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Mitigation Of Area Prone To Landslide In Anticipating The Impact Of Climate Change

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Abstract: Climate change is felt very influential in the wet tropics as in Indonesia. The impacts of climate change that felt much were floods and landslides during the rainy season and drought during the dry season. The occurrence of landslides in mountain slopes is mostly caused by soil, topography, geology, hydrology and climate. The purpose of the study is to determine the areas prone to landslides in the Samin River Basin area on the western slopes of Lawu mountain, and management efforts through mitigation areas prone to landslides in order to anticipate the impacts of climate change. The research method is overlapping topography map, land map, land use map, climate map, geological map and earth map as base map. Besides, field survey was conducted to observe the morphology of soil landslide events and in-depth interviews. The results showed that the research area of 6,797.06 ha consisted of very prone to landslides (73.64%), prone to landslide 26.25%, and slightly prone to landslide 0.11%. The most influential factors in the landslide are topography, rainfall and land cover. Landslide type that occurs mostly is slump landslide, followed by rockfall and landslide. Soil sensitive type of landslide are Andosol and Latosol. Land use that is very prone to landslides is the land tha are used for vegetable cultivation and land conversion functions for road construction. Management efforts to mitigate landslides among others are landslide reforestation potential landslides, and land use systems with an intercropping system of annual crops with agro forestry on cultivated land.

Keywords: Mitigation, landslide, climate.

1. Introduction

Most of the landslides in Indonesia occurs after heavy rains or long rains including at the district of Karanganyar (Central Java) and its surroundings have suffered severe landslides in late December 2007 and even until April 2017 together with other regions in Indonesia (Purworejo, Banjarnegara, Magelang, Yogyakarta, Bandung, Kediri, Lumajang, Lombok, Aceh, North Sumatera, Bengkulu, West Sumatera, Sulawesi, Maluku, Bali, Banten, Lampung, Jambi, West Kalimantan) some are still underway.

The hazard of landslides (mass movement) often occur in steep slopes. Landslides are slope-forming materials such as rocks, rags, moving soil from the upper slopes sliding downward. In principle a landslide occurs if the driving force on the upper slope is greater than the retaining force. The driving force is affected by the high rainfall intensity, the slope slope, the load and the impermeable layer, the thickness of the soil solum, and the soil type of soil. In the case of the retaining force is generally affected by soil shear resistance, density and strength of plant roots and rock strength (Sidle & Dhakal, 2003).

When the rainy season comes there is an increase in the amount of infiltration water that affects the saturated soil, the soil pore is easily destroyed and soil aggregation becomes very weak so that the shear resistance decreases. Besides that, the water saturated condition resulted in increasing the burden of the soil will eventually trigger the landslide from higher to lower ground and haul the objects and all the plants it passes and even bury the whole village and its inhabitants (Abe & Ziemer, 1991). Changes caused by landslides can have a negative impact both on the site of the disaster and on the landslide sites deposited. To change the soil physical properties due to landslide is indicated by the destruction of the soil structure, infiltration rate and the ability of the soil to retain the reduced water as well as the fragmented land and reduce the area of cultivated land (Pustekkom, 2005).

In relation to the above matters, land management efforts are needed to reduce soil damage and able to restore or increase the productivity of the land by mitigation. Therefore, the definition of mitigation here is very important, since mitigation is a series of efforts to reduce disaster risk, both structurally with physical and non-structural development such as awareness and capacity building of society in facing the threat of danger (Priyono, Kharis & Martana, 2011). Therefore, it is necessary to investigate and mitigate landslides in order to anticipate climate change impact in Samin Sub-Basin, Karanganyar Regency, Central Java. This study aims to determine the areas that are prone to landslides, dominant types and factors leading to landslide and landslide mitigation efforts in anticipating the impact of non-structural climate change.

2. Research Methods

The research steps include 3 steps (pre-field, field, and advance) that are interconnected and complementary. Pre-field includes: Literature studies, data collection from relevant agencies such as rainfall data, administrative data, slope maps, village administration maps, soil type maps, river maps, land use maps, and geological maps continue analysis, map interpretation and overlay by system GIS at Pusdatt Yogyakarta. Fields include; Survey, observation, soil description, and soil sampling. Advance includes: Laboratory analysis, implementation and testing of mitigation models and drawing conclusions / recommendations.

Research place around landslide-prone lands along Samin Sub-watershed in Karanganyar Regency (represented by 5 districts prone to landslide: Jatiyoso, Tawangmangu, Matesih, Karangpandan, Jumantono). January 15, 2017 to December 15, 2017). Processing & analyzing of data is done in Pusdatt Yogyakarta, learning Room, and Laboratory of Agriculture Faculty of Sebelas Maret University (UNS) Surakarta & Faculty of Agriculture Slamet Riyadi University (UNISRI) Surakarta. Equipment: Hardware and Software. Hardware (computer, flash, scope, meter, camera, clinometer, pnetrometer, altimeter,, calculator, drill, plastic, compass and knife); Software (Arc View 3.3 GIS, SPSS). Materials: digital maps (1: 40,000 scale slopes map, 1: 40,000 scale land map scale :, river map, land use map scale 1: 40,000, geologiskal map 1: 40.000, bulk hujanskala map 1: 40.000), and regional maps (Regency, Village) that is prone to landslide.

