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Flood disaster mitigation concept of settlements in Sario watershed area

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Abstract. There are five large rivers which passes through and empties into Manado City, one of them is the Sario River. In 2014, the settlements around the Sario watershed area was severely damaged due to flash floods, in fact there was one neighborhood in Kelurahan Ranotana Weru where almost all houses were washed away and were lost due to the flood. In addition there are also fatalities and other material losses. Flood disasters in the Sario watershed area occur periodically every year, but the most severe damage was in 2014, it was even designated as a national disaster because it struck almost the entire city of Manado. Therefore, a study was conducted to obtain the concept of flood disaster mitigation at this location which is expected to prevent disaster, reduce risk and minimize the impact that will occur. This concept is divided into structural and non-structural mitigation. Structural mitigation includes efforts to minimize disasters through the construction of various physical infrastructure and technological approaches, such as the construction of disasters-resistant buildings, the construction of canals for flood prevention, evacuation routes, green open spaces, etc. Non-structural mitigation includes making policies or rules such as spatial planning or community capacity building. This research found that the boundary area of the river needs to be rearranged, the river embankment and drainage channel are repaired, the high density of the building needs to be reduced to provide sufficient open spaces, the need to build disaster evacuation routes and improved building conditions.

Keywords: *flood disaster, mitigation concept, Sario watershed, settlements*

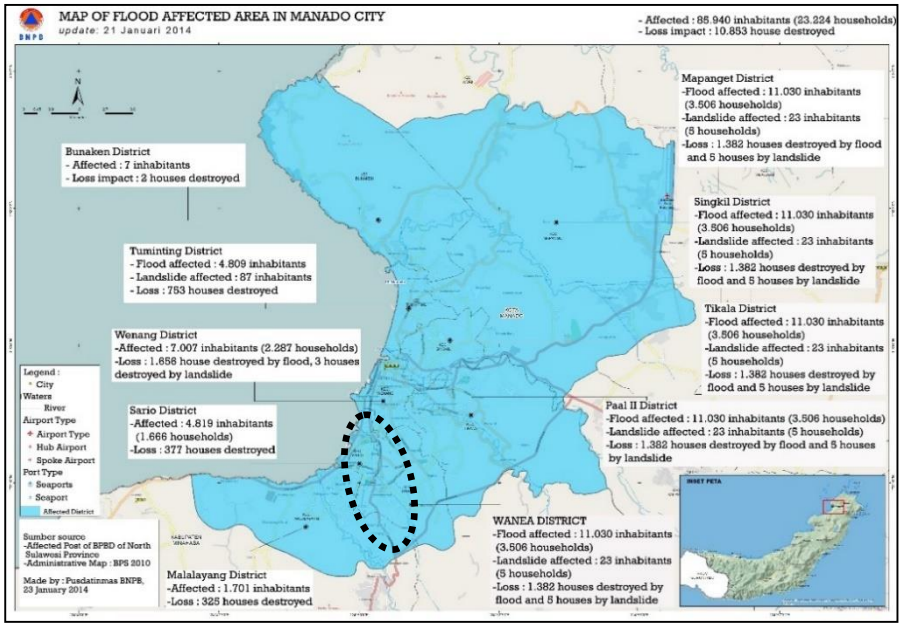
1. Introduction

1.1 Background

Disaster mitigation is the planning and implementation of actions to minimize the impact of a disaster that was carried out before the disaster occurred, including preparedness and long-term risk reduction measures.

One of the area that has a high level to disasters vulnerability is Manado City. Types of disasters found in this city include floods, landslides, tsunamis and tidal waves as well as earthquakes and volcanic eruptions.

