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Research Article

Relationship between land degradation, biophysical and social factors in Lekso Watershed, East Java, Indonesia

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Abstract : Degraded lands are getting extensive worldwide. Even its existence has projected as a solution to fulfill agricultural land scarcity to meet the global demands of food and other agricultural goods, the rate of its extension should be inhibited. Some factors play important role. This research was aimed to find the explanation about how degraded land, biophysical and social factors are related. Research site was located in Lekso Watershed, East Java, Indonesia. Land degradation is assessed by evaluation of the critical land status based on procedure established by Indonesia's Ministry of Forestry in form of Regulation No. P.32/Menhut-II, 2009.A series of field survey using secondary data obtained from GIS tool performed to collect data for quantify the critical land status. Social factors in this study were limited on people perception, awareness and participation. These data collected by in-depth interview to the respondents. Site of presented respondent selected with purposive sampling, while the respondents in each site selected with stratified random sampling method. The research revealed that surface cover demonstrated high correlation and regression toward critical and very critical land (average r = -0.9822, R^2= 0.9648). However, slope steepness located in high altitude showed a contrary trend in which increasing slope steepness decreased the number of total moderate, critical and very critical lands. The functional area of this location as protected forest gave a good surface cover on the steep slope and resulted on small area of degraded land. On the other side, negative perception about cultivation on forest and steep slope resulted in positive correlations with the area of very critical land (r = 0.6710 for cultivated forest, and r = 0.9113 for cultivated steep slope). Moreover, people awareness about flood, landslide and drought gave a negative correlation (r = -0.6274) with critical and very critical area. At last, people participation on farmers' organization could not be used to elucidate the range of degraded land as the participation in this context did not include the competency building about soil and water conservation values.

Keywords: *awareness, land degradation, participation, perception, slope, surface cover*

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Introduction

Land degradation is a term representing a complex concept that integrates different aspects such as changes in soil condition, biodiversity, productivity and socio-economic implication, compared to a reference state (Andreade and Overbeck, 2015). Land degradations can be recognized in form of soil erosion, alkalinization, salinization, water lodging, soil pollution, and desertification (Asthana and Asthana, 2006).As a part of land, soil has become subject of a series of degradation and threats (Panagos et al., 2017). In tropical countries, soil erosion caused by rain from water is the biggest threat for soil degradation. Briones (2010) revealed that soil erosion is the most important cause of land degradation that relates to many aspects include both economic and policy sectors. Babaev et al. (2015) found that land degradation induces the change of soil bulk density and porosity, both decreases humus and nutrient content. Furthermore, soil degradation has been proven on decreasing land productivity. Sharda et al. (2010) found that soil degradation especially caused by erosion and runoff brings impact on production loss for major cereal, oilseed and pulse crop cultivated. On the other side, land degradation reported linked to specific loss of environmental services, elicited by a process called landscape transformation (Smiraglia et al., 2016).

The high influence of land degradation on crop productivity and other economic results is unfortunately supported by the extensive area of degraded land worldwide. Stavi and Lal (2015) reported that degraded lands are covering approximately 23% of the globe's terrestrial area, increasing at an annual rate of 5 – 10 million ha, and affecting about 1.5 billion people globally. This condition becomes a special challenge because of the dependency of human to fulfill their food demand from this type of land, as Gibbs and Salmon (2015) stated that degraded lands have often been suggest as a solution to issues of land scarcity and an ideal way to meet mounting global demands for agricultural goods.