3. Results And Discussion

Survey, mapping, morphological description, laboratory analysis, and modeling of mitigation were conducted in areas prone to landslides (table 1- 8). Furthermore, the results that are presented Analysis Morphology / Geomorphology Landslide Place consists of tables 1 - 5 about the condition / characteristics of the prone to landslide of the area in the study sites and tables 6 - 8 on landslide mitigation efforts in anticipating climate change.

Description Morphology / Geomorphology Landslides are listed in Table 1 - 5 on the condition / characteristic of the vulnerability of the area to the landslide.

3.1 Tawangmangu Sub-district.

The Tawangmangu sub-district (table 1) is particularly prone to landslides, as there are many factors that drive and trigger such events as 18 - 40% slopes, andesite rocks, intensive use and intensive gardening and soil excavation without regarding to conservation rules, small roots, geluh pasiran textures, and crumb land structures until globs rounded the type of landslide is a strong slump and subsidence.

Table 1: Morphology / Geomorphology of Village Example from Tawangmangu Sub District

No	Atribut	Blumbang Village	Guyon Tengklik Village
1	Coordinates	517485; 9152965	513413; 9153867
2	Altitude	1425 m asl (above sea level)	985 m asl (above sea level)
3	Slopes	18%	40%
4	Land use	Vegetable gardens, new roads	Moor. vegetable gardens.
5	Litology	Andesit	Andesit
6	Surface rock	0%	2%
7	Water depth	Shallow (origin of River Samin)	<2 m (shallow)
8	Type of landslide	Strong Slump	Subsidence and Strong Slump .
9	Soil color	Dark brown	Dark brown
10	Soil texture	Silty loam	Clayey loam
11	Structure	Crumbs, Sub Angular blocky	Angular blocky
12	Rooting	Micro	Micro-Medium
13	Level of vulnerability	Very vulnerable	Very vulnerable

3.2 Karangpandan Sub-district.

The Karangpandan sub-district (table 2) is particularly prone to landslides, as several factors contribute to the incidence of such slopes such as 12-35% slopes, napal and andesitic rocks, mixed use of mixed-use zones, soil excavation irrespective of conservation rules, small roots, glue clay, crumble ground structure until rounded lump, type of landslide is slump.

Table 2: Morphology / Geomorphology of Village Example from Karangpandan Sub District

No	Atribut	Gerdu Village	Salam Village
1	Coordinates	508789; 9157351	511466; 9155587
2	Altitude	750 m asl (above sea level)	780 m asl (above sea level)
3	Slopes	12%	35%
4	Land use	Moor	Garden
5	Litology	Napal	Andesit
6	Surface rock	1%	1%
7	Water depth	2 – 3 m (medium)	2– 3 m (medium)
8	Type of landslide	Strong Slump	Strong Slump
9	Soil color	Dark brown	Dark brown
10	Soil texture	Clayey loam	Clayey loam
11	Structure	Sub Angular blocky	Crumbs , Angular Blocky
12	Rooting	Micro	Micro-medium
13	Level of vulnerability	Very vulnerable	Very vulnerable

3.3 Matesih Sub-district.

The Matesih sub-district (table 3) is prone to landslide, as several factors contribute to the incidence of 10-15% slopes, napal and andesitic rocks, intensive use of moor irrespective of conservation rules, minimal rooting and crumble ground structures until globs are rounded, the type of slide is slump.

Table 3: Morphology / Geomorphology of Village Example from Matesih Sub District

No	Atribut	Girilayu Village	Ngadiluwih Village
1	Coordinates	508053; 9154275	506755; 9154254
2	Altitude	598 m asl (above sea level)	520 m asl (above sea level)
3	Slopes	10%	15%
4	Land use	Settlement	Moor, Garden
5	Litology	Napal	Andesit
6	Surface rock	0%	0-2%
7	Water depth	2-3 m (medium)	<2 m (shallow)
8	Type of landslide	Slump	Small slump (small glide)
9	Soil color	Dark brown	Dark brown
10	Soil texture	Sandy loam	Sandy loam
11	Structure	Crumbs	Sub Angular blocky
12	Rooting	Micro	Micro-medium
13	Level of vulnerability	vulnerable	Somewhat vulnerable

3.4 Jatiyoso Sub-district

Jatiyoso sub-district (table 4) is prone to landslide, since there are several drivers and triggers such as 24-30% slopes, andesite rocks, intensive intensive use and unsuitable soil excavations, small to moderate roots, type of landslide is strong Slump.

Table 4: Morphology / Geomorphology of Village Example from Jatiyoso Sub District

No	Atribut	Banaran Wukirsawit Village	Karangsari Village
1	Coordinates	506677;9152515	509508; 9149896
2	Altitude	574 m asl (above sea level)	650 m asl (above sea level)
3	Slopes	5%	24%
4	Land use	Settlement	Moor
5	Litology	Andesit	Andesit
6	Surface rock	2%	1%

7	Water depth	<2 m (shallow)	>2 m (deep)
8	Type of landslide	Strong slump	Slump
9	Soil color	Dark brown	Brown
10	Soil texture	Clay	Clayey loam
11	Structure	Angular blocky	Angular blocky
12	Rooting	Micro	Micro-medium
13	Level of vulnerability	Very vulnerable	Vulnerable

3.5 Jumantono Sub-district.

Jumantono sub-district (table 5) is prone to landslide because there are many factors.

