PalArch's Journal of Archaeology of Egypt / Egyptology

THE RATE OF EROSION AND EROSION HAZARD LEVELS (TBE) IN THE UPPER AREA, FARMER RIVER FLOWS (DAS) IN NORTH SUMATERA

Shanti Desima Simbolon[1], Zulkifli Nasution[2], Abdul Rauf[3] & Delvian[4]

[1,2,3,4,]Universitas Sumatera Utara, Medan, Indonesia

[1]Corresponding Author : shantisimbolon@uhn.ac.id

Shanti Desima Simbolon, Zulkifli Nasution, Abdul Rauf & Delvian, The Rate Of Erosion And Erosion Hazard Levels (Tbe) In The Upper Area, Farmer River Flows (Das) In North Sumatera-Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(7),ISSN 1567-214x

Abstract. This study aims to determine the rate of erosion that occurs and determine the amount of permissible erosion (Edp) and how the Erosion Hazard Level (TBE) and evaluate the value of the nutrient content of Nitrogen, Phosphorus and Potassium (NPK) lost due to erosion in the upstream area of the Farmer's Sub-watershed and economic losses due to the loss of these nutrients in North Sumatra, Indonesia. Tests were carried out using a component-based SEM (Structural Equation Modeling) approach through GeSCA (Generalized Structured Component Analysis) software. The results showed that the highest prediction rate of erosion that occurred in the upstream area of the Farmer's Sub-watershed was 11,302 tonnes /ha /year (classified as very heavy) or equivalent to 941.9 mm / year in SPT-24 cultivating banana plants, which had a negative average income, namely in the amount of IDR. 805,895.75 while the lowest erosion rate prediction is 13.72 tonnes / ha / year at SPT 12 or equivalent to 1.14 mm/year (classified as very light) where SPT-12 cultivates bananas and papayas has an average income of IDR 10,820,367. Based on the results of the TBE evaluation, it can be concluded that the damaged land is 15.38 ha and the land still suitable for development for pineapple, papaya, chilli, cabbage farming is 5.38 ha.

Keywords: Sustainable agricultural systems, Erosion Hazard Level, rate of erosion,

1. Introduction

Sustainable development is a development process that has the principle that meeting the needs of the present does not sacrifice the needs of future generations.The phenomenon of land management that is not in accordance with the potential of land resources is growing, economic factors are used as a determining factor in management actions. The use of land is forced for activities that are more considering economic benefits. In an effort to obtain economic benefits, farmers force to plant seasonal crops on sloping land to hilly even though this action causes excessive erosion and decreased water absorption into the soil (Haeron, 2010). Soil erosion in agricultural areas is a serious problem that needs to be solved from the roots. Understanding soil erosion in cropland is an important step towards developing an effective soil conservation strategy.

Humans have a huge task to ensure food security for present and future generations. Importantly, reducing top soil loss due to erosion, implementing conservation will preserve soil fertility and allow the soil to maintain higher yields which will have a positive impact on the economy.

Agricultural land is the main area with the highest level of soil erosion, the main contributing factor is agricultural management that is not in accordance with the land potential. Examples include farming on very steep slopes and cultivation on slopes without protective measures. Information regarding the biophysical conditions of the land can provide an overview of the constraints and problems of land management in the upstream area of the Farmer's Sub-watershed so that the identification and evaluation of the biophysical conditions of the land is an absolute requirement in the formulation of a sustainable agricultural land management strategy.

In this study, the biophysical components of land observed were topography, average annual rainfall and soil types and properties related to the potential of an agricultural land. The upstream area of the Farmer's Sub-watershed is currently faced with biophysical limiting factors such as relatively steep slopes, high rainfall, soil types and characteristics which are dominated by soil types that are sensitive to erosion.The high demand for agricultural land causes annual crops to be cultivated not only on flat land, but also on sloping land> 16%, which should be used for annual crops or forests. This process has been going on for a long time and has resulted in degradation of agricultural lands. Even though a land use appears to be economically rational in the short term because of the value and direct benefits obtained, the benefits often do not match the costs required to restore land that has been damaged due to uses that are not compatible with the potential for land suitability (Crook &Clapp, 1988).

Basically, agricultural cultivation practices in the upstream area of the Farmer's Sub-watershed have opportunities and strategic positions. Since time immemorial, many farmers have lived and used the upstream area of this sub-watershed to meet their daily needs and support their family's economy. Most of these farmers cultivate horticultural crops. Horticultural plants are a group of plants consisting of fruits, vegetables, flowers, ornamental plants and biopharmaceutical plants. Horticultural commodities are usually produced intensively. The production of this commodity is capital intensive and labor intensive, but promises high returns. This causes high market demand (Poerwanto and Anas, 2014). However, cultivation of horticultural crops in the upstream area of the sub-watershed is generally faced with biophysical limiting factors such as relatively steep slopes, high rainfall, and erosion. Erosion takes place on top soil which causes soil to be eroded and washed away, as well as nutrients which are important as "food material" for plants and directly affect soil fertility (Kartasapoetra, 1989).

Nitrogen supply in the soil is a very important factor. If there is a severe N deficiency it will stop the growth and reproduction process of plants (Nyakpa et al., 1988). P functions in plants: a) accelerate root growth of seedlings; b) accelerate the growth of young plants into mature plants; c) accelerate fruit ripening; and d) increasing grain production (Sutedjo, 2002). Meanwhile, the K element plays an important role in opening and closing the stomata, and the work process of growth enzymes. If these essential nutrients are not sufficient for plants, it will result in low production (Poerwanto and Anas, 2014).

The upstream area of the Farmer's Sub-Watershed is a sloping area that has experienced land degradation due to erosion. The slope of the Farmer's Sub-watershed is dominated by a class from slightly steep to very steep with a fairly high average annual rainfall. This situation is exacerbated by the type and nature of the soil that is owned, which is dominated by soil that is sensitive to erosion (BP DAS Wampu Sei Ular, 2013). The interaction of the three biophysical conditions causes the upstream area of the Farmer's Sub-watershed to have a high risk if it is managed without implementing conservation measures, especially seasonal crops which usually have shallow roots.

The farmers' carelessness in managing their farms has resulted in farmers having to pay additional costs to restore their soil fertility by buying fertilizers in larger amounts than they should if the erosion that occurs is classified as heavy to very heavy on their agricultural land. The additional costs incurred on fertilizers directly increase the cost of agricultural production. The provision of fertilizers in an effort to restore soil fertility is very burdensome for farmers. Through this research, it is hoped that data on the total number of potential losses of farmers in economic terms per hectare will arise so that farmers' awareness to apply soil conservation measures will arise.

