Estimation of Soil Loss Using Revised Universal Soil Loss Equation in Madagascar

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1. Introduction

Madagascar, located approximately 400km east of Africa is the world's fourth largest island. Because of its isolation it is occupied by some of the most unusual and rare species of plants and animals on earth. However, many plants and animals species are severely endangered due to the deforestation. The problem of deforestation is deep rooted in the agricultural methods that have existed there for centuries. Indeed, in the other hand, this method has given way to severe erosion and descriptions of Madagascar as the Great Red Island. This area loses so much soil to erosion about 400tons/ha/yr (PNUD, 1994). Erosion in the rainy season causes severe damage to one of Madagascar's major areas of irrigated rice cultivation: huge quantities of sand are washed into the canals and rice fields in the lower reaches of the River Betsiboka. As a consequence, these fields are lost to rice production, and considerable erosion damage occurs in the catchment area, sometimes forming canyons several meters deep.

In order to estimate the degree of the soil degradation, we attempt to assess the average quantity of soil loss during a year, computed by Revised Universal Soil Loss Equation (RUSLE) in Mahajanga area, the western part of Madagascar. The physical and morphological properties, climatological conditions and the agricultural activities in Thailand areas are considered for this study (Kingshuk, 1997). The average annual rainfall in the highlands of Northern Thailand is around 1280mm and the amount of runoff is about 384mm per year. The climate in Mahajanga area is characterized by sub-humid-tropical, influenced by orographic system, with 1530mm average annual rainfall. The geology of this area is sedimentary rock formed by marine deposit or continental deposit.

2. Methodologies

To estimate of soil erosion in Madagascar we have to consider three main factors; (i) soil infiltration rate, (ii) runoff and (iii) soil loss. The water balance model is applied to compute surface runoff and soil infiltration rate. This model is stated as; $Pr = E + Ru + I \pm \Delta w$, where: Pr is average annual rainfall (mm), E is average annual actual evapotranspiration (mm) as a function of potential evapotranspiration (ETo), Ru is average annual runoff (mm) and Δw is the reserve in the stock. We used Thornthwaite method for estimation of ETo.

Due to inadequate data in Mahajanga area, we considered the data in Thailand to assess the soil loss using Revised Universal Soil Loss Equation. This area is selected because it has similar annual rainfall amount as Mahajanga area. The equation consists of various factors that influence erosion. It is stated as; $A = RKLSCP$, where: A is soil loss (ton/h/yr), R is rain erosivity factor (m-ton/ha), K is soil erodibility factor, L is slope length factor, S is slope steepness, C is cover-management factor and P is soil conservation practice factor.

3. Results and discussion

Results of runoff and infiltration computed by water balance are shown in the **Table 1**. It illustrated that 55% of rainfall is transformed into runoff and only 7% represents infiltration. The average annual runoff and erosivity index R from the four stations are 817.4mm and 1043m-ton/ha, respectively. And through the physical characteristics and the results obtained in Thailand, we can predict the soil loss in Mahajanga.

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[**]Keywords: Mahajanga, Erosion, RUSLE, Water balance.

Table 1 Hydrous Assessment in Mahajanga areas of Madagascar.

Meteorological Station	Pr (mm)	ETo (mm)	E (mm)	I (mm)	D s (mm)	Ru (mm)
Port-Bérgé (15°34'S)	1525.3	1046.1	701.4	99	-99	823.9
Marovoay (16°07'S)	1506.5	1052.2	711.8	99	-99	794.7
Ambato-Boëni (16°21'S)	1584.1	1041.8	718.5	99	-99	865.6
Mahajanga (15°40'S)	1486	1034.5	700.6	99	-99	785.4

Table 2 illustrated the results of RUSLE in Mahajanga area, using soil formations, physical properties and the agricultural activities in the Northern Thailand. We used global tolerance and erosion classification for Thailand to assess the erosion hazards in Mahajanga (**Table 2**). The results show that the erosion hazard in upland and high land areas for different kinds of soils are almost severe but in forest area it classified very slightly. This result explains that due to the deforestation practice, the erosion hazard is significant in this area.

Table 2 Results of Revised Universal Soil Loss Equation.

Landform	R	K (1)	C (1)	P (1)	LS (1)	Estimation of erosion rate in Mahajanga			
						ton/ha/yr	Tolerance	ton/rai/yr (3)	S.E.C. (4)
Upland	1043	0.16	0.49	1	2.737	223.80	over limit	35.81	severe
	1043	0.21	0.49	1	1.475	158.30	over limit	25.32	severe
	1043	0.21	0.47	1	0.28	28.82	over limit	4.612	slight
	1043	0.27	0.49	1	0.829	114.39	over limit	18.30	moderate
	1043	0.29	0.49	1	2.374	351.85	over limit	56.29	severe
Highland	1043	0.35	0.46	0.8	0.165	22.16	over limit	3.54	slight
	1043	0.31	0.49	1	1.775	281.21	over limit	44.99	severe
	1043	0.31	0.47	0.8	0.152	18.47	over limit	2.96	slight
	1043	0.43	0.47	1	0.73	153.87	over limit	24.62	severe
Forest	1043	0.23	0.23	0.003	1	0.16	acceptable	0.03	very slightly
	1043	0.27	0.27	0.003	1	0.23	acceptable	0.04	very slightly

Note: (1) We consider the morphological properties in Northern Thailand and their agricultural activities. (2) Classification according to Global tolerance rate = 12.5 ton/ha/yr. (3) The rai is the unit of area in Thailand (1ha=6.25rai). (4) Soil erosion classification (S.E.C.) of Thailand (ton/rai/yr); very slightly<1.00, 1.01<slight<5.00, 5.01<moderate<20.00, 20.01<severe<100 and 100.01<very severe<967.

4. Conclusion

The fact of the lack of the physical parameters data in Mahajanga area, we tried to predict the erosion hazard through Thailand data by using RUSLE. The results show that erosion hazard in this area is more serious than in the Northern Thailand, which rose due to the deforestation practice. As a result the erosion rate in the upland and the highland is very high, which sometimes causes the big gully (called lavaka) formed due to the poor vegetation in lands and the change in land use purpose.

Reference

1.Kingshuk R, (1997). Development of a soil loss equation and its applicability in farmlands, PH.D.thesis, Arid Land Research Center. Page118-124.

2.PNUD – World Bank, (1994). Report on environmental situation in Madagascar, Edition, Institute National of the Statistic in Madagascar. Page 62-69.