Table 5: Morphology / Geomorphology of Village Example from Jumantono Sub District

No	Atribut	Tunggulrejo Village	Gemantar Village
1	Coordinates	506677; 9152515	506002; 9151060
2	Altitude	574 m asl (above sea level)	486 m asl (above sea level)
3	Slopes	5%	10%
4	Land use	Settlement	Moor
5	Litology	Andesit	Andesit
6	Surface rock	0%	2%
7	Water depth	<2 m (shallow)	<2 m (shallow)
8	Type of landslide	Slump	Slump
9	Soil color	Dark brown	Brown
10	Soil texture	Clay	Clayey loam
11	Structure	Crumbs	Crumbs
12	Rooting	Small Micro Root	Micro-medium
13	Level of vulnerability	Vulnerable	Somewhat Vulnerable

That encourage and trigger the incident such as 5-10% slope, andesite rocks, land use moor and soil excavation less attention to conservation rules, moderate to medium rooting, texture to cling to clay and to crumble ground structure, the type of landslide that ever happened was slump.

4. Discussion Of Local Prone Characteristics To Landslides

4.1 Description Morphology / Geomorphology of point Landslide Occurrence

First. Survey results and laboratory analysis. From the results of the survey and the laboratory analysis showed that Tawangmangu and Karangpandan sub-districts are the most prone to landslide compared to other sub-districts (Matesih, Jatiyoso and Jumantono sub-districts). This is due to a combination of highly influential factors, the highest level of slope and very intensive land ignorance aspects to the use of land conservation. Besides that, especialy in Tawangmangu subdistrict, there is uniqueness, that is source of origin of Samin river in Blumbang Village, and also existence of landslide slides at high altitude area in Guyon Tengklik village, this can be a big part to strengthen the occurrence of high landslide. While Jatiyoso sub-district is more prone to landslides than Matesih, and Jumantono sub-districts, this is due to a combination of highly influential factors, higher slope and more intensive land use ignoring land conservation aspects.

Hardiyatmo (2006) and Priyono (2015) stated that there are many factors causing the landslide: (1) topography, (2) climate, (3) weather changes, (4) geological and hydrological conditions, (5) human act, all of which can work together or only a few factors (not entirely) can affect the stability of the slope, which results in the event of a landslide. The following are clearly the trigger of landslides: a) Human factors include: (1) the increasing of load on the slope, it can be the establishment of many buildings, bad drainage (additional load by water into the pores of the soil or, (2) the excavation or cutting of soil on the slope foot, (3) soil excavation which resulted in sharpening the slope, (4) the rapid water palm on the dam, river, drainage facilities / infrastructure that has not been good and others, (5) land use that is incompatible with its capacity (clearing of forests / cultivation, transfer of agricultural land status to non-agricultural land uncontrolled), and (6). In fact, according to Rathna (2008) triggered by the existence of government institutions and the unstable society, b) natural factors, among others: (1) the addition of dynamic loads by wind-blown plants and others, (2) lateral rise of pressure by water / heavy rain (water that fills the cracks will push the ground towards the lateral), (3) decrease of slope soil shear resistance by resultant rise in moisture content, increase in pore water pressure, seepage pressure by waterlogging in soil, which is easy to inflate and shrink as well as some white color, (4) the vibration / earthquake, (5) even triggered from the effects of global warming.

Priyono (2013) states that there are two factors that accelerate the occurrence of landslides, namely internal factors and external factors. Internal factors that cause the occurrence of landslide is from the weak (soil cohesion) of soil / rock so that the grains of soil / rock can be detached from its bond and move down by dragging other grains around it to form larger mass. The weakness of soil / rock bond can be caused by the nature of porosity and water permeability of the soil / rock and the intensive fracture of the soil / rock. While external factors that can accelerate and become a trigger soil landslide can consist of various complex factors such as steep slope, soil moisture changes / rocks due to the entry of rain water, land cover and the pattern of land treatment, erosion by water flowing (surface water), act humans such as excavation, soil processing and so forth.

