Estimation of erosion and sediment yield of Ekbatan Dam drainage basin with EPM method, using GIS

***Somayeh Amini [1] ; Behrouz Rafiei [2] ; Saeed Khodabakhsh [2] and Mojtaba Heydari [2]**

[1]M.Sc student, Islamic Azad University, Khorasgan branch, Isfahan- Iran
E-mail: s.amini1@yahoo.com

[2] Dept. of Geology, Bu- Ali Sina University, Hamedan- Iran

Abstract

Soil conservation and control of erosion is a basic problem in all countries. The goal of this research is to estimate erosion and sediment yield in Ekbatan Dam drainage basin by Erosion Potential Method (EPM), using Geographic Information System (GIS). The basin is located in Hamedan Province, West of Iran, in a cold and semi-arid region, with an average annual rainfall of 334.28 mm. The study area is about 218.1 km^2 and is divided into 8 sub-basins. Sub-basins 1 and 6 are the largest (49.14 km^2), and smallest (9.92km^2), respectively. Elevation is ranged between 1960 to 3580 m. The litho- units include schist, granite, hornfels, limestone, sandstone, (Pre- Jurassic to Neogene in age), conglomerate and recent alluvium. Most sediment in the basin is generated from erosion of schists. The main factors in the EPM method (slope average, present erosion, rock and soil erosion, land-use) were evaluated using GIS software. Data layers used in this study were created from topographic, homorain, homotemp, geology, lithology maps, landsat ETM digital images and field observations. According to calculated results the coefficient of erosion and sediment yield (z) for this basin divided to moderate and heavy erosion class. For avoiding soil erosion in this basin, therefore, soil conservation operation should be performed.

Keywords: *Ekbatan Dam; EPM method; Erosion; GIS; Hamedan; Sediment yield.*

INTRODUCTION

Erosion is a process that separates soil and transport to other places (Rafahi, 2005). Water is the most important agent for transportation. If a dam has been constructed on a river that carries large amount of sediments, accumulation sediments in dam reservoir are unavoidable. Rivers transported sediments that are generated by erosion, however identify erosion types and sensitive lithology of basin to erosion and capability of transportation sediments in rivers is most important. By recognition and controlling these factors, sediment yield decreases in dam reservoir, which leads to increase of the effective volume of reservoir.

STUDY AREA

The basin is located in Hamedan province, West of Iran. The area of Ekbatan Dam drainage basin is 218 km^2 which is located between 48° 28' and 48° 40' E longitude, and 34° 35' and 34° 46' N latitudes. The maximum and minimum heights of the basin area are 3580 and 1960m, respectively. The drainage basin area is divided into 8 sub-basins (Mazaheri, 1996). Sub-basins 1 and 6 are the largest (49.14 km^2), and smallest (9.92km^2), respectively. The area is positioned in a cold and semi-arid region (according Ambergie climograph), with an average annual rainfall of 334.28 mm. The study area is a part of the Alvand batholith which is a part of the Sanandaj- Sirjan zone. The lithologies include schist, granite, hornfels,

limestone, sandstone, (Pre- Jurassic to Neogene in age), conglomerate and recent alluvium. Abshineh (yalfan) is the main river in drainage basin, and the Ekbatan Dam has been constructed on this river.

MATERIALS AND METHODS

EPM METHOD

The Erosion Potential Method (EPM) is a model for qualifying the erosion severity and estimating the total annual sediment yield of a catchment's area (Solaimani et al, 2009). EPM method was created based on erosion measurements after forty-year research in the former Yugoslavia and for the first time was introduced in River Stream International Conference (Gaverlovic, 1988) .Sediment estimation in this method is based on four following factors:

Y: The coefficient of rock and soil erosion, ranging from 0.25- 2.

Xa: The land use coefficient, ranging from 0.05- 1.

Ψ: The coefficient for present erosion type, ranging from 0.1- 1.

I: Average- land slope in percentage (Rafahi, 2005).

Necessary information's for these factors are: Geology and rock, land use, slope and erosion maps are used to calculate the mentioned above factors.

