Conservation planning on eroded land based of local wisdom in Kintamani sub-district, province of Bali

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Abstract. Location determination is based on the compilation of soil type's map, land use map and slope map. Uniformity of soil type, slope and land use is classified into one unit of land, so that there are 48 units of land to be use as sample points. The purpose of this research are to identify patterns of land use, determine the amount of erosion, the amount of erosion that is tolerable and erosion control through a conservation plan based on local wisdom. The erosion prediction used USLE method, erosion of tolerated (*Edp)* using the formula Hammer.Results of laboratory and field observations having analyzed using USLE showed some level of erosion on land use in the Kintamani classified from very mild to very severe: 4.79 to 370.60 t ha-1yr-1, while Edp ranges from 30.00 to 48.00 t ha-1 yr-1. erosion Severe to very severe found on the use of mixed garden/citrus garden, dry land and shrubs/ reeds.The planned of use of land is intercropping annuals with horticultural crops (cabbage), citrus trees intercropped with flower of gumitir and bush land planting with elephant grass on a slope of less than 25% and planted of trees on land with a slope above 25%.

1. Introduction

In an effort to maintain the agriculture as a source of food and the preservation of an agrarian culture, the presence of agriculture need to be maintained towards the conservation and sustainable agriculture approaches. In relation to land use, the pattern of land management by local farmers, traditionally which are known as local wisdom that has been practiced by the farmers for a long time which need to be raised again to avoid production failures.

Local wisdom is an idea, action and truth that has been a tradition, traditional rules (*awig awig*) in an area, formed as a local culture of excellence, the value it contains is considered very universal. Local wisdom in an area different from other regions[1][2][3]. One of the local wisdom of Bali which has been recognized globbally is rice paddy farming system[4][5].

In nature actually impossible obviate erosion, especially lands that are cultivated on sloping ground, so need conservation action and conservation methods applied to be able to suppress the erosion rate becomes smaller till to the tolerated limit.Lowland rice farming system in Bali is one of the local wisdom, not just a source of food and income for thr farmers, but also the prevention of soil erosion, especially on sloping lands.

The use of land in the district of Kintamani is still less attention to the rules of conservation, in areas with a slope slopes above 25%, is still used for farming seasonal crops. As is known Kintamani

is upstream of several rivers vital for the region Bali, one of which is the Watershed of Ayung. Overcome this, the necessary efforts to improve the condition of the watershed with the soil and water conservation, so that controlled the interrelationships of natural resources and environment of the watershed. In an effort to tackle the downturn is more severe on land resources, the necessary land use follow the rules of soil and water conservation to minimize erosion, and can increase farm production.

Based on the issues described earlier, then do research on the amount of erosion and erosion tolerated, at some certain pattern of land use and land conservation action based on local wisdom, if erosion exceeds the tolerable erosion. The purpose of this research is (1) to identify patterns of land use, (2) determine the amount of erosion, (3) the amount of erosion that is tolerable, (4) erosion control through a conservation plan based on local wisdom.

2. Methodology

2.1. Research location

The study was conducted in several land uses in the district of Kintamani, Bali. Kintamani District is geographically located on 115º18'27 " *BT* until 115º 23'00"*BT* and 08º10'00 " *LS* until 08º20'00"*LS*. Total rainfall is very high in this research area which can causes high potential for erosion. Erosivity value average is 1355.59 for Kintamani area near an observation station and to the observation post Catur 2764.80. Soil type is Regosol, these lands are vulnerable to erosion. Land use is dominated dry land. Most people live from farming.

2.2. Materials of the research

Materials used in this research are: map of the earth (1: 25,000)[6], a map of soil types (1: 25.000), land use maps (1: 25,000). [6] [7].