Second, Determination of landslide type. In the research can be determined kind / type of slump, rockfall, landslide, and subsidence slide. Slump (landslide rotational) is a landslide with a curved avalanche field, because it is a rotation of ground material movement in the concave field. In the concave areas affected by avalanches can be very dangerous especially if there are settlements that are above it, because it is prone to buried and can lead to casualties. Rockfall (avalanche stone collapse) is a condition where there is a collapse of stone directly and also free fall from top to bottom. This can happen on steep hills and has steep slopes. Conditions like this become very dangerous when it occurs on the coastal cliffs beneath which there is a community settlement, because the falling material can be a large rock that can cause damage to objects underneath. Landslide (Landslide translation) is type of landslides that occurs on soil that has a flat topography or rippling shape. Landslide this one proves on a flat ground can also experience landslides. Besides that there is a dangerous landslides (called rombakan / debris avalanche / debris landslide). Ambles (Subsidence) is caused by geological and hydrological conditions in the soil ie light ground with a cavity in the soil; which is supported by: a) inadequate land use such as for vegetable crops, b) burden on the surface of the earth is quite heavy such as the establishment of housing and settlement, consequently when the rainy season is very easy to cause landslide. According to AGS (2007) and Priyono (2015), there are 12 types of movement, namely landslide rotational / landslide of arch / lorotan / slide / rotation landslide / soil slump, block slide / soil slide movement, , translational landslide / soil slide, lateral spread, debris avalanche / lanslide, rockfall, ground creep (creep), collapsed material ruins topples, earthflows, debris flow, subsidence, complex slides etc. On the other hand Bappenas (2013), and Priyono (2015) classify the types landslides based on the rate of speed, high-speed landslides of fall, landslide and topples, while slow-moving landslides are creep, even BGS (2011) and Priyono (2015) landslides carrying deposits and or bedrocks may cause water blockage (reduction of permeation) and trend to damage soil form.

4.2 Determination Of Landslide Prone And Landslide Mitigation

Based on the results of the identification of vulnerability in vulnerable areas (vulnerable / affected) landslides and biophysical factors that affect the level of vulnerability of the area continue to continue the determination of mitigation efforts and such as table 6 - 8 below.

First, level of Landslide Occurrences. To determine the level of prone to landslide it is required data / information about the characteristics of land biophysical factors that influence and extent of prone to landslide. Each of the biophysical factors and their characteristics are presented in table 6 with figure 1and table 7 with figure 2.

Table 6: Rainfall connection with other biophysical factors against avalance resistance in sub-district Karanganyar 2018 – 2020

Sub-Districts & Village	High Place (MDPL)	Rainfall (000 mm/yrs) 2018-2020 (BMKG)	Slope (%)	Type of Soil	Land Use	Lithology	Insecurity
1. Tawangmangu							
a. Blumbang	1425	>3	18	Andisol	Vegetable garden, road new	Andesit	Very vurnerable
b. G. Tengklik	985	>3	40	Latosol	Moor, Vegetable garden	Andesit	Very vurnerable
2. Karang pandan							
a. Salam	780	2.5 - 3	35	Latosol	Moor	Andesit	Very vurnerable
b. Gerdu	750	2.5 - 3	12	Latosol	Garden	Andesit	Very vurnerable
3. Matesih							
a. Girilayu	598	2.5 – 3	10	Latosol	Pemukiman	Andesit	Vurnerable
b. Ngadiluwih	520	2.5	15	Latosol	Garden	Andesit	Somewhat Vurnerable
4. Jatiyoso							
a. Banaran	650	3	30	Latosol	Moor	Andesit	Very vurnerable
b. Karangsari	650	3	24	Latosol	Moor	Andesit	Vurnerable
5. Jumantono							
a. Tunggulrejo	574	<2	5	Latosol	Pemukiman	Andesit	Vurnerable
b. Gemantar	486	<2	10	Latosol	Moor	Andesit	Somewhat vurnerable

Sources: Results analysis

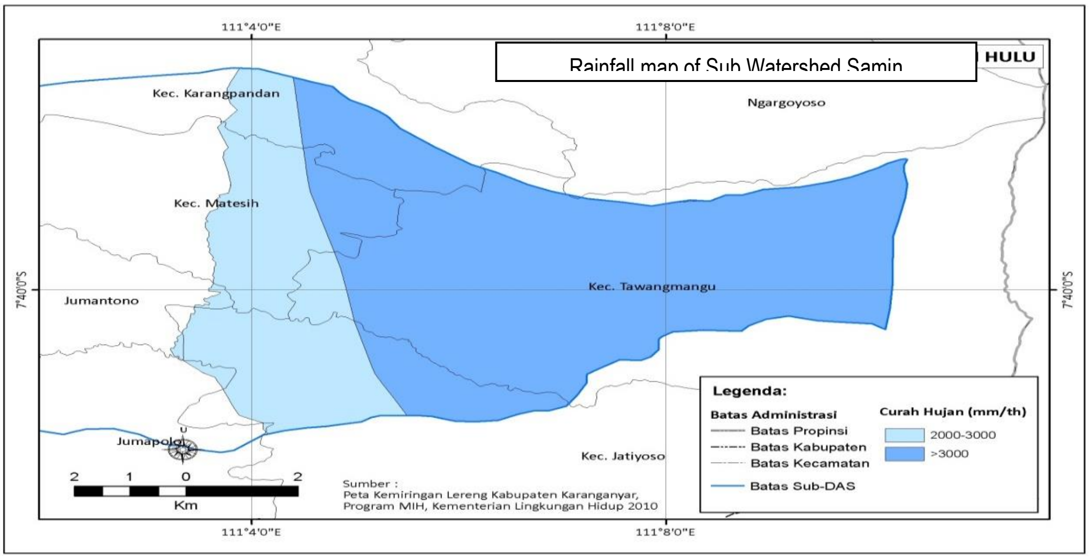

Fig. 1: Rainfall map of Sub Watershed Samin

Furthermore, the prone of landslide area in Sub watershed Samin is classified based on area, percentage, and frequency of occurrence, so that from wide the area of research 6,796.06 ha which is classified as: 1) very prone to landslide has an area of 5,005.35 ha (73.64%); and 25 times the landslide; 2) landslide prone areas have 1,784.23 ha (26.25%); and 18 landslide events; 3) a less prone to landslides have an area of 7.48 ha (0.11%); and no landslide events such as table 7 with figure 2.

