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ABSTRACT

Landslide is caused by meteorological and geomorphological factors. Landslide is one of the most common disaster that occur in Indonesia. Purworejo is one of the potential area that could be experiencing landslides, because the geomorphological conditions which are included in Menoreh Hills are geographically sloping to very steep. Based on the Indonesian Disaster Information Data (DIBI) and the National Disaster Management Agency (BNPB) in the last five years from 2014 to April 2019 there have been 64 landslides in Purworejo. To reduce the impact of landslide, effective evacuation routes are needed. Determining of evacuation routes can be done in various methods, one of methods is use a spatio-cost approach. The purpose of this research is to determine the most effective evacuation routes to reduce the impact of landslide. Spatio-cost parameters obtained by certain paramaters. The parameters are physical parameters and some social parameters derived from the appearance on the surface of the earth, such as housing, number of population, land use, slope direction, roads and also the wide of the roads. These parameters are processed to look for evacuation routes using Least Cost Path (LCP) method. The expected result of this research is evacuation routes that can help people around disaster-prone areas to prepare. This on going research is important to improve disaster manajemen in Indonesia, especially for landslide in Bruno, Purworejo, Central Java.

Keywords: Landslide, evacuation routes, least cost path (LCP).

1. INTRODUCTION

Purworejo is a regency in Central Java Province with an area of 1,034.82 km2. Purworejo consists of 16 districts. Purworejo in 2015 had a population of 710,435 people (Badan Pusat Statistik Republik Indonesia, 2016)[1]. Purworejo is a district that has developed quite well in agriculture. In addition, it also developed in the field of trade and services. Purworejo has a variety of potentials, both beneficial and adverse potential. Favorable potential is the potential in terms of natural resources and human resources, while the potential for harm is the potential for natural disasters. This study discusses mitigation efforts in dealing with landslides in Purworejo. Purworejo is one of the districts in Indonesia that is prone to landslides. Landslides can be found in areas that have steep slope physiographic conditions. This is in accordance with the topography in the western and northern regions of Purworejo. Therefore, modeling of landslide vulnerability is important to do. Landslides are often referred to as slope instability caused by geomorphological factors, especially the slope angle (Aman et al, 2014)[2].

This study departs from research on landslides in Purworejo with a different purpose. The route of evacuation of landslides disaster should be analyzed specifically due to the necessary of mapping accuracy and effectiveness of geospatial analysis. We choose Bruno Subdistrict in this study. The first reason is Bruno Subdistrict include in the one of subdistrict that classified into "Extreme Vulnerable" of landslide disaster in Purworejo. The second reason is no evacuation route found in Bruno, Purworejo. The last reason is the effectiveness of evacuation route using least cost path method. The method used is also very diverse and developed by previous researchers (Hadmoko et al., 2010[3]; Nugraha, 2014)[4], Sharma et al. (2015)[5]. The results of previous researchers refer to the conclusion that the Purworejo is prone to landslides. The result is quite satisfactory because it is able to produce landslide hazard maps with accuracy of up to 81.8% (Ba et al., 2017). IVM is a model developed from information theory to conduct statistical analysis, which considered the factor of landslide parameters. Each parameter used, has the same level of equality.

Based on previous research, it is followed up through this research to plan the landslide disaster evacuation route. This research is based on spatial data and processed using Geographic Information System (GIS) using parameters that are considered very influential according to previous research. The parameters used are roads, slope, landuse, and assembly point. This research will produce a conclusion on how the evacuation route is most effective to reduce the impact of landslides

2. STUDY AREA

The study area is Bruno, Purworejo, Central Java as shown at figure 1 below. Bruno as Sub-district in the part of Purworejo Regency in Central Java Province was due to the fact that in the IVM result has been observed before included in "Extreme Vulnerable" of landslide disaster. Administratively Bruno Sub-district consists of 18 villages. Geographically, Bruno Sub-district of Purworejo Regency is located in the south-central part of Java Island, more precisely located at 109° 47' 28'' - 110° 8' 20'' East Longitude dan 7° 32' - 7° 54'' South Latitude, sized 108,43 km².
Administratively, Bruno borders on several regions, namely:
North side: Wonosobo Regency, Central Java Province
West side: Pituruh Sub-district, Purworejo Regency, Central Java Province
East: Wonosobo Regency, Central Java Province
South: Kemiri Sub-district, Purworejo Regency, Central Java Province

