SOIL EROSION ESTIMATION IN LOWLAND AGRICULTURAL AREAS USING UNIVERSAL SOIL LOSS (USLE) – A CASE IN FELDA JENGKA 15, PAHANG

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ABSTRACT

This short treatise is a small attempt to estimate the amount of soil erosion annually for a lowland agricultural area in FELDA Jengka 15, Pahang, employing a widely used mathematical formulation for soil erosion, the USLE. The contributing area under studies is around 1574.84 hectares and this is quite a sensible area in order to derive a suitable and sound indication for its erosion problems. On the other hand, this is particularly important from a management side since it reflects how effective FELDA handles the erosion problems. The value the annual loss computed for three stages under due considerations; the site clearing (phase I), earthwork activities (phase II) as well as the planting stage (phase III) indicated that the erosion problems are generally temporary and found to be more severed during site clearing and earthworks prior to the re-establishment of the vegetations. These values (4.78/0.57/0.17 tons/hectare/year) for phase I, II and III respectively also gave us an indication that the study area falls under a low category soil loss (Agricultural Department)

INTRODUCTION

Soil erosion has both on-farm and off-farm impacts. Reduction of soil depth can impair the land's productivity and the sediments transport can degrade streams, lakes and estuaries. To address these problems, the government through its Department of Environment has been providing guidelines for the prevention and control of soil erosion and siltation for almost 10 years.

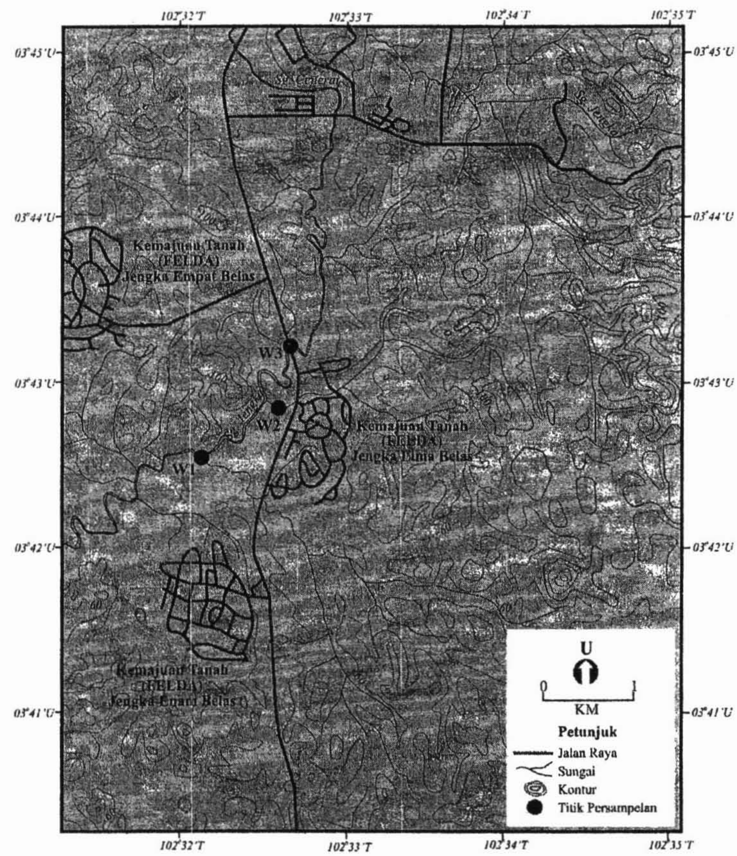
There are mainly two types of soil erosion, geological and accelerated, which represent contrasting types of soil removal (RRIM 1990). Geological erosion is the erosion of land in its natural environment without the influence of any human activities. It is a universal phenomenon. Accelerated erosion is caused by the human activities when it disturbs the equilibrium between geological erosion and soil formation. Activities such as deforestation, cultivation and urbanization will tend to accelerate the removal of soil material in excess to that removed by geological erosion. Soil erosion by water takes place by the detachment of individual particles from the soil mass and their transportation down slope through the action of raindrops and surface runoff. Its rate of progress is dependent on such factors as slope, soil type, density of vegetative cover, amount and the intensity of rainfall. An improper method of cultivation, overgrazing and burning will tend to intensify soil erosion.

The USLE, annual soil loss A (t/ha) is a product of the rainfall erosivity (R), the soil erodibility (K), an index of slope length and slope steepness (LS), the crop management factor (C) and the conservation practice factor (P) (Wischmeier & Smith 1978). Although the model was initially developed based on plot studies at Rocky mountains in the USA, the model has become one of the most extensively used with common applications in the tropics (Morgan 1986; Balamurugan 1991). Several attempts have been made to modify and further develop the USLE but the original USLE still remains the most widely used due to its simplicity.

THE STUDY AREA

FELDA Jengka 15 is an area with a longitude between 102 ° 31' to 102 ° 34'E and latitude 3 ° 42' to 3 ° 44' N. The total area is roughly 1787.51 hectares with 1574 hectares of plantation area, 126.88 hectares of village and 77.98 hectares of swampy area. It is surrounded by Jengka reserved forest to the east, FELDA Jengka 14 to the west, FELDA Jengka 16 to the south and Bandar Pusat Jengka to the north (Figure 1). Topographically, the area consists of 73 % of low-lying lands, 15% of hilly side and 12 % of swampy area. The main soil series area is from the Segamat and Bungor series. Both series contain more than 80% clay with low infiltrative but allowing high capacity for surface runoff (Hartley 1988).