2.3. Research procedure

Research procedures are as follows:

1) Digitizing a map of the study area Sub District Kintamani. using the program GIS. [8].
2) Making a map of the land unit based overlaying map soil type, slope maps and land use maps, in order to obtain a map of the land unit using the program GIS (Figure 1.)
3) Based on the map of the land unit of each soil sample was taken one to represent, in order to get 48 samples, for analysis of physical (bulk dencity, permeability, soil structure), and chemical (organic matter content) properties of the soil. Laboratory analysis coducted in the departement soil and environment, faculty of agriculture, University of Udayana, Denpasar-Bali.
4) Identify land-use patterns is dry land/moor, mixed garden, bush, forest and settlement or open land.

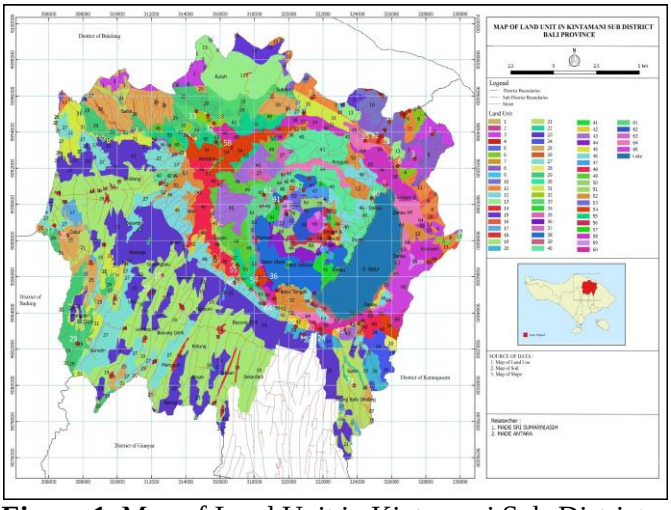

Figure 1. Map of Land Unit in Kintamani Sub-District

2.4. Method of data analysis

Erosion is calculated by using the formula of the *Universal Soil Loss Equation* (USLE) [9]. The amount of erosion is A = R.K.L.S.C.P, where A is the number of eroded soil (t ha^{-1} yr^{-1}), R is a factor rainfall or erosivitas (mm/ha/day/ yr). R = 6.119 (monthly rainfall in cm)$^{1.21}$ (number of rainy days per month)$^{-0.47}$ (maximum daily rainfall 24 hours)$^{0.53}$. K = soil erodibility (tonnes ha/day rain/ha), 100K=1.292 {2.1$M^{1,14}$ (10-4) (12-a) +3.25 (ba) +2.5 (c-3)}. LS is the length and slope factor, LS = √L (0.0136+0.00965S+0.00138S2). C is a factor of soil and vegetation cover crop management, P is a factor of soil and water conservation measures. CP value is determined by the approach of the state in the field with the results of the Land Research Center, Bogor. CP value is the value of crop management factor (vegetation) and the value of land management or conservation measures

Erosion is tolerated *(Edp*) on some land use was analyzed according to the formula Hammer [10], calculated of *Edp*namely:

$$Edp = \frac{\text{Dept of the soil x factor of dept soil}}{\text{The useful life of land}} \quad (1)$$

If the existing conditions causing erosion exceeds the tolerable erosion it needs improvement in land and crop management(CP) with a few scenarios through simulation such as by changing the pattern of land use, so that the erosion rate is smaller than the tolerable erosion. Erosion is tolerated (*Edp*), if a maximum speed of soil loss per year is still tolerated in order to maintain the optimum use of soil productivity for a long period. In determining the value of *Edp* such as the thickness of the layer of soil, soil physical properties and organic matter decline should be considered.

