MAPPING THE POTENTIAL RISK OF LANDSLIDES IN CIAMIS DISTRICT, WEST JAVA.

A.B.Suriadi M Arsjad
Geospatial Information Agency.
Jl. Raya Jakarta Bogor Km. 46, Cibinong,
budiman6109@gmail.com

KEY WORDS: HAZARD MAP, EXPOSURE, VULNERABILITY, CAPACITY.

ABSTRACT

This paper is a part of the results of the research on Potential Disaster related to Extremes Climate Variability on the south part of West Java. There are at least five natural disasters related to extreme climate such as floods , landslides, storm, extreme waves , and long droughts. However in this paper the discussion focused on landslides in terms of both the causes as well as the potential risks it caused. The results of this study are geospatial information or maps about landslide. Those maps are: Map of Landslide Prone, Map of people's Vulnerability to Landslide Hazard, Map of the Capacity of residents facing disasters, as well as Map of the Risk Potential of Landslides. To produce these thematic maps is needed some layers of data. These layers is derived from geospatial data such as SRTM DEM, Landsat imagery, topographic maps, as well as statistical data of population density, the availability of infrastructure for disaster mitigation, awareness of people facing disaster or people's preparedness for natural disaster that may be happen etc. The method used is the application of GIS and remote sensing . Landsat imagery used for interpretation of land use . SRTM DEM is used to calculate and mapping slope steepness. SRTM DEM combined with Landsat imagery has used for interpretation of land forms. Data on slope steepness, land use, landform and drainage density were scored and used as a parameter in landslide hazard mapping. Landslide hazard then divided into three categories: low, medium, and high. Statistical data are mapped on the basis of villages boundary. Based on Landslide Risk Potential Map produced, Ciamis District has a high potential risk by 21%, 36% moderate risk and low risk 43% of the total area of the district.

1. INTRODUCTION.

1.1 Background.

Some global climate phenomenon that affects the climate in Indonesia, among others, is Elnino and Lanina. Elnino or ENSO (Elnino Southern Oscillation) is often associated with a long drought in Indnesia, which is marked by warming of sea surface temperatures around the equatorial Central Pacific, in other words, the occurrence of positive anomalies (ie a temperature hotter than the average). Meanwhile, the extent of the influence of El Nino in Indonesia, depends on the condition of Indonesian territorial waters. Phenomenon El Nino effect in the territory of Indonesia is drastically reduced rainfall. According to experts, these effects can occur when the temperature conditions of Indonesian waters cold enough. Conversely, when the sea temperature in Indonesia is quite warm, it will not affect the lack of significant rainfall. However, because of the vast territory of Indonesia, it is not the entire area affected by the El Nino phenomenon. While La Nina is the opposite of El Nino is marked by a negative sea surface temperature anomalies (colder than the average) in the Central Equatorial Pacific. La Nina phenomenon in general cause rainfall in Indonesia increased when coupled with the warming of the sea surface temperature in Indonesian waters. As with El Nino, La Nina effects have no effect to the entire territory of Indonesia.

Other global climate phenomenon is Dipole Mode, which is the phenomenon of ocean-atmosphere interactions in the Indian Ocean. This phenomenon is predicted based on the difference in value between the sea surface temperature anomaly in the sea around the coast of East Africa with the sea surface temperature anomalies on the west coast of Sumatra island. The difference in the value of the sea surface temperature anomaly is referred to as the Dipole Mode Index (DMI). If positive DMI, would generally have a lack of rainfall in the western region of Indonesia, and if DMI is negative, will impact increased rainfall in the western region of Indonesia.

There is another phenomenon of climate/weather, known as the Madden Julian Oscillation (MJO) with an indication of the activity of the growth oscillations clouds along the path starting from the top of the East African sea to sea in the western part Pasisfik, in northern Papua. Oscillation period is relatively short, about 30-50 days (intra-seasonal). This phenomenon is often associated with the beginning of the dry season in Indonesia.

Frequent extreme weather due to global climate change bring many natural disasters such as floods, landslides, crop failure, and others. Because Indonesia is located on three active tectonic plates, then the tectonic earthquake with very strong shocks also increase the susceptibility of Indonesia against geological disasters.

