IDENTIFICATION OF LANDSLIDE AND FLOOD PRONE AREAS USING GIS (GEOGRAPHIC INFORMATION SYSTEM) (CASE STUDY: KEDIRI DISTRICT)

Muhammad Taufik, Akbar Kurniawan, Alfi Rohmah Putri
Geodynamics and Environmental Laboratory - Geomatics Departement - Sepuluh Nopember Institute of Technology

taufik_srmd@yahoo.com , akbar@geodesy.its.ac.id , alfi.rohmah07@gmail.com

Abstract. Indonesia is a disaster-prone country from the aspect of geographical, climatological and demographic.The geographical position of Indonesia between two continents and two oceans caused Indonesia has excellent potential in the economy as well as prone to disaster. Based on the IRB (Disaster Risk Index) by BNPB (National Disaster Management Agency) in 2013, Kediri ranks 7th out of 381 districts / cities in Indonesia's index flood disaster. As for the landslide disaster risk index, Kediri ranks 65th out of 497 districts / cities in Indonesia. To avoid such losses, made disaster risk management measures. By utilizing the Tandem-X to do the processing of surface hydrology to determine the flow of the river obtained from DEM. Result from processing streams of DEM then validated by a watershed in the field and then used as river map. River map then overlay with slope map of the processing results from tandem-X, soil types map, land cover map, rainfall map and geology map in order to obtain a new spatial data areas of landslide and flood prone areas. The result of research indicating that 12 villages of the Mojo, Semen and Banyakan district have a high level of landslide-prone by 8,26% . That areas are located in an area with very steep slope by 25-40% and more than 40% with litosol soil types. Meanwhile,areas with high level floodprone are located spread all across district by 2,70%. But the district with most high level floodprone is Kras district. The area lies in the lowlands with a flatter slope and alluvial soil type. Result of surface hydrology showed a high degree of fit on the uplands and low on flat areas.

Keywords: Flood, Landslide, Surface Hydrology, GIS, TanDEM-X

1. Introduction

Floods are events or circumstances in which an area or land are drown due to increased of water volume. One of the cause of the flood is the presence of stagnant water that occurs somewhere within a certain time. Landslides are a type of mass movement of soil or rock, or a mixture of both, down or off the slopes as a result of disruption of the stability of soil or rocks making up the slope. Landslides occur because there is interference on the stability of the soil / rock slope composing[UU No 24 Tahun 2007].

Based on the IRB issued BNPB in 2013, Kediri Regency is one of regencies / cities in East Java which has an index of high disaster. For flood disaster risk index, Kediri ranks 7th out of 381 districts / cities in Indonesia. As for the landslide disaster risk index, Kediri ranks 65th out of 497 districts / cities in Indonesia[BNPB. Indeks Resiko Bencana 2013]. Because of that, Kediri vulnerable to natural disasters such as floods and landslides.

To avoid such catastrophic losses, made disaster risk management measures. One way to manage the risk of disasters is to estimate the area potentially affected by flood or landslide. This analysis can be done using the parameters of the causes of flood and landslide by utilizing GIS. Analysis of flood and landslide done based on parameters that cause both such as land cover, rainfall, soil type, geology, DAS networks, slope and elevation then do the weighting method, scoring and overlay. DEM data processing performed with surface hydrology to determine the flow of the river by using GIS.

The output of this research is a map of areas prone to landslide and flood in Kediri. This map can be used as a reference in mitigating natural disasters as well as to the recommendation in spatial planning.

2. Research Method

2.1 Research Area

In this study, the research area covers five region in Kediri. The five region are Mojo ,Semen, Banyakan, Kras and Ngadiluwih .

