Disaster Mitigation Plan Based Flood Event Occurred on January 30th, 2021 in Kuta-Mandalika, Lombok, Indonesia

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Abstract. There was flood event that occurred on January 30th, 2021 in Kuta Mandalika Lombok. There were many infrastructure damages but no injured people were reported. According to information, this January flood is the biggest flood that occurred in Kuta Lombok. The research method consists of is field survey that was carried out in order to figure out the actual condition of the flood, supporting data relating to the flood analysis was also collected from any competent sources. In order to analyze factors affecting the occurrence of the flood, data collection was conducted. According to all data collected, scientific analysis is performed to identify which factors contribute much to the occurrence of the flood. Analysis results, soil condition was saturated due to two consecutive days of rainfall, when the 145.5 mm rain came, the runoff coefficient was already high. Inundation was mainly caused by the blocking of buildings, therefore the water could not enter the drainage system. In the coastline area, inundation was also caused by high tide. There were two disaster mitigation plans. Short term to overcome which are physical action and urgent whereas long term mitigation plan to preventive and non-physical action.

Keywords: factors affecting · evident · rainfall intensity · term mitigation

1 Introduction

In some places in Kuta, actually flood is frequently occurred every year during rainy season, but according to common information, this January 30th, 2021 flood is the biggest flood occurred in Kuta Lombok. In order to analyze factors affecting on the occurrence of the flood, data collection was conducted. A field survey was carried out in order to figure out the actual condition of the flood. Data relating to the flood analysis was also collected from any competence sources. Video and photo capturing the flood are the very important data in order to understand the actual condition during the flood. According to all data collected, a scientific analysis is performed to identify which factors contribute much to the occurrence of the flood.

In this research, all data collected that supposed to be important on the flood analysis is presented as evident. Mostly, evident is classified based on the kind of data, and location where the evident is take place.

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2 Factors Affecting and Flood Evident

2.1 Flooded Area

Kuta-Mandalika Basin consist are 3 cathments, i.e.: Tebelo, Ngolang and Balak cathment area. Figure 1 is describing DEM (digital elevation model) and map of study location in Kuta-Mandalika Basin, Lombok, Indonesia. There are three rivers flowing to this watershed, Tebelo River in the western part, Ngolang River in the middle part, and Balak River in the eastern part, whereas the flood was occurred only in Tebelo and Ngolang River (Fig. 2).

2.2 Rainfall Intensity

There is a rainfall station in Rembitan (Fig. 1) the closest rainfall station which available for long period recorded data. The hourly rainfall data is presented in Table 1. According to data recorded from 1995 to 2018, the design rainfall for some return period is presented

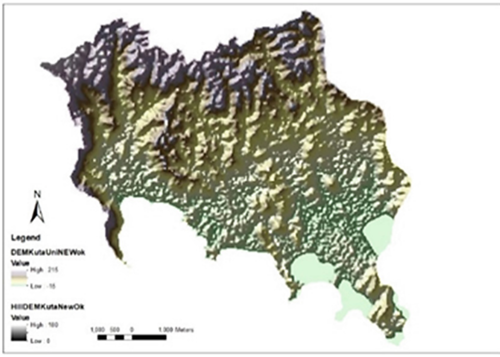

Fig. 1. DEM Kuta-Mandalika Basin, Lombok.

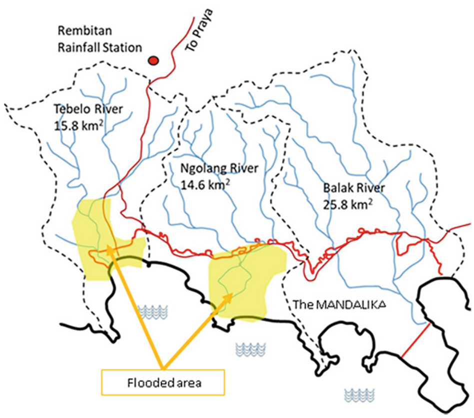

Fig. 2. Study location of the flooded area during the January flood.

