UDC 551.3.053:543.5

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A COMPARISON OF EPM AND WEPP MODELS FOR ESTIMATING SOIL EROSION OF MARMEH WATERSHED IN THE SOUTH IRAN

SUMMARY

Soil erosion and sediment yield is one of the main challenges in Iran, and quantity estimation of them is an important issue. Two models (the empirical Erosion Potential Method (EPM) and the physical Water Erosion Prediction Project (WEPP) were applied to predict soil loss and sediment yield for the Marmeh Watershed. After watershed modelling, the simulated sediment yield values were compared with the observed sediment yield values. In the calibration and validation periods, the Nash–Sutcliffe model efficiency (E_{NS}) values for the WEPP and EPM were 0.977 and 0.981, and 0.903 and 0.927 for WEPP and EPM, respectively. Also, deviation (R_e) between the mean simulated and observed sediment values for the WEPP and EPM models were -8.5% and -2.4%, and -2.0% and -0.5%, respectively. These results indicate that the WEPP simulations were better than EPM, and could be used for soil loss and sediment yield estimation in the Marmeh Watershed.

Keywords: Soil loss; Sediment yield; Calibration, Validation

INTRODUCTION

Soil erosion, and its associated impacts, is one of the most significant (yet perhaps the least well known) of today's environmental problems (Ekwue and Samaroo, 2011). It has been recognized as a serious degradation problem. In addition, it can reduce soil productivity and increase sediment and other pollution loads in receiving waters (Qiang Deng et al., 2008).

In Iran, soil is lost due to erosion approximately 19 times faster than it forms. Therefore, the present and future potential for soil degradation is very great (Emadodin et al., 2012). Different types of soil erosion affect approximately 1.2 million km^2 of the land area of Iran (Ahmadi, 2004). Water erosion removes a maximum of 500 million tons soil from about 15 million ha of agricultural land each year (Samani et al., 2009). According to Pimentel et al. (1995), soil formation takes between 200 and 1,000 years to form 2.5 cm of topsoil.

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Note: The author declare that they have no conflicts of interest. Authorship Form signed online.

Accelerated soil loss and associated nutrient loss are a great concern for sustainable farming and, more commonly, sustainable land use management. Estimation of the rate of soil erosion on a range of time scales is significant for land use planning, erosion risk assessment, and for evaluating the effects of land use change (Croke and Nethery, 2006; Rose et al., 1997).

During the last decades, researchers have developed soil erosion models of empirical or conceptual nature for prediction of soil loss variables. Soil erosion models can be divided into empirical and physically based models (Pandey et al., 2008). Empirical models usually establish relationships between runoff, sediment yield and precipitation, plants, soil types, land use types, tillage styles, water conservation measures and so on (Rose et al., 1997). They are still used because of their simple framework and ease of application. Since they are based on coefficients computed or calibrated from measurements and/or observations, they cannot explain or simulate the erosion process as a set of physical phenomena (Amore et al., 2004; Raclot and Albergel, 2006).

The Erosion Potential Method (EPM) is an empirical model, which originally was developed for Serbia by Gavrilovic (1988). It estimates soil erosion from an area simply as the product of empirical coefficients, which must therefore be accurately evaluated. This method is in use also in Bosnia & Herzegovina, Croatia, Italy, Iran, Montenegro, Macedonia, Serbia and Slovenia, as well as in some countries of Central and East Europe: Czech Republic and Bulgaria (Kostadinov et al., 2014). The EPM is distinguished by its high degree of reliability in calculating sediment yields as well as transport and reservoir sedimentation (Ristic et al., 2011). This method has been tasted in some catchments area in Iran, and it is appeared that output results are compatible with field observation. (Nadjafi, 2003; Maleki, 2003).

Physically based models simulate the separate elements of the whole erosion process by solving the corresponding equations; and so it is argued that they tend to have an extensive range of applicability. Such models are also in general better in terms of their capability to assess both the spatial and temporal variability of the natural erosion processes (Rose et al., 1997; Amore et al., 2004).