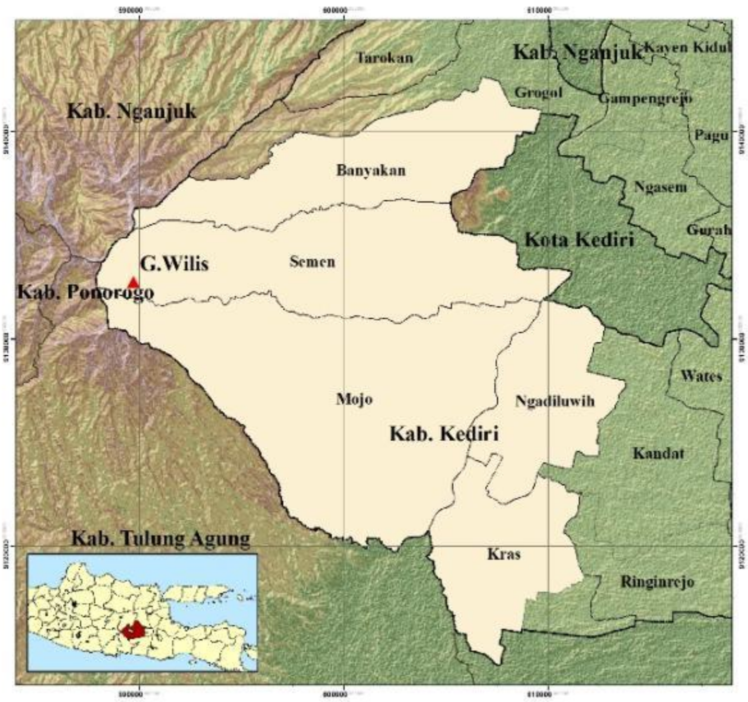


Figure 1. Research Area

2.2 Data

The data used in this study are :

a. TanDEM-X Image
b. Landsat 8
c. Daily rainfall data Kediri
d. Geologic Map
e. Soil type Map

2.3 Flowchart of Data Processing

To determine area affected by flood and landslide, first we must obtain parameters that cause landslide and flood.For landslide there are 5 parameters meanwhile for flood there are 6 parameter. Flood and landslide have similiar parameters but different scoring. The first parameters is annual rainfall. Rainfall processing is done by creating Thiessen polygons from 9 rainfall station in the research area. Thiessen Method is a method that is determined by making a polygon between stations in a specified area(Agustin Winda. 2010). Then calculate the annual rainfall on tabular data daily rainfall in 2015. Landsat 8 processing done by performed supervised classification classed into 6 classes of land cover such as forests, fields, shrubs, settlements, farms and vacant land. Then the accuracy of the test results of the classification performed by ground truth.

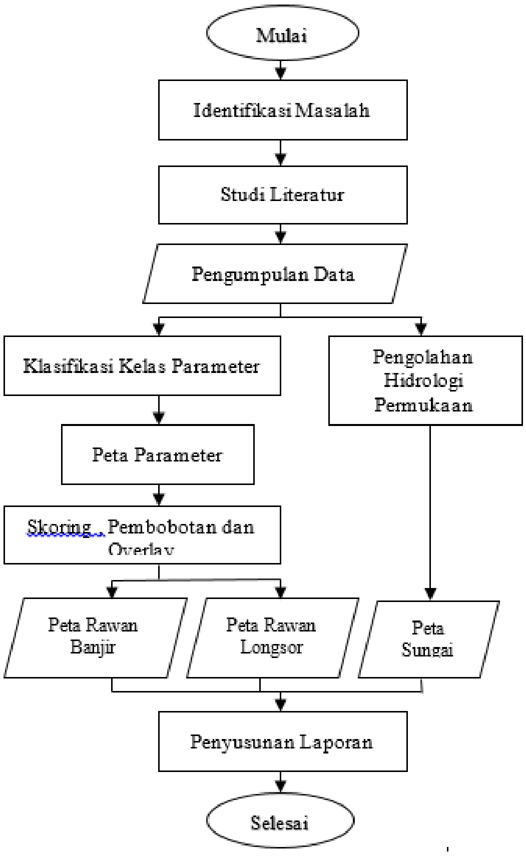


Figure 2. Flowchart of Data Processing

.Processing Tandem-X is divided into surface hydrology processing and classified slope. In Surface hydrology processing do :

- Improved data by function fill sink
- Analysis of the river flow direction (flow direction)
- Analysis of the accumulation of water flow (flow accumulation)
- Development of a river network

The results of the processing surface hydrology is a map of the river that were then validated with a map of the river network in the field. While on the processing of the slope, DEM extracted into contours and slope. DEM slope classified into 5 classes. Having obtained the parameters of floods and landslides then carried scoring in each class and weight to each parameter then overlay. Potential analysist areas prone to flood and landslide based on the total score in each area. The following parameters were used:

Table 1. Flood parameter (Ariyora, Yuan K.S.2014)