Table 1. Hourly rainfall recorded in Rembitan Station (in mm).

Date\Time	6-7 AM	7-8 AM	8-9 AM	9-10 AM	10-11 AM	11-12 AM	12-1 PM	1-2 PM	2-3 PM	3-4 PM	4-5 PM	5-6 PM	6-7 PM	7-8 PM	8-9 PM	9-10 PM	10-11 PM	11-12 PM	12-1 AM	1-2 AM	2-3 AM	3-4 AM	4-5 AM	5-6 AM	Daily (mm)
23-Jan-21						1			3	2	1	0.5	0.5												8.0
24-Jan-21																					1	9	0.5	0.5	11.0
25-Jan-21				6												1									7.0
26-Jan-21												1	2	1				1							5.0
27-Jan-21												0.8													0.8
28-Jan-21									7	3.8												2.5			13.3
29-Jan-21		12							3.5	16						14	7	7	1						60.0
30-Jan-21		The day of the flood											1	65	30	43	5	1.5							145.5
31-Jan-21					5														1	1	1	1.5	0.5		10.0

Table 2. The design return period of rainfall in Rembitan Station.

Return Period	Design Rainfall (mm)
2 year	107.1 mm
5 year	137.2 mm
10 year	152.9 mm
20 year	165.9 mm
25 year	169.6 mm
50 year	180.5 mm
100 year	190.2 mm

Table 3. Evident of daily rainfall higher than 5-year return period.

Year of the event	Day-2 (mm)	Day-1 (mm)	Rainfall (mm)
2000	4	25	142
2003	67	0	153
2009	17	7	160
2013	0	12	168
2015	0	7	182
2016	0	13	148
2021	13.3	60	145.5

in Table 2. Comparing these two tables, the rainfall that cause the January flood is relatively similar to the 10 year return period design rainfall. Because the occurrence of the flood depends on the land condition, especially level of saturation, it is also important to show the daily rainfall prior to the extreme rainfall. During the available data, the event of extreme daily rainfall and the two days rainfall prior to the event is presented in Table 3.

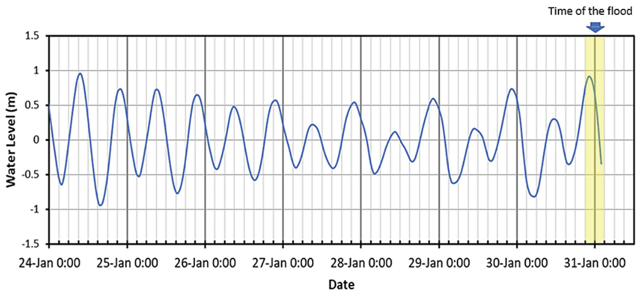

Fig. 3. Tide condition on January 2021 in Kuta-Mandalika, Lombok

Table 4. The change of housing area in three rivers in Kuta-Mandalika, Lombok

	Housing Area (km^2)			Percentage to Cathment	
	2009	2020		2009	2020
Tebelo	0.65	3.22	Tebelo	4%	20%
Ngolang	0.31	1.63	Ngolang	2%	11%
Balak	0.30	0.88	Balak	1%	3%

2.3 Tide Condition

Location of the flood is close to estuary where tide condition takes much effect on the flow condition in the river. According to the lunar calendar, the event of flood was occurred on the day of 16th when the tide was extreme (Fig. 3).

2.4 Land Use Change

There is an increasing of housing area in Tebelo, Ngolang, and Balak catchments. Comparing between condition in 2009 and in 2020, there is a high increasing in Tebelo and Ngolang (Table 4).

2.5 Texture and Soil Classification

Soil texture and classification in this study are based on soil class and texture maps from Department of Forestry and Environmental, NTB Province (2008). In this study location, soil class represents combination of mediterranean to regusol with clay soil textures in the upstream to middle stream, unless in part of downstream are alluvial (Fig. 4).

