Soil Erosion and Conservation in Kokap Yogyakarta: An Analysis Using Geospatial Information

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Abstract. Soil erosion is one of the causes of declining land quality. Conservation is the solution that can be done to improve the quality of a land. Land conservation is the utilization of a land in accordance with its ability, in order to create a sustainable environment and produce maximally. The purpose of this research is to map the hazards of erosion and provide conservation directives in order to improve the quality of land in Kokap, Yogyakarta. The method to be used to map the erosion hazard is to use the Mathematical formula contained in the model of USLE (Universal Soil Loss Equation). Conservation directives are carried out using the limiting factor in land capability classification. The results showed that the research area was dominated by heavy and very heavy erosion with an area of 3240.1 (Ha) or 46%. Land conservation directives are based on the classification of potential degradation (1) high, (2) moderate, and (3) low. The research area shows that most of the study areas are in high degradation potential zone with an area of 3855.5 (Ha) or 54.8% of the total area of the study area. The research area shows that most of the research areas are in high degradation potential zone with an area of 3855.5 (Ha) or 54.8%. The research area of high degradation potential will be mechanically conservated. Information on erosion, land capability, and conservation directives using geospatial information.

Keywords: Soil Erosion, Conservation, Geospatial Information.

INTRODUCTION

Soil erosion is the process of transporting soil and rock material from higher regions to lower regions [10]. Erosion is in principle a process of soil rarefaction that is affected by the force of gravity [4]. Erosion is the transport of soil or parts of the soil from one place to another by natural media [1]. Water is the main force of erosion in the tropics, especially in wet tropical regions such as Indonesia. Erosion is one of the processes that cause changes in the form of land. Changes in landforms are caused by the erosion of the soil by water at different speeds and volumes. The difference is due to the length and slope of the slope and different land use.

One of the geomorphic processes occurring on the surface of the land is soil erosion [10]. In addition to erosion, there is also a landslide and weathering that is part of the geomorphic phenomenon. These three processes can cause changes in the shape of the land on the surface of the earth. Geomorphic processes that work on landforms result in a decrease in land quality. The decrease in the quality of land is caused by loss of nutrients and soil damage to land due to erosion and landslides. The loss of nutrients and the destruction of the soil affect the decrease in productivity of a land [10]. In addition to erosion and landslide factors, there are other factors that affect the quality of a land. In order to maintain the quality of land due to erosion processes occurring on the surface of the land, conservation efforts are needed [1].

Conservation is an act done for land use in accordance with the ability of land [1]. Each soil has different characteristics from one to the other. Different characteristics are caused by the origin of the parent material and the different formation process. Soil conservation needs to be done with a land characteristic approach that is using a unit form of land or geomorphology. Geomorphology has the main object of study is the form of land. Geomorphology is the study of the shape of the land on the surface of the earth both above and on the surface of the sea and related to nature, genesis, development process, the material arrangement, and its relation to the environment [10].

The shape of the land is a surface appearance of the earth with distinctive characteristics and can be distinguished by morphology, structure, and process and its development [10]. Variations of landforms are the result of changes in the shape of the earth's surface caused by geomorphological processes. The existence of geomorphological processes that work, causing the formation of different landforms and has distinctive characteristics on the surface of the earth. Different landforms require different ways of managing the soil.

The change of a landform is possible if there is a dominant influence on a landform. A hill that has a steep slope with high rainfall conditions has the potential to erode the soil due to the erosion process. The processes generated by geomorphological forces occur over a period of time, causing morphological changes in a given form of land. The morphological differences in a landform will determine the type and management of the land. Differences in land management require appropriate adaptation for humans. Errors in land management lead to land degradation that causes the land to become critical.

The steep slope and thin solum are the next environmental factors that can affect the quality of the land. These physical environmental factors have limited and hindered for more intensive land use. The existence of the use of sloping land on hilly land for agricultural activities actually triggers for the occurrence of higher erosion. Intensive land use is also influenced by a thick factor of solum. Soils that have deep and permeable solum are not easy to erosion [1].

The deep soil can absorb more water, thus reducing the amount of surface flow. Easily or not eroded soil is also determined other factors such as texture and soil structure and organic matter content. Other factors that can limit the quality of a land such as a drainage, rock distribution, and gravel in the soil surface, as well as the threat of flooding. To assess the ability of a land, it will first be classified land capability.

