Soil erosion assessment

Introduction

The Northeastern area of Thailand has faced natural disasters such as floods, droughts and soil erosion. This results in the loss of life, natural resources, economic foundation, and environmental and ecological systems (Teerawong, 2002). Conserved national resources have been used to help flood victims and to restore the affected areas and structures. As natural resources are more heavily exploited, these incidents happen more frequently and with greater severity. Although these natural catastrophes cannot be avoided, their effects can be reduced by proper measures and management. In the past, the natural disaster was managed by a relief effort and restoration of the affected areas. However, when disasters become more frequent and severe, the relief and restoration budget became larger. Prevention and mitigation required far more efficient ways to manage the problem. In this study, the author used GIS and a well known parametric equation, the Universal Soil Loss Equation (USLE), to evaluate the risk area of soil erosion in the case of Maha Sarakham province in Thailand for the year 2010.

Materials and methods

The study area

Maha Sarakham province, which consists of 13 districts, 133 sub-districts and 1804 villages, was selected as a study location. It is shown in Figure 1. Maha Sarakham borders Kalasin to the north, Surin and Buriram to the south, Roi-Et to the east and Khon Kaen to the west (Teerawong, 2012). For political and administrative structure, areas in Maha Sarakham are divided into 13 districts, 133 sub-districts, and 1804 villages. In 2011 the province had a total population of 940,911, of which 466,552 were male and 474,359 were female (Teerawong and Poramate, 2012).

The use of USLE

The USLE is the most commonly used estimator of soil loss caused by overland erosion. The equation is based on an extensive set of more than 10,000 plot years of runoff and soil loss data from experimental centres in the eastern USA. It was developed to predict average annual soil loss from sheet and rill erosion, not gully or other forms of erosion. The USLE may properly be used to (Wishmeier, 1978; Okalp, 2005; Ozcan, 2008; Sawet et al., 2011): 1) Predict average annual soil movement from a given field slope under specified land use and management conditions, 2) Guide the selection of conservation practices for specific sites, 3) Estimate the reduction in soil loss that would result from a change in cropping or conservation practices, 4) Determine how conservation practices may be applied or altered to allow more intensive cultivation, 5) Estimate soil losses from land use areas other than agricultural purposes, 6) Provide soil loss estimation for determining conservation needs (Shahram and Leroy, 2001). The USLE, derived empirically, is (Lal, 1994):

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

This equation, detailed in Wishmeier and Smith (1978), describes soil loss (A) as a function of rainfall (R) amount and intensity; soil erodibility (K) related to texture, percentage of organic matter, structure, and permeability of soil; morphology, especially the length of the slope (L) and the slope gradient (S); vegetation cover (C); and erosion control practices (P).

The USLE was designated “universal” because it is free of some of the generalisations and the geographic and climatic restrictions inherent in earlier models. It has been criticised as not being universal because original parameter values were presented for conditions of the eastern two-thirds of the United States. Regardless of whether the name is fully accurate, the USLE identifies the major factors affecting soil loss.

Each of the five factors in the USLE has been formulated by Wishmeier and Smith (1978) in such a way that it is linearly related to soil loss. Each variable can be isolated and quantified into numbers using standard USLE plots or unit plots. When the variables of the USLE are multiplied together, the answer is the amount of soil loss. Owing to its simplicity and the relative ease of evaluating each factor, in most parts of the world, including countries in

Asia-Pacific like Thailand, China, and India, its gives acceptable results (Omakupt, 1986, 1989; Ma et al., 1987; Saha and Singh, 1991; Teerawong, 2002). USLE can be used in Thailand to assess soil loss erosion. In this work, the USLE was used to evaluate the risk area of soil erosion.

The five parameters of USLE were evaluated for the study area using remotely sensed ground observation and existing map data. Remotely sensed data was the main source of information for the establishment of land-use/land-cover, geology, geomorphology, and soil map, as well as for deriving a scheme of watershed distribution using both digital image processing and visual interpretation.

Rainfall amount and intensity maps were established based on observation data obtained over several decades. The processing and/or interpretation work involved deriving each factor. The final potential soil erosion and soil erosion hazard maps are described below.

1. Rainfall Factor (R)

R factor (rainfall erosivity) is the principal function of USLE. Maximum rainfall intensity for 30 years expressed as a kinetic energy of rainfall is used to compute the R factor, as it is reported to have the best correlation with the soil loss rather than lower or higher intensity. R is expressed in terms of annual erosivity in ton/ha/yr. The formula is shown in equation 2 (EL-Swaify et al., 1985).

$$R = 38.5+0.35P \quad (2)$$

where P = total rainfall amount in mm.

2. Soil erodibility factor (K)

A monogram developed by Wishmeier and Smith (1978) was used to obtain the value of the (K) factor on the basis of the percentages of silt, very fine sand, and organic matter (a); soil structure (b); and permeability (c). The first three physical maps were used, especially in the case of medium and small scales. Field observations are available for deriving permeability, and were gathered in some cases when information on the soil profile was insufficient. The factor (K) can be estimated by using equation 3.

K = 2.1M1.14 (10 -4) (12-a) + 3.25 (b-2) + 2.5 (c -3) (3)

where a = % of organic matter

b = soil structure class

c = soil permeability class

M= (% silt + % very fie sand) or (100- % clay)

3. Slope factor (LS)

An aerial unit, upon which determination of slope and corresponding slope length are based, is identified by slope and aspect classes. Slope and aspect map layers are generated from a digital elevation model. These are, in turn, generated from elevation contours of topographic maps at 1:50,000 scale. Overlay operation on the slope and aspect layers yields a polygonal layer, each polygon of which is an area unit used for determination of slope length. The LS-factor layer is then generated from equation 4 (Wishmeier and Smith, 1978).

LS = (L/22.1) * (0.065 + 0.04SS + 0.0065S2) (4)

where m = 0.5 for S> 5%

0.4 for S 3-5%

0.3 for S 1-3%

0.2 for S < 1%

S = slope (%), L = slope length (m).

4. Vegetation cover factor (C) and erosion control practice factor (P)

The factors (C) and (P) were estimated based on land-use/land-cover maps, which are produced from multi-temporal satellite data (Landsat-TM on 2010) based on the digital image processing method and from research results obtained from field data at soil erosion observation stations situated in Thailand as well as in other countries in Southeast Asia.

GIS for soil erosion

Each of the USLE factors with associated attribute data is digitally encoded in a GIS database to eventually produce five thematic layers. These are then spatially overlaid to produce a resultant polygonal layer. Application of the USLE model to the resultant layer yields a soil erosion map with 3 classes of soil loss.