3. Results and discussion

This research was conducted by looking atland use pattern in the district of Kintamani, which is the upstream part of the ayung watershed, one of the longest watersheds in the province of Bali. The followings are the factors that affect erosion:

1) Climate is a factor that affects the hydrological processes and is an important element in the process of hydrology. One of the climate elements that affect most of the hydrological processes is rainfall. Rainfall data in Kintamani Sub-district is obtained from *Tuban* Meteorology and Geophysics Agency (*BMKG*) based on rainfall observation stations located in the village of Kintamani and Catur.
2) The type of soil in the Kintamani Sub-district [7] is Regosol Humus, Brown Regosol and Gray Regosol. Each covers an area of 8729.74 ha; 12014.61 ha and 412.90 ha. This soil type is sensitive to erosion. It is means the soil is easily to be eroded particularly in a land uses that do not follow the rules of soil and water conservation. If the rainfall with hight intencity If it rains with high intensity, then a layer of surface soil (top soil) is easy to carry rainwater runoff into the form of erosion or landslides. The calculation of land value from 0.02 to 0.34 erodibilitas classified from very low to very high.
3) Topography factor of research area show the shape of the area, including differences in slope steepness. The length and slope are two elements that most influence on erosion. Topography affects the hydrological processes, especially on the transformation of rainfall into runoff. Increasingly steep slope, so the greater of rainfall becomes runoff or erosion caused by rainwater into the fall was not given the opportunity infiltrated. Length slopes in the study area is from 10 meters to 100 meters with a slope of 2% up to 41%.
4) The land use is dominated dry land area of 1960,55 ha; mixed garden is 994.73 ha; forest is 318.51 ha; bush 175.64 ha; open land 163.46 ha and undeveloped land is78.34 ha. The use of dry land, mixed garden/citrus area with a less dense planting, patio there is not maintained and without strengthening plants such as elephant grass or patio plants that can maintain the stability of aggregates. The use of dry land and mixed garden in the upper without the principles of

conservation and with high rainfall intensity will cause severe to very severe erosion. This means it is very necessary repairs and maintenance of existing porch with terrace strengthening plants that have dual functions as reinforcing the terrace so that erosion can be minimized and economic value, because it can be used as a means of *upakara* especially for Hindus (based on local wisdom). Value of crops and land management (CP) obtained at the existing condition is 0.005 to 0.28, the lowest CP value obtained on land use for forest land-use and highest in shrubs or overgrown with weeds

Results of laboratory analysis and field observations was analyzed using *USLE* showed tha some level of erosion on land use in the Kintamani district classified from very mild to very severe, namely: 4.79 to 370.60 t $ha^{-1}yr^{-1}$, while erosion is allowed (*Edp*) ranges from 30.00 to 48.00 t ha^{-1} yr^{-1}. Severe erosion to very severe erosion found on the use of mixed garden/citrus garden (land units 1, 6, 25, 29, 33, 35, 46, 52, 55, 61 and 64), dry land (land units 2, 11, 19, 23, 31, and 58), and shrubs/ reeds (land units 15, 41, 47, 53, 59 and 65) (Figure 2). Erosion analysis presented in Table 1. While the erosion of the result of improved land management and crop management (simulation result) is presented in Figure 3.

Based on the analysis at Table 1, erosivity and erodibility factors (R, K) is a natural factor that can not be repaired, while the factors of slope and slope length (L,S) can be repaired, but the costs necessary to make the building mechanically (terrace) is large and expensive, the factor which most can be corrected is the crop and land management (CP). In the planning of erosion control, so the most effective conservation action and acceptable by local communities is based on local wisdom, which is planted intercropped with plants that can live in the study site, but it has economic value that can increase farmers' income.