2.6 Landsystems

One of factor affecting flood is landsystem. In this research, landsystems consist are hillslope and flow direction in this study that can generate from the DEM's data with SRTM type and 1-arcsecond resolution (Fig. 5).

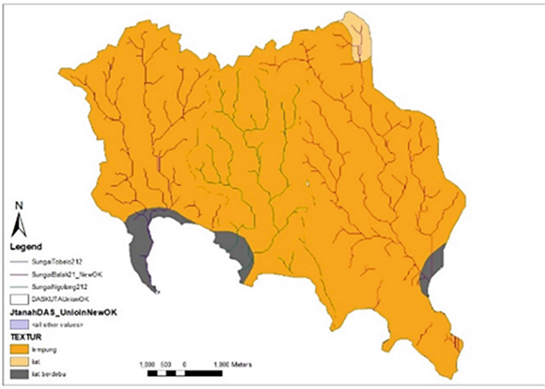

Fig. 4. Map of soil texture in study location (source: KLH-NTB, 2008).

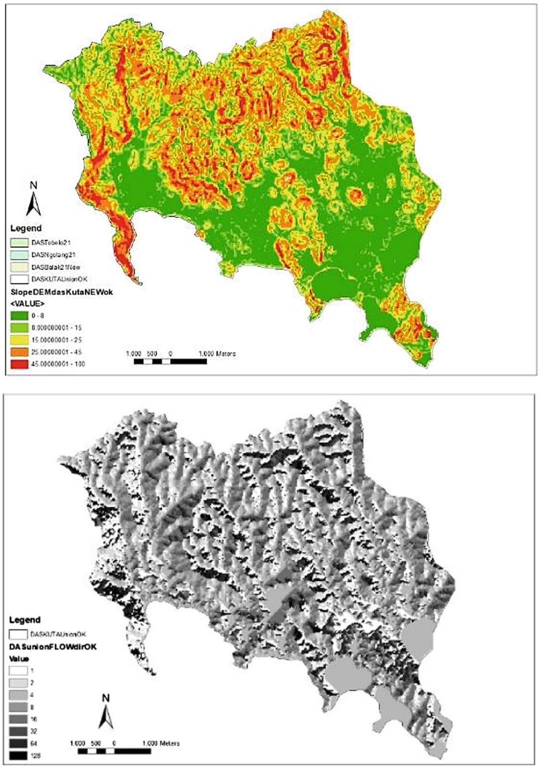

Fig. 5. Hillslope and flow direction Map in study location.

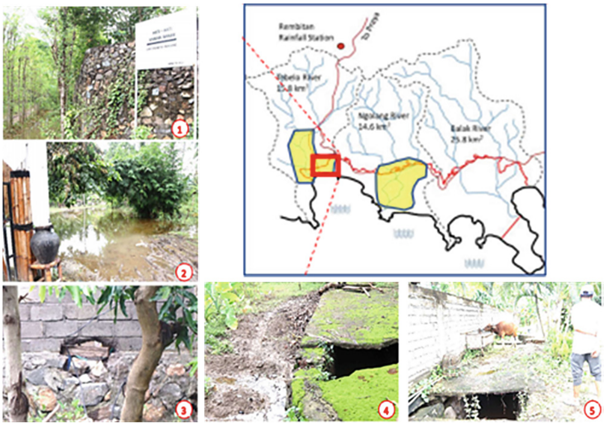

Fig. 6. Condition of river, drainage and inundated area in Tebelo cathments area.

3 Flood and Local Characteristics

3.1 Flood in Tebelo River

In Fig. 6, in this location is frequently inundated by flood (1). Runoff water entering to the natural drainage canal is blocked by masonry fences and buildings (2,3). The drainage canal is utilized by the land owner by constructing any structure that block the runoff water to enter the canal (3,4). Water was blocked by the surrounding structures to enter to the river. There was a big difference between water head inside and outside of the wall, made the wall collapse. Inundation of runoff can be collapse some structures due to flood in Tebelo River.

