which initially absorbed water area and now caused flooding. This paper discusses floods in the Batang Kuranji and its solution by restoring environmental functions and water resources infrastructure systems. Discussions are about disaster management facilities available in the Padang City level. This paper recommends a method for better river management.***

Index Terms: ***Disaster management, flood hazard, infrastructure, Batang Kuranji river***

I. INTRODUCTION

Management of water resources is an effort to plan, implement, monitor and evaluate the implementation of conservation of water resources, utilization of water resources and control of water damage. Water has destructive power that can harm life, for example in the form of a flood that becomes a disaster. Control of the destructive power of water includes initiatives of prevention, response, and recovery of damaged environment that may be caused by the water damage.

The prevention of damage by the destructive power of water is conducted before the disaster occurs, implemented by building physical infrastructures and non-physical measurements, balancing upstream and downstream of the river area. Response activities are conducted afterward of the disaster by alleviating the suffering caused by the disaster. The recovery after disaster aims to restore ecological function and water infrastructure; conducted by flood defense, river engineering, and flood mitigation.

Revised Manuscript Received on April 09, 2019.

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River engineering consists of channel improvement such as build new channel, widening or deepening the channel, channel resectioning, channelrealignment, bank protection, build dikes and dams(retarding and storage dam) [1].

Flood reduction is implemented by topographic manipulation, such as slope engineering, terracing, gully control, surface, and underground water storage; and vegetation regulation. In an urban area, the flood may be reduced by increasing water infiltration by build infiltration wells and retention basin [2].

West Sumatra Province [3] has a land area of 42,297 square kilometers which is equivalent to 2.17% of the Republic of Indonesia, with a population of around 5.3 million. Two main earthquake epicenters flank the province location. Those are the Semangko fault located along the BukitBarisanof Sumatra Island and the subduction zone which a converge of the Indo-Australian plate with the Eurasian plate located 250 km from the coastline to the west. The province also has 4 active volcanoes and has abundant water resources with a total of 254 rivers, flow into the east and west coasts of Sumatra Island and four large lakes. West Sumatra Province has a sea area of ± 186,500 km2 with a coastline of 2,420 km and has 375 large and small islands. The topography conditions vary from 0 to 3,100 masl. Based on the height of the region, the physiography of the Province of West Sumatra can be classified flat, sloping, bumpy and mountainous. The highlands in the West Sumatra region are on Bukit Barisan mountain with an irregular topography which is the upstream area of the rivers that flow to the east coast and west coast of Sumatra.

Those geological and geographical conditions above made West Sumatra province is considered as a high hazard region of earthquakes, tsunamis, volcanic eruptions, floods, landslides, hurricanes, and tidal waves.In this regard, Padang City as the capital city of West Sumatra province is also a prone area to the disasters caused by climate changes and human interventions along watersheds.In general, the occurrences of flooding due to the decreasing capacity of the environment, changes in landscape due to human activities, and changing of geomorphological rivers.

Notable floods that have occurred were flash floods that hit Padang City on September 26, 2018, and December 12, 2018; those occurred onmain rivers that cross the city that includeBatangKuranji, BatangArau, Batang Air Dingin, and its tributary (Fig. 1). The rivers in the section have a steep slope so that it can drain water at high speed and have high potential damage. Those three big rivers have flood control infrastructures, consisting of channel gates, flood canals, retarding basins in the downstream of the river and drainage channels.

After the September 30th, 2009earthquake, the Padang city administration offices have moved to the upstream area the BatangKuranji watershed (Fig. 2). This is changing the land use in the catchment area and therefore often occurrence of flood in Padang City after a few hours of rain.

Fig. 1: Map of Batang Air Dingin, BatangKuranji (yellow colored area) and BatangArau watersheds.

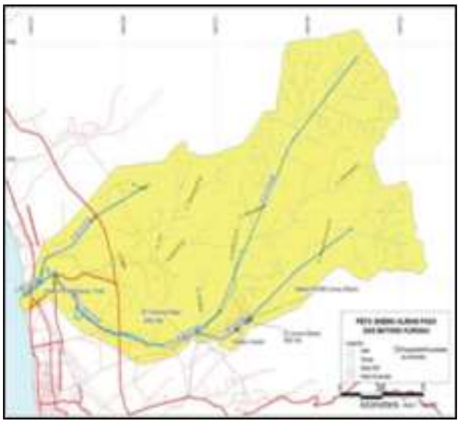

Fig. 2: River scheme on the watershed of BatangKuranji.

II. RESEARCH METHODS

River infrastructure performance assessment is conducted by several stages. There are four stages: tracking the river, river inventory, performance appraisal (facilities/infrastructure) and infrastructure rehabilitation activities (if any).

River tracking activities are carried out from downstream to all review locations. The tracking is to get a complete picture of the condition of the river and its infrastructure. The next activity is the river inventory. Performance appraisal is usually divided into two types, physical conditions and functional conditions. Assessment of physical conditions is carried out based on an assessment of the physical condition of the infrastructure itself. Physical assessment is divided into four components: the main structure, hydraulic, foundation and material. For assessment of functions, an assessment is carried out on whether the structure is still functioning correctly and continues with planning and implementation.

