Field Validation of Erosion Hazard Zones for Effective Management of Watersheds

By

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Statement

"This dissertation was submitted to the department of civil Engineering of the university of Moratuwa, Sri Lanka, as a Partial fulfillment of the requirement of the degree of Master of Philosophy."

Declaration

This Dissertation has not been previously submitted in whole or part to any University or any Institute for a higher degree.

G.R.N. Karunatilaka
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Abstract

Land and water resources are primarily important for all developing countries, particularly in countries like Sri Lanka where the majority of the people are either directly or indirectly dependent on agriculture for their livelihood. Hence soil erosion is one of the most serious environmental problems of agricultural based developing countries since it removes soils rich in nutrients, increase natural level of sedimentation in rivers and other water bodies and causes flood and water quality problems. The final results are the reduction of the productivity of land, which can lead to increase in expenditure in fertilizers to maintain yields and reduction in capacity of rivers increasing the risk of flooding, blocking of irrigation canals and shortening the design life of reservoirs. Due to this critical nature of soil erosion, prevention of soil erosion is important. This means reducing the rate of soil loss to approximately to the loss that would occur under natural conditions, which relies on selecting appropriate strategies for soil conservation. Although all the areas under the threat of erosion cannot be developed due to financial constrains, it is necessary to prioritise the vulnerable areas. This requires an understanding of the processes of soil erosion.

The factors, which influence the rate of soil erosion is rainfall, soil type, slope length and steepness, plant cover and presence or absence of conservation measures. Considering these factors, most common method of estimation of soil erosion is the Universal Soil Loss Equation (USLE). A=RKLSCP where R is the rainfall erosivity, K is the soil erodibility, L & S are slope length and slope steepness factors, C is the cover management factor and P is the conservation practice factor. It predicts the long-term average annual rate of erosion. The USLE was developed by W.H. Wischmeier, D.D. Smith and others with the U.S. Department of Agriculture (USDA), Agricultural Research service (ARS), Soil Conservation Service (SCS) and Purdue University in the 1950s. However the factors in this equation requires field validation prior to their application for a particular region. This study was carried out for a relatively small area.

University of Moratuwa premises which covers the 25 ha was selected as the research area since the area has different land cover, topography, etc. and most importantly detailed field data can be collected easily.

Geographical Information System (GIS) is the best option in comparing different scenarios and finding out the optimum solution for such situations. The soil erosion model was prepared using GIS Arc/Info and Arc/View software, considering the factors effecting soil erosion.

The data related to rainfall erosivity, soil erodibility, slope length and steepness, cover management and conservation practice factors were obtained out from various departments, literature and field surveys. Final model was developed by taking weighted average of RKCP in the polygons within each similar LS polygon since slope class is polygon specific

A field survey identified some spatial units with four erosion classes and these data were used for model calibration and verification. Out of 200 polygons, a randomly selected 100 were used for model calibration and the rest were used for verification. Parameter optimization shows a very good match with the results ranging from 0 to 47.9 tons/ha/yr. Mean Ratio of Absolute Error (MRAE) which is MRAE=(1/n) $[(E_0-E_c)/E_0]$ where E, o, c, n are for erosion level, observed, calculated and for number of samples respectively, was used as the objective function for calibration and verification of the model. Based on the calculated erosion values and trial and error matching process a weighting scheme was selected during optimization process.

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List of Abbreviation

Abbreviation	Content
ADB	- Asian Development Bank
AE	- Annual Erosivity
ARS	- Agricultural Research service
AWC	- Available Water Capacity
CAD	- Computer Aided Drafting
CEA	- Central Environmental Authority
CLO	- Crown Land Ordinance
DOA	- Department of Agriculture
FAO	- Food and Agricultural Organization
FD	- Forest Department
FOs	- Farmer Organizations
GIS	- Geographic Information System
KE	- Kinetic Energy
LS	- Slope Length and Slope Steepness factors
NRDP	- Nuwara Eliya Rural Development Project
MRAE	- Mean Ratio of Absolute Error
SALT	- Sloping Agricultural Land Technology
SCS	- Soil Conservation Service
SOC	- Soil Organic Carbon
UMC	- Upper Mahaweli Catchment
USDA	- United States Department of Agriculture
USLE	- Universal Soil Loss Equation
VM	- Vegetation Management