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Economic Valuation of Soil Erosion on Cultivated Drylands in Langge Sub-watershed, Gorontalo, Indonesia

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Abstract
Soil erosion is processes of destruction of soil particles that oftenly suggest large external impacts. Many cases of topsoil losses are caused by the intense rainfall and soil material transport by surface run-off. These events have various negative impacts on agriculture and forestry. This study aims to analyze economic value of soil erosion on cultivated drylands in the Langge sub-watershed, Bolango Watershed, Gorontalo province, Indonesia. Total economic value of natural resources is the amount of use value and non-use value, use value consists of direct use values and indirect use values. In this study, calculation of economic value is focused on indirect use value, related to the soil fertility losses. Calculation of economic values is based on the cost-based method by estimating any replacement cost. Therefore, estimation of the loss value caused by soil erosion is based on value of organic fertilizers, Urea, SP-36 and KCl. The soil loss in four land units is 406.3 t/ha/season, in which the total rainfall was 855.5 mm/season, total nutrients lost are 2,648.15 kg C/ha/season, 230.26 kg N/ha/ season, 30.47 kg P/ha/season, and 69.74 kg N/ha/season, respectively. Total economic value of the nutrient loss is 14,231,904 IDR/ha/season.
Keyword : Soil erosion, nutrient losses, economic value.

1. Introduction

Farming activities is a major source of farmers income, however usually these activities become one of the major causes of land degradation and soil erosion (Cassanovas et al.,2002), surface runoff (Bergkamp et al., 1996), declining water quality (Fawcet et al., 1994; Parry, 1998 and Lal, 1998) and leaching of soil nutrients (Andrew et al., 1999) . Erosion, run-off and soil nutrients losses are on-site effects due to farming activities, while reducing in water quality is classified as a off-site effect or external effect (Chen and Saileung, 2011; Jha, 2011).

Soil erosion is processes of destruction of soil agregates and transport of sediments that oftenly suggest various external impacts. Many cases of topsoil losses are caused by intense rainfall and soil material transport by surface run-off (Liu, *et al*., 2000). These events result in various negative impacts on productivity of the agriculture and forestry systems.

Soil erosion are usually related to changes in landuse; it is a serious environmental problem that threatens the human life, particularly in developing countries. Each year, about 75 billion tons of soil material loss due to erosion; the amount mostly comes from agricultural land (Mahmoudi, 2010). Sadeghi *et al*., (2009) found that an average rate of soil loss in Asia about 138 t/ha/year. Ibrahim (2008) conducted a study in the Bolango watershed, it reveals that based on calculation of soil losses prediction on the existing condition of watershed, using maximum daily rainfall in five years, the soil loss was about 4,636,448 t/year in an area of 39,783 ha. It means that the average soil loss about 116.54 t/ha/year. This erosion rate is classified in Rate Class III (very heavy erosion) (Arsyad, 2010)

Soil erosion and sedimentation in the Bolango watershed are seriously problems, and it is an important threat to the productivity and sustainability of agricultural lands. Results of analysis in 2010 showed that about 86% of the Bolango watershed suggest the high level of erosion hazard (> 180 t/ha/year) . The actual erosion rate is higher than soil erosion tolerance 14 t/ha/yr (Management Board of Bone Bolango Watershed, 2010). Most of soil erosion are at the middle and upper slopes of watershed, both of these areas are more than 25% slope (Liu *et al.,* 2000). The common soil erosion type is surface erosion; but in any location, are gully erosion and hill erosion (Asdak, 2007).

Soil erosion and sedimentation has induced any societal concerns, especially when its impact causes significant external damages, such as siltation of irrigation channels and reservoir, floods and land slides. The negative impacts which are rarely being paid attentions are topsoil losses, it leads to soil qualities degradation of soil fertility losses. This kind of negative impact cannot be seen immediately, yet it really causes more severe ecological-economic problems in the future. There have been a declining soil productivity; consequently, farmers need to apply more of fertilizer in order to maintain their crop productivity (Bosede, 2010).