Kecamatan Kokap which is the study area in this study has experienced an intensive process of erosion and many events landslide. Intensive land use has also accelerated the rate of erosion. In addition to erosion, the environmental problems occurring in Kecamatan Kokap are a landslide. Based on previous explanations on erosion, landslide, and other limiting factors in Kecamatan Kokap has caused a number of losses. Losses incurred in the form of environmental damage, loss of property, can even cause casualties. On the basis of previous explanations, to solve the problems contained in Kokap Subdistrict, a land management formula based on land characteristics is required through conservation activities.

Based on the research problems that have been described previously, there are 2 research problems that will be the focus for further study in depth in this research, namely: 1) erosion is the environmental problems that cause environmental degradation of the environment, 2) Environmental problems that can affect the quality a land is not only erosion, there are other limiting factors such as landslide, soil erodibility, and thick solum. These limiting factors are used as a limiting factor in classifying land capability. Land use considerations are needed as a basis for land use directives.

METHODS

Study Area

This research was conducted in Menoreh Hills which is administratively included in Kokap District, Kulon Progo Regency, Yogyakarta Province, Indonesia. The selection of research sites in Menoreh Hills Kecamatan Kokap due to the research area including areas experiencing environmental problems are very high that is the degradation of land due to erosion and landslide events. Through this research is expected land use directives conducted in accordance with the ability of a land, so that land degradation that has occurred can be reduced. The location of the study is presented in Figure 1.

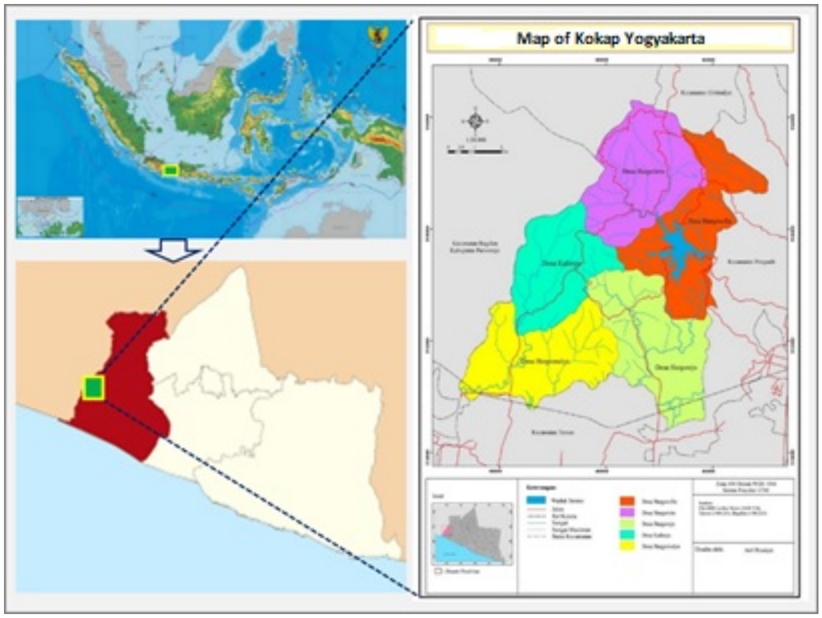

Fig 1. Study Area

Data

In accordance with the purpose of research, then the first step is to determine the level of erosion hazard. Determination of erosion hazard by using erosion prediction model [12], with the formula:

$$A = R . K . L . S . C . P$$

Explanation:
A : erosion (ton/hectare/year)
R : rainfall erosivity factor
K : soil erodibility factor
L : slope length factor
S : slope inclination factor
C : crop management factor
P : land management factor

The predicted erosion (A) predicted results with subsequent USLE models with a thick solum approach are used to determine the level of erosion hazard. The results of large erosion calculations by thick solum approach are then matched with the erosion hazard classification table as presented in Table 1.