This is due to the condition of the city of Manado which is a choppy plain with an area of 44% and a sloping plain with an area of 38% of the total area and has a landscape with tridimensional elements, namely the beach, land and hills and many rivers flowing from the hilly area and empties into the coast in the Manado Gulf. There are 5 big rivers and 13 tributaries that pass through and flow through Manado City. The five major rivers namely the Tondano River, Bailang River, Malalayang River, Sawangan/ Tikala River and Sario River. In January 2014, all rivers in Manado City overflowed due to very high rainfall and caused flooding in almost all areas of Manado City and surrounding, causing so many losses, both material and non-material losses. One of the areas that experienced the worst impact was the settlement area around the Sario watershed in Wanea District, with the details affected by the flood were 11.030 inhabitants and 1.382 houses destroyed. In fact there was one neighborhood in the Ranotana WeruSub District (Wanea District) whose entire house was lost or washed away by flash floods. Not only that, there were even fatalities washed away in this watershed area.



Source: Regional Disaster Management Agency of North Sulawesi, 2019

Figure 1. Map of flood affected area in Manado City2014

Figure 2. The condition of settlements after flash flood in 2014

1.2 Objectives

Objective of study is to analyze the flood disaster mitigation concept in Sario watershed area. It is expected tobe one of the solutions to prevent disaster, reduce risk and minimize the impact that will occur in this area.

1.3 Understanding of Flood Disaster Mitigation

Disasters are phenomena that occur because of the triggering components, hazards and vulnerabilities that work together systematically so as to cause risks to the community (National Board of Disaster Management, 2015 : 10). According to Law of Indonesian Republic Number 24 of 2007 on Disaster Management, types of natural disasters consist of earthquakes, tsunamis, mountains erupting, flooding, drought, typhoons, and landslide. Therefore a series of efforts need to be made to reduce risk disaster, both through physical development and awareness and increased ability to deal with threat of disaster.

These efforts are called disaster mitigation, which consist of structural and non-structural mitigation. Structural mitigation includes the development of infrastructure to drive impact minimization, for example by strengthening buildings and infrastructure that are potentially affected by disasters, making building codes, engineering designs, and construction to hold and strengthen structures to prevent the settlements such as embankment, drainage system, etc and non-structural mitigation including the formulation of regulations, spatial management, training and community empowerment and local government.

2. Method

2.1 Aspects of Analysis

Aspects of analysis are focused on flood disaster mitigation aspects, with the following description:

Table 1. Aspect of Analysis

Main Aspects	Sub Aspects
Structural mitigation	
Condition of river border area	
Buildings conditions	General condition
	Structure and construction
Flood infrastructure system	Embankments
	Drainage channels
	Street and evacuation system
Non-structural mitigation	Land use planning

2.2 Method of Collecting Data

The primary data collection method is observation and survey to see the condition of settlements such as buildings condition, availability of flood infrastructure and river border area. Secondary data collection is through the collection of government information and policies such as regulations of river borders, etc. The research instruments are maps, photographs, drawings and documents on the condition of the study sites.

2.3 Data Analysis Method

The method of analysis is qualitative to describe the existing settlement and watershed conditions and then can be recommended to improve the settlement better than the previous condition. For spatial analysis and map plan using ArcGis 10.3 software.