Table 1. Erosion, Tolerated Erosion (*Edp*), CP Value, and Erosion of the Improvement Result of CP Value (Simulation)

Unit of Land	Name of Village	Land Use	Erosion (t ha^{-1} th^{-1})	Edp (t ha^{-1} th^{-1})	CP Value After Improvement	Erosion of Improvement Result of CP Value (t ha^{-1} th^{-1})
1	Belandingan	Mixed garden	19.85	48	0.003	0.74
2	Belandingan	Dry land	70.06	36	0.021	5.25
3	Belandingan	Mixed garden	21.60	48	0.003	0.81
4	Belandingan	Bush	17.19	30	0.005	4.09
5		Settlement				
6	Belandingan	Mixed garden	91.41	48	0.003	3.43
7	Subaya	Forest	14.48	48	0.004	11.58
8	Belandingan	Mixed garden	36.71	48	0.003	1.38
9		Settlement				
10	Belandingan	Bush	24.86	30	0.005	5.92
11	Subaya	Dry land	118.22	36	0.021	8.87
12	Belandingan	Forest	8.59	48	0.004	6.87
13	Belandingan	Mixed garden	38.60	48	0.003	1.45
14		Settlement				
15	Belandingan	Bush	37.04	30	0.005	8.82
16	Belandingan	Mixed garden	38.60	48	0.003	1.45
17	Catur	Mixed garden	15.98	48	0.003	0.60
18		Settlement				
19	GunungBau	Dry land	111.95	36	0.021	8.40
20	Buahan	Forest	4.97	48	0.004	3.97
21	A. Batu Dinding	Mixed garden	36.80	48	0.003	1.38
22		Settlement				
23	Ulian	Dry land	167.93	36	0.021	12.59
24	Buahan	Forest	10.97	48	0.004	8.78

25	Catur	Mixed garden	59.22	36	0.003	2.22
26		Settlement				
27	Buahan	Mixed garden	37.71	48	0.003	1.41
28	Sukawana	Forest	11.13	48	0.004	8.91
29	Mengani	Mixed garden	132.22	48	0.003	4.96
30		Settlement				
31	Subaya	Dry land	320.72	36	0.021	24.05
32	Sukawana	Forest	17.17	48	0.004	13.74
33	Bantang	Mixed garden	49.27	48	0.005	11.73
34		Settlement				
35	Pinggan	Mixed garden	126.01	48	0.040	63.01
36	Batur Selatan	Forest	4.79	48	0.004	3.83
37	Kintamani	Mixed garden	25.06	48	0.003	0.94
38		Open land				
39		Settlement				
40	Songan A	Dry land	73.95	36	0.021	5.55
41	Kintamani	Bush	62.41	30	0.005	14.86
42	Songan A	Forest	6.07	48	0.004	4.86
43	Suter	Mixed garden	61.22	48	0.003	2.30
44		Open land				
45		Settlement				
46	BayungGede	Mixed garden	59.69	48	0.003	2.24
47	Kintamani	Bush	48.19	30	0.005	11.47
48	Songan A	Forest	10.17	48	0.004	8.13
49	Suter	Mixed garden	48.97	48	0.003	1.84
50		Open land				
51		Settlement				
52	Manikliu	Mixed garden	73.19	48	0.003	2.74
53	Kintamani	Bush	51.35	30	0.005	12.23
54	Batur Selatan	Forest	20.67	48	0.004	16.53
55	Kintamani	Mixed garden	114.50	48	0.040	4.29
56		Open land				
57		Settlement				
58	Sukawana	Dry land	370.60	36	0.021	27.79
59	Kintamani	Bush	248.91	30	0.005	59.26
60	Buahan	Forest	32.85	48	0.004	26.28
61	Sukawana	Mixed garden	250.28	48	0.003	9.39
62		Open land				
63		Settlement				
64	Batur Tengah	Mixed garden	167.31	48	0.003	6.27
65	Batur	Bush	170.81	30	0.005	20.67

Source: result analysis

Unit of land : 5,9,18,22,26,30,34,38,39,44,45,50,51,56,57,62,63 is the land use settlement or open land.