Economic valuation is an attempt to provide an economic quantitative value of goods and services produced by

natural resources and natural environment, regardless of whether it already has any market value (price) or not (Hidayat, 2008). According to Hufschmidt (1987), economic assessment of natural service s can be done with some different approaches, such as benefit assessment techniques. This technique assessed benefits of some environmental goods, when the cost of it utilization is not enforced yet. The main properties of this technique are the use of market prices whenever possible.

The natural soil fertility is usually related to an availability of nutriens in soil (Hardjowigeno, 2010). However, in general, agricultural soil (especially in the tropics) sugested some nutrients deficiencies, especially N, P and K (Ailincai, 2010). Soil degradation affected of economic farm-input to be supplied in crop production system. Based on these considerations, economic valuation of soil erosion was based on value of C, N, P and K nutrients.

2. Reseacrch Method

Field research was conducted in the Langge sub-watershed, Bolango watershed, Tapa sub-district, Bone Bolango regency, Gorontalo province, Indonesia; from January 2012 until December 2012. The Langge sub-watershed is geographically located at 0° 34' 40"- 0° 39' 05" North Latitude and 123° - 03 '59" - 123° 13 '16" East Longitude

2.1. Soil Losses Estimation using USLE (Universal Soil Losses Equation)

The estimated maximum soil losses (erosion) was determined using a formula developed by Smith and Wischmeier (1978), known as the Universal Soil Loss Equation (USLE). The USLE formula is:

$$A = R \times K \times LS \times C \times P$$

where A is Number of Soil loss ($t.ha^{-1}.yr^{-1}$), R is rainfall erosivity factor, K is soil erodibility factor, LS is length and slope factor, C is crop management factor, and P is soil conservation factor.

Rainfall Erosivity Factor (R)

Rainfall data used in this research are the monthly average rainfall for 2001 - 2011. Calculation of the rainfall erosivity factor involved the following formula:

$$EI_{30} = 2{,}21\ R^{1{,}36}$$

This formula was proposed by Levain (1975), and revised by Bols (1978); in which EI_{30} is the monthly erosivity index, and R is the monthly rainfall in centimeters.

Soil Erodibility Factor (K)

Soil erodibility factor was assigned to each homogeneous land units, each land unit contained data on physical and chemical soil properties, soil permeability, soil structure, soil texture, and soil organic matter content. Values of soil erodibility factor (K) can be obtained through the use of Nomographs (Wischmeier, 1971) or can be calculated using equation proposed by Wischmeier and Smith (1978):

$$100 = 1{,}292\ [2{,}1\ M^{1{,}14}\ 10^{-4}\ (12 - a) + 3{,}25\ (b - 2) + 2{,}5(c - 3)]$$

where K is the soil erodibility factor, M is [(percentage of very fine sand and silt) x (100-percent clay)], a = organic matter content (% C x 1.724), b = soil structure classes, c = soil permeability classes.

Slope Factor (LS)

Slope factor is derived from multiplication of slope length (L) and slope degree (S). Slope length (L) is obtained using the equation introduced by Morgan (1995):

$$LS = \frac{\sqrt{L}}{100}\ (1.38 + 0.965S + 0.138\ S^2)$$

where LS is the slope factor, L is slope length in meters S is the slope degree.

Crop Management Factor (C), Soil Conservation Factor (P)

Crop management factor (C) and soil conservation factor (P) are adopted from the values in Arsyad (2010).

2.2. Economic Valuation

Total economic value of some natural resources consist of the use value and non-use value. Use value consists of direct use values and indirect use values (Pearce and Turner, 1990; Pearce and Moran, 1994; Turner et al., 1994). In this study, economic valuation of soil erosion is limited to the indirect use value in relation to soil fertility losses (Fauzi, 2010).