3.2 Flood in Ngolang River

There is flood canal system but not integrated yet. Some areas were not covered by the system. Some parts of the system are under construction. It was not serve the catchments area properly condition of drainage system that was not connected yet, under construction. The drainage system is not connected yet, the existing bridge is small, there is possibility of being blocked by floating object during flood (Fig. 7).

3.3 Flood in Balak and Other River

There was no flood occurred in Balak River, but there was an interesting evident in other river out of Kuta-Mandalika Basin area (Fig. 8).

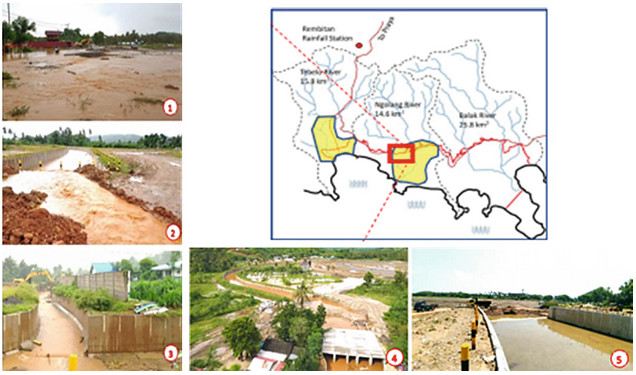

Fig. 7. Flood in Ngolang River and condition of drainage system in Mandalika Street Circuit.

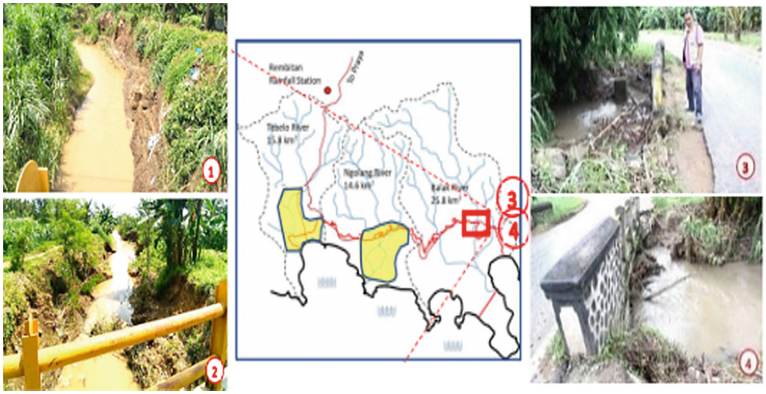

Fig. 8. Condition of Balak and other river outside of The Mandalika area.

4 Analysis and Discussion

4.1 Short Term Mitigation Plan

In Fig. 1 show high drainage network density, characterized by a large number of branches in the flow area, more quickly to the inlet, so that flood is getting higher [1].

The rain intensity was about 10-year return period, that is not too high in term of design flood for river structures which is 25 or even 100 year return period, however it caused the biggest flood. One of possible factors was land condition which was saturated of water due to two days consecutive rainfall (Table 1 and Table 3) [2]. In the other words, the runoff coefficient was higher compare to the one during the other floods. In term of the runoff coefficient, it is also be affected by the current land use. According to Table 4, there is a significant increasing of housing area, especially in Tebelo and Ngolang catchment area. This increasing will magnify the runoff coefficient; therefore, the flood is getting higher.

The time of flood was at the same time of high tide (Fig. 3). In the area close to the coastline, such as in the traditional market in Kuta, the flow velocity to the sea was reduced while incoming flood from the upstream was still continuing. There was an inundation in the traditional market and the surrounding areas. When the tide was changed to low tide, the inundation was reducing. In Fig. 5 hillslope and flow direction have a main influence on the contribution of flooding. Kuta Mandalika Basin is surrounded by hills in the West to part of the East. This causes a large slope gradient in this area, whereas flow direction can run to go to downstream area in southward and southwest because the lowest land system is in this section [3]. In Fig. 6, mainly Kuta-Mandalika Basin have texture of soil are clay. This one is easy for soil moisture exceeded (saturated), especially in the rainy season. So that, there is rainfall with intensity and antecedents falls on the surface, it will be a surface runoff thoroughly until the capacity of the field is refillable water again [2].