The Water Erosion Prediction Project (WEPP) is a physically based model that simulates soil loss, sediment yield and deposition using a spatially and temporally distributed approach (Flanagan and Nearing, 1995). The WEPP watershed model is a continuous simulation computer program that predicts soil loss process from overland flow on hill slopes, sediment yield and deposition from concentrated flow in small channels, and sediment deposition in impoundments. It computes spatial and temporal distributions of sediment yield and deposition, and provides clearly estimates of when and where in a watershed or on a hill slope that erosion occurs so that conservation measures can be selected to most effectively control soil erosion (Flanagan and Nearing, 1995).

The aim of this study was to evaluate the application and differences of two models EPM and WEPP at the arid region, Marmeh Watershed in the south

Iran, by evaluating and comparing the output data related to erosion processes and the sediment yield.

The EPM

The EPM calculates coefficient of erosion and sediment yield (*Z*) of an area by following equation (Gavrilovic, 1990):

$$Z = Y.X.(\varphi + \sqrt{I}) \tag{1}$$

where *Y* (dimensionless) is soil erodibility coefficient; *X* (dimensionless) soil protection coefficient; φ (dimensionless) the erosion development coefficient; and the factor *I* is the mean land slope %.

The analytical equation for the calculation of the annual volume of detached soil due to surface erosion is as follows (Blinkov and Kostadinov, 2010):

$$W_{SP} = T.H.\pi.Z^{1.5} \tag{2}$$

where W_{SP} is the average annual specific production of sediments per km^2 in m^3/year; *T* is a temperature coefficient, calculated as:

$$T = \left(\frac{t}{10} + 0.1\right)^{0.5} \tag{3}$$

with *t*, the mean annual temperature in degrees celsius; *H* the mean annual precipitation in mm; *Z* calculated from equation (1).

For field scale applications, local values of such factors can be obtained from diagrams and tables, which were originally developed after experimental research in Serbia (Gavrilovic, 1988). The actual sediment yield was calculated as follows (Spalevic et al., 2014):

$$G = W_{SP}.R_u \tag{4}$$

where *G* is the actual sediment yield in m^3/year; R_u is sediment delivery ratio, calculated as:

$$R_u = \frac{(\sqrt{P.D})}{0.2(L+10)} \tag{5}$$

where *P* is perimeter of the watershed in km; *D* is the average difference of elevation of the watershed (or sub-watershed) in km; *L* is length of the watershed in km. Average difference of elevation calculated as:

$$D = \frac{\sum_{i=1}^{n} f_i . h_i}{F_w} - H_{\min} \tag{6}$$

where f_i represents area between two contour lines (km^2); h_i, average altitude between the contour lines (m); and H_{min}, the minimal altitude of the watershed (m).

The WEPP model

WEPP is a process-based soil erosion prediction model (including infiltration, runoff**,** and soil detachment) that has been developed over the past 25 years by the USDA. It can be applied to small watersheds (up to about 260 ha) that are included of multiple hillslopes, channels, and impoundments. Despite this limitation, several test of WEPP capabilities have been conducted on watershed size greater than 100 km^2 (e.g., Amore et al., 2004).

GeoWEPP, a geo-spatial erosion prediction model, was developed to integrate the advanced features of GIS (Geographical Information System) within the WEPP such as processing digital data sources and generating digital outputs (Yuksel et al., 2008; Wu et al., 2000). GeoWEPP overcomes the limitation of the WEPP, which is that the user must manually generate necessary input data.

The GeoWEPP approach, permit much easier model setup for larger watershed simulations, since digital elevation model (DEM) and other land use/land cover and soil GIS data layers can be automatically processed to generate the watershed structure and slope inputs, and other geospatial data can provide soil and land use information (Flanagan et al., 2013).