Indirect use value of the watershed resources are indicated by erosion impact, economic valuation based on the cost-based method by calculating any replacement cost (Farber *et al*., 2002). The calculation of loss value caused by soil erosion, was based on the value of N, P and K nutriens losses in soil erosion (Babier, 1995). The economic value of these nutirients are based on price of organic fertilizer, urea, SP-36 and KCl.The formula used is:

$$EV\text{-}er = \sum LV\text{-}C_i\ x\ P\text{-}C + LV\text{-}N_i\ x\ PN + LV\text{-}P_i\ xPP + LV\text{-}K_i\ x\ PK$$

where EV-er is Economic Value of erosion; LV-C is loss value of C element on rainy days (i), P-C is price of organic fertilizer per kg; LV-N is loss value of N nutrient, on rainy days (i), P-N = price of Urea per kg; LV-P is loss of P nutrient, on rainy days (*i*) P-P = price of SP- 36 fertilizer per kg; LV-K is loss of K nutrient, on rainy days (*i*); PK is price of KCl fertilizer per kg.

The amount of nutrients (organic-C, N, P, and K) transported in sediment material were converted into the

organic fertilizer, Urea, SP-36 and KCl. The amount of losses were converted in terms of fertilizers based on nutrient content . The nutrient contents of Organic fertilizer, Urea, SP-36, and KCl are 12,30% C, 46.6% N, 36% P_2O and 60% K_2O (Hardjowigeno, 2010). The fertilizer price used in this study was the market price at the research periode. The organic fertilizer price is 550 IDR/kg, Urea price is 1,800 IDR/kg, SP-36 price is 2.500 IDR/kg and KCl price is 11.000 IDR/kg.

3. Result and Discussion

3.1. Land Characteristics

A land unit is an area of land, based on some land characteristics can be assumed to have homogenous characteristics (such as climate, soil, and land cover). Components of land (elements of land- form is also called as units of areas or segments of surface land) are frequently used as a land unit, especially due to the border of land (Van Niekerk, 2010).

In this research, land unit was derived from overlaying the geological map, the geomorphological, topography, and land-use map of the certain area. There were 12 land units (LU) found in the study area which are presented in Table 1 and Figure 1. The name of land unit was based on landform, degree of slope, land use type, and area of land unit.

Table 1. Land characteristics and their components in the Langge sub-watershed, Bolango watershed, Gorontalo

No LU	Landform	Slope (%)	Land Use Type	Area (ha)
1.	Alluvial plain	1- 3	Cultivated dryland	7
2.	Stream belt	1- 3	Cultivated dryland	109
3.	Alluvial fan	3- 8	Cultivated dryland, mixed gardens, shrubs	281
4.	Colluvial plain	3 – 8	Mixed gardens	51
5.	Colluvial plain	8- 15	Cultivated drayland	100
6	Old volcan hill	15- 25	Cultivated dryland, mixed gardens, shrubs	117
7.	Old volcan hill	25- 40	Secondary forest	228
8.	Old volcan mountain	> 40	Secondary forest, and a small part of cultivated dryland	1,539
9.	Hills volcanic intrusion	15 – 25	Cultivated dayland, mixed gardens, shrubs, and forest	1,818
10.	Hills volcanic intrusion	25 – 40	Cultivated dryland, mixed gardens, shrubs, and forest	1,241
11.	Mountanin volcanic intrusion	> 40	Cultivated dryland, mixed gardens, shrubs	109
12.	Karst mountain	> 40	Secondary forests	722
			Total	6,322