Based on information from BNPB of various disasters that occurred during 2010, the hydro-meteorological disasters is the most dominating. Of 644 disaster events, 577 or 89.6 percent are hydro-meteorological disasters. National Disaster Management Agency (BNPB) reminds hydro-meteorological disasters is still great potential in Indonesia this year. Map of disaster-prone areas are made by BNPB mention that, one of the three villages in Indonesia is a disaster-prone villages. (Gema BNPB, MARCH 2011 VOL.2 NO.1)

Of the 497 districts and cities in Indonesia, 176 counties and cities which are at high risk of flooding, among which 154 high risk of landslides, and 153 districts / cities at high risk of drought, http://news.detik.com/read/2011/01/04 / 003 748/1538482/10 / coordinating minister-People`s Welfare. The head of Volcanology and Geological Hazard Mitigation (PVMBG) Surono said that the province of West Java, as the region with the highest natural disasters in 2010.

1.2 Study Objective

The purpose of the study is to assess and map areas prone to landslides and potential landslide risk in Ciamis District, West Java.

1.3 Definitions And Limitation Of Study

Extreme weather.
Weather is the atmospheric conditions that occur in a particular time and place. While extreme weather is abnormal weather events, which can result in a loss, especially threats to life and property. (Regulation of the Head of the Indonesian Agency for Meteorological, Climatological and Geophysics No.009 of 2010 on the implementation of standard operating procedures early warning, reporting, and dissemination of information of extreme weather).

Disaster.
A disaster is an event or series of events that threaten and disrupt the lives and livelihoods caused by both natural factors and / or non-natural factors and human factors that lead to the emergence of human casualties, environmental damage, loss of property, and psychological impact. While the natural disaster is a disaster caused by an event or series of events caused by nature such as earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes, and landslides (Law of the Republic of Indonesia No. 24-2007, on Disaster Relief).

Based on this definition, the potential for disaster is a situation or condition that allows natural disasters. For example, unstable soil conditions with steep slopes that are landslide-prone areas, in the event of extreme weather high rainfall may lead to landslides. Landslides can bring disaster risk both social and economic risk.

Disaster risk is the potential loss caused by the disaster in an area and period of time that can be death, injury, illness, loss of a sense of safety, refuge, damage or loss of property, and disruption of community activities. (BNPB, 2012).

Landslides are one of the types of soil movement (mass movement / mass wasting) is a natural phenomenon in the form of a mass movement of soil by gravity follows the slope (Selby MJ, 1985). A **landslide**, also known as a **landslip**, is a geological phenomenon that includes a wide range of ground movements, such as rockfalls, deep failure of slopes and shallow debris flows. Landslides can occur in offshore, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability. Typically, pre-conditional factors build up specific sub-surface conditions that make the area/slope prone to failure, whereas the actual landslide often requires a trigger before being released. (From Wikipedia, the free encyclopedia). Another type of mass wasting is **Debris slide.** A debris slide is a type of slide characterized by the chaotic movement of rocks soil and debris mixed with water or ice (or both). They are usually triggered by the saturation of thickly vegetated slopes which results in an incoherent mixture of broken timber, smaller vegetation and other debris.

Vulnerability
United Nations/International Strategy for Disaster Reduction (UN/ISDR), defines vulnerability as the ''conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards''. (UN/ISDR, 2004) in Joern Birkmann

Coping capacity is defined as the characteristics of an individual or group of people in his ability to anticipate, cope with, resist and recover / impact of a disaster event ((Blaikie dkk.,1994 in Samaddar, 2007).

2. THE STUDY AREA

Study area includes the District of Ciamis and the City of Banjar. This region consists of 42 subdistrict with a total number of 375 villages.

Figure 1. Location of Study Area

3. DATA AND METHOD

3.1 Data.

There are four elements of the physical condition of the area is used as a parameter in determining areas prone to landslides, namely; drainage density; slope steepness; landform/Relief , and landcover/land use as shown in Table 2 (Suriadi A.B.M.A, 2012). In addition to the existing data in table 2 other data used for the analysis of natural disaster risk is statistical data. This study uses data PODES 2011. PODES 2011 is the statistical data that is used for various purposes in Indonesian socio-economic analysis. For disaster risk analysis, among others, may use demographic data, that is data on village community preparedness in facing the possibility of the occurrence of natural disasters. To assess the exposure of the population to disasters have used population density data combined with the level of vulnerability to landslides. To assess the capacity of the population in the face of disaster, such as the availability of equipment used for overcoming disaster, whether or not the education of knowledge of disaster in the village, whether or not the mutual support institutions in the village, presence or absence of an early warning system against hazards in the village, and other.