Topographically, the shape of the upstream area of the Farmer's Sub-watershed is dominated by steep to very steep slopes with high average annual rainfall and soil types and properties that are sensitive to erosion. Most of the livelihoods of the people in the upstream area of the Farmer's Sub-watershed are farming horticultural crops which generally have shallow roots. This situation creates vulnerability to erosion if it is not accompanied by adequate land and water rehabilitation and conservation efforts. This causes this area to be vulnerable to erosion, which is one of the causes of land degradation.

The loss of nitrogen, phosphorus and potassium nutrients due to erosion is felt directly by farmers by decreasing soil fertility so that farmers have to pay additional costs for the purchase of fertilizers because the dosage usually given by farmers is not sufficient for optimal growth of their plants. Therefore, it causes the farmer's income to decrease. At present, the application of soil conservation measures found in the study area is dominated by inadequate conservation measures. Inadequate conservation, operationally it is defined as follows, namely no vegetation of ground cover crops, no terraces on steep to very steep agricultural land, exacerbated by the types of crops planted are shallow-rooted seasonal crops (such as mustard greens, lettuce, etc). If there is a terrace on a sloping land, the condition of the terrace is not maintained and is badly damaged, most of the terraces are built along the slope. In addition, farmers have not used their agricultural land according to the potential of their land and other conditions

In addition, the economy of the farmers in the upstream area of the Farmer's Sub-watershed is classified as weak. The life of farmers in the study area is often below the poverty line where farmers are unable to meet the standard of decent living needs (KHL). This is one of the reasons why farmers are unable to care for and maintain the quality of their farm land, considering that meeting their daily needs is very difficult. Together all of these problems, either directly or indirectly, have an impact on the productivity of agricultural land that is being managed. Therefore, all of these problems were studied in depth with a sustainable horticultural crop farming system approach through analysis of biophysical latent variables of land, latent variables of erosion rates, latent variables of land evaluation and existing conservation and economic latent variables of farmers so that the root causes of problems in the field can be identified and can be identified. formulated effective location-based solutions that can be applied to agricultural land. The problems in this research are as follows (1) how much erosion has occurred in the upstream area of the Farmer's Sub-watershed? Has the allowed erosion exceeded (Edp) and what is the Erosion Hazard Level (TBE) of the area? (2) to what extent is the effect of the amount of erosion that occurs on the loss of nutrients nitrogen (N), phosphorus (P), and potassium (K) and how much is the economic loss due to the loss of these nutrients?

2. LITERATURE REVIEW

2.1. Estimation (prediction) of the amount of erosion that occurs on agricultural land

Erosion prediction is a way to estimate the rate of erosion that will occur from the soil. Erosion prediction or the estimation of the amount of erosion that will occur on land is carried out using the Universal Soil Loss Equation (USLE) formula by Wischmeier and Smith, 1978 in Hardjowigeno and Widiatmaka (2007), namely:

$$A = R \times K \times LS \times C \times P \qquad (1)$$

Where :

A = amount of soil eroded (tonnes / ha / year)
R = rain erosivity factor
K = soil erodibility factor
LS = length and slope factor
C = land cover vegetation factor and crop management
P = factor of special soil conservation measures

Rain Erosion Factor (R). The ability of rain to cause erosion is known as rain erosivity. Rain erosivity factor is the result of the multiplication of the kinetic energy (E) of a rain event with a maximum rainfall intensity of 30 minutes (I30). The EI30 value obtained from each rain event is a measure of the erosion power of rain for the period or season concerned (Arsyad, 2012). Due to the very limited distribution of automatic rain gauges, other methods of determining EI30 using rainfall records are generally available. Lenvain (1975 in Bols, 1978) obtained the relationship between EI30 and annual rainfall (R) as follows:

$$EI_{30} = 2{,}34\ R^{1{,}98} \qquad (2)$$

while Bols (1978) developed the EI30 estimator equation as follows:

$$EI_{30} = 6{,}119\ (RAIN)_m^{1.21} \cdot (DAYS)_m^{-0{,}47} \cdot (MAXP)_m^{0{,}53} \qquad (3)$$

Where :
EI30 = monthly rainfall erosion index
RAINm = average monthly rainfall (cm)
DAYSm = average number of rainy days per month
MAXPm = maximum rainfall for 24 hours in the month concerned (cm)
Annual EI30 or the value of R (rain erosivity) a year is obtained by adding up the monthly EI30 for a year (Arsyad, 1989).

Soil Erodibility Factor (K). Soil erodibility factor (K) is the sensitivity of the soil to erosion which indicates whether or not it is easy to erode the soil which is determined by various physical and chemical properties of the soil (Arsyad, 1989). If there is no field experimental data, then the K value can be calculated using the following equation (Arsyad, 2012):

$$K = 1{,}292\ [\ 2{,}1\ M^{1{,}14}\ (10^{-4})\ (12\text{-}a) + 3.25(b - 2) + 2{,}5\ (c\text{-}3)\ ]\ /\ 100 \qquad (4)$$

Where :
K = soil erodibility value
M =% very fine sand and dust (diameter 0.1 - 0.05 and 0.05 - 0.02 mm) x (100 - % clay)
a =% organic matter (% C organic x 1.724)
b = code (value) of soil structure
c = code (value) soil permeability (can be seen in Table 2)

Table 1. Assessment of Soil Structure (Hammer, 1979)

No.	Structure Type	Score
1	Granular sangat halus (< *1 mm*)	1
2	Granular halus (*1 - 2 mm*)	2
3	Medium to coarse granular (2 - 10 mm)	3
4	Gumpal blok, blocky, plat, masif	4

Source: Hardjowigeno and Widiatmaka (2007)

Table 2. Soil Permeability Assessment

No.	Permeability Class	cm / hour	Score
1	Fast (rapid)	> 25,4	1
2	Medium to fast (enough to rapid)	12,7 – 25,4	2
3	Medium (enough)	6,3 – 12,7	3
4	Medium to slow (enough to slow)	2,0 – 6,3	4
5	Slow (slow)	0,5 – 2,0	5
6	Very slow (very slow)	< 0,5	6

Source: Hardjowigeno and Widiatmaka (2007)

The K value classification (soil erodibility) can be seen in Table 3 below.

Table 3. Classification of Soil K Value.