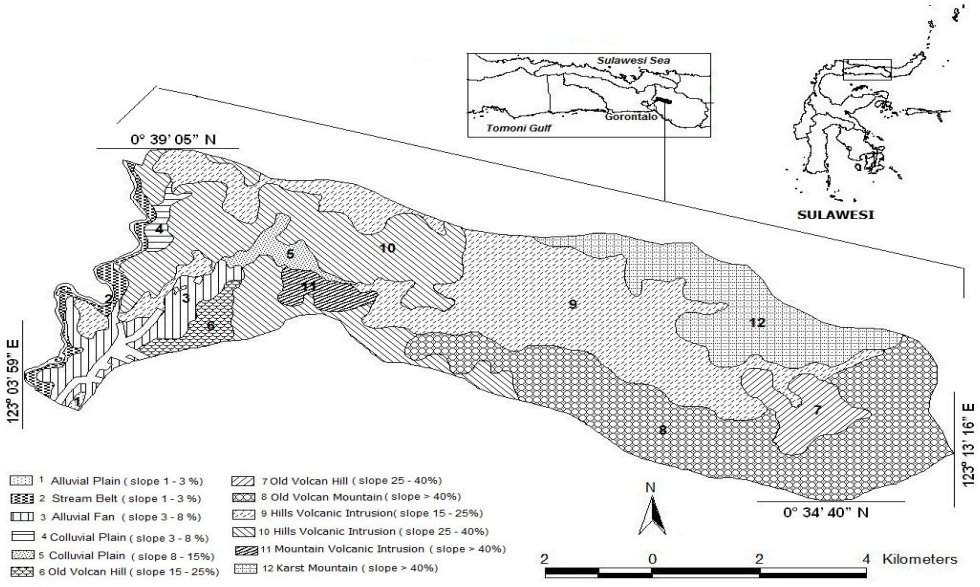

Figure 1. Land Characteristic in the Langge Sub-watershed, Bolango Watershed. Gorontalo

3.2. Soil Loss Prediction

Erosion hazard levels shown in Table 2 on study area can be classified into three, namely: (1) "Light" with an average soil loss of 6.62 t/ha/yr , it includes an area of 2,334 ha (LU-1,LU-3, LU-7, and LU-9); (2) "Moderate" with an average soil loss of 15.56 t/ha/yr, it includes an area of 2.521 ha (LU-2, LU-4, LU-5, and LU-12); (3)

"Very Heavy" with an average soil loss of 404.40 t/ha/yr , it includes an area of 1,467 ha (LU-6, LU-10 and LU-11).

Table 2. Prediction of Soil Losses in The Langge Sub-watershed

Land unit	Area (ha)	Slope (%)	Soil depth (cm)	Soil losses (t/ha/yr)	Level of erosion
1	7	1 - 3	46	0.09	Light
2	109	1 - 3	55	12.91	Moderate
3	281	3 - 8	60	10.25	Light
4	51	3 – 8	35	11.12	Moderate
5	100	8 – 15	60	22.38	Moderate
6	117	15 – 25	73	334.09	Very heavy
7	228	25 – 40	68	8.20	Light
8	1.539	> 40	62	19.72	Moderate
9	1.818	15 – 25	65	7.94	Light
10	1.241	25 – 40	74	340.37	Very heavy
11	109	> 40	80	539.03	Very heavy
12	722	> 40	100	15.89	Moderate

Surface runoff and soil erosion, in addition to be potentially affected by rainfall and land slope, was also affected by land use and farming activities (Van Rompaey *et al.*, 2001). Soil erosion is one of the most significant impact of land degradation (such as soil reduction, declining soil fertility, and slope instability) and is significantly affected by land use and cropping management (Rey, 2003; Bini *et al.*, 2006).

3.3. Economic Valuation of Soil Erosion

Economic valuation (imposition of monetary value) of soil erosion is generally estimated by the Total Economic Value (TEV). Recovery value and the value of prevention of damages and pollution of soil and water are very difficult to be calculated. Assesment of total economic value of the agriculture ecosystem, for example, then all the calculated economic value consisting of components production (food crops, feed crops and others) and ecosystem services (hydrological, biodiversity, pollution and climate services for downstream) should be taken into account. All of economic values need to be included in the assesment even though data and information are still very limited. Therefore, economic valuation conducted in this study, both economic value of land and value of damages (soil degradation) is not fully implemented, and assessment was focused on soil losses valuation through economic value of C-organic, N, P, and K, in the transported sediment. According Bosede (2010), environmental and economic impacts of agricultural land due to the soil fertility losses, soil erosion, intensive cropping and intensive soil tillages, and crop management. Soil fertility losses affected crop production, and lowering the water holding capacity of soil result in the great vulnerability of crop to drought effects (Betrie *et al.*, 2011). According to FAO (1994), the loss of soil fertility in many developing countries suggested any direct threats to food production and can lead any seriously human impacts.