3.2 Data Of Physica Condition Of The Study Area

Tabel 2. Parameters used for identification of landslide prone.

Data layer	Class	score
1. Drainage density (Dd)	1. low	1
	2. moderate	5
	3. high	9
2. Slope steepness S (%)	≤ 40	3
	41 - 70	5
	>70	9
3. Landform/Relief (BLH)	1. Fluvial plain	1
	2. Moderately to slightly dissected plains	2
	3. Strongly dissected plains	3
	4. Slightly dissected hills	4
	5. Moderately dissected hills	6
	6. Strongly dissected hills	8
	7. Slightly dissected mountain	5
	8. Slightly dissected mountain	7
	9. Slightly dissected mountain	9
4. Landcover/land use (LLH)	1. Water body	1
	2. Forest	2
	3. Settlements	4
	4. Mixed garden	5
	5. Rice field	1
	6. Scrub / shrub	3
	7. Bare land	5

Source: Suriadi A.B.M.A(2012)

3.3 Rainfall Data.

There are two years data of rainfall available for the study are as seen of figure 2 below:

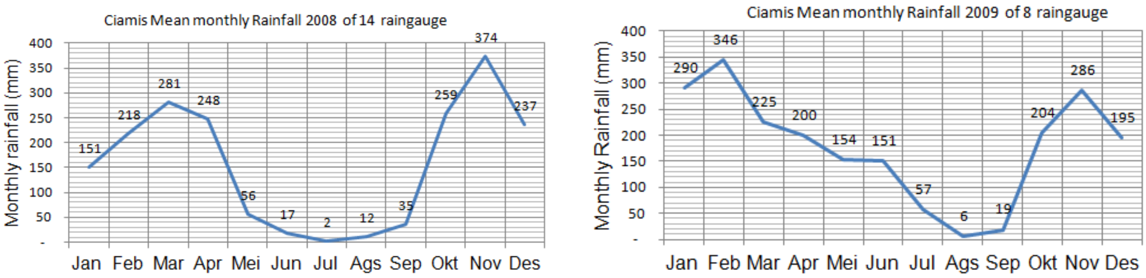


Figure 2. Mean monthly rainfall of several rainfall station in Ciamis district.

Based on rainfall data, it appears that the rainy season starts in October and ends in April. The peak of the rainy season occurs between the months of November to March. Thus the danger of landslides might occur in these months

3.3 Method

Map of landslide hazard derivated from combination of landform data, landuse data, slope steepness data and drainage density or degrees of dissection data as can be seen in table 2. All data is presented in the form of a spatial layer. In the figure 3 shows the index of damage and population exposure index is used as an input for vulnerability maps. However, in this study does not discuss the problem of damage and loss of property because it requires a large work due to unavailability of statistical data relating to the damage and loss of material caused by landslides. Figure 3 shows the flowchart of Risk Mapping proces.

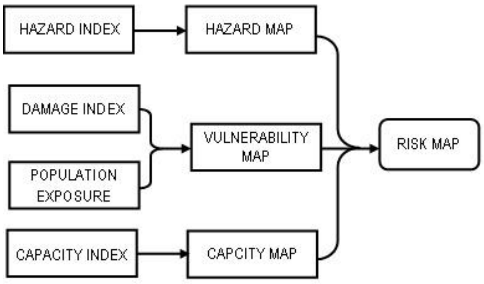


Figure 3. Modelling Disaster Risk Map (BNPB,2012).