No.	K value	Dignity
1	0,00 – 0,10	Very low
2	0,11 – 0,21	Low
3	0,22 – 0,32	Moderate
4	0,33 – 0,44	It's a little tall
5	0,45 – 0,55	High
6	0,56 – 0,64	Very high

Source: Arsyad (2012).

Slope Length Factor (L). Arsyad (1989) states that L value is the ratio of the amount of erosion of a slope to the amount of erosion from a slope with a length of 22 meters, so the value of L can be stated as follows:

$$L = (X/22)^m \qquad (5)$$

where X is the length of the slope in meters, and m is a constant equal to 0.5 for slopes whose steepness is> 5%; 0.4 for slopes 3.5 - 4.5%; 0.3 for the slope steepness 1 - 3%; and 0.2 for slopes <1%.

Slope steepness factor (S). Arsyad (2010) explains more about the steepness of the slope which is expressed in degrees of slope angle or percent. If you use the slope steepness in percent, the equation for the factor S becomes:

$$S = \frac{0,43 + 0,30s + 0,04s^2}{6,613} \qquad (6)$$

where S is the steepness of the slope in percent. The LS value for a land can be calculated with the following equation:

$$LS = \sqrt{x}\ (\ 0,0138 + 0,00965s + 0.00138s^2) \qquad (7)$$

where x is the length of the slope in meters, and s is the steepness of the slope in percent.
However, in practice, the L value and S value are calculated at the same time as a LS factor. LS is the ratio between the amount of erosion on a plot of land with a certain slope length and steepness to the amount of erosion from identical soil located on a slope with a length of 22 m and a steepness of 9% (Asdak, 2004). The assessment of the LS value is presented in Table 4 below.

Table 4. Slope Class Assessment (LS Factor).

No.	Slope (%)	LS Score
1	0 - 8	0,25
2	8 - 15	1,20
3	15 - 25	4,25
4	25 - 45	9,50
5	> 45	12,00

Source: Hardjowigeno and Widiatmaka (2007)

Plant Management Factor (C). Basically, the determination of the magnitude of the C index is very complicated because it must consider the nature of plant protection against rain erosivity. P factor (Soil Conservation Engineering). The P factor is the ratio of the amount of soil erosion with a certain conservation measure to the amount of erosion of the treated soil according to the slope direction. P factor values for various soil conservation measures.

2.2. The need to establish a maximum permissible erosion limit (Edp)

Determination of the maximum permissible rate of erosion rate is necessary because erosion that occurs beyond the permissible erosion causes a decrease in soil fertility and land quality (Arsyad, 2012). Wood and Dent (1983), proposed an equation for calculating Edp, taking into account the minimum depth of soil and the speed of the soil formation process as follows:

E d p =	DE - Dmin / Soil sustainability	Soil Formation Speed

(8)

Where :

Edp = allowed erosion
DE = equivalent depth (effective depth x depth factor)
Dmin = minimum allowable soil depth

Arsyad (1989) expresses his opinion that if the rate of erosion that will occur can be estimated and the allowable erosion rate (Edp) can be determined, then the policy of land use and soil conservation measures needed can be determined so that soil damage does not occur and the soil can be used productively. and sustainable. Soil conservation and land use measures that are chosen and implemented are those that can reduce the rate of erosion to equal or less than the permissible erosion (Edp).

2.3. Erosion Hazard Level (TBE) as an indicator of damage to farmers' agricultural land

The maximum amount of land lost in order for land productivity to remain sustainable, basically must be less than or equal to the amount of land formed through the process of soil formation. Usually the sloping area is located in the upstream area of a watershed where the amount of land lost is (almost) always greater than the land formed (Hardjowigeno and Widiatmaka, 2007). To determine TBE, the Ministry of Forestry (1986) used an approach to soil solum thickness and the amount of erosion as a basis. The shallower the soil solum means that there is less soil that can be eroded, so that the level of erosion hazard is quite large even though the lost soil (erosion size = A) is not too large (BBSDLP, 2011). TBE assessment based on the thickness of soil solum and the magnitude of the erosion hazard is presented in Table 5.

Table 5. Erosion Hazard Level Based on the Thickness of Soil Solum and the Amount of Erosion Hazard (Maximum Amount of Erosion, A).

No.	Soil Solum Thickness (cm)	Maximum Erosion (A) = tonnes / ha / year				
		< 15	15 – 60	60 – 180	180 – 480	> 480
1	> 90	SR	S	S	B	SB
2	60 – 90	R	B	B	SB	SB
3	30 – 60	S	SB	SB	SB	SB
4	< 30	B	SB	SB	SB	SB

Source: Ministry of Forestry (1986); BBSDLP, 2011).
Shell: SR = very light, R = light, S = moderate, B = heavy, SB = very heavy

2.4. Loss of Nitrogen, Phosphorus and Potassium (NPK) Nutrients Due to Erosion

Nitrogen is the main nutrient needed by plants in large quantities during their growing period. Nitrogen nutrients are highly mobile nutrients, easily washed by water flows during the rainy season or collect on the surface and then evaporate during the dry season. The movement of nitrogen to a deeper layer of soil will make it very difficult for the roots to absorb it, especially if the cultivated plants have shallow roots like vegetable plants (Sipahutar, 2013).When there is a severe lack of N it will stop the growth and reproduction process. Lack of N is one cause of stunted plants (Nyakpa, et al., 1988).

Phospor (P) is the second essential element after N which plays an important role in photosynthesis and root development. The availability of phosphorus in rare soils that exceeds 0.01% of total P. Most of the phosphate forms are bound by soil colloids so that they are not available to plants (Ginting et al., 2012). There are several ways to lose P from the soil, namely: (1) transported by plants, (2) washing and (3) erosion. The loss of P nutrients through erosion is relatively greater than the loss by other factors (Poerwanto and Anas, 2014).Nyakpa, et al. (1988) stated that potassium functions to strengthen the straw so that plants do not fall easily, increase production and improve yield quality, increase plant resistance to disease attacks. If these essential nutrients are not sufficient for plants, it will result in low production.