Parameter	Magnitude	Score	Weight
Slope	<8%	5	20%
	8-15%	4	
	15-25%	3	
	25-45%	2	
	>45%	1	
Height	0 - 12.5 m	5	10%
	12.5 - 25 m	4	
	25 – 50 m	3	
	50 - 75 m	2	
	75 – 100 m	1	
	> 100 m	1	
Annual Rainfall (mm/year)	<1000	1	20%
	1000-2000	2	
	2000-2500	3	
	2500-3000	4	
	>3000	5	
Soil Type	Very rough	1	10%
	Rough	2	
	Moderate	3	
	Smooth	4	
	Very smooth	5	
River	0-25 m	3	20%
	25-100 m	2	
	100 - 200 m	1	
Land cover	Forest / dense vegetation	1	20%
	Gardens and mixed scrub	2	
	Plantations and irrigated field	3	
	Industrial estates and residential	4	
	Vacant land and water bodies	5	

Table 2. Landslide parameter ([DVMBG] Direktorat Vulkanologi dan Mitigasi Bencana Geologi. 2005)

Parameter	Magnitude	Score	Weight
Slope	<8%	1	15%
	8-15%	2	
	15-25%	3	
	25-45%	4	
	>45%	5	
Annual rainfall (mm/year)	<1000	1	30%
	1000-2000	2	
	2000-2500	3	
	2500-3000	4	
	>3000	5	
Soil type	Not sensitive	1	20%
	Less sensitive	2	
	Less sensitive	3	
	Sensitive	4	
	Very sensitive	5	
Geology	Alluviaal material	1	20%
	Vulkanic 1 material	2	

	Sediment 1 material	3	
	Sediment 2 Vulkanic 2 material	4	
Land Cover	Forest / dense vegetation and water bodies	1	15%
	Gardens and mixed scrub	2	
	Plantations and irrigated field	3	
	Industrial estates and residential	4	
	Vacant land	5	

3. Results

3.1 Surface Hydrology

In this research, DEM data used for surface hidrology processing become river map. Then the result from surface hidrology processing validated with river in ground truth. From 2 map river then overlayed to validated the result from TanDEM-X processing.

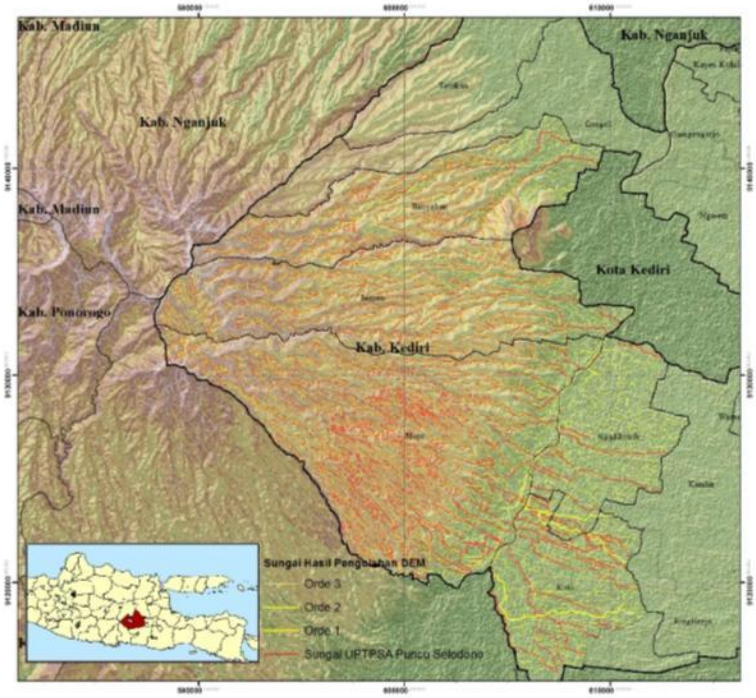
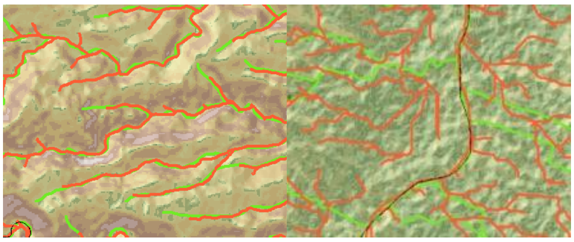


Figure 3. River Map

From the figure above, the result TanDEM-X processing shown similiar pattern in the upland, meanwhile in the lowland there is big differences.The diferrences in the upland and lowland can be seen in following figure :



(a) (b)

Figure 4. The difference in the upland (a) and lowland (b)

Differences in the pattern of flow in the lowlands can be caused due to the determination of the flow direction in the DEM used D8 algorithm where the algorithm compares the relative height of 1 pixel to 8 pixel around it. Furthermore, the determined flow direction of the steepest slope to the surrounding pixels. In lowland areas there is no tilt striking or relatively flat so it is difficult to determine the watershed. So that the lowland happen very striking pattern of differences between the actual river with DEM processing results.