RESULTES

The Erosion Potential Method (EPM) calculates the coefficient of erosion and sediment yield (Z) of a sub- basins area by the following equation **(**Tangestani, 2006):

$$Z= Y.Xa (\Psi + I^{0.5}) \qquad (1)$$

In which Y is the coefficient of rock and soil erosion (Fig 1-A), Xa is land use coefficient (Fig1- B), Ψ is the coefficient for present erosion type (Fig 1- C) and I is the average land slope in term of percentage (Fig 1- D).

The following classification is given for erosion intensity: < 0.19 = very slight erosion intensity, 0.2< Z < 0.4= slight erosion intensity, 0.41< Z < 0.7: moderate erosion intensity, 0.71< Z< 1= heavy erosion intensity, Z >1= severe erosion intensity.

The coefficients(Y, Xa, Ψ, I), are added to basic layers(slop average, present erosion, rock and soil erosion, land-use).The layers are overlaid in Geographic Information System (GIS) , and, then, erosion- intensity map (Z) is produced(Fig 2).

The coefficient of erosion and sediment yield (z) is classified into 2 erosion classes for sub-basins (table1).

The volume of soil erosion is calculated by the following equation in this method:

$$W_{SP}= T. H. \pi . Z^{1.5} \qquad (2)$$

In which, W_{SP} is the volume of soil erosion ($m^3/km^2/yr$), H is annual rainfall (mm), Z is erosion intensity and T is coefficient of temperature which is calculated as bellow:

$$T= (t /10 + 0.1)^{0.5} \qquad (3)$$

In which, t is mean annual temperature (°c).

Volume of soil erosion (W_{SP}) in drainage basin is varied from 494.35 to 1190.09 ($m^3/km^2/yr$) (table2).

CONCLUSION

Based on the results the coefficient of erosion and sediment yield (Z) obtained for Ekbatan Dam basin shows moderate and heavy erosion. The most important effective factor affecting in erosion is geology and lithology according to calculated coefficients and field observations in basin. The observed sediment yield (on the basis of stations data) is about 6.43 ton/yr; calculated sediment yield by EPM method is about 9.72 ton/yr. This indicates the results of method are close to actual sediment yield and it can be used for another basin.

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Table1: Coefficient of Erosion and Sediment yield (z) for all sub basins of Ekbatan Dam basin

Sub basins / Coefficient	1	2	3	4	5	6	7	8	Basin
z	0.52	0.73	0.97	0.89	0.72	0.71	0.72	0.75	0.76
Erosion Intensity	Moderate	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy

Table2: The Volume of Soil Erosion (W_{SP}) calculated for all sub basins of Ekbatan Dam basin

Sub basins / Coefficient	1	2	3	4	5	6	7	8	Basin
W_{SP} ($m^3/km^2/yr$)	494.35	670.67	1190.09	768.67	725.84	584.13	668	805.79	942.29