Table 7: Relation of Landslide Prone Areas and Frequency of Landslide Occurrence of Samin River Basin

Level of vulnerability	Area (ha)	Percentage (%)	Frequency of occurrence
Very vulnerable	5,005.35	73.64	25
Vulnerable	1,784.23	26.25	17
Somewhat vulnerable	7.48	0.11	1
Sum	6,797.06	100,00	43

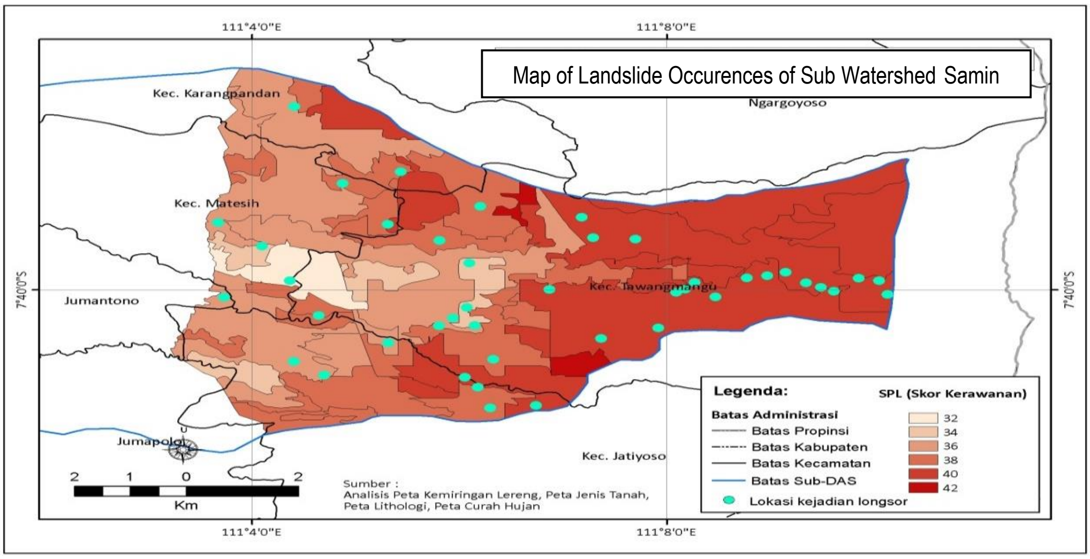

Fig. 2: Map of Landslide Occurences of Sub Watershed Samin

Geoscience Australia (2011) suggests that the characteristics of factors that influence the vulnerability or prone to landslides can be observed from physical characteristics (biophysical) and social (socioeconomic) conditions. Furthermore, in BPS Karanganyar (2018-2020), biophysical factors include geological, biological, hydrological, climatological, geographic, and technological, while the socio-economic conditions of society include social, cultural, political and economic conditions.The description includes: 1) biophysical form of soil quality, water quality, thick of solum, land use, biodiversity, geology (rock), climate, soil fertility, soil loss, water flow, soil type, slope, conservation land and others; 2) the socio-economic conditions of villagers / farmers (number of families, age, sex, income, agriculture, consumption, land ownership), utilization of support services (credit, information, technology), management practices (decision making) institution (organization and level of participation), education, health, market, local wisdom, social services and others (Birkmann & Wisner, 2006; Ebert, Kerle & Stein, 2007; Preuth, Glade & Demoulin, 2010; Budiasa, 2011; BP DAS Citarum, 2013).

The indicator of landslide prone can be seen from the following factors: rainfall, slope, land use, geology, fault / fracture / sliding / slickenside, soil depth, infrastructure and density (Paiman, Sukresno & Pramono, 2009). Furthermore, the results of this identification can be prepared (synthesis) to something important concerning: 1) level of prone of lands to landslide; 2) the level of landslide threats to human settlements; 3) the responsibility to the one who are in charge against land use in landslide prone areas; 4) proposed appropriate control activities (models) on landslides. Variation in the level of prone of a landslide prone area consists of 3 levels (National Council on Climate Change, 2011), namely: 1) high prone to landslides zones are high-potential areas to experience movement and density of their settlements, or there is very expensive or important building construction. This area often experiences ground motion (landslide) especially during the rainy season or earthquake; 2) medium prone to landslides zones are high-potential areas for underground movement, but there are not any residential and threatened building construction; 3) low prone to landslides areas are high-potential areas for land movement, but there are not any risk of human / building casualties (including areas with less prone to landslide potential, but expensive residential / building construction). So the calculation of the prone to landslide can be measured from the sum of the value of factor (weight and score) that affect the landslide, the results are, very high, high, medium, low, very low (Juventine, 2012). Then from the level of prone to landslide can be made the mitigation model.