Due to the important role of terrestrial area to sufficient food demand, and to the increasing rate of land degradation, it is important to see the factors affecting land degradation. It expects to be easier to find the solution or improvement of degraded land by recognizing the causative factors. Gao and Liu (2010) found that land cover change by deforestation, over cultivation and grazing, and excessive reclamation of grassland for farming were the factors worsened land degradation. Additionally, high steep slope and magnitude of rainstorm contributes to high sediment and runoff yields, as a process of soil erosion leads to land degradation (Inbar and Zgaier, 2016). However, land degradation can be accelerated by human activities that are represented from their social and economic conditions. Kumar Shit et al. (2015) revealed that farmer education, number of economically active household members, farming experience, and age are positively responsible to soil erosion and soil water conservation. Additionally, farmers' perception has a significant relation to the farmer's incentives and willingness to adopt terraces as soil conservation measure (Hammad and Borresen, 2006). Perception is defined as a set of internal sensational cognitive processes of the brain at the subconscious cognitive function layer that detects, relates, interprets, and searches internal cognitive information in the mind (Wang, 2007). Willingness and desire of the farmers in question are forms of emotion as Wang et al. (2006) stated that emotion is a part of cognitive process at the perception layers (emotion, motivation and attitude) of LRMB (Layered Reference Model of the Brain).Furthermore, Weiner (1980) revealed that emotional reactions provide the motor and direction for behavior. We can notice from those facts that perception and other social economic conditions of people play a significant role to determine the successful of soil-water conservation program. Hammad and Borresen (2006) pointed out that land degradation is a problem faced by many developing countries. Indonesia is becoming one of the countries dealing with the same problem. Degraded land in Indonesia reached 24.3 million ha in 2013 and was mainly caused by inappropriate land use, no soil and water conservation applied in such areas that entailed to severe erosion, sedimentation and degradation of water condition in term of its quality and quantity (UNCCD & Indonesia's Ministry of Environment and Forestry, 2015). This paper deals with a result of study about relation between biophysical and social factors presented by people perception, concern and participation toward soil degradation. This research expected will complete other results about the role of biophysical and social conditions as the factors that encourage the high rate of soil degradation.

Materials and Methods

Study Site

The research was located in Lekso Watershed that is situated in Blitar District, East Java Province, Indonesia. East Java was selected as study site as Sitorus and Pravitasari (2015) revealed that this province is one of the provinces with more than one million ha of degraded lands. It is expected that Lekso watershed represent one of the condition of East Java watershed both on biophysical and socioeconomic. This watershed with 139 km^2 of area is located between 200 to 2,840 m above sea level. A small amount of the area (8%), however, is located in Malang District. The watershed consists of 28 villages with five soil orders viz. Andisols, Inceptisols, Entisols, Alfisols and Molisols. The wide variety of land covers include natural forest, secondary forest, plantations, paddy field, shrubs, settlement, pasture and agricultural rain-fed areas.

Land Degradation Assessment

Degraded land in Indonesia is presented by the term called critical land. Determination of critical land in this study performed using a standard described in the Indonesia's Ministry of Forestry Regulation No. P.32/Menhut-II, 2009 about 'The arrangement procedure of technical forest and watershed rehabilitation plan (Indonesia's Ministry of Agriculture, 2009). In this procedure, degraded land assessed based on functional of group areas. Three functional areas include protected forest area, cultivated area for agriculture, and protected area outside the forest area. Each group consists of some criteria that will match with actual conditions in the field. Criteria and the weighting for protected forest include land cover (50%), slope (20%), soil erosion (20%), and management (10%). Different criteria established for cultivated areas consisting of productivity (30%), slope (20%), soil erosion (15%), surface rock cover (5%), and management (30%). Criteria and weighting factor for protected area outside forest area were similarly set as protected forest area. Furthermore, the level of critical land is categorized in five levels viz. very critical land, critical land, moderate critical land, potential critical land, and not critical land. Each group of functional area has different range of value to be categorized in each level.

Data collection

A series of survey conducted to collect biophysical data used for quantifying degraded land. The watershed area, at first, divided into some of land units using GIS (Geographic Information System) tool. The data obtained from each land unit were percent of land cover, soil texture, slope steepness, soil drainage condition, effective of soil depth, percentage of surface cover by stone, soil erosion, and flood risk. People perception, awareness, and participation data were collected by in-depth interview method to the selected respondents. List of questions was prepared in a questionnaire. Representative location for selecting the respondent was determined with purposive sampling method. Watershed area was divided into three parts viz. upper, middle, and lower part, furthermore in each part, the villages were determined. Respondents in each village were selected by a stratified random sampling method. The villager's livelihood was used as consideration to select the respondents. There were three main kinds of livelihood in the study site viz. farmer, non-farmer (trader, civil servant, etc.) and village government. The locations of field cultivated by the farmers consist of two sites, viz. forest area and private land. As farmers dominated the number of villager, they were considered as the highest number of selected respondents with the total number of respondents was 130 people.

Data Analysis

The data were analyzed using descriptive statistic that deals with coding and scoring of the information collected from in-depth interview and field survey. Data categorization used to describe the condition of degraded land, people perception and other measured variables. Regression and correlation analyses used to explore the relation between people perception, awareness and participation.