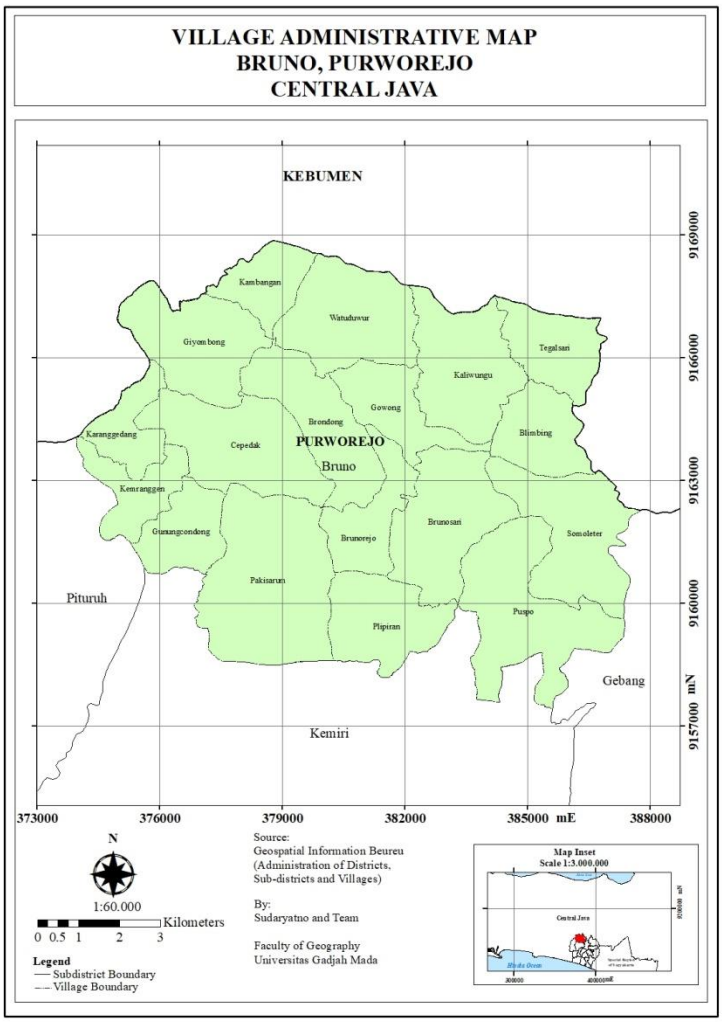


Figure 1 Map of Research's Area

3. METHODOLGY

3.1 Tools and Materials

Research Tools

a. Avenza Map to collect gathering and evacuation point form field surveying
b. Laptop to process the data which is equipped with:
   - ArcGIS 10.3 : used to process vector data such as Land use, Roads, and Digital Elevation Model (DEM) with each weighting method for converting into raster data and combining them into cost raster. Cost raster with gathering point as input raster are used for Cost Distance Algorithm and then with evacuation point as destination for Least Cost Path Algorithm.

Research Materials dan Datasets

a. Digital Elevation Model (DEM) Alos Palsar Image
b. Vector Data (Shapefile) Land Use Interpretation Data using SPOT 5 Image
c. Vector Data (Shapefile) Roads in Bruno Sub-district using Indonesian Geospatial Data - Purworejo Regency
d. Vector Data (Shapefile) Assembly Point using Field Surveying with Avenza Map Application
e. Vector Data (Shapefile) Evacuation Point using Field Surveying with Avenza Map Application

3.2 Step of Research

Weighting Method for Land use vector, Roads vector data, and Digital Elevation Model (DEM) data

The first step is to create all the input data such as land use vector, roads vector data, and Digital Elevation Model (DEM) data with each different algorithm have new classification. The aim of the new classification is for arrange input data with weighting method and then the lowest number class is best for evacuation plan decision. Land use vector data have five classes which is bare land are weighted one as the lowest, settlement areas are weighted two, agricultural fields area are weighted three, non-agricultural fields area are weighted four, and water area aren't weighted. Roads vector data are used Euclidian Distance Algorithm for buffering the roads for each two meters with the first of two meters are weighted one as the lowest etc. Digital Elevation Model (DEM) data are converted using Slope Algorithm for extract degree value and then the value is classified using Tobler Hiking Function rules for each ten degree of slope with the first of ten degree of slope are weighted one as the lowest etc.