The WEPP erosion model uses a steady state sediment continuity equation to describe downslope movement of sediment (Foster et al., 1995):

$$\frac{dG}{dx} = D_f + D_i \tag{7}$$

where G, sediment load (kg/m^2/s) at distance x from the origin of hillslope; x, distance down slope (m); D_i, interrill sediment delivery rate to rill (kg/m^2/s); and D_f, rill detachment rate (kg/m^2/s). D_i was calculated using following equation:

$$D_i = K_i I_e \sigma_{ir} SDR_{RR} F_{nozzel} \left(\frac{R_s}{w} \right) \tag{8}$$

where K_i, adjusted interrill erodibility (kg s/m^4); I_e, effective rainfall intensity (mm/h), σ_{ir}, interrill runoff rate (mm/h); SDR_{RR}, interrill sediment delivery ratio; F_{nozzle}, adjustment factor for sprinkler irrigation nozzle impact energy variation; R_s, rill spacing (m); and w, width of rill (m). Then, D_f was calculated using following equation:

$$D_f = K_r(\tau_f - \tau_c)\left(1 - \frac{G}{T_c}\right) \tag{9}$$

where K_r, Adjusted soil erodibility parameter (s/m); τ_f, flow shear stress (kg/m/s^2); τ_c, adjusted critical shear stress of the rill surface (kg/m/s^2) (When $\tau_f < \tau_c$, detachment is zero.); and T_c, sediment transport capacity of the rill flow (kg/m/s). T_c was calculated as follows (Huang et al., 1993) (Foster et al., 1995):

$$T_c = K_{tr}.q_w.s \tag{10}$$

where K_{tr}, constant parameter; q_w, flow discharge per unit width (m^2/s); and s, slope (%). Finally, net deposition was computed as follows (Foster and Meyer, 1972; Foster et al., 1995):

$$\frac{dG}{dx} = \frac{\beta_r V_f}{q_w}(T_c - G) + D_i \tag{11}$$

where V_f, effective fall velocity of the sediment (m/s); and β_r, raindrop induced turbulence coefficient (0-1)(β_r=0.5) (Storm et al., 1990).

MATERIALS AND METHODS

Study Area description. The Marmeh Watershed is located in the south of Fars province, Iran. It extends over a total area of 124.56 km^2 within ten sub-watersheds, with an elevation of 880-1700 m above the sea level and between 27˚58′ to 28˚07′ N latitude and 53˚44′ to 53˚53′ E longitude (Fig. 1). The mean slope of the watershed area is 20.3%. The mean annual air temperature is 21.4˚C. Mean annual precipitation is 240.2 mm. Main land use types are rangelands (>66%) and croplands. The main soil type are Entisols and Inceptisols. The study area is covered mainly by limestone formation and after that by Quaternary alluvium.

Input Data. In order to provide the best comparison between the two models, input data were prepared to have a standard basis. Particularly, Watershed was partitioned into morphological subdivisions (see Fig.1) or homogeneous parts, hill-slopes, and their geometric, geological and land use characteristics were defined and quantified before application of the models. Specific data for each model were then prepared separately, as required, for each model.

Fieldwork and laboratory analysis. Fieldwork was undertaken to gather detailed information on the intensity and the forms of soil erosion, the status of plant cover, condition of land use and the measures in place to reduce or diminish the erosion processes. Morphometric methods were used to determine the slope, the specific lengths, the exposition and form of the slopes, the depth of the erosion base and the density of erosion rills (Spalevic et al., 2014).

During the field work 24 pedological profiles had been opened, and soil samples were taken for physical and chemical analysis. Particle size distribution and soil texture was determined by the hydrometer method (Bouyoucos, 1962). Organic Carbon (OC) was determined using a wet combustion method (Nelson and Sommers, 1982). Cation Exchange Capacity (CEC) was determined using sodium acetate (NaOAc) at a pH 8.2 (Chapman, 1965).

EPM application

In order to correctly apply Eq. (1) on each sub-watershed, proper values of all factors had to be chosen. Values of soil erodibility coefficient Y, related to rock and soil type, resistance to erosion were taken from tables (values available at Gavrilovic, 1972), based on geological structure available from the digital geological map of the areas.