III. LITERATURE REVIEW

There are some lessons learned from floods from some countries that helps to understand river risk management.

In China [4], floods are caused by many factors: heavy rain, strong winds on the water, high tide waves, tsunamis, or dam failures, overflowing retention ponds, or other damaged alignments. Periodic floods occur in many rivers, forming surrounding areas known as floodplains. River channel maintenances include channel widening, embankment construction and reinforcement, and river dredging so that less flooding from design flooding can be reduced without inundating land along the river. In China, flood transfer areas are rural areas that are deliberately flooded in emergencies to protect the city. Many suggest that loss of vegetation (deforestation) will cause an increase in risk. With natural forest cover, the duration of the flood must decrease. Deforestation strengthens the incidence and severity of flooding.

In July-August 2015, major flooding caused extensive and severe damage throughout Myanmar [5]. Disaster response from the Myanmar government, prevailing weather conditions, and the function of river infrastructure were investigated in the Bago River Valley. It found that disaster risk reduction is managed through the Emergency Operations Center, which is regulated in the National Natural Disaster Management Act, which was passed in 2013. Disaster response systems in Myanmar were functioning at the local level, with local institutions sharing relevant information and provide the information to the public. It is clear that the authorities in the Bago River Valley have learned from the previous floods in 2011 and have implemented structural and non-structural measures for flood risk reduction.

Flooding is one of the most devastating natural disasters in the world, claiming more lives and causing more property damage than anyone imagines. In Nigeria [6], although not leading in terms of claiming a life, floods affect and displace more people than other disasters; it also causes more damage to the property. At least 20 percent of the population is at risk from the flood. More often, sovereign states and national governments adopt corrective reactions, where relief materials are given to the affected victims. The causes of flooding in Nigeria are varied, for example is the expansion of Owerri the capital city of Imo. The results obtained in this study imply that landfills within river channels, buildings development in floodplains, and high rainfall are the leading causes of flooding in the city, especially, in the rainy season. Recommendations were made on the management of the flood disaster in Owerri metropolis.

There are many disruptive effects of flooding in human settlements and economic activities. However, flooding can bring benefits, such as making the soil more fertile. Periodic floods are significant for the well-being of ancient people along the Tigris-Euphrates Rivers, Nile River, Indus River, and Ganges River. The viability for hydrologically based renewable sources of energy is higher in flood-prone regions.

IV. DISCUSSION

From river infrastructure assessment to the three main rivers in Padang City, it has been identified issues and challenges in river risk management.

1. Physical problems in water and land availability

This is a result of the influence of global climate change and damage to river areas or watersheds. Global climate change such as the "greenhouse effect" in urban areas, global warming and so on causes the frequency and intensity of extreme climates to become more frequent, such as the La Nina phenomenon which poses the threat of flooding and El Nino which poses a threat of drought [7].

Increasingly widespread degradation of watersheds, such as in the upstream of the Batang Kuranji watershed due to changes in land use, agricultural and plantation practices that do not follow aspects of soil and water conservation thus increasing the rate of erosion and sedimentation.

Spatial and land use policies that are not encouraging. The use of upstream areas for economic and social activities as well as agriculture and plantations are carried out intentionally or unintentionally and on a small or large scale. Lack of attention of spatial planners to allocate space for safe and healthy settlements, many riverbanks are occupied by settlements, narrowing the riverbed and inhibiting the flow of water. An example is in the Batang Kuranji catchment area in Padang City.

Water availability is also affected by damage to water sources. The decreasing capacity of rivers in urban areas, due to the high level of sludge content due to erosion and sedimentation, damage to watersheds and due to waste dumped by residents around the river. Water ponding areas have been converted into residential areas that cause decreasing groundwater recharge, such as is the coastal and upstream areas of Padang City.

A limited allocation of funds for infrastructure operations and maintenance also affects water availability. The allocation of funds provided by the government and stakeholder contributions to the operation and maintenance of water resources infrastructure that has been built is relatively limited. For example, the allocation of operating and maintenance costs for the Padang flood control infrastructure is only about 10 percent of the costs needed every year.

2. Flood control infrastructure and development of drainage in the city of Padang

Structural flood control structures have long been carried out in the city of Padang. It started from the Dutch colonial era; it was marked by the construction of the Flood Way canal (locally called Banda Bakali Systems). This system is implemented to divert a portion of the flow from the BatangArau river which passed the Padang City trade.

Because of the frequent occurrence of flooding in the city of Padang, a more comprehensive study was carried out for flood prevention in 1983. This study was conducted by JICA (Japan International Cooperation Agency) under the name of the Padang Area Flood Control Project. This activity aims to conduct in-depth studies on flood control, drainage plans, and feasibility studies to identify and prioritize activities to be immediately implemented. The results of this study until now have become the basis of flood control projects in Padang City [8].