Table 1. Classification of Erosion Hazard Level

Thick Solum Soil (cm)	Erosion (ton/hectare/year)				
	I < 15	II 15 - 60	III 60 - 180	IV 180 - 480	V > 480
> 90	SR	S	S	B	SB
60 – 90	R	B	B	SB	SB
30 – 60	S	SB	SB	SB	SB
< 30	B	SB	SB	SB	SB

Explanation: SR=very low, R=low, S=moderate, B=weight, SB=very weight
Source: Hardjowigeno dan Widiatmaka (2011)

Table 2. Classification of Land Capability

Factors	Land Capability Class							
	I	II	III	IV	V	VI	VII	VIII
1. Slope	L_1	L_1	L_2	L_3	L_1	L_4	L_5	L_5
2. Erosion Sensitivity	KE_1, KE_2	KE_3	KE_4, KE_5	KE_6	(1)	(1)	(1)	(1)
3. Erosion	e_0	e_1	e_2	e_3	(2)	e_4	e_5	(1)
4. Effective Depth of Soil	k_0	k_1	k_2	k_3	(1)	(1)	(1)	(1)
5. Top Layer Texture	t_1,t_2,t_3	t_1,t_2,t_3	t_1,t_2,t_3,t_4	t_1,t_2,t_3,t_4	(1)	t_1,t_2,t_3,t_4	t_1,t_2,t_3,t_4	t_5
6. Lower Layer Texture	sda	sda	sda	sda	(1)	sda	sda	sda
7. Permeability	P_2,P_3	P_2,P_3	P_2,P_3	P_2,P_3	P_1	(1)	(1)	P_5
8. Drainage	d_1	d_2	d_3	d_4	d_5	(2)	(2)	d_0
9. Gravel/Rock	b_0	b_0	b_1	b_2	b_3	(1)	(1)	b_4
10. Flood	O_0	O_1	O_2	O_3	O_4	(2)	(2)	(1)
11. Landslide	LS_1	LS_2	LS_3	LS_3	(2)	LS_4	LS_5	LS_5

Source: Arsyad with modifications (2012)
Explanation: (1) = can have any properties (2) = not applicable LS = modified factors

Having obtained the level of erosion hazard, the next is to determine the classification of land capability. The classification of land capability is to group land based on the ability and characteristics of the land for a particular purpose of use. The relationship with land conservation planning is that the land use class will be considered for referrals in land use in accordance with the natural capacity of the land. Classification of land capability used is classification according to Arsyad and added with a factor of occurrence of a landslide in research area [1]. The land capability classification is presented as in Table 2.

The next step is to determine the priority of land conservation based on the level of erosion hazard (Table 3) and land capability (Table 4). The classification of land conservation priorities is presented as Table 5.

Table 3. Erosion Hazard Level Score

No	Level of Erosion Hazard	Score
1	Very Low	50
2	Low	40
3	Moderate	30
4	Weight	20
5	Very Weight	10

Table 4. Field Capability Score

No	Land Capability Class	Score
1	I	80
2	II	70
3	III	60
4	IV	50
5	V	40
6	VI	30
7	VII	20
8	VIII	10

Table 5. Classification of Land Conservation Priorities

No	Priority Score	Priority Classification	Potential Degradation
1	20,00 – 56,90	I	High
2	57,00 – 93,90	II	Moderate
3	94,00 – 131,00	III	Low

RESULTS AND DISCUSSION

The erosion hazard in the study area is determined by the ratio between the amount of soil erosion (A) the result of the USLE model and the thickness of the solum. The result of large comparison of erosion and thickness of solum resulted in erosion hazard. The classification of erosion hazard levels in the study area is presented in Table 6.

Table 6. Level of Erosion Hazard in Research Areas

No	Erosion Hazard Level	Large	
		(Ha)	%
1	Very Low	374,4	5,3
2	Low	310,7	4,4
3	Moderate	3125,9	44,3
4	Weight	1840	26,1
5	Very Weight	1400,1	19,9
Amount		7042	100

Based on the data analysis presented in Table 8, it shows that the erosion hazard in the research area is mostly at the level of heavy erosion hazard (26,1%) and very heavy (19,9%). Most of the dangers of heavy erosion are found in northern volcanic forms and are very heavy in the southern structural structures. Classification of land capability is a systematic assessment of the land and its grouping into several categories or by the nature of potential and limiting factors (Arsyad, 2012). Classification of land capability in this study using limiting factor on the classification of Arsyad (2012).