Results and Discussion

Degraded land and biophysical factors

The data revealed that degraded land affected by biophysical factors including land cover and slope steepness. Land cover plays important role for determining the magnitude of critical land range. The data generated from 190 land units with five types of surface cover of plant canopy. Correlation and regression analyses between cover percentage of surface cover and the total number of land units with critical and very critical land resulted in a high coefficient of correlation and coefficient of determination.

Table 1. Coefficient of correlation and coefficient of determination between percentage of surface cover, and critical and very critical land units

Functional Area	**r**	**R^2**
Cultivated Area	-0.9072	0.8229
Protected Forest	-0.9247	0.8550
Protected Area Outside the Forest	-0.9743	0.9493
Average*	-0.9822	0.9648

* surface cover vs. average of critical and very critical land units from cultivated area, protected forest, and protected area outside the forest

The mechanism on how the surface cover affects the rate of critical land is the capability of surface cover to protect soil from kinetic energy of rainfall that leads to the erosion process. Parlak and Ozaslan Parlak (2010) revealed that the higher the crop covers percentage, the lower the splash erosion occurred. Furthermore, soil erosion as one of the driving factors for soil degradation has its own role. However, slope steepness demonstrated negative correlation with soil degradation rate in moderate, critical and very critical land criteria. In this study, the protected forest area that is commonly located in high place, gave a negative trend in which increasing slope steepness actually decreased the number of total moderate, critical and very critical lands.

Cultivated area that is generally located in the middle and lower places, however, did not show the same trend (Figure 1). This result seems to be similar with the result of Okou et al. (2014) who found that high slope angles in high elevation often result in lightly degraded soil. This condition is allegedly due to the effect of high dense of canopy cover in protected forest that decreases kinetic power of rainfall that will damage the soil through soil erosion process.

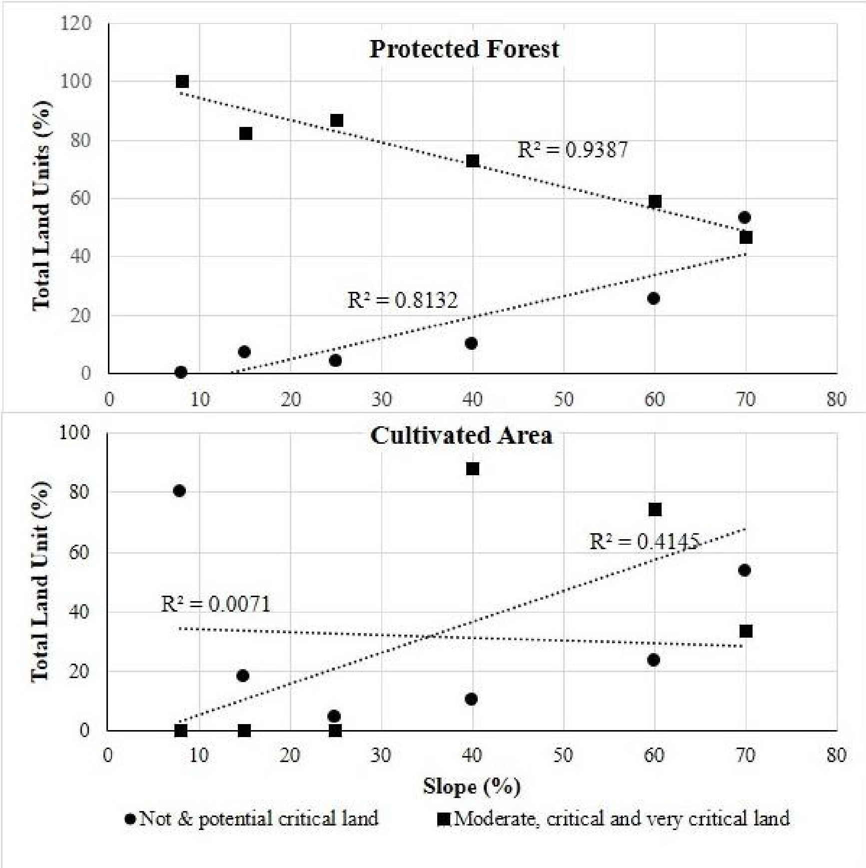

Figure 1. Effect of steep slope on decreasing the number of land units with moderate, critical and very critical criteria