Converting input data into raster data and combine them using raster calculator

The second step is to process the weighted land use and road classification vector data to raster data using conversion tools which is polygon to raster and then all the raster data are combined by pixel to pixel with the same size with raster calculator. The code for calculate them are plus or "+" symbol which would extract them into cost raster as a new raster with the lowest weighted as best route for evacuation plan decision.

Cost Distance Algorithm using gathering points as an input

The third step is using Cost Distance Algorithm using spatial analyst tools with the input is gathering point and the cost raster. Gathering points are collected in the field surveying with the criteria such as having enough space for massive people near the villages such as school, empty field, and administrative building. Avenza Map is the application for acquisition the point which is have nine samples area as the assembly point. The algorithm has relation one to one model for making any evacuation route which would make all the gathering point are used partially with the same cost raster for the process. The result of this step are nine cost distance raster with nine backlink raster for input.

Least Cost Path Algorithm using evacuation points as an destination point

The fourth step, which is the final step, is using Least Cost Path Algorithm using spatial analyst tools with the input is evacuation point and the cost distance raster with the backlink raster. Evacuation points are collected in the field

surveying with the differences criteria than gathering point such as having large enough space for massive people and could make large evacuation tent with clear accessibility such as large scale of outdoor football field. The Avenza Map is the same tools or application for acquisition the point which is have two samples area as the destination point. The algorithm has relation one to one model for making any evacuation route which would make all the evacuation point are used partially with the same cost distance for the process. The result of this step are eighteen Least cost path as the all scheme for evacuation route which is the output of the process.

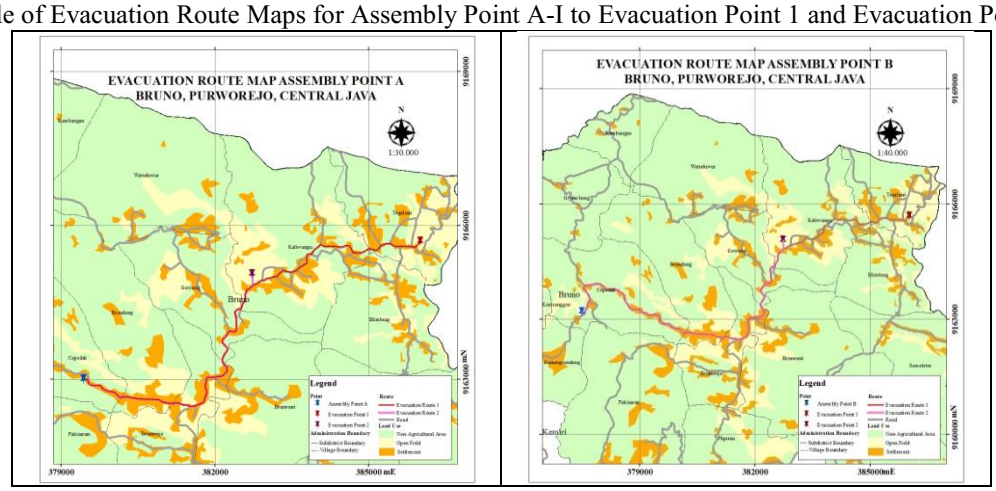
4. RESULTS AND DISCUSSIONS

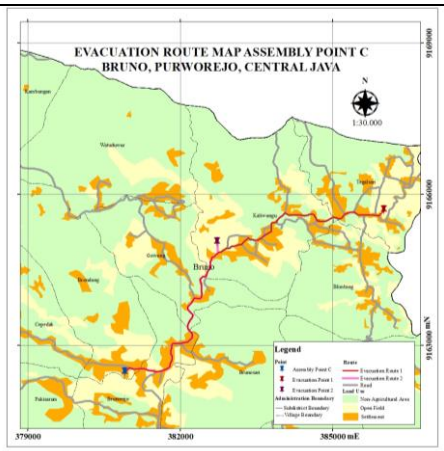
Evacuation routes that have been created using the Least Cost Path method involve 9 Assembly points and 2 evacuation points. Assembly points are given letter notation and evacuation points are given number notation. The following are the gathering points and evacuation points intended previously:

- Assembly point:
    A. Field
    B. Volleyball court
    C. Mosque
    D. Offices
    E. Open land 1
    F. Open land 2
    G. Sub-District Office
    H. Village administration office
    I. Tegalsari Elementary School
- Evacuation Point:
    1. Field, The field used for evacuation point is wider than the one used for assembly point.
    2. Open land, The open land used for evacuation point is wider than the one used for assembly point.