Several models to formulate risk as shown in the following table 2

Table 1. Conceptual models of Risk

Concep models	Author
Risk = Natural hazard * Element at risk* vulnerability	UNDRO(1991), extended from Fournier d'Albe(1979)
Risk = (Hazard*vulnerability)- Coping capacity	Wisner (2001)
Risk = (hazard *vulnerability) - mitigation	Wisner (2000)
Risk = hazard * exposure*vulnerability	De La Cruz Reyna, (1996)
Risk = hazard * exposure*vulnerability*interconectivity	Yurkovich (2004)
Risk = hazard * exposure*vulnerability/Resilience	UN (2002)

Source: Global Risk Indentification Programme, UNDP Bureau for Crisis Prevention and Recovery, www.griweb.org

For this study the formulation of risk based on the concept of the UN (2002) with little change is to replace the "resilience" with "coping capacity" as follows:

$$\text{Risk} = \frac{\text{Hazard} * \text{Vulnerability}}{\text{Coping Capasity}} \quad (1)$$

Hazard in this formula is a natural hazard, the hazard of landslides, mapped as Landslide Prone Map with hazard level classification from low, moderate to high. Vulnerability here is represented by exposure of a community to a dangerous condition. Logical assumption in this case there is no people who is not vulnerable to landslide hazards. Likewise assuming that where there are a lot of people, there are also associated with the presence of their property. Thus, the degree of vulnerability can be based on the number of people exposed to the possibility of landslide hazards. The number of people exposed to landslides hazard is calculated based on how dense the population living in each level of the landslide hazard. In the language of GIS can be calculated by means of multiplication or addition Landslide hazard scores with a score of population density.

Population density class as follows:
<= 500 low density, 500-1000 medium density,> 1000 high density. Population density is calculated based on the area of the village. (number of inhabitants per area of the village), for example, 500 people / sq km. This population density class is scored as follow:

Density	Class	Score
<= 500 people/Sq km	low	1
500 – 1000 people/Sq km	moderate	3
>1000 people/Sq km	high	6

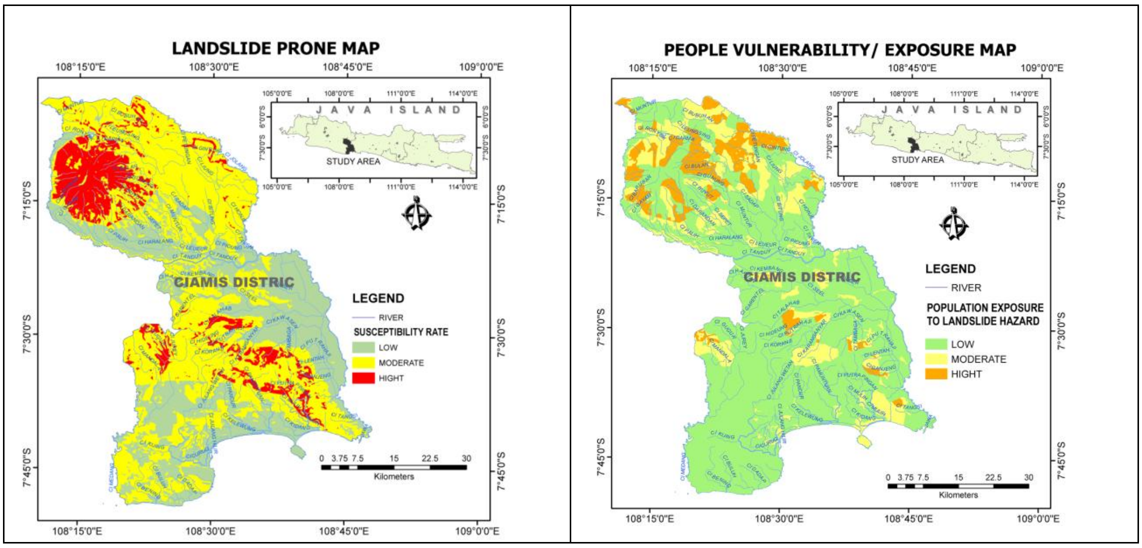
After the landslides hazard map is completed, then overlaid with maps of population density will result in population exposure maps.

In this PODES data there are at least four parameters that are used as benchmarks in determining community preparedness for natural disasters, namely:

	Parameter	Exist	Score
1.	availability of equipment used for overcoming disaster	yes	2
2.	whether or not the education of knowledge of disaster in the village	No	1
3.	whether or not the mutual support institutions in the village	yes	2
4.	presence or absence of an early warning system against hazards in the village	No	1
5.	and other, for example evacuation roads	yes	2

These parameters are then mapped into community capacity Map.