3. Results and Discussion

3.1 Regional Overview

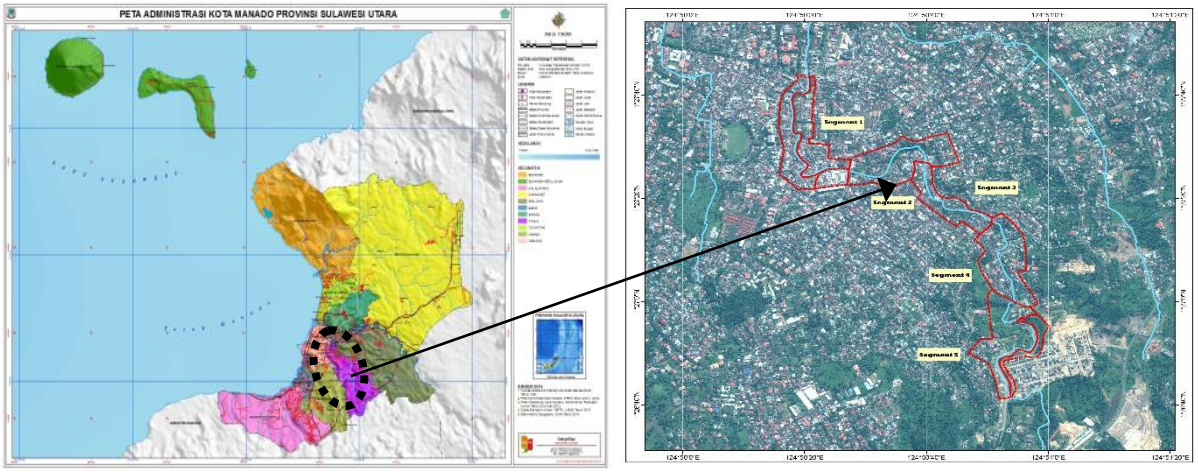


Figure 3. Map of Manado City and Sario Watershed (location of research)

The site of study is located in the Sario watershed, in Manado City. Manado city is the capital of North Sulawesi Province, one of the eastern provinces of Indonesia, with the sub-climate type Am (tropical rain), where in the rainy season the amount of rain is quite large, so that although there is a short dry season drought. Based on rain type, Manado City including rain type class A (very wet). Annual average rainfall is 3,187 mm, while the average annual air temperature is 25ºC - 27ºC.

Sario watershed is one of the strategic parts of Manado City because it is located right in the middle and divides the city of Manado. Delineation of the site is in the settlements around the Sario watershed with the large of 51,70 hectares, which flows from the Citraland residential to the bridge/statue of Sam Ratulangi. In addition, this area is also located between densely populated settlements. There are several important urban infrastructure such as Pinasungkulan Market; the oldest market in Manado, Karombasan terminal, Sam Ratulangi Statue and Citraland residential; the most famous residential in Manado. Every year the river rises due to the rainy season, and often causes flooding in the surrounding settlements. The biggest flood occurred in early 2014 where flash floods occurred which resulted in flooding throughout the settlement area that was crossed by the river, to the destruction of houses, public buildings, regional infrastructure and even to the death of a number of residents living around the river.

3.2 Analysis of Structural Mitigation

3.2.1 Conditions of River Border Area

This river has a length of approximately 15 km and widths vary between 3-12 meters with a river height of about 2-6,5 meters. To facilitate analysis, the location is divided into 5 segments. In Segment 1, the river is quite wide ranging between 8-12 meters, but there is no border because residents have built houses. In Segment 2, the river is quite wide around 5-10 meters, but the flow is small because it is full of garbage & wastewater. In Segment 3, the river wide is around 5-8 meters but the embankment is directly adjacent to the residents' houses. In Segment 4, the river conditions are quite good, about 5-10 meters wide and a dike has been built with a heigh about 4-5 meters. In Segment 5, the river is quite wide which is around 8-12 meters but does not have dykes.

