Estimation of Erosion and Sedimentation in Karoon Basin using EPM with in Geographic Information System

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Abstract - **Soil is one of the main natural sources in each country. Nowadays, soil erosion is considered as one of the most serious dangers for development. In areas which erosion has not been controlled well, soil has eroded with loss of fertility and production cycle. Therefore, identification the critical and sensitive areas are required, to implement protective activities. The study area was Karoon watershed in Khuzestan Province (IRAN) with 48°15´ to 50°15´ longitude and 30° to 32°45´ latitude. The goal of this research was to apply an EPM model and GIS system to have the most possible accurate assessment of the soil erosion and sedimentation in the area of interest. The main factors in the EPM (slope average percent, erosion, rock and soil erosion and land- use) were evaluated using GIS software. Since different factors have various effect and importance rates in erosion, each of the parameters has been classified base on their importance, in different categories finally; the prepared layers integrated and overlaid in EPM model and soil erosion map calculated. The priority of conservation projects for controlling erosion in different areas can be identified by using erosion map. Results showed that 94.4% of the total watershed area had low sedimentation, 5.2% moderate sedimentation, 0.3% high sedimentation and 0.009% extremely high sedimentation. In the south part, soil erodibility was moderate due to the lower slope, and in the north, the erosion is intensive because of soil material and poor land use. In conclusion, erosion was low-to-moderate in investigate area.**

Keywords—EPM Model, GIS, Sedimentation, Erosion, Watershed

I.Introduction

Soil erosion is a global problem in the current century. FAO estimates 3 million hectares of agricultural land lost due to erosion annually. The United Nations in its development plan has reported that at the present rate of soil erosion in Iran is about 20 tones/hectares. Whereas the global average natural erosion is about 2 to 5 tones [6]. The total volume of annual watershed sediment must be assessed in order to soil conservation projects, erosion control methods and reduce sedimentation and also the volume of the reservoir dams. Estimating the erosion, annual sedimentation and preparing soil erosion landscape are essential in order to control soil erosion and mechanical and biological performance. Direct and indirect methods are two general tools to measure soil erosion. In the direct method, erosion and sedimentation rates measure different quantitative tools. In the indirect methods, erosion and sediment measurement are based on empirical models and other parameters. Providing models with details characterization of local watersheds are difficult due to lack of sediment measurement stations in most watersheds. Therefore, using empirical models are inevitable, but significant problems with empirical models are lack of accuracy in processing and the large amount of data which should be digitalized by GIS system and analyzed by mathematical models. Nowadays Remote Sensing and GIS techniques and methods are used in natural resources and watershed management. Lillesand and Kiefer (1994) used these methods

successfully for generation soil map with scale 1:5000[4]. They used multi temporal images, and aerial photos for production and correction soil and Land use maps. Multi-spectral remote sensing techniques along with Geographic Information System is the powerful tools for data collection in

order to the spatial distribution of erosion [5]. Fahmi (2006), used advanced weighted method and Fuzzy Clustering [1]. Erosion Potential Method (EPM) is one of the models for qualifying the erosion severity and estimating the total annual sediment yield of a catchment area. This model was created based on erosion measurements during 40 years in previous Yugoslavia, and for the first time introduced In River Stream International Conference by Gavrilovic in 1988[2]. Because of simplicity and practicality of this technique, this method has been chosen as a proper method for estimating erosion and sedimentation. The main four factors are in EPM: erosion (Φ), land uses (Xa), rock and soil erosion sensitivity (Y) and the average slope, which are analyzed in watershed units.