3. Methods

This type of research is quantitative research. The research was conducted in several areas in North Sumatra, Indonesia. Data analysis was carried out by testing the amount of erosion carried out using a comprehensive soil loss prediction equation approach. The approach put forward in The Universal Soil Loss Equation (USLE) which has been revised according to Smith et al. (2007) in Hardjowigeno and Widiatmaka (2007) are:

$$A = R \times K \times L \times S \times C \times P \qquad (9)$$

Where :
A = estimated erosion that occurred (tonnes / ha / year)
R = rainfall and runoff factor (rain erosivity)
K = soil erodibility sensitivity factor
LS = slope length and slope factor
C = land cover management factor (plant)
P = soil management action factor (soil conservation)

Determination of permissible erosion is calculated based on the equation proposed by Wood and Dent (1983) in Hardjowigeno and Widiatmaka (2007) with the following formula:

$$Edp = \frac{DE - Dmin}{\text{Soil sustainability}} \quad \text{Soil Formation Speed}$$

(10)

Where :
Edp = allowed erosion
DE = equivalent depth (effective depth (mm) x depth factor)
Dmin = minimum soil depth (mm) allowed
Soil formation rate is the average soil formation process in Indonesia estimated at about 1.00 mm / year.

4.Result and Discussion

4.1. Result

4.1.1. Erosion Danger Level (TBE) Analysis

The soil solum thickness approach and the amount of erosion are used as the basis for analyzing the level of erosion hazard. Solum depth is the thickness of the soil above the soil parent material, which consists of horizons A and/or B). The shallower the soil solum means that there is less soil that can be eroded, so that the level of erosion hazard is quite high, even though the lost soil (erosion hazard = A) is not too large (Hardjowigeno and Widiatmaka, 2007).The assessment of the level of erosion hazard is based on the thickness of the soil solum and the magnitude of the erosion hazard. By determining the TBE criteria for agricultural land, the actual level of damage to agricultural land will be known. Therefore, TBE can be used as an indicator of damage to farmers' agricultural land.

4.1.2. Analysis of the availability of N-total, P-available, and K-available nutrients

Nutrient data of N-total, P-available and K-available and organic material obtained from laboratory analysis were processed, along with the results of prediction of erosion that occurred at the research location. Data processing is done by converting the amount of erosion that occurs. The amount of erosion that occurs in tonnes / ha / year is converted into tonnes / year. Furthermore, the data of nutrients lost from the soil are processed by multiplying the original soil nutrient content with the amount of eroded soil.

Table 6. Laboratory Analysis Methods for Physical and Chemical Properties of Soil.

No.	Soil Properties	Laboratory Analysis Methods
	Soil Physical Properties::	
1	Texture *	Pipette Method
2	Permeability **	Sample Ring
	Soil Chemical Properties ** :	
1	pH	Potentiometry
2	C Organic	Volumemetry / Walkley
3	N total	Volumemetry / Kjeldahl
4	P is available	Spectrophotometry / Bray 2
5	K is available	AAS / Ammonium acetate 1 N
6	Ca available	AAS / Ammonium acetate 1 N
7	Mg available	AAS / Ammonium acetate 1 N
8	Na available	AAS / Ammonium acetate 1 N
9	KTK	Volumemetry / NaCl 10%
10	KB	Ammonium acetat 1 N

Source:
* Balittanah, Bogor (2017); ** PPKS RISPA, Medan (2017)

Structural Equation Model:
Erosion = -0.680 land biophysics……………………… (11)

This equation shows that the chance of erosion is negatively affected by the biophysical conditions of the land, which is 0.680. A negative sign can be interpreted that there are opposite directions in the two variables. The opposite direction in the equation means that the worse the biophysical condition of the land is represented by the three indicators, namely the steep slope of the topography aspect, the very high annual average rainfall and the types and properties of soil that are sensitive to erosion, the erosion that occurs in horticultural farmers' agricultural land in the upstream area of the Farmer's Sub-watershed will also be higher. Based on the results of the study, 89% of the observation area spread over 25 SPT of 28 SPT has exceeded the permissible erosion limit, only 11% does not exceed the permissible erosion, namely on SPT-12, SPT-17, SPT-26 (can be seen in Table 7).

Table 7. Edp Categories in Each SPT in the Research Location

No.	Category	SPT	Total SPT	(%)
1	**A > Edp**	SPT - 1, SPT - 2, SPT - 3, SPT - 4, SPT - 5, SPT - 6, SPT - 7, SPT - 8, SPT - 9, SPT - 10, SPT - 11, SPT - 13, SPT - 14, SPT - 15, SPT - 16, SPT - 18, SPT - 19, SPT - 20, SPT - 21, SPT - 22, SPT - 23, SPT - 24, SPT - 25, SPT - 27, SPT - 28	25	89
2	**A < Edp**	SPT - 12, SPT - 17, SPT - 26	3	11
		Total	28	100

Source: Results of data processing

If the permissible rate of erosion and erosion rate (Edp) have been determined, then the policy of land use and soil conservation measures needed can be determined to avoid land degradation.The level of erosion hazard (TBE) in the study area also shows that TBE, which is dominated by TBE, is very severe (Table 8). This illustrates the condition of the upstream area of the Farmer's Sub-watershed which is very vulnerable and has the potential for serious land degradation which in turn will affect the land productivity of horticultural farmers in this area.

Table 8. TBE Categories in 28 SPT in the Upstream Area of Farmer's Sub-Watershed.

Category	SPT	SPT Total	(%)
SR	SPT - 12	1	4
R	Empty	-	0
S	SPT - 3, SPT - 17, SPT - 22, SPT - 26	4	14
B	SPT - 8, SPT - 9, SPT - 10, SPT - 13, SPT - 27	5	18
SB	SPT - 1, SPT - 2, SPT - 4, SPT - 5, SPT - 6, SPT - 7,	18	64
	SPT - 11, SPT - 14, SPT - 15, SPT - 16, SPT - 18,		
	SPT - 19, SPT - 20, SPT - 21, SPT - 23, SPT - 24,		
	SPT - 25, SPT - 28		
	Total	**28**	**100**

Source: Ministry of Forestry (1986); BBSDLP, 2011).
Shell: SR = very light, R = light, S = moderate, B = heavy, SB = very heavy

The results of these studies indicate that the degradation of agricultural land in the upstream area of the Farmer's Sub-watershed is dominated by erosion problems. Without permanent protection of productive agricultural land, horticultural crop cultivation activities cannot take place sustainably. The relationship between the two variables in this equation can be proven based on the results of the research that has been done and can be seen in Table 9.

