Evaluation of Morgan and Morgan –Finney soil erosion model using GIS in Mehr watershed, Northern Iran

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Introduction

Soil erosion is a two stages process involving detachment and transport as soil particles by such agents as water and wind (Morgan, 1995). Soil erosion has become a global issue widely considered in management and conservation of natural resources (Agassi, 1996; Morgan 1995). Moreover one of the main objectives of land resource management is aimed at soil conservation, since maintenance of integrity of soil quality, properties, processes, and diversity is deemed essential to ensuring sustainable land use (Morgan, 1995). Confident evaluation and assessment of soil degradation rate and potential for food producing because of continuous men's needs to soil resources and increasing of common knowledge from soil degradation and erosion is being expanded (Lai et al, 1998; El Swaify et al 1994). In the other hand information on sediment transport and nutrient from watershed and its erosive process are some necessities that for watershed management. Morgan (1995) developed a method for estimation of annual soil loss in small catchments. The model of Morgan and Morgan- Finney acts as a bridge between practical models (like USLE) and completely physical based models such as ANSWERS and WEPP.(Morgan, 2001). In this model soil erosion includes two important components: splash erosion by rain drops and soil transportation by overland flow (Morgan, 2001). Total soil loss is estimated by comparison of splash detachment and overland flow transportation. This model validated by Morgan in 76 sites in 12 countries and its application verified in 47 cases (Dadrasi Sabzevar, 1997). Morgan and Morgan-Finney model has used for soil loss prediction by other researchers (Iampornrat et al 2000; Sherestha, 2001; Morgan 2001, Dadrasi Sabzevar, 1997). The objective of this study was to evaluate of Morgan and Morgan-Finney model in Mehr watershed in Northern Iran using GIS.

Material and Methods

The study area covered 25.29 km^2 is a part of Mehr watershed located at 52 km of Sabzevar city in Khorasan province, northern Iran between 57° 10′ 10″ and 57° 11′ 48″ E longitudes and 36° 22′ 36″ and 36° 23′ 18″ N altitudes(Fig 1). Annual precipitation is 209 mm and average annual temperature is 15 ° C. Using digital elevation model slope map of study area prepared and combining with other maps(Geology, Soil, Land Use) 27 elements were identified using GIS software(ITC,2001) (Fig2). After obtaining basic information and required maps with regard to field work and typical tables of model in water phase, average annual precipitation intensity was lumped and the other variables of this phase took as distributed variables. In sediment phase all of model input variables in elements were considered as distributed variables except soil erodibility factor in order to prepare map of soil detachment by splash (F). All of input variables for generation of sediment transport by overland flow map (G) were used as distributed variables. Finally annual soil loss map calculated by comparison of (G) and (F) maps and taking their minimum rate in to consideration. For validation of results of model, throughout the watershed three checkdams identified that constructed 7 years ago and then their sub-watersheds, which supplied their sediments, were delineated. The sediments behind of each

checkdam evaluated volumetrically using digging 10 profiles in the sediments. Sediment weights were calculated using sediment bulk density and then soil loss was estimated by sediment delivery ratio (SDR). Finally mean soil loss ,which calculated by GIS for three sub-watershed, compared to actual soil loss, which derived by checkdams, to evaluate Morgan and Morgan-Finney model in the study area.