Karnawati (2005) and National Council on Climate Change (2011) assert that the characteristics of landslide prone areas are: 1) high rainfall level, 2) steeper than 20 ° (> 40%), 3) slope area in the river arch, 4) bend area slope (transition area between steep slopes and sloping slopes).

Second, Mitigation toward Landslide. The result of mitigation conducted by the society around the landslide prone areas, presented table 8 with picture 3.

Table 8: Mitigation efforts of landslides by communities in landslide prone areas

District, Village and level of vulnerability	Respondents (people)	Mitigation Measures	Mitigation Tool
1. Tawangmangu a. Blumbang Very vulnerable	9	Sweep, Hoe, Cres cent, Kentongan (Javaness tools made by woods can be used to patrol)	Meting system is low. Temporary grass cleaning, repair and cultivation of conservation crops are almost non-existent, only directly planting vegetables and intercropping, agroforestry
b.Guyon Tengklik Very vulnerable	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is good. Temporary grass cleaning, repair and cultivation of conservation crops are almost non-existent, only directly planting vegetables and intercropping, agroforestry
2. Karangpandan a. Salam Very vulnerable	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is good Temporary grass cleaning, repair and cultivation of conservation crops are almost non-existent, only directly planting vegetables and intercropping, agroforestry
b.Gerdu Very vulnerable	11	Sweep, Hoe, Cres cent, Kentongan	Meting system is very good Regular grass cleansing, improvement and cultivation of good conservation crops, vegetable cultivation, intercropping, agroforestry and well-coordinated
3.Matesih a. Girilayu Vulnerable	11	Sweep, Hoe, Cres cent, Kentongan	Meting system is very good Regular grass cleansing, improvement and cultivation of good conservation crops, vegetable and intercropping cultivation, well coordinated agroforestry
b.Ngadiluwih Somewhat vulnerable	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is very good Regular grass cleansing, improvement and cultivation of good conservation crops, vegetable cultivation and intercropping are well coordinated
4.Jatiyoso a. Banaran Wukirsawit	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is not so good. Regular Temporary grass cleaning, conservation planting and cultivation are rare, only direct vegetable and intercropping cultivation, less coordination agroforestry

Very vulnerable b.Karangsari Vulnerable	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is not so good Temporary grass cleaning, conservation planting and cultivation are rare, only direct vegetable cultivation and intercropping, less coordination agroforestry.
5. Jumantono a. Tunggulrejo vulnerable	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is not so good Temporary grass cleaning, conservation planting and cultivation are rare, only direct vegetable and intercropping cultivation, less coordination agroforestry
b.Gemantar Somewhat vulnerable	10	Sweep, Hoe, Cres cent, Kentongan	Meting system is not so good Temporary grass cleaning, conservation planting and cultivation are rare, only direct vegetable and intercropping cultivation, less coordination agroforestry.