3.2 Flood

Determining the level of vulnerability to flooding based on the results obtained from the cumulative score overall parameters. The result ranged from 4.60 to 0.80 which was converted on several levels according need. In this study used three classes of vulnerability, low, medium and high. Here is a map of the result of the determination of flood-prone areas:

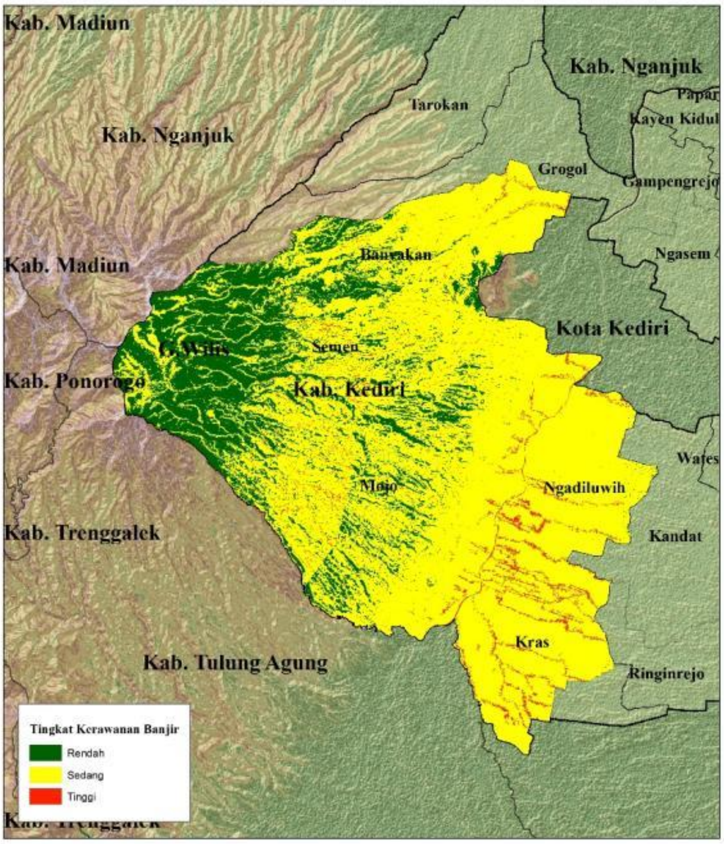


Figure 5. Flood-prone Map

Based on the picture above, it can be seen that areas with high levels of insecurity in the eastern part following the river flow patterns. Distribution zoning flood-prone areas in this study showed similar results with a map of the river flow. An area with a moderate impact is spread evenly from the west to the east area of research. While the low level of vulnerability areas located in the western part of the study area. Here are the results of the area vulnerability of flood :

Table 3. Level of Floodprone

No.	Potential level Flood	Value	Area (ha)	percentage
1	Low	<2,06	7983.38	21.03
2	Moderate	2.06 to 3.33	28958.83	76.27
3	High	> 3,33	1024.78	2,70

From the above table can be seen in the level of moderate was dominating with the percentage of 76.27% or a total of 28958.83 hectares. While the low-prone areas have an area of 7983.38 ha, equivalent to 21.03%. Last high flood prone area is 2,70% or 1024.78 ha.

Table 4 Area of Flood Prone Areas

No.	districts	Area (ha)
1	Banyakan	67.28
2	Kras	342.95
3	Mojo	294.22
4	Ngadiluwih	194.11
5	Semen	126.21
Total		1024.78

Based on the table above, high-potential area is spread on the entire district area of research. But the extent of flood-prone areas with the most extensive high lies in District of Kras in the amount of 342.95 ha. This is in accordance with the state of the District of Kras is located in the lowlands with a flat slope with alluvial soil types. Alluvial soil is alluvial soil of the river and are generally located in the lowlands.