Similarly, a digital map related to the cropping management values (X factor) was built, by marking each land use type as indicated in EPM tables (values available at Gavrilovic, 1972). The erosion development coefficient (φ) is numeral equivalents of visible and clearly exposed erosion process, based on field investigation and digital stream network. In addition, I, P, D, and L values calculated by the topographic analyses. Table 1 reports for the ten sub-watersheds, as obtained from the above described procedures. Erosion severity is classified according to values of Z, areas with $Z>1.0$ ‘severe erosion’ and those with $Z<0.19$ have very slight erosion. In order to obtain the total soil loss and sediment yield for each area, the sediment delivery ratio R_u was calculated by its, respective.

WEPP application

WEPP model requires four input variables including slope, climate, soil, and management to describe hillslope geometry, meteorological characteristics, soil properties, and ground cover, respectively (Yuksel et al., 2008).

The WEPP model uses CLIGEN (Climate Generator), which is a stochastic weather generation model (USDA, 2003). In CLIGEN, four precipitation-related variables (precipitation depth and duration, peak storm intensity and time to peak) are of particular importance because previous studies have shown that predicted runoff and soil loss are most sensitive to these precipitation variables (Nearing et al., 1990; Chaves and Nearing, 1991).To generate climate file with daily values of rainfall and maximum and minimum temperature, collected over a 35-year period from the Marmeh weather station.

Land use/management file were from interpretation of IRS P6 LISS-4 (5 m resolution) satellite imagery, based on field investigation (Fig. 2). The slope file is generated based on necessary hillslope parameters such as slope gradient, shape, width, and orientation along its length. GeoWEPP utilizes TOPAZ (TOpography PArameteriZation) software to produce sub-watershed profiles and to determine the channel network (based on the steepest down slope path) based on DEM data.

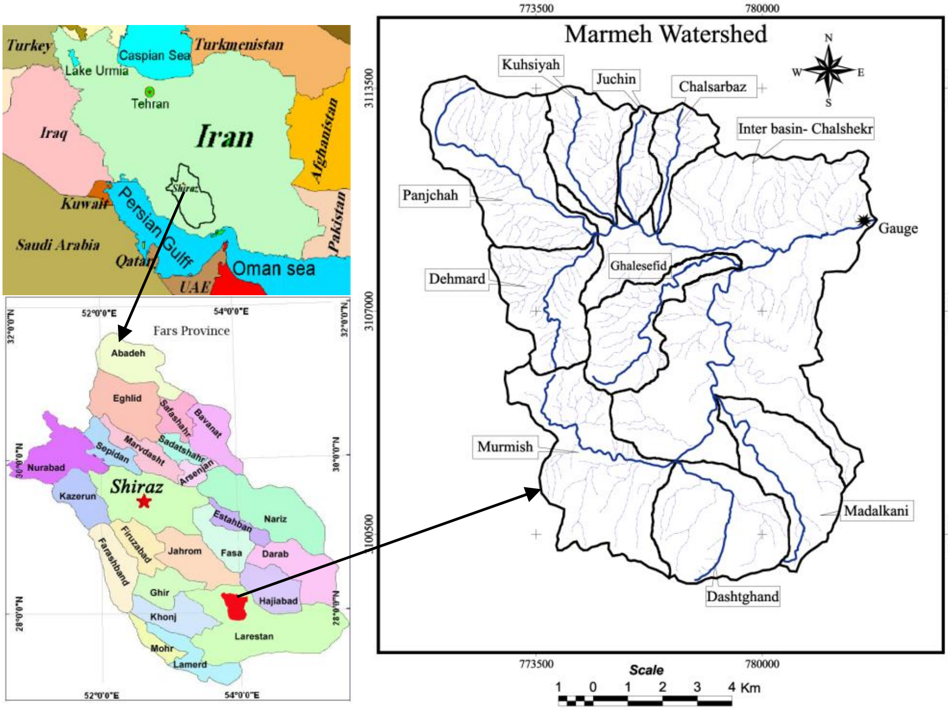


Figure 1.Location map of the study area, Marmeh watershed, Fars province, Iran.