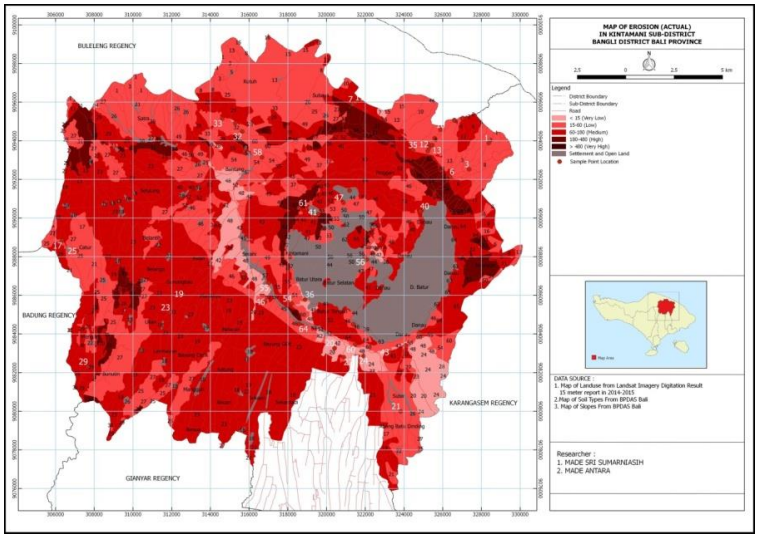

Figure 2. Map of The Erosion Actual in Sub-District Kintamani

The use of land for mixed garden/orange seemed to be filled plants sidelines due to lack of appropriate terms of land cover (crop factor or C factor), because the plant canopy at the time the plant was three years less dense, high rates of erosion caused among citrus crop there are still parts of land that is not covered by the canopy of citrus. This is when it rains with high intensity will cause erosion, because there is no canopy of leaves that withstand the kinetic energy of the rainfall. As for the use of the existing terrace moor land should be maintained by planting amplifier terrace, which has a dual function. On land overgrown with reeds or left bush/shrub should be planted with elephant grass, in addition for animal feed, can also prevents erosion, especially on steep slopes.

The use of dry land, mixed garden/citrus, and shrubs/reeds patio that there are not maintained properly, causing erosion exceed erosion tolerated, it needs management. While on land that is overgrown with shrubs/reeds should be managed well with land management and intercropping crops, maintaining terraces of *gulud* existing with planted by h elephant grass as a reinforcement of the terrace and can be used to feed livestock (has a dual function), so that erosion on land that is left alone with weeds can be minimized.