This following are the result of evacuation routes presented in 9 maps to compare the nearest and most effective evacuation point for each assembly point.

Table 1. Table of Evacuation Route Maps for Assembly Point A-I to Evacuation Point 1 and Evacuation Point 2




EVACUATION ROUTE MAP ASSEMBLY POINT C
BRUNO, PURWOREJO, CENTRAL JAVA
N
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Bruno
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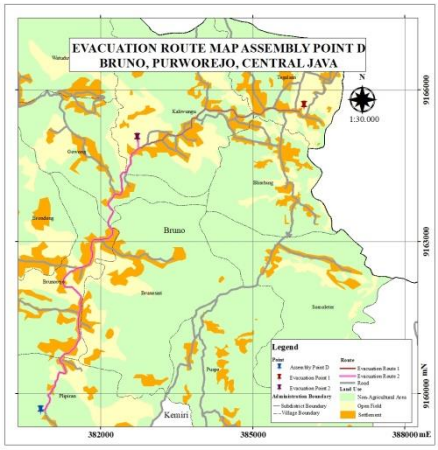
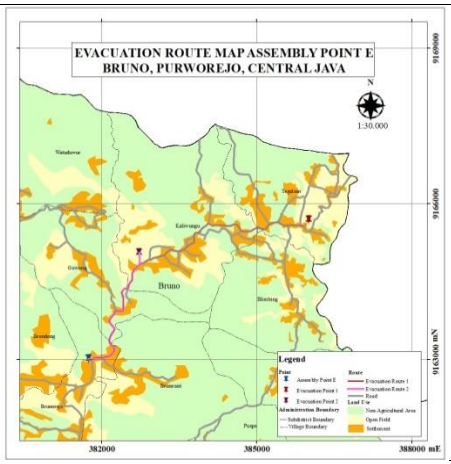
379000
382000
385000 mE
9169000
9166000
9163000 mN


EVACUATION ROUTE MAP ASSEMBLY POINT D
BRUNO, PURWOREJO, CENTRAL JAVA
N
1:30.000
Bruno
Kemiri
Legend
382000
385000
388000 mE
9169000
9166000
9163000 mN


EVACUATION ROUTE MAP ASSEMBLY POINT E
BRUNO, PURWOREJO, CENTRAL JAVA
N
1:30.000
Bruno
Legend
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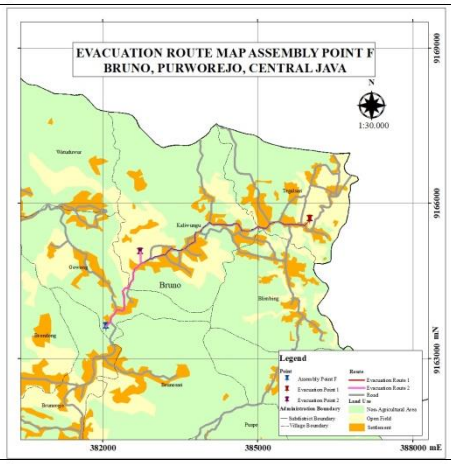
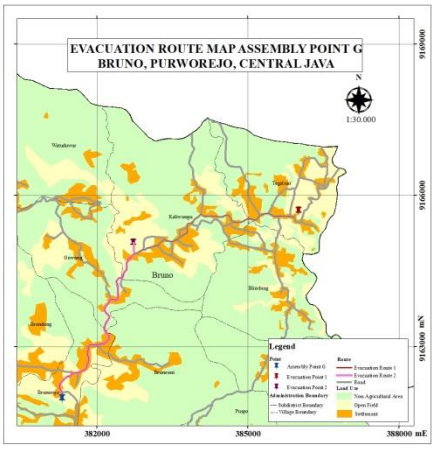
385000
388000 mE
9169000
9166000
9163000 mN