3.3 Landslide

Determining the level of vulnerability to landslides based on the results obtained from the cumulative score overall parameters.The result of pekalian ranged from 5.00 to 1.33 which was converted on several levels as needed.In this study used three classes of vulnerability, low, medium and high.Here is a map of the results of the determination of areas prone to landslides:

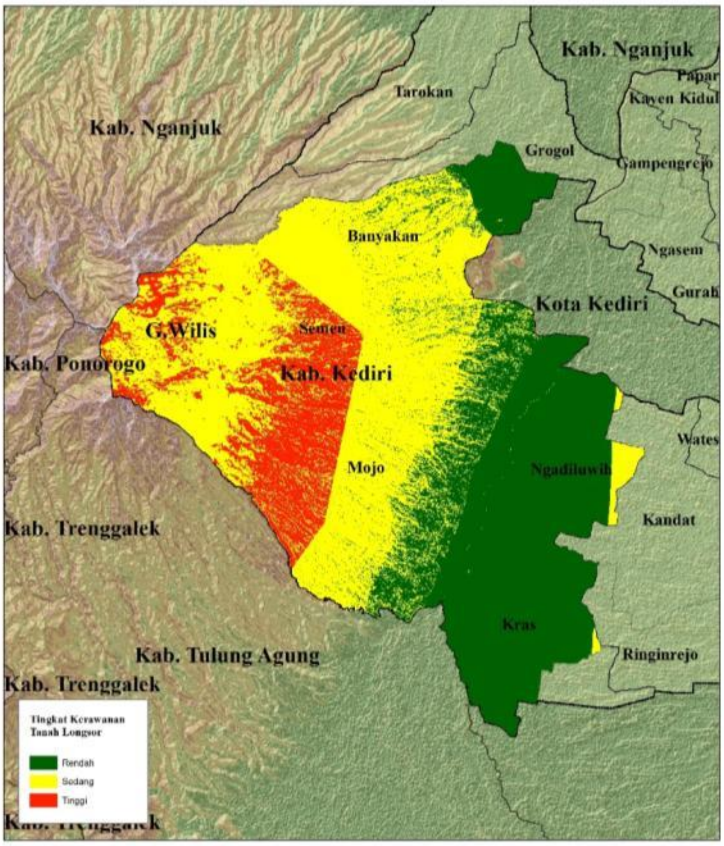


Figure 6. Landslide Prone Map

Based on the picture above, it can be seen that areas with high levels of vulnerability lies in the western part of the study area. Distribution of zoning areas prone to landslides in this study showed similar results with geological maps, rainfall and slope. An area with a moderate impact spread from the west to the middle of the study area. Whereas the vulnerability of the low area located in the eastern area of research. Here are the results of the area of the level of vulnerability to landslides:

Table 5. Level of Insecurity Landslide

No.	Potential level Landslide	Value	Extents (ha)	percentage
1	Low	<2,26	14896.40	39,24
2	moderate	2.26 to 3.53	18303.57	48.21
3	High	> 3.53	4767.03	12,56

Based on the above table, we can see the area being mendominisi level as much as 48.21%, equivalent to an area of 18303.57 hectares. Kenudian area has a low level of vulnerability to the extent of 14896.40 ha or equivalent 39.24%. Recently, the area has a severe impact area smallest of 4767.03 ha, equivalent to 12.56%.

Table 6. Size Landslide Prone Areas

No.	Village name	districts	Area (ha)
1	Ngetrep	Mojo	151.72
2	Keniten	Mojo	121.92
3	Blimbing	Mojo	660.03
4	Jugo	Mojo	841.43
5	Petungroto	Mojo	790.13
6	Pamongan	Mojo	403.53
7	Ponggok	Mojo	29.84
8	parang	Banyakan	266.33
9	Joho	Semen	473.40
10	Konyoran	Semen	771.74
11	Pagung	Semen	36.18
12	Selopanggung	Semen	220.77
Total			4767.03

High potential landslide area located in 12 villages in three sub-districts Mojo, Semen and Banyakan. The area is located on the slopes of Mount Wilis with a slope of more than 25-45% and 45%.

4. Conclusion

The conclusion based on this research are:

a. Processing Tandem-X to demonstrate the adequacy of surface hydrology in the upland areas are high while in the lowlands reverse.
b. Landslide-prone areas are divided into three levels, namely lower by 39.24%, medium by 48.21% and a high by 12.56%.Regions with high potential landslides found in 12 villages in the district Mojo, Semen and Banyakan with an area of 4767.03 ha.The area has a degree of slopeness ranging between 25-40% and over 40% with soil type litosol.
c. Flood prone area is divided into three levels, namely lower by 21.03%, medium by 76.27% and high by 2.70%. Area with high potential flood to spread throughout the district premises area of 1024.78 ha.However Districts with the largest extent of flood-prone areas lies in Kras,Locatedin the lowlands with a flat slope and alluvial soil type

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[DVMBG] Direktorat Vulkanologi dan Mitigasi Bencana Geologi 2005 *Manajemen Bencana Tanah Longsor.*