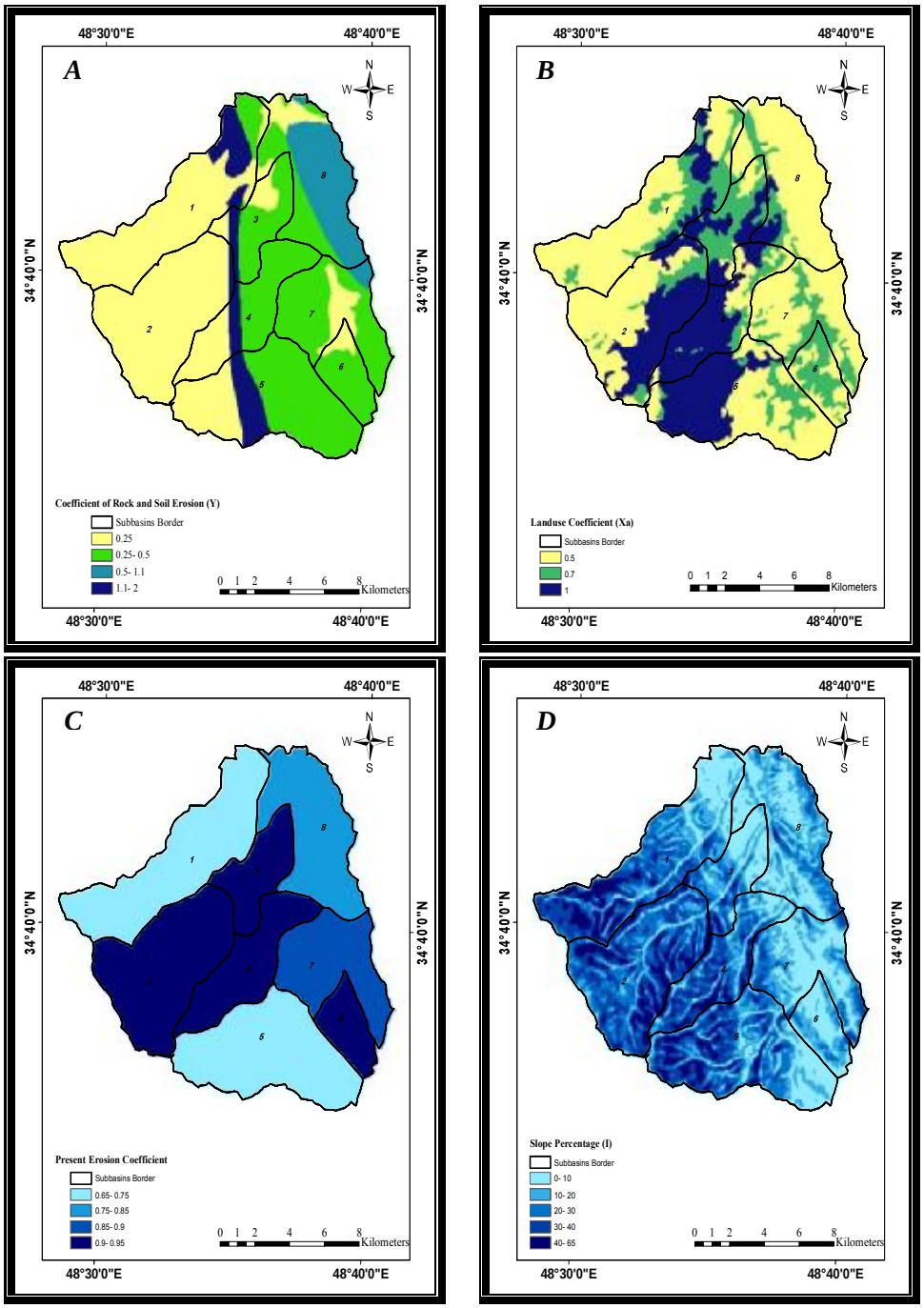

Fig 1: Various maps of basin by GIS. A: Map of Rock and Soil Erosion Coefficient(Y); B: Map of Land use Coefficient (Xa); C: Map of Present Erosion Coefficient (Ψ) and D: Map of average- land slope in percentage (I).

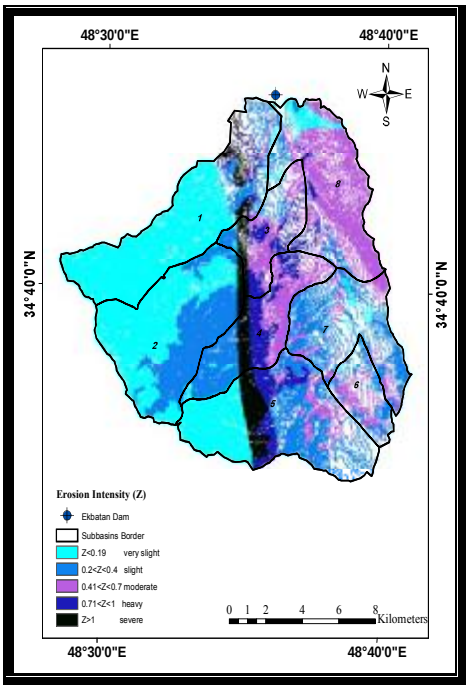

Fig 2: Erosion intensity map of study area (Z).