Table 9. Relationship Between Variable Biophysical Conditions of Land and Erosion in terms of Very Steep Topography

SPT	1. LAND BIOPHYSICS			2.EROSION		
	Topography	CH Annual average	Sensitivity Soil	Erosion Prediction = A. (tonnes / ha / year)	Edp	TBE
SPT - 5	very steep	very wet	sensitive	3192.88	A >Edp	SB
SPT - 10	very steep	very wet	sensitive	415.07	A >Edp	B
SPT - 14	very steep	wet	very sensitive	1527.94	A >Edp	SB
SPT - 19	very steep	wet	very sensitive	1086.53	A >Edp	SB
SPT - 24	very steep	very wet	very sensitive	11302.79	A >Edp	SB
SPT - 28	very steep	very wet	very sensitive	1532.58	A >Edp	SB

Source: Research results, processed data.

SPT-5, SPT-10, SPT-14 and SPT-19, SPT-24 and SPT-28 have a very steep topography where the average annual rainfall includes wet to very wet climates with variations in soil sensitivity to erosion classified as sensitive to very sensitive. The four SPTs show that the erosion that occurs in the SPT exceeds the permissible erosion with the level of erosion hazard that occurs classified as heavy to very severe. In Table 9 it can be seen that the rate of erosion that occurred at SPT-14 was classified as very heavy, namely 1527.94 tonnes/ha/year. The driving factors for the high rate of erosion at this SPT are the slope steepness factor where the slope is 46%, the annual rainfall is quite high (2841.4 mm/year is classified as wet) and the soil type is Regosol which has soil properties that are very sensitive to erosion. Taken together, these factors interact with each other resulting in serious damage to agricultural land. Adimihardja (2013) explains the phenomenon of agricultural land with slopes of more than 15%, even more than 100%, the rate of erosion is certain to be very high due to high rainfall. Asdak (2004) added that the kinetic energy of rain is the main factor for the peeling off and the transport of soil particles from their aggregates (erosion mechanism).Damage conditions that occur on agricultural land can be seen in Figure 1 below.


Figure 1. Degradation of agricultural land due to very heavy erosion impacts on SPT-14 in Merdeka District.

Therefore, in using a plot of land to become agricultural land, the biophysical aspect needs to be managed seriously so that the biophysical conditions of the land do not become an obstacle in farming management. One of these management is to follow the directions of soil conservation measures aimed at maintaining the sustainability of the horticultural crop farming system in the upstream area of the Farmer's Sub-watershed. Proper land management often requires changes in other use patterns either mechanically or vegetatively or even adopting adaptive commodity alternatives to achieve optimal agricultural yields or often called agricultural land manipulation. Through biophysical manipulation of the land, either in the form of changing the shape of the steep land topography through the creation of terraces, rorak to accommodate excessive rainwater or changing plant types that are more suitable to the potential of the land. The slightest shape given to the land will change the land.

Table 10. Relationship Between Variable Biophysical Land Conditions and Erosion

SPT	1. LAND BIOPHYSICS			2. EROSI		
	Topography	CH Annual average	Sensitivity Soil	Erosion Prediction = A. (tonnes / ha / year)	Edp	TBE
SPT - 3	flat	wet	a little sensitive	48.02	A >Edp	S
SPT - 8	flat	very wet	sensitive	144.86	A >Edp	B
SPT - 12	flat	wet	sensitive	13.72	***A <Edp***	SR
SPT - 17	flat	wet	not sensitive	24.76	***A <Edp***	S
SPT - 22	flat	very wet	sensitive	116.41	A >Edp	S
SPT - 26	flat	very wet	very sensitive	21.06	***A <Edp***	S

Source: Ministry of Forestry (1986); BBSDLP, 2011).

Shell: SR = very light, R = light, S = moderate, B = heavy, SB = very heavy

In contrast to the actual biophysical conditions which have a flat topography, the average annual rainfall is wet to very wet with soil properties classified from insensitive to very sensitive resulting in erosion rates ranging from 13.72 tonnes / ha / year to 144.86tonnes / ha / year (Table 10). The amount of erosion that occurs is much lower than the biophysical land with a very steep topography, namely 415.07 tonnes / ha / year to 11,302.79 tonnes / ha / year. The erosion that occurs in SPT-12, SPT-17 and SPT-26 does not exceed the permissible erosion where the erosion that occurs is 13.72 tons / ha / year, 24.76 tons / ha / year and 21.06 tons / ha / year respectively. The level of erosion hazard is dominated by moderate erosion. The results showed that on land with a flat topography of 2%, the rate of erosion that occurred was very light. In SPT-12, erosion that occurs on agricultural land is only 13.72 tonnes /ha / year (classified as very light based on the classification of erosion hazard levels).

Figure 2. Papaya and Banana Farming in flat topography in SPT-12, Namorambe District.

This is due to the flat topography, even though the rainfall that occurs is quite high (wet), namely 2786.6 mm/year, but the raindrops that cause the splash will be evenly distributed in all directions but on the contrary, on very steep land due to splashing raindrops, the soil will be thrown down according to the slope of the land. The evenly distributed splash causes very light erosion (Figure 2). This is in line with the opinion of Yustika and Dariah (2010), climatic factors, especially rainfall, determine the level of erosion in an area due to the kinetic energy of rainwater droplets.This condition is very dangerous for the sustainability of horticucture farming which is dominated by seasonal plants with shallow roots in the upstream area of the Farmer's Sub-watershed if preventive measures are not taken. Erosion that occurs must be endeavored to reach erosion that does not exceed the permissible erosion (Edp) so that the level of erosion hazard (TBE) is also classified as very light.

Second Equation:

Loss of NPK due to erosion = 0.570 biophysical land + 0.314 erosion…………………….. (12)

The structural equation model indicates that the NPK nutrient loss due to erosion is influenced by land biophysical latent variables and erosion latent variables with the magnitude of the influence of each variable being 0.570 and 0.314. Both of these variables have a positive effect. This means that if the biophysical conditions of the land are properly managed, it will prevent nutrient loss by 0.570. Therefore, horticultural farmers must strive for the biophysical conditions of their agricultural land to support plant growth so that there is no loss of nutrients due to erosion of 0.570. Likewise, the latent variable of erosion has a positive influence on the presence of nutrients, meaning that if a farmer wants nutrient conditions to be maintained properly, horticultural farmers must protect their agricultural land so that the erosion that occurs does not exceed the permissible erosion so that it can withstand nutrient loss. NPK of 0.314. The erosion that occurs causes a decrease in the nutrient content of NPK through the topsoil erosion process.