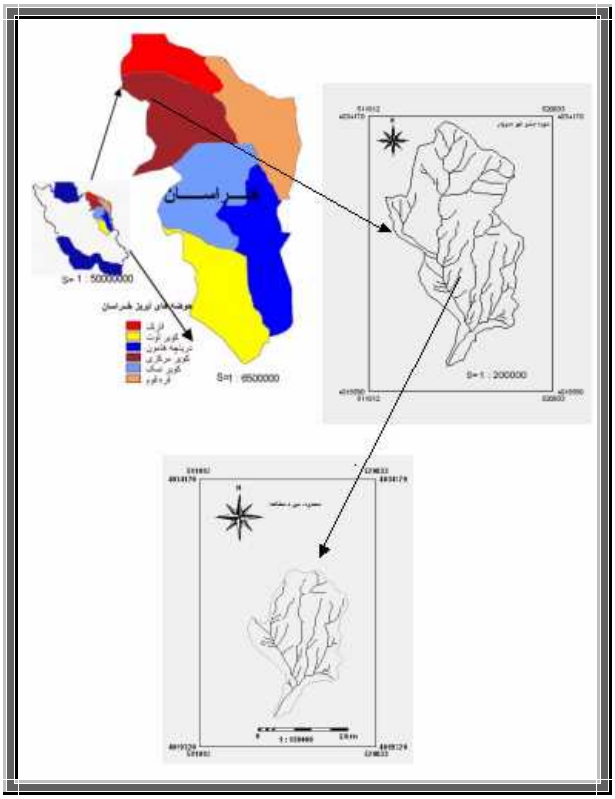

Fig 1- Location of study area and watershed

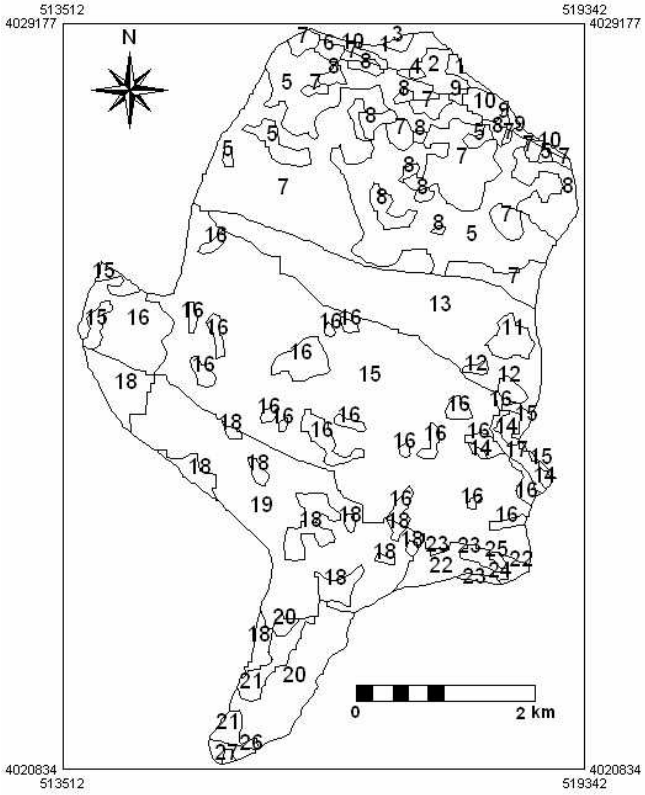

Fig 2- Element delineations in study area

Results and Discussion

The spatial predicted soil loss maps which produced by splash and transported by overland flow are presented in Fig 3-a and 3-b respectively. Summary statistical description of the results of two processes is presented in Table 1. Average physical process of soil detachment and sediment transport was about 1.29 and 247.2 kg m-2 respectively in this sub- watershed Comparison of figures 3-a and 3-b has originated the annual loss map which illustrated in Fig 3-c.

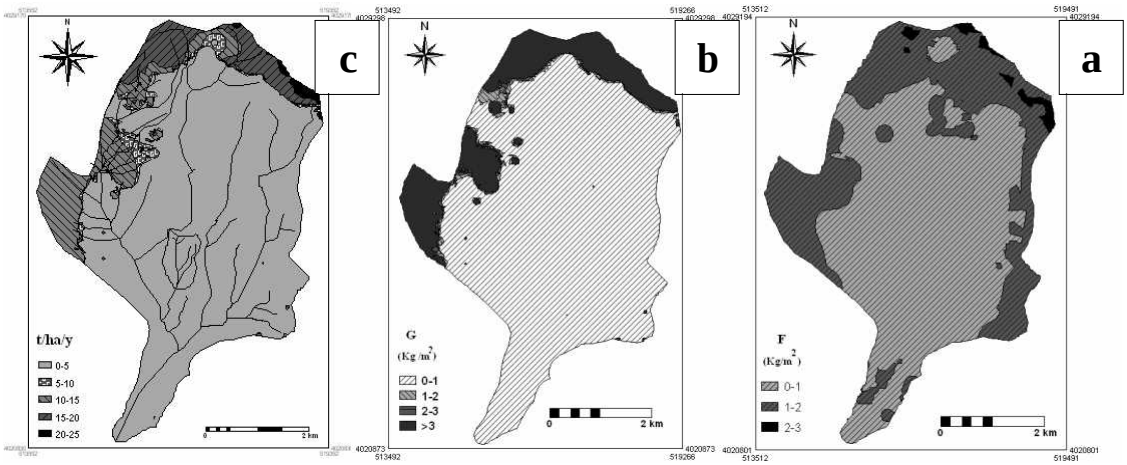

Fig 3- Spatial variability of soil particles detachment by splash(a), soil particle transportation by Overland flow (b), and annual soil loss in the study area.

Table 1- Summary statistical descriptions of two processes in the whole watershed

Soil Loss Processes	Statistic criteria	Kg/m^2
Soil detachment by splash	Min	0.12
	Mean	1.29
	Max	2.46
Soil transported by overland flow	Min	0
	Mean	247.2
	Max	52135.4

The result of predicted soil loss in three sub-watersheds, which is an estimation of actual soil erosion in these sub-watersheds, is presented in Table 2. As the results reveal soil loss in three sub-watersheds varied from 4.16 to 13.3 ton/ha. year. The average soil loss that has evaluated by Morgan and Morgan-Finney model also is presented in the Table 2.

Table 2- Predicted soil loss using model and actual soil loss in three sub-watersheds

Soil loss ton/ ha.year	**Sub-watershed 1**		**Sub-watershed 2**		**Sub-watershed 3**	
	actual	**model**	**actual**	**model**	**actual**	**model**
	13.3	**0.004**	**37.9**	**1.9**	**4.16**	**0.87**

The average soil loss predicted by the model varied from 0.004 to 0.87 ton/ha.year for three sub-watersheds. Comparison of predicted soil loss by model and actual soil loss (checkdams) indicates that the amount of soil loss predicted by model is significantly less that the actual soil loss in three sub-watersheds. It is concluded that the Morgan and Morgan-Finney model could not evaluate soil loss reliably in the study area. This may be induced by individual characteristics and conditions of the study area such as soil, topography, rain fall, geology, topography and land use (Dadrasi Sabzevar, 1997; Rahnama Mobarakeh, 1994). On the other hand this result probably due to low applicability of the model in the watersheds with high intensity soil loss (Morgan, 2001). This case study suggests that application of model with the initial parameters would be useless to predict soil loss in the given study area and in the future researches will be needed to parameterize and calibrate the model for practical purposes.

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