As the flood is getting higher, the floating object such as bamboo tree, coconut leaves and so on can be floated. In some parts, such as in the bridge that crossing the road, where the width of the river is reduced, the floating objects was trapped and block the river flow. As for the consequences, overflow occurred, and due to the existence of many buildings that block the flow, the road is the remaining open space for the overflowed water to flow. This kind of phenomena was caught in many photos and videos.

In some locations in Tebelo catchments area, especially for older buildings, elevation of the road is higher than the building, therefore the water was come and inundated. There is no way for water to return to the river, it was blocked by the surrounding buildings, fences/wall (Fig. 6). In some cases, the owner of the wall made holes in order to release the inundated water. In other cases, the inundated water was accumulated, getting higher and it made a big difference of water head between the inside and the outside of the wall, then the wall collapsed. In Ngolang River, where the drainage system is still under construction, mostly the flood was caused by connection between each of all canal reaches has not been connected yet. One thing that need more intention is when the canal cross a road. In many cases, the structure used is like a box rather than a bridge. The box has the width smaller than the height (Fig. 7). For sure it was designed that flow capacity of the boxes is sufficiently enough transferring flood design flow, however the presence of floating objects can reduce the capacity of the boxes because they trapped in the front of the box that functioning as a screen bar (Fig. 9).

There was an evident comparing phenomenon of floating objects. In Fig. 9, there was a small bridge that full of floating object trapped beneath the bridge. It was found that overflow occurred. In contrast, showing a bridge in Balak River which flood didn't occur. It is believed that there was no blockade in Balak Bridge, capacity of transferring flood flow was not reduced, overflow was not occurred. As a verification, according to common historical information, there has no flood been occurred in Balak River [4].

4.2 Long Term Mitigation Plan

Some recommendations for long term mitigation are constructed based on the analysis that already done.

Fig. 9. Comparison of box bridge and regular bridge; a bridge consist of boxes, their capacity transferring flow during flood will be reduced by the trapped floating objects.

a. Constructing drainage system therefore all drainage water in the service area able to flow to the main drainage system (the sea or the river).
b. Considering the floating objects, construction of the crossing structure between road and drainage system (river or canal) must be ensure that the floating object will not trap in the structure therefore reduce the capacity of the structure flowing the flood
c. Flood plain of the river must be maintained therefore not be occupied by the per-sonal ownership.
d. When the east part of The Mandalika is developed, it must be aware that the land use in Balak catchments area will change drastically. In term of flood, runoff coefficient will increase rapidly.
e. Involvement every human making river care community which can provide education about human awareness of waste and river maintenance [5].
f. Optimizing early warning system tools from meteorological and climatological agency (BMKG) which community based and socializing online monitoring of weather during extreme conditions and increasing community preparedness [6].
g. Always cooperate and communicate with BMKG and BPBD in disaster prevention and response actions.

5 Conclusion

There are many factors contribute to the occurrence of the January flood in Kuta. The below are the factors:

a. The soil condition was saturated due to two consecutive days of rainfall, when the 145.5 mm rain came, the runoff coefficient was already high. The runoff coefficient was magnified by the increasing of housing area in the river catchment area.
b. Capacity of drainage system was smaller than the flood due to: there was no flood plain in the riversides, the presence of floating objects trapped in the smaller width of the river, canal, or bridge and drainage canal system has not been connected each other.
c. Inundation was mainly caused by blocking of buildings, therefore the water could not enter to the drainage system. In the coastline area, inundation was also caused by high tide.

d. There were two disaster mitigation plans. Short term to overcome which are physical action and urgent whereas long term mitigation plan to preventive and non-physical action.

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