The results of the study prove that SPT-5, SPT-10, SPT-14, SPT-19, SPT-24 and SPT-28 with very steep topographic biophysical conditions, the climate is classified as wet to very wet and the soil sensitivity is very sensitive to erosion. loss of NPK due to high erosion, wherein SPT 5 showed a total N-loss of 11,175.1 kg / ha, loss of available P-21.2 kg / ha and loss of available K of 46.07 kg / ha. Likewise, the SPT-10 showed a total N-loss of 3,901.7 kg / ha, a loss of available-P was 2.23 kg / ha and a loss of K-available was 4.53 kg / ha. Furthermore, the SPT-14 showed a total N-loss of 5,806.2 kg / ha, loss of available-P was 54.49 kg / ha and loss of available K was 16.09 kg / ha. SPT-19 showed a total N-loss of 6,301.9 kg / ha, loss of available-P was 31.04 kg / ha and loss of K-available was 38.56 kg / ha. SPT-24 showed total N-loss of 24,866.1 kg / ha, loss of available P of 495.97 kg / ha and loss of available K of 132.24 kg / ha. The SPT-28 showed a total N-loss of 2,452.1 kg / ha, loss of available-P was 8.71 kg / ha and loss of K-available was 38.85 kg / ha.

This condition is very dangerous for the sustainability of horticucture farming, especially on agricultural land which is dominated by shallow-rooted seasonal crops. This is because erosion takes place on top soil which has a very important meaning for plant growth and development because it contains various nutrients as plant food ingredients (Hardjowigeno et al., 2007). In addition, heavy to very heavy erosion that takes place continuously causes soil to be eroded in the surface layer so that over time it will cause the appearance of rocks on the surface. This occurs because the top soil layer has been lost so that the rocks that are in the lower layer appear to the soil surface or it can occur due to the erosion process where the heaviest particles carried by erosion will stay in the soil surface layer (Sitorus, et al., 2010). Figure 3. shows the emergence of rock on the land surface due to very heavy erosion. The appearance of rocks on the soil surface is one indicator of land degradation due to erosion which has an impact on the loss of NPK nutrients.

Figure 3. The appearance of rocks on the land surface due to very heavy erosion.

Therefore, to overcome the loss of NPK nutrients in agricultural land in the upstream area of the Farmer's Sub-watershed, erosion control measures are needed so that the erosion that occurs does not exceed the permissible erosion. One of the erosion control measures that are still relevant is soil conservation measures both vegetatively and mechanically adjusted based on land needs and the ability of farmers both economically and knowledgeably in their application.

4.2. Discussion

The release and separation of particles from the soil mass occurs when raindrops hit the soil surface. When heavy rains hit the soil surface continuously, it severely weakens the soil (Morgan, 2005) so that erosion is one of the main causes of decreased productivity of dry land, especially cultivated for seasonal crops (Abdurachman and Sutono, 2005; Kurnia et al., 2005). Hardjowigeno and Widiatmaka (2007) explain that the causative factor is that the most vital part of the soil is the top soil. Top soil generally only has a thickness of about 15 to 30 cm or more or less an inch. However, it has a very important meaning because it contains various "food ingredients" for plant growth and development such as organic matter (humus) and various mineral nutrients. Soil erosion has a negative impact on agricultural production, water quality sources, and soil (Fayas, et al 2019). Impacts where erosion occurs, namely loss of soil from a land, depletion of nutrients, and reduced depth of arable soil. Erosion also reduces soil moisture making conditions more prone to drought.

The immediate effect is that land productivity decreases, which limits what can be planted and leads to increased expenditure on fertilizers to maintain yields. The loss of soil fertility through erosion ultimately leads to abandoned or critical land (Gilsdottir and Stocking, 2005). Erosion removes the most productive active chemical parts (such as organic matter and clay fractions) from the soil so that in the end, yields and soil fertility also continue to decline due to erosion (Bronick and Lal, 2005). In addition, over time, erosion also causes rocks that are in the lower layer to emerge to the soil surface because the top soil layer has been lost where the heaviest soil particles will stay in the soil surface layer. The more rock on the surface causes less arable area. Rocks on the surface will affect land use and management. In addition, the more rocks make it more difficult to cultivate the soil, so that the more the percentage of rock on the surface indicates that the land conditions are increasingly critical (Sitorus et al., 2010). In dealing with soil damage caused by erosion rates at a dangerous level, it is necessary to study in depth the factors involved in the erosion process. These factors are climate, soil characteristics, topography and ground cover vegetation and soil conservation measures.

Climate greatly affects plant growth. A suitable climate is one of the factors that determines the achievement of optimal growth / production. The influence of climate on erosion is through the kinetic power of rainwater, especially the intensity and diameter of rainwater droplets (Asdak, 2004). Furthermore, Harto (1993) explained that a very high intensity of rain will have a very large destructive power to the release of soil aggregates into smaller particles that are easy to be washed away. Soil characteristics. Soil characteristics that play a role in the process of erosion are soil texture, organic matter, soil structure and soil permeability. Soil texture is usually related to the size and pores of soil particles. Soil with large aggregate particles has a large resistance to the carrying capacity of surface runoff because it requires a large amount of energy to transport these soil particles (Asdak, 2004). Erosion affects soil texture due to the selection of soil particle separation (Bronick and Lal, 2005). Organic matter is an important component of soil that keeps soil particles together so that it will create resistance to soil erosion. Li et al. (2018) refer to the ideas of Gholami, Sadeghi, and Homaee (2016) and Lalande, Gagnon, Simard, and Cote (2000) which emphasize that organic matter will increase enzyme activity and microbial biomass thereby reducing splash erosion and delays in surface runoff. Adiningsih (1988) also states that organic matter has an important role in maintaining the stability of soil aggregates. Soil structure is highly influenced by climate change, biological activities, and soil management practices, and is very sensitive to mechanical and physicochemical destructive forces. Hardjowigeno (2010) explains that the soil structure must not be easily damaged (steady) so that the soil pores do not close quickly when there is rain. Improvement of soil structure also supports an increase in fertilization efficiency, because plant roots can develop well, so that nutrient absorption is maximized (Oyedele, Schjonning, Sibbesen, & Debosz, 1999). Soil permeability is an indicator of the soil's ability to pass water (Asdak, (2004). The reduced permeability rate of the soil results in less rainwater entering the soil and greater surface flow. Slope and slope length are two factors that determine the topographical characteristics of an area. river flow. These two factors determine the velocity and volume of surface runoff. The longer the slope, the greater the erosion that occurs (Arsyad, 2012). The steeper the slope will increase the amount and velocity of surface runoff, thereby increasing the water transport energy resulting in more grain numbers. soil grains that are splashed down by the impact of the grains.