Table 1: Sub-watershed wise input data used in EPM model

EPM input data	Parameters for different sub-watersheds									
	Chlshekar	Chalsarbaz	Juchin	Kuhsiyah	Panjchah	Dehmard	Ghalesefid	Murmish	Dashtghand	Madalkani
X	0.8	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.9
Y	0.9	0.9	0.9	1.1	0.9	0.9	0.9	0.9	0.9	0.9
φ	0.8	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.6
I(%)	8.3	42.5	40.0	18.5	18.0	18.5	42.5	8.5	18.5	2.5
P(km)	55	10.15	8.43	12.00	17.89	13.84	13.07	22.40	13.12	15.35
D(km)	0.135	0.338	0.320	0.361	0.355	0.450	0.180	0.152	0.160	0.090
L(km)	9.82	3.86	3.45	4.31	6.48	4.45	4.42	5.55	4.24	5.64

In this research, 10 sub-watersheds and channels (Fig. 1) in the study area were derived from 25 m DEM (Fig. 3), generated by using TOPAZ based on the 1:25 000 scale topographic maps.

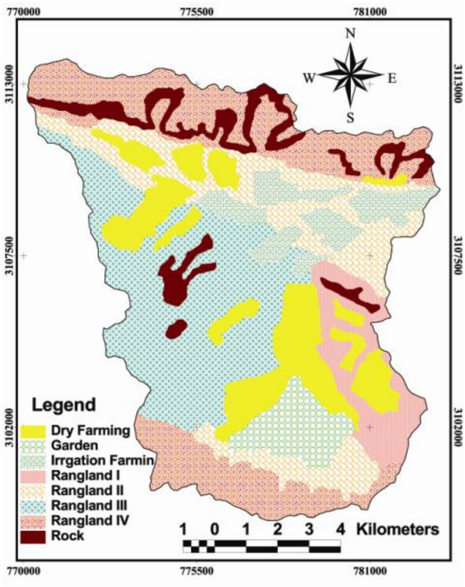


Figure 2. Land use of Marmeh Watershed

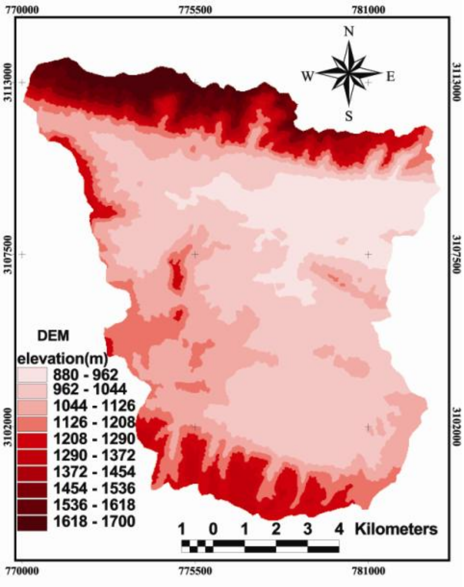


Figure 3.DEM of Marmeh Watershed

Table 2:Sub-watershed wise input soil parameters used in WEPP model

Soil parameters	Parameters for different sub-watersheds									
	Chlshekar	Chalsarbaz	Juchin	Kuhsiyah	Panjchah	Dehmard	Ghalesefid	Murmish	Dashtghand	Madalkani
Albedo	0.44	0.54	0.42	0.33	0.47	0.43	0.42	0.5	0.39	0.41
Initial satur. level (%)	75	75	75	75	75	75	75	75	75	75
Sand (%)	44	58	33	37	54	27	55	53	49	42
Clay (%)	16	9	32	38	11	13	11	13	13	12
Organic (%)	0.81	0.27	0.87	1.48	0.58	0.81	0.87	0.47	1.07	0.97
CEC (meq/100 g)	10.05	7.02	15.25	17.39	7.78	9.33	8.74	9.17	9.55	9.09