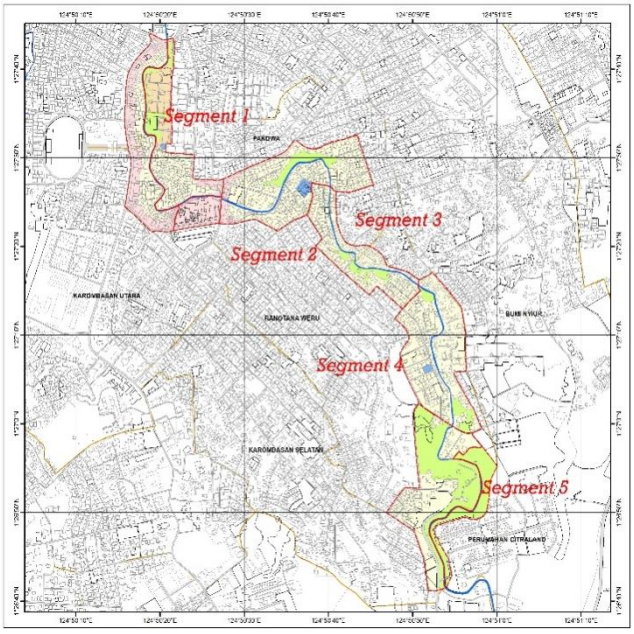


Figure 4. Map of segmen division

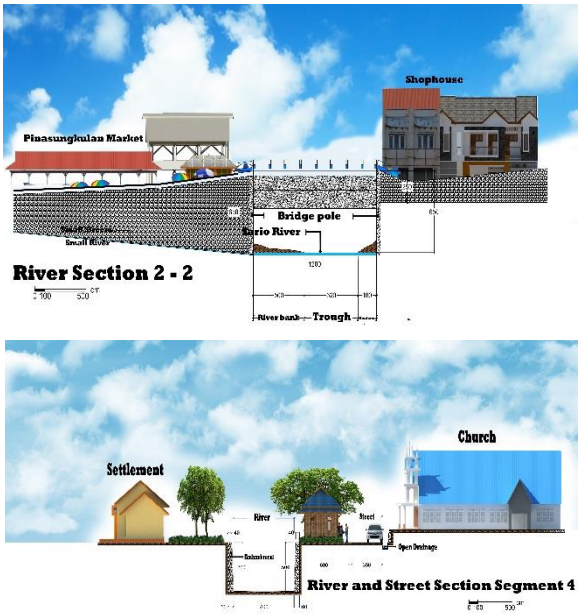


Figure 5. The section of river border area (existing)

According to Spatial Planning Regulation of Manado City of 2014-2034 and The Mayor of Manado's Regulation number 55 of 2014 concerning the river border and its utilization, Sario watershed including large river with embankment in urban areas that must have at least 15-17 meters border in the right-left body of the river. In fact, river border distance does not meet the standard, almost along the river border has been placed buildings and others fuction.

Figure 6. The condition of embankment and river border area in Pinasungkulan Market dan Ranotana Weru Sub District (Segment 1 & 2)

3.2.2 Buildings Condition

- *General condition.* Many houses have been built in the river border area with a fairly high density level with most conditions being semi-permanent. In Segment 1, there are 424 buildings, of which 76 buildings are built in the river border area. Public facilities that have been built in this segment are the Pinasungkulan Market, sewage treatment plants and sports field. In Segment 2, there are 220 buildings, of which 51 buildings are built in the river border area. Public facilities that have been built in this segment are nursing home, security post and Church. In Segment 3, there are 184 buildings, of which 63 buildings are built in

the river border area. Public facilities that have been built in this segment are school and church. In Segment 4, there are 218 buildings, of which 54 buildings are built in the river border area. Public facilities that have been built in this segment are school and church. In Segment 5, there are 75 buildings, of which 5 buildings are built in the river border area. Public facilities that have been built in this segment are school and church. Vulnerability to flood hazard is also influenced by the numbers of buildings built in the river border area causing loss of water catchment areas and green open spaces in the area and the absence of flood evacuation routes. In addition the position and orientation of the building is not clear because it develops sporadically.

According to Manado Mayor Regulation Number 55 of 2014 that for the category of large rivers such as the Sario River, the width of the left and right border area is 15-17 meters, so it is necessary to relocate for non-habitable buildings in the border area of the river in order to construct green open spaces and construct residential areas outside the river boundary with riverfront or waterfront settlement concept.

Table 2. Number of buildings in the river border area

Segments	Number of buildings
1	76
2	51
3	63
4	54
5	5
Total	249

- *Structure and Construction.* Overall, the structure and construction of buildings in this area is in ratio of 60:40 (permanent: non permanent), where non-permanent buildings are mostly found in Segment 1 and 2. This leads to non/semi permanent buildings around the river border at high risk of being damaged or washed away by floods.