Some of the activities that have been carried out for flood control in the City of Padang include the normalization of the Flood Way canal and Batang Arau river in 1992-1997, normalization of Batang Kuranji river, Batang Air Dingin river (widening, deepening and reinforcement of concrete lining) and construction groins in Padang beaches in 1997-2001.

3. Changing in land use.

After the 2009 earthquake in the city of Padang, there are predictions of a massive earthquake and tsunami that is likely to occur; therefore, the city area is divided into three red zones, a yellow zone and a green zone. The red zone is located along the coast as far as 1 km towards the mainland; the yellow zone is an alert area with a distance of 1-3 km towards the land; and the green zone of the area, which is estimated to be safe, located 3 km towards the to the east.

This massive earthquake prediction and the zoning have affected the settlements and offices to move to the green zone which was previously a retarding basin area. Even the Padang Mayor's office also moved to the green zone location in the Air Pacah area which near the Batang Maransi river sub-watershed (2nd order of Batang Kuranji river).

The impact of this rapid development is the increase in the frequency of flood that may be caused by reduced retarding basin areas around the Air Pacah. Istijono [9] explained that there had been 12 times flooding between 2011-2013 in the Air Pacah area (Fig. 3) that results in property losses and the surrounding community must bear even loss of life. The operation of the government and the economy were disrupted due to the paralysis of the Padang By-pass road (Fig. 4 and Fig. 5), as well as community's failed harvests rice fields that can also affect national food stocks.

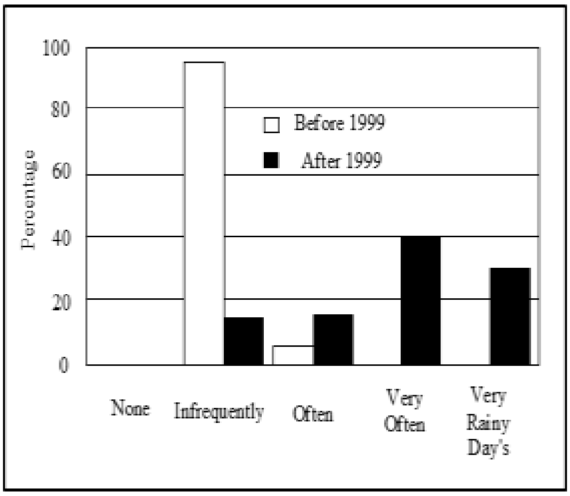

Fig. 3: Public perception of the frequency of flooding.

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Fig. 4: The area around the Padang Mayor's Office was inundated.

Fig. 5: Areal around the Baiturahmah Dental Hospital also submerged in water.

4. Establishment of the Air Pacah area as the center of the administration of the City of Padang.

With the establishment, it is expected that the Air Pacah area can become a flood-free area. The implication is that the government must implement increasing of the capabilities of BatangLuruih river and BatangMaransi river, the main river in the Air Pacah area so that it will be able to accommodate flood returns period of 25 years, discharge 120 m3/second and 34 m3/second of each river respectively. Technically, the BatangMaransi and BatangLuruih flood control are expected to be able to manage peak discharge, their riverbeds can be used as a water reservoir, and the river environment is functional [10].

Also in the flood control must be constructed several collecting ponds and pumping systems in the Air Pacah area because the downstream riverbed of Batang Kuranji river can only accommodate 870 m3/ second flood discharge (Fig. 6). After the completion of the upstream flood control infrastructure of BatangKuranji river, it must be followed by its management, including regional spatial management and by providing adequate operational and maintenance funds.

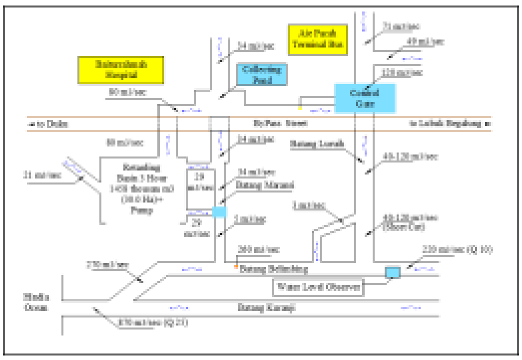

Fig. 6: Schematic distribution of BatangMaransi and BatangLuruih floods

V. CONCLUSION

a. Before the rapid development in the Air Pacah area, the factor that significantly affected floods was the length of rain time. After the development of the area, four dominant factors significantly influence the occurrence of flooding, namely the length of time of rain, lack of retarding basin areas, the number of settlements and offices, and weak the drainage conditions.

b. The completion of the flood control infrastructure of this area needs to be prioritized, followed by the provision of sufficient operational and maintenance funds.

c. Spatial planning for the Air Pacah area of Padang needs to be guided.

ACKNOWLEDGMENTS

We want to express our sincere gratitude to the University of Andalas for the Research Grant (PDU-KRP1GB-Unand) in the year 2019.

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