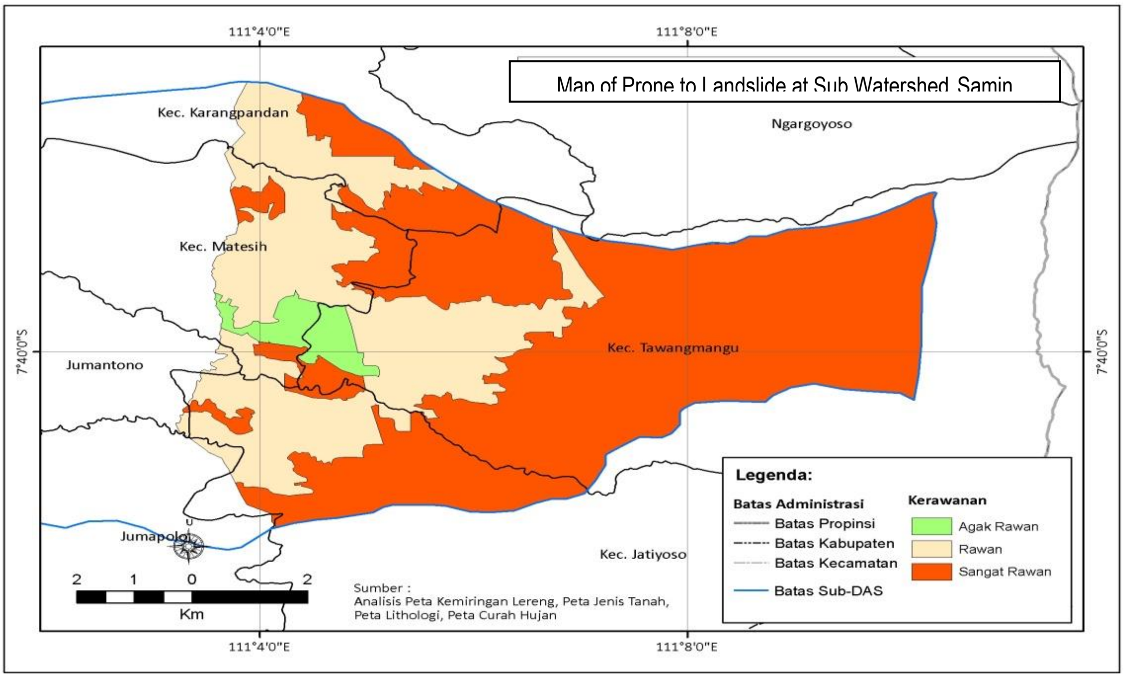

Fig. 3: Map of Prone to Landslide at Sub Watershed Samin

4.3 The discussion mitigation on landslide prone areas. in anticipating the impacts of climate change

Mitigation carried out in this research is non structural mitigation that can be used as one of the source to improve understanding and ability of the parties in controlling area prone to landslide. It is intended that the society and the parties can early identify areas prone to landslides, having preventive actions, reduce possible losses due to disasters, and prepare for emergency response, in accordance with their respective functions and roles, among others, temporary, conservation planting and replanting are rare, vegetable and intercropping cultivation, agroforestry, lack of coordination. While the tool used is Sweep, Hoe, Sabit (bended sword used to cut grass by farmers for feeding their cows, Kentongan (a tool of communication made of wood). According Karnawati (2007) non-structural mitigation actions that need to be done for landslide mitigation include identification of disaster prone areas, control techniques and early warning techniques (with kentongan as an alarm).

Furthermore, Karnawati (2007) stated that all of these actions are not possible to be unilateral from top down or bottom up, but an integrated action from above and from below. Thus, the awareness of people in disaster prone areas is needed and society empowerment in the mitigation of natural disasters must always be done in real time.

The frequent landslide occurences in Karanganyar District (Sub Das Samin) indicate that they are a combination process (multi-process) of biophysical factors (table 6), especially climate factors (> 3000 mm / year), slopes (> 30%) and land use (seasonal / vegetable crops on sloped land and conversion of forest land into open land for production crops and new road construction), continues to be supported by other factors such as andesite lithology (which plays an important role in forming Andosol and Latosol soils) prone to soil movement, so that the two factors (lithology and soil type) mutually support the prone to landslides in Karanganyar District. This can be shown (table 7) if the total area of research 6,797.06 ha, can be obtained that each region is very prone to landslides 5,005.35 ha (73.64%); prone to landslide 1.784.23 ha (26.25%); and some prone to landslide 7.84 ha (0.11%). As a consequence of sudden and unpredictable climate change with great intensity (long and dense rain, and long drought and high temperature) has caused landslides in Samin Sub-District of Karanganyar Regency. Technically generally mitigation can be grouped into structural mitigation and non structural mitigation. Structural mitigation relates to physical construction efforts, while non-structural mitigation includes land-use planning in accordance with the prone of its territory and enforcement of development laws. The identification of prone is sorted between identification of landslide-prone and potential / potential areas. It is important to facilitate the systematic way of identifying disaster sources in order to obtain effective and efficient control techniques.

Through the identification above, it can be analyzed the causal connection of landslide occurences in the region. According to Paiman, Sukresno & Pramono (2009) and Paiman, Sukresno & Purwanto (2010), identification of landslide-prone areas is done systematically. Based on identification results obtained synthesis as follows: 1) The level of prone/ prone of lands to landslides; 2) The level of landslide threats to residents / settlements and the blockage of the riverbed; 3) Land use in areas prone to landslide disaster, related to the responsibility of who is in charged; and 4) Proposed appropriate landslide control activities.

Control techniques (technical mitigation) landslide consists of vegetative methods and civil engineering, among others: 1) Areas that are not prone to landslides can be done with routine lawn cleansing, channel / talud improvement and good conservation planting, vegetation planting with multiple cropping (intercropping, interculture, interplanting, mix cropping, alley cropping, intercropping, cropping, forest / agroforestry, and surjan system as a typical model of cropping pattern originated from Central Java), and reforestation of tree crops to strengthen, especially the environment / region itself; 2) Areas prone to landslide prone areas can be done by reforestation (reforestation / reforestation / reforestation to safeguard the protected areas and surrounding areas as a conservation effort of the wider nature / environment). As mentioned in table 8, this activity (mitigation) of course always requires good coordination, so that with good management by the community, such as Gerdu Karangpandan, Ngadiluwih Matesih and Girilayu Matesih villages, compared to seven other villages, landslide disaster that will come easier and faster handled (controlled). According to Paiman, Sukresno & Pramono (2009) and Paiman, Sukresno & Purwanto (2010), the direction of landslide control techniques should be differentiated for different levels of landslide and land use. Mitigation actions of landslides should be more careful if in the same place also degraded due to surface erosion. Thus, the landslide control approach should be different from the control of surface erosion, even in contrast.

5. Conclusion

Based on the results of the research analysis shows that the area of Sub Watershed Samin especially part of Karanganyar Regency is very prone to landslides, so it is not feasible for agricultural land and human settlements, considering from the area of 6,797.06 ha, each area is very prone to landslides 5,005.35 ha (73.64 %); prone to landslide 1.784.23 ha (26.25%); and some prone to landslides 7.48 ha (0.11%). The most influential factor in the successive landslide is topography, rainfall and land cover. Landslide type that occurs mostly are in the form of slump, followed by the form of rockfall and landslide. Soil sensitive type of landslides are Andosol and Latosol. The use of the land that are prone to landslide are cultivation vegetables and land conversion for road construction. Nevertheless, if still insisting to cultivate for agriculture, it can utilize area of width 7,48 ha (0,11%), but the society must pay attention to the aspect of environmental sustainability (mitigation accompanied by soil and water conservation activity). Mitigation efforts for landslide vulnerable through lands and water management are always well-controlled, among others, reforestry land which has landslide potensial, and land use systems with multiple cropping systems, such as mix cropping, alley cropping, strip cropping, surjan, and intercropping of annual crops with seasonal crops (agroforestry) on cultivated land.