Degraded land and people perception

People perception in the study site was focus on the people view about soil conservation principles that closely related to the magnitude of land degradation. Two statements asked to all the selected respondents as close-ended question to assess their perception about soil conservation principles. The first question was *"Is it a problem if we use forest as cultivated land to grow our cash or annual crops?"*The second question was *"Is it a problem if we use a steep area as cultivated land to grow our cash or annual crops?"*However, despite the question was formed as close-ended questions, the signification of the questions needs to be clarified to the respondents in the interview process. A term in the question that needs to be clarified is *"problem"* that refers to the problem related to soil water conservation, such as soil erosion, flood, soil organic matter loss, landslide, soil water and nutrition depletion, and other problems related to soil water conservation and land degradation. Additionally, the term *forest* asked in the question refers to the concept in which forest is a landscape component that protects, conserves biological diversity, functions in forest ecosystem and have role on ecosystem services (Chazdon et al., 2016). This clarification needs to be emphasized too so they understand its meaning and give the answer that corresponds to the expected meaning of the question. Moreover, the questions considered and expected to represent the perception of the community in the watershed area because one of land degradation driving factors in Indonesia is land use change from forest to another land use. Forest cover in Indonesia, especially in Java Island is low due to high conversion rate of forest for other land uses as a consequence of economic development, even in the recent time the rate tends to decrease (Djaenudin et al., 2016). Slope characteristics have proven giving important role on soil erosion. Wang and Shi (2015) revealed that steep slope encourages the rolled down of heavy particles in the runoff water due to the strong gravity and material force in the direction of slope that contribute to the high level of bed load transport mechanism. It found that 88% of total respondents have a negative perception on the first question and 78% on the second question (Lestariningsih et al., 2017). It means that the respondents gave the "No" answers for the first question. These answers indicate that cultivation of annual crops was assumed not to give impact on soil and water conservation problems. Moreover, as many as 78% of respondents gave the "No" answer for the second question that means they assumed that the usage of steep slope land to be cultivated for annual crops will not give impact for soil water conservation problems. The negative answer of the respondents on both questions reflected their misleading concepts of soil and water conservation principles. Apparently, the perceptions have a strong relationship with the magnitude of very critical land in the study area (Figure 2). It is found that negative perception about the problem caused by cultivated forest and steep slope has a positive trend with the number of very critical land units (r = 0.6710 and R^2 = 0.4503 for cultivated forest; r = 0.9113 and R^2 = 0.8305 for cultivated steep slope). These mean that the higher the number of misleading people about soil water conservation principles, the higher the very critical land areas occurred.

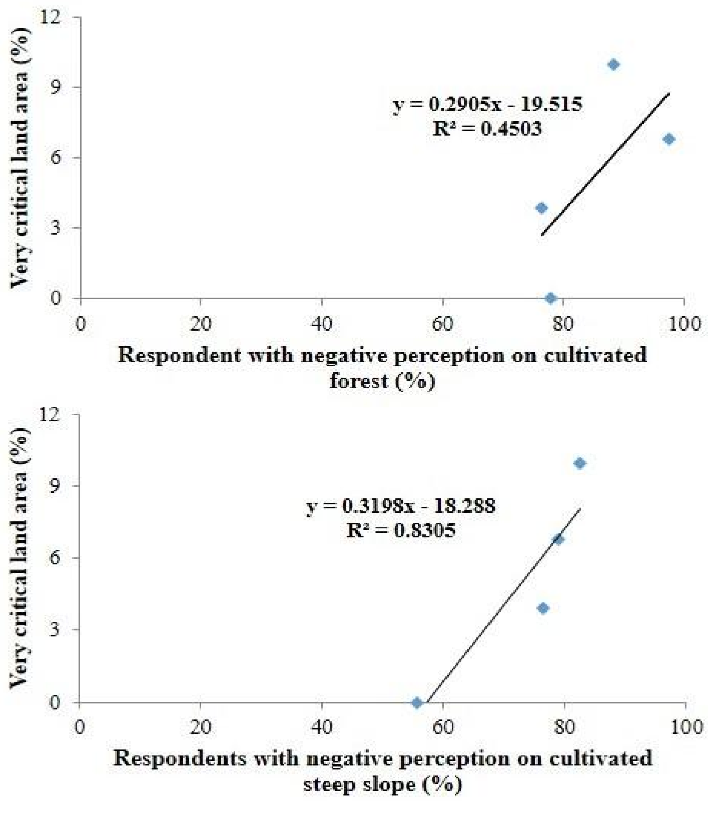

Figure 2. Relationship between respondents with negative perception about cultivated forest and steep slope area and very critical land units (Lestariningsih et al., 2017)