Based on the condition of land resources in the study area, discussion of the rate of soil erosion, sedimentation and nutrient losses, were grouped based on the type of landform and its slope. These types of landform are (1) "undulating land"with a slope of 3-8% , it is located in land unit No.3; (2) "rolling land" with a slope of 8-15% , it is located in land unit No.5; (3) "small hilly" with a slope of 15-25% , it is located in land unit No.6; and (4) "terrain land" with a slope of > 40% , it is located in land unit No.11.

3.3.1. Land Unit No 3 (LU-3)

The area is located on the alluvial fan landform, undulating land (3-8% slope) with a slope length > 291 m; it is formed from parent material of fine and coarse colluvium materials. Landuse in this unit consists of cultivated land, mixed farms, and some shrubs. Area of land unit No.3 is 281 hectares or 4.35% of the study areas. Crops cultivated on these lands are maize, pickpea, groundnut and eggplant, with the crop rotation is: Maize – Maize – Vegetables. Farmers not yet apply any soil conservation technologies.

Calculation of the economic value of soil erosion was done through an analysis of soil losses containing nutrients (C, N,P, and K). Table 3 shows the Total Economic Value per hectare in land unit No.3 for March to July 2012.

Table 3. Total Economic Value of Soil Erosion in Land Unit No.3 for March to July 2012 in the Langge Sub-watershed.

	March	April	May	June	July	Total
Rainfall (mm)	374,0	125,0	87,5	67,0	202,0	855,5
Sediment (t/ha)	3,99	0,14	0,06	0,06	2,87	7,12
Nutrient Losses (kg/ha):						
Carbon	49.05	1.75	0.79	0.77	35.24	87.60
Nitrogen	5.18	0.19	0.08	0.08	3.73	9.26
Phosphorus	0.78	0.03	0.01	0.01	0.56	1.40
Potassium	4.50	0.16	0.07	0.07	3.23	8.04
Economic Value (IDR/ha) of nutrient losses base on price of:						
Organic fertilizer	219,328	7,809	3,531	3,438	157,585	391,692
Urea	20,286	722	327	318	14,575	36,228
SP-36	5,441	194	88	85	3,909	9,717
KCl	82,505	2,938	1,328	1,293	59,279	147,343
Total Economic Value (IDR/ha)	327.560	11.663	5.274	5.135	235.349	584.980

Economic valuation for the imposition of monetary value was based on the nutrients losses within the transported soil materials. The calculation of economic value is the total loss of nutrients (organic-C, N, P and K) in transported soil material and it is converted into the economic value base on price of Organic fertilizer, Urea, SP-36, and KCl.

Table 3 shows results of soil erosion (sediment) estimation in land unit No.3. The total rainfall is 855.5 mm, and the estimated soil loss (sediment) is 7.12 t/ha/season; the nutrients losses are 87.60 kg-C/ha/season, 9.26 kg-N/ha/ season, 1.40 kg-P/ha/season, and 8.04 kg-K/ha/season. Total economic value of the nutrient losses is equivalent to 584,980 IDR/ha/season.

3.3.2 Land Unit No.5 (LU-5)

This area is located on the plain alluvial landform, the rolling land (8 - 15% slope) with a slope length of 103 m, it is formed from parent material of fine and coarse colluvium materials. Landuse consists of cultivated land, mixed farms, and some shrubs. Area of land unit No.5 is 100 hectares or 1.56% of the study areas. Crops cultivated in these lands are maize, pickpea, and eggplant, with the crop rotation is Maize – Maize – Vegetables. Farmers cultivated their crop on the bench-terrace land.