References

Abe, K., & Ziemer, R. R. (1991). *Effect of tree roots on shallow-seated land slides. USDA forest* Service Gen. Tech. Rep. PSW-GT 130: 11-20.

AGS. (2007). *Practice Note Guidelines for Landslide Risk Management 2007: These schematics illustrate the major types of landslide movement*.

Bappenas. (2013). *Disaster-prone areas*. http://kawasan.bappenas.go.id/index. php?view=article & catid=34:su.

BGS. (2011). *Landslide assessment*. Natural Environment Research Council. Geo Reports. Mam Tor Derbyshire UK.

Birkmann , J., & Wisner, B. (2006). *Measuring the Unmeasurable The Challenge of Vulnerability*. Bonn: UNU EHS.

BMKG. (2018-2020). Prakiraan Musim Hujan di Indonesia tahun 2018-2020.Jkt Po Box.3540/Agt.2018-2020.

BP DAS Citarum-Ciliwung. (2013). *Laporan Penyusunan Urutan Prioritas DAS di BP DAS Citarum-Ciliwung. http: //www.bpdas ctw.info/file downloaden/ produk_Buku / Naskah-Urutan prioritas_DAS.pdf-windows internet exp*.

BPS Karanganyar. (2018-2020). Karanganyar Dalam Angka 2018-2020.BPS Karanganyar 2018-2020. ISSN:0215-6172.33130.13.01.

Budiasa, I. W. (2011). *Pertanian Berkelanjutan. Teori & Pemodelan*. Denpasar: Udayana University Press. Bali.

Ebert, A., Kerle, N., & Stein, A. (2009). *Urban Social Vulnerability Assesment with physical proxies and spatial metrics derived from air and spaceborne imagery and GIS data*. Natural Hazard (48). 275-294.

Geoscience Australia. (2011). *Hazard, risk and impact analysis. Australian Government*. http://www.ga.gov.au/hazards/risk-and-impact-analysis. html

Hardiyatmo, H. C. (2006). *Handling of Landslide and Erosion*. Ygy: Gama University Press.

Juventine, E. J. (2011). Landslide Hazard*: Household Vulnerability, Resilience and Coping in Bududa District, Eastern Uganda*. Submitted in partial fulfillment of the requirements for the degree Master in Disaster management in the Disaster managemen Training & Education Centre for Africa, At the Univ. of The Free State.

Karnawati, D. (2005). *Natural Disasters of the Movement of Land Mass in Indonesia and its Countermeasures*. Ygy: Jur. Geologi FT UGM.

National Council on Climate Change. (2011). *Vulnerability Mapping in Provinces and Policy Inventories and Institutions in the Framework of Anticipating Climate Change Impacts*. Executive Summary. Jakarta: Kementerian BUMN RI Lt.18.

Paiman, Sukresno., & Pramono, I. B. (2009). *Flood Mitigation Technique and Landslide Mitigation. Balitbang Kehutanan.Tropenbos International Program*. PO Box 494, Balikpapan 76100

Paiman, Sukresno., & Purwanto. (2010). *Rapid Degradation of SUB DAS. Balitbang Forrestly*. Bogor.

Pustekkom. (2005). *Penyebab Terjadinya Kerusakan Tanah dan Dampaknya terhadap Kehidupan*. http://www. edukasi. net/ modul online / MO 98/geo 107 20.htm

Preuth, T., Glade, T., & Demoulin, A. (2010). Geomorphology: .*Stability analysis of human-influenced landslide in eastern Belgium*. Landslide geomorphology in a changing environment. http://www. sciencedirect.com / science / article / pii / SO169555X09003882

Priyono, Kharis, T., & Martana. (2011). *Study on the Physical, Chemical, and Biological Properties of Vulnerable Agricultural Farms on the Western Slope of Mount Lawu Region of Karanganyar Regency, Central Java. Fundamental Lit DP2M Dikti Report. Surakarta: Unisri.*

Priyono. (2015). *Longasor classification relationship, Landslide Classification Classification and Classification of Soil Landslide Farm,* Gema Uniba Th. XXVII/49/Agustus 2014-Janauri 2015.

Rathna. (2008). *Management of Watershed Management Watershed in Efforts to Address Flood and Landslide Hazards. mhtml:file*://G: Pengelolaan%20DAS%20Perencanaan%20Pengelolaan%20D…

Sidle, R.C., & Dhakal, A.S. (2003). *Recent advances in the spatial and temporal modeling of shallow landslies*. http://www.mssanZ.org.au/MOD SIM03/Volume_02/A11/08_sidle.pdf.