II. Material and methods

2.1 Case study

Karoon is the biggest and only navigable river in Iran. The study area is located in Khozestan province in south west of Iran. The longitude of this area is 48°15'' to 50 ° 15'' eastern and the latitude of is 30° to 32° 45'' northern. The area and perimeter of this area is 27694.8 Km2 and 1233 Km. The source of the Karun River is Zard Kuh in the Zagros Mountains, and this river connects to the Arvand Rood River in Khorramshar. Length of Karoon river in the area is 744.236 Km.Fig.1

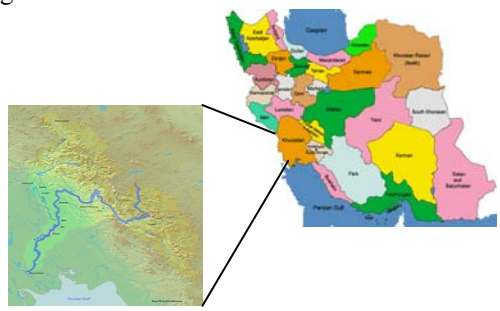

Figure1: Location of the study area

2.2 EPM model

Systematic investigations of the intensity of erosion were begun in former Yugoslavia sixty years ago, and they enabled the development of The Method for the Quantitative Classification of Erosion (MQCE) in 1954 [3]. During last fifty years, continued of permanent developing process results as a complex methodology for investigation erosion process, mapping, sediment calculating and torrent classification. Name of this method is "Erosion Potential Method". Since 1968. EPM is a standard method for erosion and torrent training engineering in water management. According to the EPM model the erosion process, is the interaction of rock – topographic Features, moreover soil type are natural, and land use are anthropogenic. The coefficient of erosion intensity (Z) is calculated by the following equation in this model:

$$Z = Y.X_a(\Phi + I^{0/5}) \qquad (1)$$

Where

Y: susceptibility of rock and soil to erosion, Xa: land use coefficient, Ψ: Erosion coefficient of watershed, I: mean watershed slope
The volume of soil erosion is calculated by the following equation in this method:

$$W_{sp} = T.H.P.Z^{3/2} \qquad (2)$$

Where

H: annual average Precipitation (mm), π: 3.14, T : coefficient of temperature that can be calculated with the formula 3 that mention below :average annual temperature in centigrade.

$$T = [(t:10 + 0/1]^{0/5} \qquad (3)$$

The sediment production rate in this model is calculated based on the ratio of eroded materials in each section of the stream to the total erosion in the whole watershed area (Equation No. 4)

$$Ru = 4\,(P.D)\,0.5\,/L+10 \qquad (4)$$

Where:
P: circumference of the watershed, L: watershed length (Km), D: height difference in the watershed area (Km)

After calculation of Ru value, the special sediment rate is estimated by equations No. 5 and 6:

$$GSP = WSP.Ru \qquad (5)$$
$$GS = GSP.F \qquad (6)$$

Where

G.S.P: Special sediment rate, WPS: volume of special erosion (m3/km2/yr), RU : Sedimentation coefficient, GS= total sediment rate (m3/yr), F= Total watershed area(km2) [6]

2.3 Implementation of soil erosion modeling using GIS

The important layers that have been used in this study are the topographic map, geology and soil map, erosion, vegetation and land use. There are lots of layers in EPM model which will be used to produce erosion map and calculate the erosion intensity. In the use of this model, the first step was to develop a topographic map in 1:50000 of the study area. Using contour map, the slope and aspects maps as well as digital elevation model were prepared. An erosion feature map was obtained using aerials photos of 1:40000 scale. In the second step land use map was obtained from supervised classification of satellite images (ETM+ 2005) and data obtained from the field visits that were used to provide information on the local topography, climatic factors, geology, pedology and land use data of the study area. Precipitation and temperature maps were obtained from the climatic data measured by gages placed in the watershed.

Moreover, overlapping geology, soil, land use, erosion feature map, slope were determine and finally, the erosion map was produce by EPM model and reclassify the raster data .Fig.2