The calculation of the economic value of soil erosion was done through the prediction of soil loss in the form of sediment containing nutrients (C, N, P, and K). Table 4 shows estimation of the total economic value per hectare in land unit No. 5 for March to July 2012.

Table 4. Total Economic Value of Soil Erosion in Land-unit No.5 for March to July 2012 in Langge Sub-watershed.

	March	April	May	June	July	Total
Rainfall (mm)	374.0	125.0	87.5	67.0	202.0	855.5
Sediment (t/ha)	0.47	0.12	0.10	0.34	1.99	3.01
Nutrients Losses (kg/ha):						
Carbon	2.942	0.751	0.619	2.116	12.518	18.95
Nitrogen	0.234	0.060	0.049	0.168	0.994	1.50
Phosphorus	0.010	0.003	0.002	0.007	0.043	0.07
Potassium	0.186	0.047	0.039	0.134	0.791	1.20
Economic Value (IDR/ha) of nutrient losses base on price of:						
Organic Fertilizer	13,156	3,359	2,769	9,463	55,975	84,722
Urea	914	233	192	657	3,888	5,884
SP-36	71	18	15	51	301	456
KCl	3,410	871	718	2,453	14,509	21,961
Total Economic Value (IDR/ha)	17,551	4,482	3,694	12,624	74,674	113,023

Economic valuation was based on land degradation that caused by the loss of nutrients in soil erosion. The total losses of nutrients (organic-C, N, P and K) in soil erosion are converted into the monetary value base on price of Organic fertilizer, Urea, SP-36, and KCl. Table 4 shows results of estimation of soil erosion on land unit No.5, total rainfall is 855.5 mm, and the estimated soil losses (sediment) is 3.01 t/ha/season, the nutrient losses are 18.9 kg-C/ha/ season, 1.5 kg-N/ha/ season, 0.07 kg-P/ha/season, and 1.20 kg-K/ha/season. Total economic value of nutrients losses is equivalent to 113,023 IDR/ha/season.

3.3.3 Land Unit No. 6 (LU-6)

This area is located on the plain old volcanic hills landform, small-hilly land (15-25% slope) with a slope length 103 m, it is formed from parent material of basaltic andesite. Land use consists of cultivated land, mixed gardens, and some shrubs. Area of land unit No.6 is 117 hectares or 1.82% of the study areas. Crops cultivated on these lands are maize and groundnut, with the crop rotation is Maize – Maize – Groundnut. Farmer have not yet practiced any soil conservation technologies.

The calculation of the economic value of soil erosion was done through estimation of soil loss (sediment) containing nutrients (C-organic, N,P, and K). Table 5 shows the total economic value per hectare of land unit No.6 for March to July 2012. Economic value was estimated base on the nutrients losses within the transported soil materials (sediment). These losses of nutrients (organic-C, N, P and K) are converted into the monetary value base on price of the Organic-fertilizer, Urea, SP-36, and KCl.

Table 5 shows results of soil erosion prediction on land unit No.6. The total rainfall is 855.5 mm, and the estimated soil loss is 316.9 t/ha/season; the nutrient losses are 1,774.6 kg-C/ha/ season, 158.4 kg-N/ha/season, 26.3 kg-P/ha/season and 52.6 kg-K/ha/season. Total economic value of nutrients losses are equivalent to 9,702,050 IDR/ha/season.

Table 5. Total Economic Value of Soil Erosion in Land Unit No.6 for March to July 2012 in the Langge Sub-watershed.