Plant roots act as a stabilizer for aggregates and increase soil porosity. Roots also have the function of "grasping" the soil mass so that it affects the value of the shear strength. Therefore, soil with good plant roots has a high ability to pass water to the lower layers and also has high resistance to water damage. However, the influence of vegetation varies depending on the type of plant, roots, plant height, crown, and growth rate (Rahim, 2006). Cover crops will allow the soil to absorb water more efficiently due to increased water-holding and filtering capacity (Taguas et al., 2010), in addition an abundant network of cover crop roots keeps the soil in place. The existence of good vegetation and plant cover, such as thick grass and dense forest can eliminate the influence of topography on erosion. Plants that cover the ground tightly don't just slow down the flow. The actions that humans give to the soil and the vegetation on it will determine the quality of that land. Any action directed at the sustainable use of natural resources can be interpreted as a conservation action. Conservation is an action to prevent the depletion of natural resources by means of moderate extraction so that in the long term natural resources remain available. Included in conservation measures are planting in strips, cultivating land according to contours, mounds and terraces, planting ground cover crops, etc. (Arsyad, 1989).

5. Conclussion

The results showed that the highest prediction rate of erosion that occurred in the upstream area of the Farmer's Sub-watershed was 11,302 tonnes / ha / year (classified as very heavy) or equivalent to 941.9 mm / year in SPT-24 cultivating banana plants, which had a negative average income, namely in the amount of IDR. 805,895.75 while the lowest erosion rate prediction is 13.72 tonnes / ha / year at SPT-12 or equivalent to 1.14 mm/year (classified as very light) where SPT-12 cultivates banana and papaya has an average income of IDR 10,820,367.

The results showed that the highest permissible erosion value in the upstream area of the Farmer's Sub-watershed was 54.40 tonnes / ha / year at SPT-27, while the lowest permissible erosion value was 16.96 tonnes / ha / year where the number of SPTs that were classified as exceeding Edp was 89. % which means the upstream area of the Farmer's Sub-watershed has an erosion problem on cultivated land. Erosion Danger Level (TBE) in the upstream area of the Farmer's Sub-watershed is dominated by heavy to very heavy groups. The erosion hazard level with the heavy group is found in SPT-8, SPT-9, SPT-10, SPT-13, and SPT-27 while the erosion hazard level with the very heavy group is 67.85% which is spread over SPT-1, SPT-2, SPT-4, SPT-5, SPT-6, SPT-7, SPT-11, SPT-14, SPT-15, SPT-16, SPT-18, SPT-19, SPT-20, SPT-21, SPT- 22, SPT-23, SPT-24, SPT-25, and SPT-28.

Based on the results of the TBE evaluation, it can be concluded that the damaged land is 15.38 ha and the land still suitable for development for pineapple, papaya, chilli, cabbage farming is 5.38 ha. The highest content of nitrogen nutrients lost due to erosion was found in SPT-21 followed by SPT-1, SPT-2, SPT-3, SPT-8, SPT-12, SPT-28 while the highest loss of phosphorus nutrient content due to erosion was found on SPT-1, SPT-2, SPT-3, SPT-4, SPT-5, SPT-8, SPT-9, SPT-10, SPT-11, SPT-13, SPT-21, SPT-28 followed by SPT -26. Potassium content lost due to high erosion rates is found in SPT-1, SPT-2, SPT-3, SPT-1, SPT-4, SPT-5, SPT-8, SPT-9, SPT-10, SPT- 13, SPT-14, SPT-15, SPT-18, SPT-20, SPT-21, SPT-22, SPT-24, SPT-25, SPT-26, SPT-27.

The highest economic loss due to the total loss of NPK nutrients was found in SPT-24, namely IDR 76,631,786 (assuming the price of Urea is IDR 3,000 / kg; SP-36 fertilizer is IDR 2,500 / kg; KCl fertilizer is IDR 6,000 / kg) with erosion rate of 11,302 tons / ha / year, followed by SPT-25 which is IDR 39,479,706, SPT-16 which is IDR 39,455,508, SPT-7 is IDR 36,075,377, SPT-2 is IDR 35,636,536, SPT-5 is IDR 33,854,681, SPT-11 is IDR 26,583,243, SPT-15 is IDR 22,364,299, SPT-19 is 19,214,593, SPT-14 is IDR 17,651,267, SPT-20 is IDR 16,925,795 and SPT-23 is IDR 10,079,606.This shows that the greater the rate of erosion that occurs, the higher the economic loss through fertilization to restore the NPK nutrient losses due to erosion. Meanwhile, the lowest economic loss was found in SPT-12, namely IDR 66,003 with an erosion rate of 13.72 tons / ha / year, followed by SPT-3 at IDR 248,683, SPT-17 amounting to 370,144 and SPT-26 amounting to IDR 475,742. The lower the rate of erosion, the smaller the economic losses that will occur.

Recommendations for farmers that are suggested based on the results of research to increase farmers' income and welfare so that the sustainability of farming is guaranteed in the upstream area of the Farmer's Sub-watershed, namely:

[1]. Selection of more suitable (adaptive) plant types based on the results of land suitability evaluation by considering the actual land quality.

[2]. Strive to reduce the rate of erosion that occurs on land with a severe to very severe erosion hazard level by implementing adequate soil conservation measures.

[3]. Agricultural land with steep to very steep slopes should not be planted with shallow root crops such as vegetables.

[4]. If agricultural land with a slope of steep to very steep slopes is still cultivated, it is better if the types of plants that have deep and strong roots, such as fruit trees, are selected.

The support of all stakeholders involved in farming activities of horticultural farmers is needed to achieve the goals of a sustainable and sustainable horticultural farming system in the upstream area of the Farmer's Sub-watershed. Farmers as managers should have an understanding of the characteristics and quality of the land they own so that they can manage their agricultural land appropriately based on existing land conditions through various media and facilities currently available.

REFERENCES

Abdurachman, A. and S. Sutono, (2005). Scaled Land Erosion Control Technology. In Dry Land Management Technology: Towards Productive and Environmentally Friendly Agriculture. P. 103-146. Center for Land and Agro-climate Research and Development. Bogor.

Adiningsih, J.S. (1988). The Role of Agricultural Waste, Especially Straw in the Application of Balanced Fertilization. In the Proceedings of the Soil Research Technical Meeting. Cipayung, 18-20 March 1986. Pages 203 - 215. Soil Research Center, Bogor.