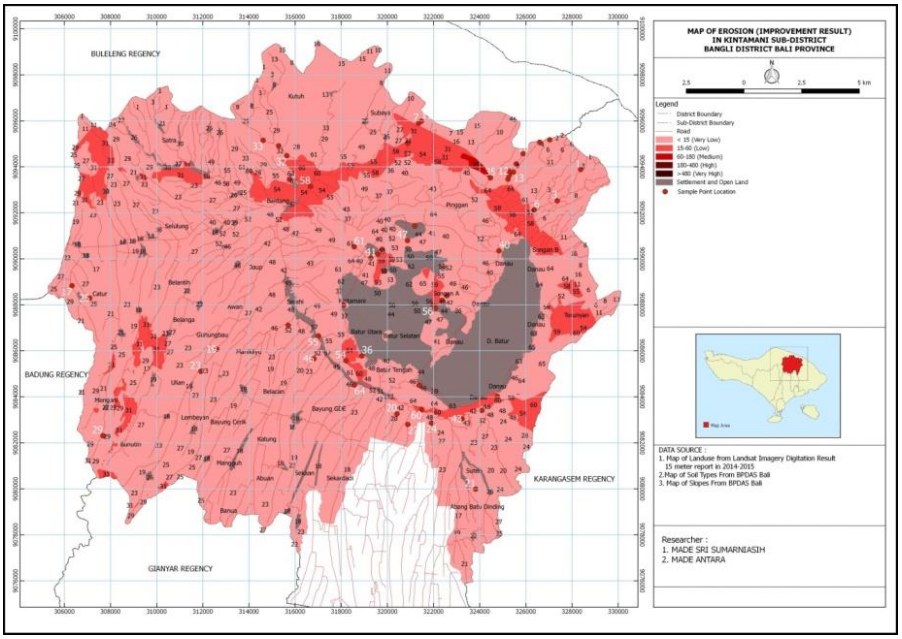

Figure 3. Map of The Erosion Result of Simulation in Sub-District Kintamani

Gumitir flower crops being planted in the hallway of citrus increase land cover so as to reduce erosion will happen, because the rainfall on the soil surface can be mitigated by a canopy of gumitir flowers. Keep in mind that the hall plants should be lower of the canopy than citrus trees so as not to disrupt the growth of the main crops (citrus trees). Patio that there should be maintained by planting plants such terrace amplifier: elephant grass plant, lemongrass, and *pandan*, it is suggested because the plant has a dual function. Elephant grass has a dual function as an amplifier terraces as well as fodder, lemongrass as the reinforcement terrace and can be used for herbs and pandan leaves as reinforcement terrace and means of *upakara* (Hindus). The plant has a socio-cultural values as a means of *upakara* and economic value because it can increase the income of farmers and protecting the environment towards sustainable agriculture.

On land shrubs/reeds, steep topography with slope above 25%, or the land is left without treatment, especially in the border river/gorge suggested planted woody trees such as pecan, *cempaka*, *sandat, beringin, bunut*, breadfruit tree, jackfruit, and others. Trees such as *upakara* plants produce leaves, flowers or fruit that can be harvested for sale, without cutting down the tree, so that the economy can increase revenue. In agro ecology can preserve the environment, the main function is to protect the steep areas to avoid landslides and springs that exist in these locations are well preserved because of the fountain in the upstream is very influential to the downstream part of the watershed.

The farming community actually know besides slope, land use is a factor affecting the surface runoff and erosion, but farmers still not yet apply the conservation techniques that right because of production costs to be incurred if the action is done. This can actually be solved by involving the community at every activity of government Provincial / District in accordance with Act No. 37 Year of 2014 Clause al 46 paragraph (4). The government also should regularly provide counseling, mentoring, greening along with the communities in which activities are conducted, and the provision of seeds required for free so that people care about and feel they have, want to keep the environment well in order to reach sustainable agriculture. In addition to growing crops interrupted the crop rotation patterns most likely be implemented is to plant annual crops with horticultural crops for rainfed paddy fields or upland. Bush land on the river banks and ravines improvements made is by planting trees or woody plants such as Albizia forest industry, Albizia, jackfruit and breadfruit. The tree is useful to keep the border river and the gorge in order not to landslides because it has deep and strong roots. Trees can also be cut down if the age is enough to be sold so as to increase farmers' income, because

they are in areas with slope <25%, but as an important note is to replace the harvested crop of young plants. Preferably prior to clearing groomed young plants or seedlings that will be planted as a replacement.

4. Conclusions and suggestion

4.1. Conclusion

Based on the results and discussion, it can be formulated some conclusions, as follow:

1. Erosion happens in Kintamani District on some land uses and belong to very mild to very severe category (4.79 to 370.60 t $ha^{-1}yr^{-1}$), whereas the tolerable erosion is 30-48 t $ha^{-1}yr^{-1}$.
2. Counter measures on the eroded land through conservation planning based on local wisdom in the use of dry land, mixed garden/citrus garden, shrubs/reeds.
3. The planned land use is intercropping annuals with horticultural crops such as, citrus trees intercropped with *gumitir* flowers and planting the elephantgrass on bush land with a slope of less than 25% and growing trees on land with a slope above 25%.

4.2. Suggestion

1. Counseling could be done periodically to prevent the conversion of agricultural land into non-agricultural land
2. In order to increase farmers' income above a decent life apart from planting economically valuable commodity, it also can be done by raising livestock and looking for side jobs such as trader, labourer or tourism activities.

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