Degraded land and people awareness

People awareness in this study presented from people concern about the recent natural disasters in their surrounding residence or village. Hassan et al. (2010) categorized the awareness into three group viz. practice, attitude and emotional awareness. Emotional awareness is defined as the accepted prerequisite for adjusting awareness which includes the cognitive aspects both monitoring and attitudinal aspects (Moradkhah and Alborzi, 2016). In this study, however, the scope of people awareness was merely restricted on the emotional awareness. Natural disasters used as the indicators for measuring the people concern were flood, landslide, drought, pest and disease of plant explosion, windstorm, and other natural disasters. Other natural disasters in this case refer to disasters such as volcanic eruption, fallen trees, fire in the residential area and forest. The recognition of those natural disasters existence indicates the concern of respondent on their surrounding environment. The awareness toward natural disaster in this study was grouped into three classes, viz. not aware, less aware, and aware. The data showed that the most natural disaster that people was concerned or aware was drought, followed by pest and plant diseases explosion, and other natural diseases. While the awareness of flood, landslide and windstorm posed a lower percentage (Figure 3).

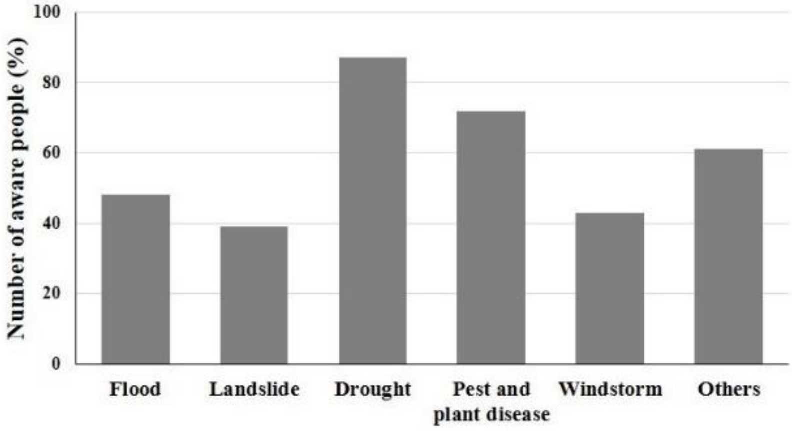

Figure 3. Comparison of the number of aware people on the types of natural disaster

Drought, pest and plant diseases were the most frequently identified natural disasters. This indicates that the disasters were the most important problem faced by people in the study area. In relation with soil degradation, it was found that even the number of aware people on flood set below the awareness of drought and pest and plant diseases, however, the awareness about flood performed closer correlation and regression with critical and very critical land area (r = 0.8651) compared to other natural disasters awareness (Figure 4). Due to the low relationships between pest and plant disease, windstorm and other disasters with land degradation that presented by critical land rate, the people awareness in the study site presented by people awareness on flood, landslide and drought. By weighting those three kinds of awareness, it resulted a negative coefficient of correlation (r = -0.6274) which means that a good awareness on the impacts of degraded land will reduce the area of critical and very critical land (Figure 5).

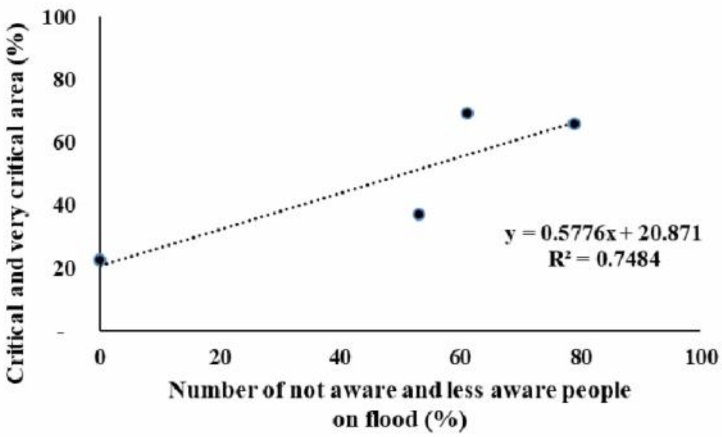

Figure 4. Relationship between awareness of flood and total area of critical and very critical lands