Arsyad, S. (1989). *Soil and Water Conservation*. UPT Production of Information Media. Information Resources Institute - IPB. Bogor.

Arsyad, S. (2010). *Soil and Water Conservation*. Bogor Agricultural Institute. Bogor.

Arsyad, S. (2012). *Soil and Water Conservation*. Second Edition. Revision. Publisher IPB Press.

Asdak, (2004). *Hydrology and Watershed Management*. Publisher GadjahMada University Press.

Wampu Watershed Management Center (BP DAS), SeiUlar. (2013). *Delivered at the Workshop on the Compilation of the General Plan for Integrated Watershed Management for the Deli Watershed*. The Garuda Plaza Hotel, December 2013.

Bols,P.L.(1978).TheIso-erodentMapofJavaandMadura.ReportTechnical Assistance Project. ATA105-Soil ResearchInstitute. Bogor, Indonesia.

Bronick, C.J. and R. Lal. (2005). Soil structure and management: a review. *Geoderma*.124: 3-22

Crook,C. andClapp, R.A.1988. *Ismarket-*

orientedforestconservationacontradictionin terms?.*EnvironmentalConservation*. 25(2) 131-145.

Ministry of Forestry., Ditjen RRL, (1986). Implementation Guidelines for the Preparation of Field Technique Plans for Land Rehabilitation and Soil Conservation. Ministry of Forestry, Jakarta.

Fayas, C. M., Abeysingha, N. S, Nirmanee, K. G. S., Samaratunga, D. and Mallawatantri, A. (2019). Soil loss estimation using RUSLE model to prioritize erosion control in KELANI river basin in Srilanka. International Soil and Water Conservation Research, 7 (2), 130-137.

Gholami, Sadeghi, and Homaee. (2016). Different effects of sheep manure conditioner on runoff and soil loss components in eroded soil. Elsevier Journal. CATENA. Volume 139, April 2016, Pages 99-104.

Gilsladottir, G., and Stocking, A. M. (2005). Land Degradation Control and its Global Environmental Benefits. Land Degradation and Development 16: 99-112. 001: 10.1 00211dr.687 Global Land Project (GLP). 2005. Global land project: Science plan and implementation strategy. IGBP Report No. 53 / 1HDP Report No. 19. IGBP, Stockholm, Sweden.

Ginting, R.C.B., R. Saraswati, and E. Husen. (2012). *Phosphate Solubilizing Microorganisms. Agricultural Research and Development Agency*, Ministry of Agriculture.

Haeron, E.H. (2010). Directions for Managing Land Resources in Anticipating Climate Change and Land Degradation in Relation to Sustainable Agricultural Development. Inside: Land Potential and Environmental Management. *Proceedings of the National Seminar on Agricultural Land Resources*; Bogor, 30 November - 1 December 2010. Center for Agricultural Research and Development, Ministry of Agriculture. P. 27-39.

Hardjowigeno. (2010). *Geology*. New edition. Publisher CV AkademikaPressindo. Jakarta.

Harto, S. (1993). *Hydrological Analysis*. Publisher GramediaPustakaUtama. Jakarta.

Kartasapoetra, A. G. (1989). *Damage to Agricultural Soil and Efforts to Rehabilitate It*. Publisher Bina Aksara. Jakarta.

Lalande, R., Gagnon, B., Simard, R. R., dan Cote, D. (2000). Soil microbial biomass and enzyme activity following liquid hog manure application in a long - term field trial.*Canadian Journal of Soil Science*, 80(2), 263-269.

Li,M., Wang, Y.K., Xu, P.,Fu, B.,Tian, C.S., & Wang, S. (2018). Cropland physicaldisturbance intensity: Plot-scale measurement and its application for soilerosion reduction in mountainous areas. *Journal of Mountain Science*, 15(1),198-210..https://doi.org/10.1007/s11629-017-4574-x.

Morgan, R.P.C. (2005). *Soil Erosion and Conversation. Third Edition.*National Soil Resources Institute, Cranfield University. Blackwell Publishing Ltd.

Nyakpa, M. Y., A. M. Lubis, Mamat Anwar Pulung, A. GhaffarAmrah, Ali Munawar, Go Ban Hong, Nurhajati Hakim. (1988). *Nitrogen supply*. Publisher, University of Lampung. Lampung.

Oyedele, D. J., Schjonning, P., Sibbesen, E., &Debosz, K. (1999). Aggregation and organic matter fractions of three Nigerian soils as affected by soil disturbance and incorporation of plant material. *Soil and Tillage Research*, 50(2), 105-114.

Poerwanto, R. and A. D. Susilo. (2014). *Horticultural Technology*. Series 1 Tropical Horticulture. PT. Publisher IPB Press. Bogor.

Rahim, S. E., (2006). *Soil Erosion Control in the Framework of Environmental Conservation*. Publisher PT. Earth Literacy. Jakarta.

Sipahutar, I., L. R. Widowati, and F. Agus. (2013). Dynamics of Nutrient N, P and K on Vegetable Cropping Patterns in the Dieng Plateau. Proceedings of the National Seminar on Increasing the Productivity of High Datan Vegetables. Center for Research and Development of Agricultural Land Resources. Agricultural Research and Development Agency. Ministry of Agriculture.

Sitorus, S., Mashudi and O. Haridjaja. (2010). Development of Criteria and Classification of Critical Land and its Relationship with Land Productivity in Bogor Regency. *Proceedings of the National Seminar on Agricultural Land Resources. Book I. Land Potential and Environmental Management. Research and Development Center for Agricultural Land Resources, Agricultural Research and Development Agency*, Ministry of Agriculture. 2013. Bogor, 30 November - 1 December 2010. Page: 259-276.

Sutedjo, M.M. (2002). *Fertilizers and Fertilization Methods*. Rineka Cipta Publisher, Jakarta.

Taguas, E.V., Pena, A., Ayuso, J.L., Perez, R., Yuan, Y., &Giraldez, J.V. (2010). Rainfall variability and hydrological and erosive response of an olive tree microcatchment under no-tillage with spontaneous grass over in Spain. Earth Surface Processes and Landforms: *The Journal of The British Geomorphological Research Group*, 35(7), 750-760.

Wood, S.R., dan F.J. Dent. (1983). Soil survey and Land Evaluation, George Allen & Unwin. London

Yustika, R.D. and Dariah, A., (2010). *Erosion Level in Dry and Wet Climates. Soil Research Institute*. Student Army Street No. 12. Bogor 16114.