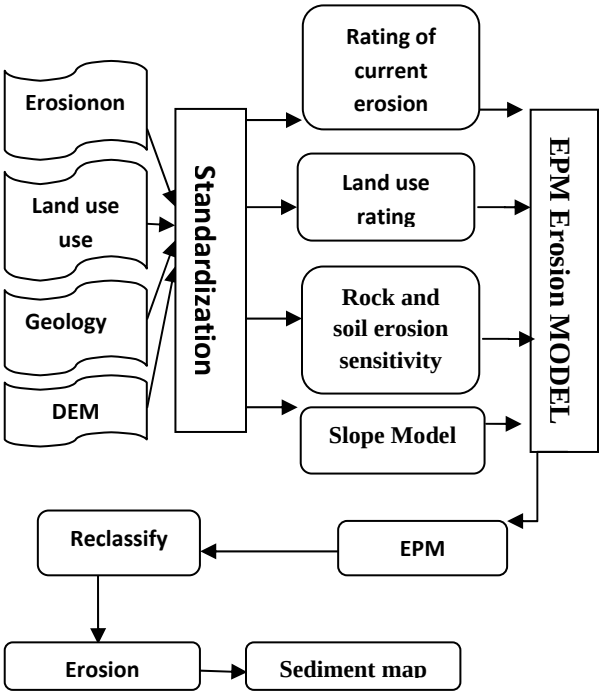

Figure: 2: Processing in EPM model

3. Result

In EPM model, some parameters such as surface erosion susceptibility of rock and soil to erosion are important. According to this research 94.4% of the study area is low erosion, 5.2% is medium,0.3 % is high and 0.009 very high erosion. The most area of watershed had low-mkhoderate erosion because of low slope.

(Table1andFig.3)

Table1. Calculated parameters in EPM Model

Volume soil erosion(m3/km 2/year)	Volume soil erosion(ton/ha/yea r)	RU	Spati al sedim ent rate	Total sediment rate (m3/year)
8374.78	*108.86*	*0.1 8*	*1507. 4*	*251.34*

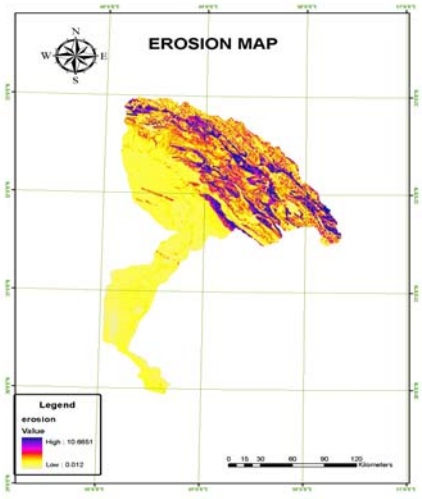

Figure3:Erosion map

4. Conclusion

By reviewing the Slope map of the study area, we noted that the slope is low in the most of areas, as an illustration in the south part, the erosion is low-moderate due to the lower slope and in the north part ,the erosion is intensive along of soil and rock material and poor land use. Although, in some areas have high slope, erosion is low-moderate due to the forest cover and grassland. By using GIS, we can easily integrate three factors of rock- soil, land use and current erosion to obtain erosion rates. These maps can identify priority conservation projects for erosion control in different areas and prevent the loss of soil as a valuable wealth.

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Table2.Descriptive factors used in EPM [6]

Land use coefficient	Xa
Mixed and dense forest	0.05- 0.2
Thin forest with grove	0.2- 0.3
Coniferous forest with little grove, scarce bushes, bushy prairie	0.3- 0.4
Damaged forest and bushes, pasture	0.4- 0.6
Damaged pasture and cultivated land	0.6- 0.8
Areas without vegetal cover	0.8- 1
Coefficient of rock and soil erosion	Y
Hard rock, erosion resistant	0.25- 0.5
Rock with moderate erosion resistance, alluvium	0.5- 0.6
Black hydro morph soils	0.6- 0.8
Mountain soils	0.8- 0.9
Hard doll stone	0.9- 1
Clastic schist, mica schist, gneiss	1- 1.1
Red sandstone, serpentine, flysch	1.1- 1.2
Weathered limestone and marl	1.2- 1.6
Loess, tuff , salty soil, steeply soil	1.6 -2
Sand, granule, schist	2
Coefficient for present erosion type	Ψ
Little erosion on watershed	0.1- 0.2
Erosion in waterways on 20-50% of the catchment area	0.3- 0.5
Erosion in rivers, gullies and alluvial deposits, karstic erosion	0.6- 0.7
50-80% of catchment area affected by surface erosion and landslides	0.8- 0.9
Whole watershed affected by erosion	1