Figure 1 : Study Area



METHODOLOGY

In applying USLE method, all the parameters need to be considered separately. The mean areal rainfall was collected from Meteorological Department; the true soil erodibility factor was taken from Soil Conservation Department, Ministry of Agriculture; the lengths and steepness of slope were determined from site and counter check with the topographical plan; the management factor for the development of oil palm plantation is extrapolated from the study conducted by Maene 1979; lastly the soil erosion control factor taken from Wischmeier & Smith 1978.

Rainfall Erosivity (R)

Soil loss is related to rainfall through the detachment power of raindrops striking the soil surface and the entrainment of the detached soil particles by run-off water down slope. Several studies have shown that in the tropics a rough approximation of R-values can be obtained by taking half the mean annual value (Roose 1977; FAO 1979; Singh et. al. 1981). Average annual rainfall over a period from 1974 to 2002 *from* gauging station in FELDA Jengka 14 approximately 2 km from the study area is 1965.3 based on the average rainfall of 153 days (Meteorological Department, 2003).

R = 1965.3 / 2 = 982.62 (soil loss unit in tons/hectare/year)
or = 982.62 / 2.24 = 438.67 (soil loss unit in tons/acre/year)

Soil Erodibility (K)

Soil erodibility (K) defines the inherent of the soil to both detachment and transport. Different soils erode at different rates when others affecting erosion are kept constant. This is due to the differences in physical properties between soils. The K factor has not been determined so far for all the soils found in this country. The true erodibility factor is gained from 5 years plot studies on representative soils under different rainfall regimes to measure soil-loss data and from this K values determined. The soil series are Segamat and

Bungor series, which represent 41% and 12 %, respectively from the study area. The true K values are 0.0050 tons/acre for Segamat series and 0.0023 tons/acre for Bungor series (Soil Conservation Department, 2003). The true K value of 0.005 tons/acre or 0.0112 tons/hectare is chosen for this study to represent the area erodibility factor.

Length and Steepness of Slope Factor (LS)

Soil erosion increases with an increase in slope gradient (S) and slope length (L) resulting from the respective increase in velocity and volume of surface run-off. LS values were calculated using the formula developed by Morgan (1986), i.e.

$$LS = \frac{\sqrt{L}\,(0.065 + 0.045*S + 0.0065*S^2)}{22.13}$$

where : L = slope length in m (60 m)
S = Slope gradient in percent (10%)

The Cropping and Management Factor (C)

Both factors (C) are expressed as the ratio of soil loss from the land cropped under specific conditions to corresponding soil loss from continuous fallow. The C factor for the first two stage of the development is 1.0, which referred to the worst case scenario, while the C factor for the planting stage is 0.29, which is extrapolated from the field test studies by Maene (1979).

Erosion Control Practice (P)

In general the protection offered by crops cultivated on slopes against erosion should be supported by soil conservation practices, which slow down the run-off flow. The P factor for study area is 1.0 for the first two stages and 0.12 for the planting phase (Wischmeier & Smith 1978).

RESULT AND DISCUSSION

The estimated soil losses at the study area using USLE method are summarized in Table 1. The study area falls under a low category soil losses (Agricultural Department) and since this is the first attempt on soil losses of Segamat series, hopefully it could be usable and applicable basis for other related studies or for the purpose of verification. The low figures obtained are, in fact, contrary to its large contributing area of approximately 1574.84 hectares. (cf: in one investigative studies conducted by Sg. Tekam Authority with 4 – 25 % slope, an average erosion rate of 144 tons/acre/year was obtained for a under clearing site and it was 19 tons/acre/year for the pre-clearing site (Drainage and Irrigation Department 1989).

Table 1: Estimated Annual Soil Losses

Development Phase	R	K	LS	C	P	A (tons /hec. /yr)
Phase 1 (site clearing)	982.62	0.0112	0.434	1	1	4.78
Phase 2 (earthworks)	982.62	0.0112	0.434	1	0.12	0.57
Phase 3 (planting)	982.62	0.0112	0.434	0.29	0.12	0.17

However it must be duly stressed here that there are certain limitations to the application of the USLE. These include: 1) considerable interdependence between the variables. For instance, rainfall influences the R and C factors whereas terracing, influences the C and P factors, 2) the equation was purposely developed to estimate long-term mean annual soil loss, therefore, it is not quite very suitable/appropriate to predict erosion from an individual storm event, and 3) the equation should not be applied to conditions for which the factor values have not been determined and therefore need to be estimated by extrapolation.

This shows that there is an urgent need for more extended research to be carried out in future to improve the prediction of soil erosion loss. The erosion control practices currently conducted by the FELDA management include staging clearing activities, maintenance of the natural cover crops, planting of groundnuts on the hills area, terracing, mulching activity and preserving the buffer zone along the Sungai Jengka riverbanks. The undisturbed swampy areas are also one of the effective but natural erosion control measures in the study area.

CONCLUSION

A good management practice to maintain a sustainable amount of soil loss erosion control currently employed by FELDA Authority is without doubt an effective tool to reduce the erosion loss. The estimated values due calculated for all the phases would suggest that soil loss were very well below any critical/permissible values. Overall, FELDA management handles the erosion problems within the study area successfully.

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