Land availability parameters include slope, erosion sensitivity, erosion, effective soil depth, soil texture, permeability, drainage, gravel and rocks, flood threats, and added landslide limiting factors. Determination of land capability classification is done by the matching method, that is to match the physical quality of land in a field with classification table. Based on the results of data analysis shows that the ability class not for agriculture is the widest area with 3940,5 Ha or 55,9% (class VI and VII). More than half of the study area is in a non-agricultural use capability class, so management of this area is recommended for protection forests and conservation forests. The classification of land capacity and area of the area in the study area is presented as in Table 7.

Table 7. Classification of Land Capability

No	Ability Class	Large	
		(Ha)	%
1	I	194,3	2,8
2	II	444,1	6,3
3	III	792,3	11,2
4	IV	1671,8	23,7
5	VI	160,8	2,3
6	VII	3779,7	53,6
Amount		7042	100

Table 8. Classification of Priority of Land Conservation in Research Areas

No	Classification	Potential Degradation	Large	
			(Ha)	%
1	I	High	3855,5	54,8
2	II	Moderate	2363,3	33,6
3	III	Low	822,5	11,7
Amount			7042	100

Table 9. The direction of Land Use based on Unit-Based Approach in the Research Area

No	**Symbols of Landform Unit**	**Land Capability Class**	**Land Use Existing**	**Land Use Directions**
1	H1V1	VII	Production Forest, Shrubs, Gardens, Settlements	Forest
2	H1V2	VII	Forest, Conservation Forest, Production Forest, Shrub, Garden, Settlements	Forest, Conservation Forest, Production Forest
3	H1V3	VI	Shrub, Settlements	Forest, Garden
4	H1V4	III	Conservation Forest, Production Forest, Garden, Settlements	Conservation Forest, Production Forest, Garden, Field
5	H1S1	IV	Forest, Conservation Forest, Production Forest, Garden, Settlements	Conservation Forest, Production Forest, Garden, Field
6	H1S2	IV	Production Forest, Garden, Settlements	Production Forest, Garden, Settlements
7	H1S3	II	Shrub, Garden, Settlements, field, Rice fields	Garden, Field, Rice fields
8	H1S4	VI	Garden, Settlements	Production Forest, Garden
9	H1S5	IV	Garden, Settlements	Production Forest, Garden
10	H1S6	III	Production Forest, Garden, Settlements	Production Forest, Field
11	P1F1	I	Garden, Field, Settlements, Rice fields	Garden, Field, Settlements, Rice fields
12	P1S7	II	Garden, Field, Settlements, Rice fields	Garden, Field, Settlements, Rice fields

Based on Table 10, the northern research area has a steep slope. Very high rainfall factor can be a trigger for a landslide. The role of human actions in land use such as cutting slopes, road construction, and cultivation patterns that do not comply with conservation rules also enlarge for the occurrence of the landslide. The priority of soil conservation in this study is a design that is made of a priority action and directed land conservation. The design of land conservation directives shall be land use directives in accordance with land tenure class. Spatial distribution is also made to indicate which location will be the location of the land conservation priority action (Fig. 2). Presentation of land conservation priorities is presented based on geographic information systems [3,5,6,7]. The classification of land conservation priorities is presented as Table 8.