Figure 7. Buildings conditions

3.2.3 Flood infrastructure system

- *The embankment*. After flash flood in 2014, the government has built embankments at some parts with a height of around 2-6.5 meters and the material of concrete rebound. In general the embankment conditions are good but there are still some parts that have not been built or repaired, especially in Segments 1 and 2.
- *Drainage channels*. In general,

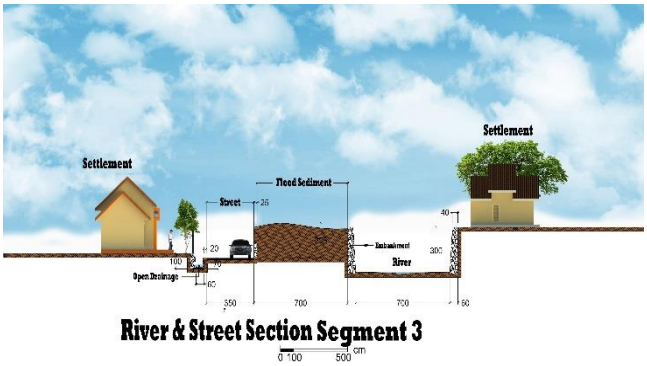


Figure 8. Section of river and street

drainage network conditions in residential areas are good, but some still need improvement because it is covered with sediment, trash and grass.

- *Street and evacuation system.* The primary street on study sites has a width of 12 meters on the Pinasungkulan Market street and 10 meters on the Mononutu street. But the effective street can be used for four-wheeled vehicles is only about 7-8 meters because part of the street has been used by traders to sell and residents to park their privat vehicles. Secondary local street have widths varying between 3-5 meters while tertiary local streets are 0.5-2 meters, so that they can only be accessed by motorcycle on certain street segments. The circulation or access system is not clear because there are many forbidden street. This makes it difficult for residents to evacuate when flood occur. The material on primary and secondary local streets is asphalt, whereas tertiary streets are paving and some are still compacted soils.

3.2 Analysis of Non-Structural Mitigation

3.2.2 Land use

In this study it was found that land use at the study site was quite high with building coverage ratio more than 80%. Almost all parts of the area have a high density level except in Segment 5 which is quite low around 20-40%. This means the designation of open space is very small. Spatial Planning Regulation of Manado City of 2014-2034 requires green open space is 30% of the area, therefore it is necessary to reduce the density of buildings by 20% in Segment 1 and 40% in another segment, by way of relocation of buildings in high density areas and uninhabitable on the river banks (Segment 1).

Table 2. Land use intensity

Segmen	Sub segment	Number of buildings per hectare	Building coverage ratio
1	1A	80	60
	1B	120	**80**
	1C	20	60
2		150	60
3		100	60
4		80	60
5	5A	50	40
	5B	10	**20**

From the intensity of existing land use above, the land use must be re-arrangement. The plan to arrange the area starts from the arrangement of the river border area, which has been regulated in Manado Mayor Regulation No. 55 of 2014 that for the category of large rivers such as the Sario River, the width of the left-right border area is 15 meters for the shoulders and 17 meters left- right of the river for the unbearable part. Referring to the regulation, a number of buildings or dwellings in the border area must be moved or relocated. The following is the border arrangement according to the rules above.

Table 3. Land use intensity

Segment	Building plans to be relocated in river border area	Land acquisition area (Hectare)
1	76	2,84
2	51	1,69
3	63	1,82
4	54	1,59
5	5	2,08
TOTAL	249	10,02

Recommendation

Based on the analysis, recommendations were made for the concept of flood mitigation in the Sario watershed area:

- Restoration of land use by increasing the percentage of open space up to about 30% through controlling or restructuring of river boundary area and reduction of building density through relocation of houses.
- Freeing the 15 meters in left and right border area of the river from the building so that it will be restored to function as an open space, water catchment area and path- evacuation route.
- Setting the boundary area of the river by improving the embankment and normalizing the river.
- Improving the quality of flood infrastructure systems including improving drainage channels, repairing damaged dikes, adding to the construction of tertiary local streets that can serve as evacuation routes, building environmental signage systems and flood monitoring post, adding green and non-open spaces green.