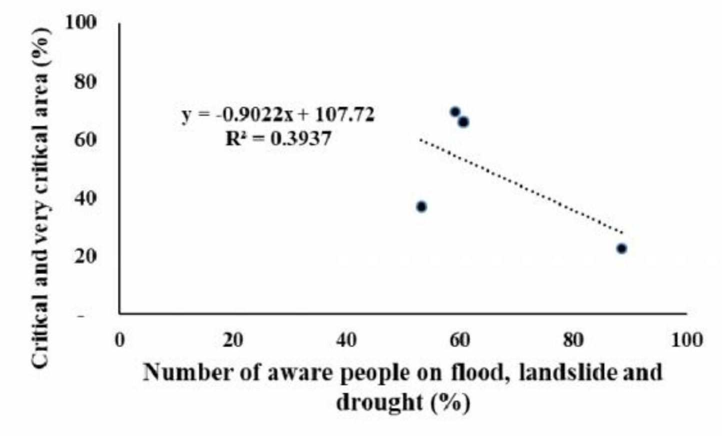

Figure 5. Relationship between critical and very critical areas and the number of aware people on flood, landslide and drought

Degraded land and people participation

People participation in this study assessed with the membership of respondents in farmer organizations. Only 53% of the total respondents involved in the farmer organizations, such as forest farmer group's organization, and non-forest farmer group's organization. However, a surprising result was revealed from the data in which a positive correlation was produced between the increasing of people participation in the farmer's organization and the total critical and very critical land area with r = 0.9952 (Figure 6). It is expected that farmer's involvement in the membership of organization will have negative effect on critical and very critical land status. This is in line with what Udayakumara et al. (2010) found that membership in organizations and committees, and professional competencies have negative effect on soil erosion.

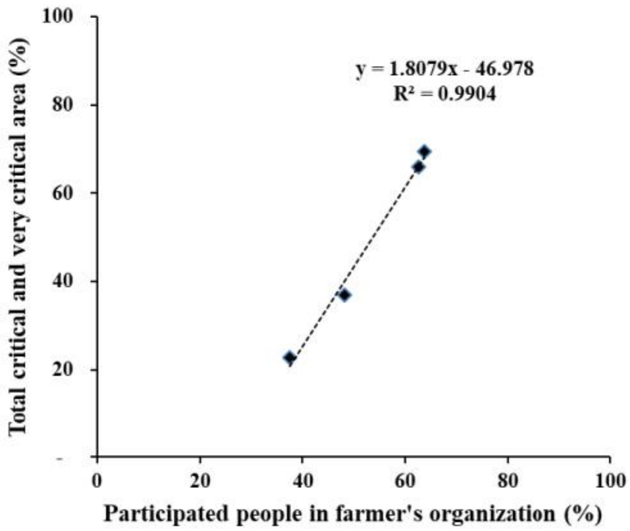

Figure 6. Relationship between the number of participated people in farmer's organization and total critical and very critical land areas

Organizational membership and professional competencies were described the farmer capability to manage their planning, budgeting, credit and market access that encourage their soil conservation effort (Shahriar et al., 2008). The data in this study revealed that organizational membership only could not reduce the amount of critical and very critical land areas. The organizational membership in this study area precisely increased the critical and very critical land areas. This can be logic if the organization establishment aimed solely to organize the farmers as a member who cultivates the forest area for their cash crop production without build and instilling values and principles about soil and water conservation. Other possibility of this phenomenon is probably caused by the economic consideration of the farmer groups and other inhabitants on the study area. Even though some programs for farmer group have established, and the people was participated, however, the participation that was encouraged from economic stimulus without considering non-financial interest that can play an important role, will not improve the adoption of soil and water conservation program (Cotler et al., 2013). Some strategic policy from government based on collective action of participation need to be established to increase people participation with regard to non-financial interest. This is in line with the research result of Sutton et al. (2016) who found that policy implications drawn by some activities based on key determinants of soil conservation efforts would encourage strategies to increase participation and effectiveness in collective action initiatives as a boost to soil conservation.

Conclusion

Biophysical factors influenced the rate of degraded land through the effect of surface cover and slope steepness. However, the slope steepness in the protected forest area demonstrated negative effect on critical land, while in the cultivated area revealed the opposite fact. From this result, we can notice that analysis on one factor only does not enough to elucidate the actual mechanism in the field. It needs to probe other alternative conditions that probably explain the mechanism. People participation in the social factors is another instance for the same case in which the result does not always follow the established theory. However, some of under wrap conditions that potentially give the actual reason should be found.

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