EVACUATION ROUTE MAP ASSEMBLY POINT F
BRUNO, PURWOREJO, CENTRAL JAVA
N
1:30.000
Bruno
Legend
382000
385000
388000 mE
9169000
9166000
9163000 mN


EVACUATION ROUTE MAP ASSEMBLY POINT G
BRUNO, PURWOREJO, CENTRAL JAVA
N
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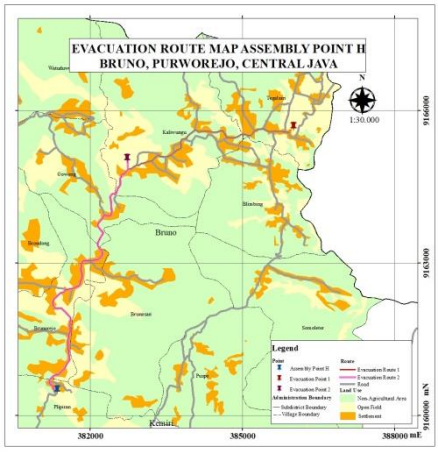
388000 mE
9169000
9166000
9163000 mN


EVACUATION ROUTE MAP ASSEMBLY POINT H
BRUNO, PURWOREJO, CENTRAL JAVA
N
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Bruno
Kemiri
Legend
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388000 mE
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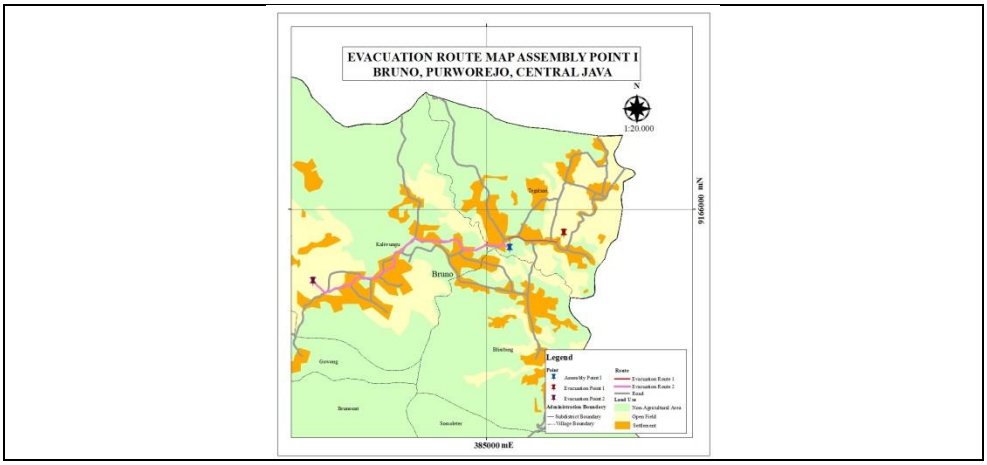
9163000 mN



Based on the results of the research above, it can be seen that each assembly point can be reached by a distributed settlement in Bruno District. Assembly points A to H have each evacuation route to get to evacuation point 1 and evacuation point 2. Evacuation routes that have been created using the Least Cost Path method have different lengths and range. The closest evacuation route from the gathering point to the evacuation point can be assumed to be the closest range. Assembly point A to H can be known the nearest reach to evacuation point 1 or evacuation point 2. Thus, the evacuation point that has the closest range can be prioritized as the main evacuation point for each assembly point in the event of a landslide in Bruno District.

Evacuation point 2 is an evacuation point that can be reached by almost all predetermined assembly points. Assembly point A through H can reach evacuation point 2 with the closest range, so that residents around can follow the evacuation route that has been mapped. While the assembly point I is the only closest assembly point that can reach the evacuation point 1. Therefore, based on the previous explanation, the evacuation point 2 can be used as the main evacuation point. The main evacuation point is expected to accommodate all refugee. Mapped evacuation routes are also in accordance with available roads in Bruno District so that evacuation can be done easily.

5. CONSLUSIONS

Based on the research that has been done, the conclusion is obtained to answer the research objectives as follows:

Between evacuation points 1 and 2, evacuation point 2 is an evacuation point that can be reached by almost all of the designated gathering points, which are assembly points A to H, while assembly point I is the only closest assembly point that can reach evacuation point 1. So evacuation point 2 can be used as the main evacuation point in the event of a landslide in the Bruno District. .

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