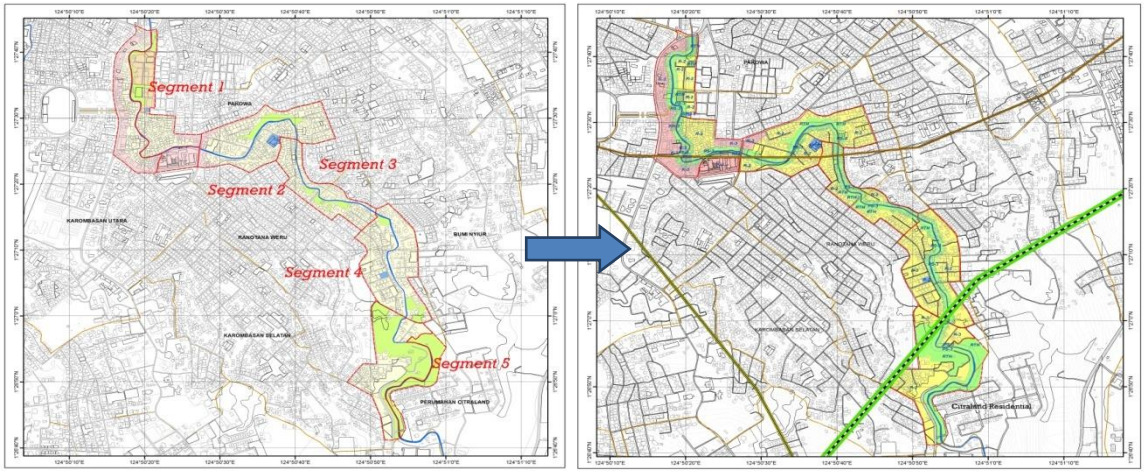


Figure 9. Map of existing and land use plans

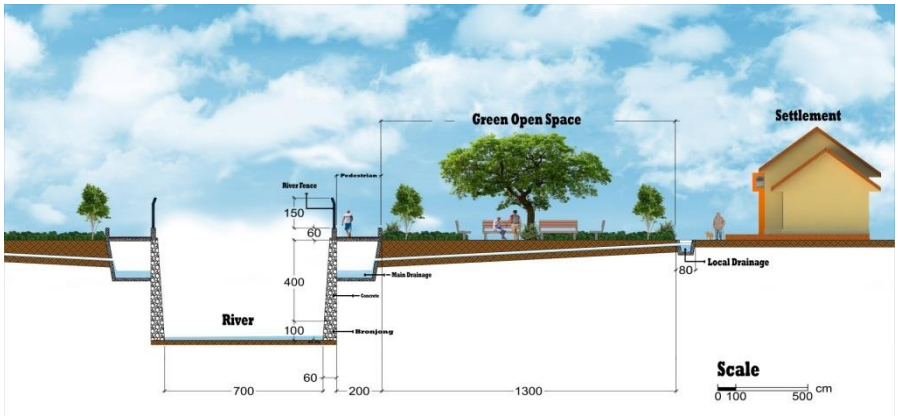


Figure 10. Section of the restructuring plan of Sario Watershed

Conclusion

From a study in the Sario watershed area, it was found that the Sario river border area needs to be reorganized based on the principles of disaster mitigation, which includes structural and non-structural disaster mitigation. Structural mitigation includes structuring and repairing building conditions, repairing and upgrading infrastructure such as the construction of embankments, roads and evacuation routes and drainage channels, while non-structural mitigation includes re-arranging land use so that sufficient land is available for green open space, water catchment area and path- evacuation route. It is expected that the results of this study can be one of the solutions to prevent disaster, reduce risk and minimize the impact from various vulnerable physical pressures.

This review needs to be followed up with studies on other aspects, such as technical aspects includes embankment conditions, river water discharge, social, culture and economics studies, etc. It aims to obtain the integrated arrangement in this area.

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