With regard to the soil input file, percentages of sand, clay, rock and Organic Matter and CEC were obtained from Fieldwork and laboratory analysis. Effective Hydraulic Conductivity (K_e) was computed internally by the WEPP model on the basis of sand and clay contents and CEC. Soil erodibility parameters, including Interrill Erodibility (Ki), the Rill Erodibility (Kr) and the Critical Hydraulic Shear (τ_c) were computed following equations as suggested in WEPP technical documentation (Flanagan and Nearing, 1995). In particular, as regard to (Kr); its value had to be adjusted each time the hillslope had a length greater than 100 m, to meet the condition for this parameter to be correct in WEPP simulations. Slope lengths longer than 100 m result in over-prediction of erosion by WEPP (Baffaut et al., 1997). The Initial Saturation Level was set equal to 50–75% based on soil water content estimated at the beginning of the first year of the entire period of simulation. The soil albedo parameter was estimated through the Baumer equation (Flanagan and Livingstone, 1995).Table2 reports for sample/pedological profiles and ten sub-watersheds, as obtained from the above described procedures.

Models evaluation

The models evaluation procedure included calibration, sensitivity analysis and validation. To calibrate the models, sensitivity analyses were performed for 2010 and 2011 by changing the value of a parameter within an acceptable range and observing the sediment yield output. Critical parameters can be identified by sensitivity analysis and can be calibrated to improve the agreement between the simulated and observed data. Sensitivity analysis provides a method for examining the response of a model in a way that eliminates the influence of error related to natural variation of the model input parameters (McCuen and Snyder, 1986). The sensitivity ratio (S_r) was determined as (McCuen and Snyder, 1986):

$$S_r = \frac{(y_2 - y_1)/\bar{y}}{(x_2 - x_1)/\bar{x}} \tag{11}$$

where x_1 and x_2 are the least and greatest values of input used, $\bar{x}$ is the average of x_1 and x_2, y_1 and y_2 are the corresponding outputs for the two input values, and $\bar{y}$ is the average of the two outputs. The parameter S_r is a function of the chosen input range for nonlinear response.

The parameter, which produced the maximum sensitivity, was adapted first, followed by the other parameters. The input parameters that showed insignificant variation were not calibrated and were taken as model default values. Thus, the calibration process focused mainly on input parameters that control sediment yield. Once the model was calibrated, it was run with the calibrated parameters, and the sediment yield values predicted for the validation period (Shen et al., 2009)

The root mean squared error (RMSE) is used to evaluate the performance of the models by deriving useful information about the nature of the difference between the observed and predicted values. Since the RMSE has the same units as the predicted and observed values, it can be easily interpreted (Willmott, 1981). The RMSE is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(P_i - O_i)^2}{N}} \tag{12}$$

where O_i and P_i are the observed and predicted values, and N is the total number of paired values. The smaller the RMSE, the closer simulated values are to observed values.

The deviation of sediment values is given by the following equation (Yen, 1993):

$$R_e(\%) = \left(\frac{P_i - O_i}{O_i} \right) \times 100 \tag{13}$$

The smaller the value of R_e is, the better the model results are. R_e would equal to zero for a perfect model.

In the present study, the goodness-of-fit criterion recommended by the ASCE Task Committee (1993) is Nash–Sutcliffe coefficient or coefficient of simulation efficiency (E_{NS}) (Nash and Sutcliffe, 1970) given by:

$$E_{NS} = 1 - \frac{\sum_{i=1}^{n} (O_i - P_i)^2}{\sum_{i=1}^{n} (O_i - \overline{O}_i)^2} \tag{14}$$

The coefficient of efficiency, E_{NS}, is commonly used as a measure of model performance in hydrology (e.g., Loague and Freeze, 1985) and soil sciences (e.g., Risse et al., 1993).