	March	April	May	June	July	Total
Rainfall (mm)	374,0	125.0	87.5	67.0	202.0	855.5
Sediment (t/ha)	154.0	39.9	32.7	11.1	79.1	316.9
Nutrients Losses (kg/ha):						
Carbon	862.53	223.70	183.11	62.20	443.08	1.774.6
Nitrogen	77.01	19.97	16.35	5.55	39.56	158.4
Phosphorus	12.78	3.31	2.71	0.92	6.56	26.3
Potassium	25.56	6.63	5.43	1.84	13.13	52.6
Economic Value (IDR/ha) of nutrient losses base on price of:						
Organic Fertilizer	3,856,837	1,000,285	818,797	278,122	1,981,257	7,935,298
Urea	301,349	78,156	63,976	21,731	154,803	620,015
SP -36	88,732	23,013	18,838	6,399	45,582	182,563
KCl	468,623	121,539	99,488	33,793	240,732	964,175
Total Economic Value (IDR/ha)	4,715,542	1,222,993	1,001,097	340,045	2,422,373	9,702,050

3.3.4 Land Unit No.11 (LU-11).

Land unit No.11 is located on the mountains volcanic intrusion landform, mountainous land (> 40% slope) with a slope length 137 m, it is formed from the granite material. Land use consists of cultivated land, mixed farms, and some shurbs. Area of land unit No.11 is 109 hectares or 1.70% of the study areas. Crops cultivated on these lands are maize, with the crop rotation is Maize - Maize. Farmers have not yet practiced any soil conservation technologies.

The calculation of the economic value of soil erosion was done through estimation of soil losses (sediment) containing nutrients. Table 6 shows the total economic value per hectare of land unit No.11 for March to July 2012. Economic valuation was calculated based on the nutrients losses which is transported through surface runoff. The total nutrients losses (C, N, P and K) are converted into the monetary value base on price of the Organic fertilizer, Urea, SP-36, and KCl.

Table 6 shows the results of estimation soil erosion on land unit No.11. The total rainfall is 855.5 mm, and the estimated soil losses is 67.9 t/ha/ season; the nutrient losses are 767.0 kg-C/ha/season, 61.1 kg-N/ha/season, 2.7 kg-P/ha/season and 7.9 kg-K/ha/season. Total economic value of these nutrients losses are equivalent to 3,831,851 IDR/ha/season.

Table 6. Total Economic Value of Soil Erosion in Land Unit No.11 for March to July 2012 in the Langge Sub-watershed

	March	April	May	June	July	Total
Rainfall (mm)	374.0	125.0	87.5	67.0	202.0	855.5
Sediment (t/ha)	30.9	7.4	4.5	2.4	22.7	67.9
Nutrient Losses (kg/ha):						
Carbon	348.69	84.04	50.32	27.37	256.59	767.0
Nitrogen	27.77	6.69	4.01	2.18	20.44	61.1
Phosphorus	1.21	0.29	0.17	0.10	0.89	2.7
Potassium	3.58	0.86	0.52	0.28	2.64	7.9
Economic Value (IDR/ha) of nutrient losses base on price of:						
Organic Fertilizer	1,559,190	375,802	225,019	122,368	1,147.341	3,429,719
Urea	108,673	26,193	15,683	8,529	79,967	239,045
SP-36	8,421	2,030	1,215	661	6,196	18,523
KCl	65,720	15,840	9,485	5,158	48,361	144,564
Total Economic Value (IDR/ha)	1,742,003	419,864	251,403	136,715	1,281.865	3,831,851

According to Table 7, the total economic values (TEV) of soil erosion base on price of the Organic fertilizers, Urea, SP-36, and KCl, in land unit No.3 is 584,980 IDR/ha/season; in land unit No.5 is 113,023 IDR/ha/season, in land unit No.6 is 9,702,050 IDR/ha/season, in land unit No.11 is 3,831,85 1IDR/ha/season. Total economic value of nutrient losses on cultivated drylands in Sub-watershed Langge is 14,231,904 IDR/ha/season. Estimation results of the total economic value of soil erosion in land unit No.3, No.5, No.6 and No.11 are presented in Table 7.