This data is integrated into village-based spatial data, then the total score for each village are classified into three levels ranging from low capacity, medium capacity, and high capacity. For The Risk map the formula (1) is applied, and the result is as Fig 4. below:



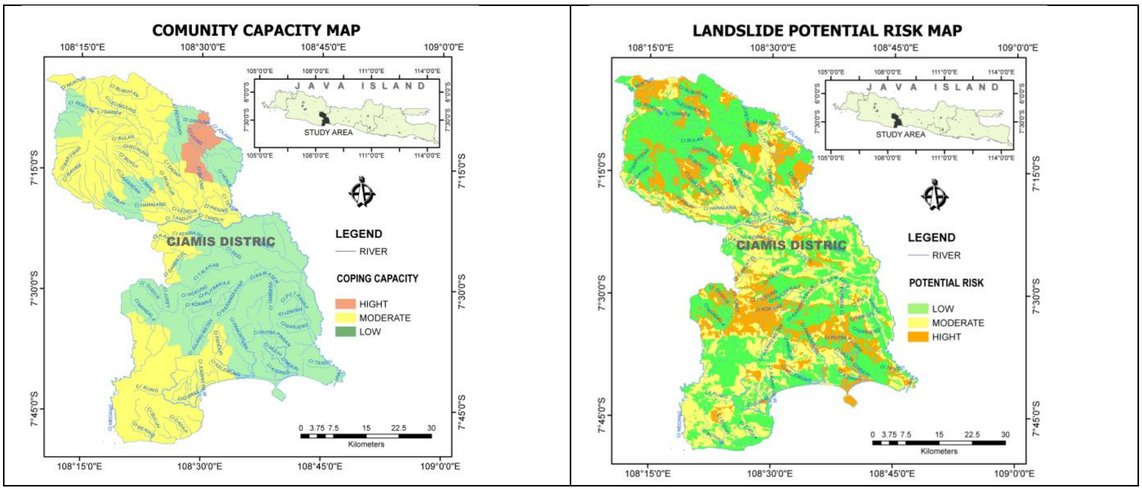


Figure 4. Map of Landslide prone, Map of Population Exposure, Map of Community Capacity, and Map of Potential Risk of Landslide.

4. RESULT AND DISCUSSION.

Main result of this study is Landslide Potential Risk Map, and the spatial data as an input to produce this map. Despite the damage and loss are not addressed in this study, but the population density is usually associated also with the density of settlement. Thus the expected estimated potential risks also include the risks to property or loss of material and people's livelihoods in affected areas of landslides. After calculating the area of each region of the three categories of potential risk, obtains the following data: areas with a low risk category by 43%, with a moderate risk area by 36% and, in areas with high risikio by 21%. Thus 114 of the 375 villages located in a landslide hazard area, and 79 of them are in villages areas with high risk.

References

Helmy H C and Wahyudi M Z, Regiaonal Kompas.com, **Berbagai Bencana Alam Masih Menanti**, http://regional.kompas.com/read/2011/01/03/

Gema BNPB - March 2011, **5 Great Disaster In Indonesia**, National Disaster Management Agency .

Jianping Yan, Disaster Risk Asseeement: **Disaster Risk Modeling**, Global Risk Indentification Programme, UNDP Bureau for Crisis Prevention and Recovery, www.griweb.org

Joern Birkmann, 2007, **Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implications**, United Nations University, Institute for Environment and Human Security (UNU-EHS), UN Campus, Hermann-Ehlers-Street, 10, 53113 Bonn, Germany

Law Of The Republic Of Indonesia Number 24 Of 2007 **Concerning Disaster Management**

National Disaster Management Agency (BNPB), Regulation Of The Head Of The National Disaster Management, Number 02 In 2012, **On The General Guidelines For Disaster Risk Assessment**

Regulation of the Head of the Indonesian Agency for Meteorological, Climatological and Geophysics No.009 of 2010 on **the implementation of standard operating procedures early warning**

Selby, M J, 1985, **Earth's Cahanging Surface an Introduction to Geomorphology**, Clarendon Press, Oxford.

Samaddar, S. and Okada, N., 2007. **The Process of Community's Coping Capacity Development in the Sumida Ward**, Tokyo – A Case Study of Rainfall Harvesting Movement. *Annuals of Disas*. 50(B):2007

Suriadi, A B M A, 2012, **Identification Of Potential Landslide Risk Through Remote Sensing Techniques And GIS In Cianjur District West Java**, Geomatics Research Division, National Coodinating Agency For Surveys and Mapping, Indonesia.