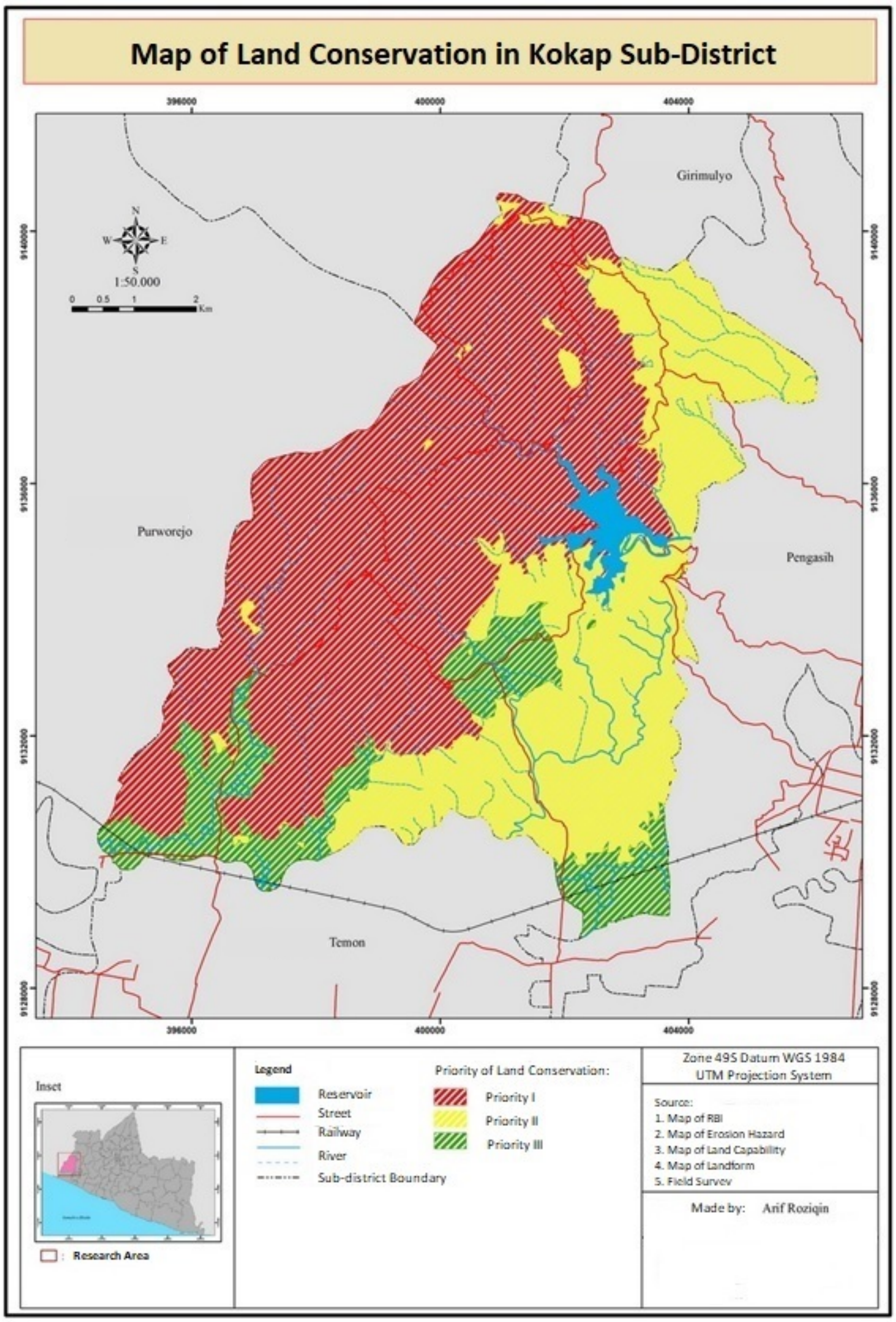

Fig 2. Map of Land Conservation in Kokap Sub-District

After the classification of land conservation priority is divided into three parts, the next is the direction of land use in accordance with the natural ability of a land. Land use directives appropriate to land capability are presented as Table 9.

CONCLUSION

On the basis of the results of data analysis and discussion that has been described in the previous section and its relation to achieving the final goal of this study, it can be concluded:

1) the level of erosion hazard in the research area is mostly at the level of heavy erosion hazard (26.1%) and very heavy (19.9%).
2) the research area is mostly in the conservation priority zones I. Priority of land conservation in the research area is divided into three classes, namely the priority I with the area of 3855.5 Ha or 54.8%, the priority II 2363.3 Ha or 33.6%, and priority III 822.5 Ha or 11.7%. Land use directives for areas with high erosion hazard and landslide events are directed to land use such as protection forests, conservation forests and production forests.

ACKNOWLEDGMENTS

The authors would like to thank the friends at the Geomatics Engineering Engineering Program of the State Polytechnic of Batam who have jointly conducted the research activities. The authors also need to express their gratitude to the Center for Research and Community Service (P3M) Batam State Polytechnic which has supported in scientific publication activities.

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