Tabel 7. Total Economic Value per hectares in Land Unit No.3,No.5, No.6 and No.11 for March to July 2012 in the Langge Sub-watershed.

Land Unit	Sediment (t/ha/season)	Economic Value (IDR/ha/season) of nutrient losses base on price of:				Total (IDR/ha/season)
		Organic Fertilizer	Urea	SP-36	KCl	
3	7.12	391,692	36,228	9,717	147,343	584,980
5	3.01	84,722	5,884	456	21,961	113,023
6	316.90	7,935,298	620,015	182,563	964,175	9,702,050
11	67.90	3,429,719	239,045	18,523	144,584	3,831,851
	394.93	11,841,431	901,172	211,259	1,278,043	14,231,904

The total economic value (TEV) does not really cover all of economic values because it does not cover the overall economic value (Pearce and Moran, 1994). In addition, many ecologists have expressed total economic value including all of economic values, there are some basic ecological functions which are synergistic so that its value is greater than the value of a single function. Meanwhile, according to Manan (1992), from the point of view of a forester, the forest has versatile functions, at least as timber, water storage regulation, shelter and growing wildlife, and recreations. It is very difficult to define the boundaries of these functions explicitly due to their interactions between these functions.

Nutrients losess in eroded soil, for traditional land tenure and uncultivated land, were 2.540 kg-C/ha/yr, 210 kg-N/ha/yr, 112 kg-P/ha/yr, and 186 kg-K/ha/yr (Lal, 1976). If the Maize – Maize cropping pattern with soil tillage (plowing system) was practiced, the nutrients losses are relatively lower. Tjakrawarsa and Hunggul (2003) have conducted a study to estimate economic value of soil erosion, sedimentation and water services in the Jeneberang Upper-watershed, South Sulawesi. In calculating economic value of soil erosion, the sources of soil erosion are farming systems in cultivated land. The results of soil erosion estimation on the 15-35% slopes is 78.34 t/ha/year, the amount of nutrient losses due to soil erosion for one month with 769 mm rainfall was 0.0412 ton/ha/yr (N), 0.0004 ton/ha (P), and 0.0007 ton/ha (K). Based on an average annual rainfall of 3,000 mm, the losses value is equivalent to approximately IDR 1.420.000 ha/yr (assuming prices for IDR.3.000/kg for urea,SP-36 and KCl). On the slope of 8-15% (sediment 26.39 t/ha/yr), the amount of nutrient loss are 0.0141 ton N/ha/yr , 0.0001 ton P/ha/yr , and 0.0025 ton K/ha/yr. The losses value is equal to IDR. 488 000 ha/yr. Based on the study area, approximately 10.680 ha in which 20% of the area is on a slope of 8-15% (2,150 ha) and 35% at the slope of 15 - 35% (3,740 ha), the estimated loss of nutrients due to the soil erosion is equivalent to 4.8 billion IDR/yr.

4.Conclusion

Erosion hazard in the research areas can be classified into three, namely: (1) "Light" with an average soil loss of 6.62 t/ha/yr, it includes land area of 2,334 ha; (2) "Moderate" with an average soil loss of 15.56 t/ha/yr it includes land area of 2,521 ha; (3) "Very Heavy" with an average soil loss of 404.40 t/ha/ yr , it includes land area of 1,467 ha. Based on observation, the total of soil loss on cultivated drylands in the Sub-watershed Langge is 406.3 t/ha/season, the total rainfall was 855.5 mm/season, the total of nutrients losses are 2,788.3 kgC/ha/season, 245.1 kgN/ha/ season, 685.15 kgP/ha/season, and 33.07 kgK/ha/season. Economic values of soil erosion in the land unit No. 3 is 584,980 IDR/ha/season, in land unit No.5 is 113,023 IDR/ha/season, in land unit No.6 is 9,702,050 IDR/ha/season. The Total Economic Value (TEV) of nutrients loss in cultivated drylands in the Sub-watershed Langge is 14,231,904 IDR/ha/season.

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