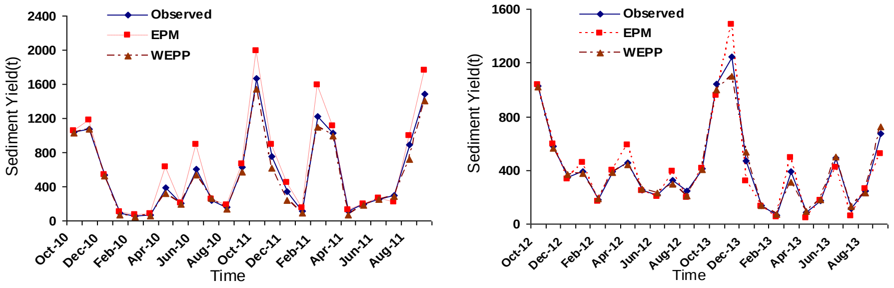
RESULTS AND DISCUSSION

Calibration and sensitivity analysis

For the models evaluation were performed calibration, validation and sensitivity analysis. In this research, a significant restriction is that the models were calibrated with the measured data at the watershed level due to inaccessible of measured sediment data at the sub-watershed level but the models were calibrated with measured data at the outlet of watershed (Pandey et al., 2008).

The Marmeh Watershed data from October 2010 to September 2011 were use to calibration. Then, the calibrated WEPP and EPM models were used to simulate monthly sediment yield for the years 2012 and 2013; the measured monthly sediment yield values were compared with simulated values to evaluate the model validation performance. The simulated monthly mean sediment yield values by the WEPP and EPM models for the calibration and validation periods were compared with observed values (Fig. 4). The scatter gram plots of simulated and observed sediment yield for the calibration and the validation periods show that the data points are scattered around 1:1 line (Fig. 5).

The high coefficients of determination (R^2) (Table 3) indicated a positive relationship between the simulated and observed sediment yields (Fig. 5). High values of Nash–Sutcliffe model efficiency (E_{NS}) of 0.977 and 0.981, and 0.903 and 0.927 for WEPP and EPM, respectively for calibration and validation periods indicate that the models are capable for simulating monthly sediment yield with acceptable accuracy (Table 3).

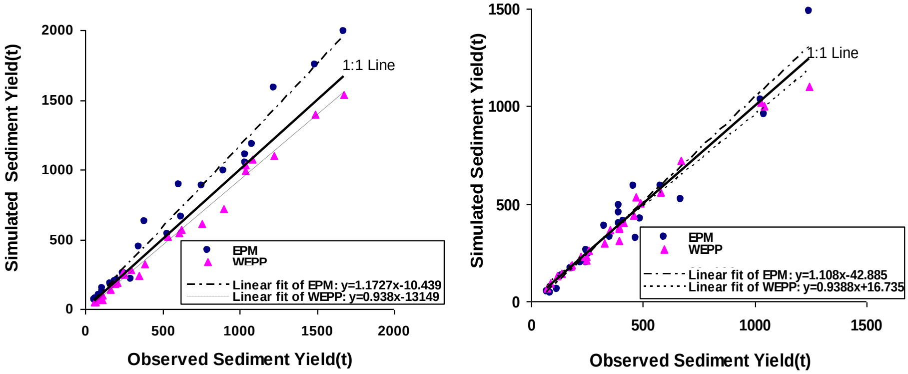


(a) Calibration (b) Validation

Figure 4. Observed and simulated sediment yield for the Marmeh Watershed.

During calibration and validation periods, the overall percent deviations (R_e) between the mean simulated and observed sediment values for the WEPP and EPM models were -8.5% and -2.4%, and -2.0% and -0.5% respectively (Table 3). This results show that the smaller the R_e values for both WEPP and EPM models, the greater the amount of sediment yield were and inversely. This is consistent with the previous studies using hillslope models (Zhang et al., 1996; Nearing and Nicks, 1997; Liu et al., 1997; Nearing, 1998, 2000; Nearing et al., 1999 and Shen et al., 2009).

For both the WEPP and EPM results, most simulated small and large events were over-estimating and under-estimating. This is inherent to all erosion models as reported by Ghidey et al., 1995; Kramer and Alberts, 1995; Nearing, 1998 and Shen et al., 2009).



(a) Calibration (b) Validation

Figure 5. Comparison of simulation sediment yield between WEPP and EPM

Table 3:Statistical analysis of observed and simulated monthly sediment yield.

Models	Periods	Mean sediment yield (t)		Re(%)	RMSE	R^2	ENS
		Observed	Simulated				
WEPP	Calibration	561.05	513.13	-8.5	70.360	0.990	0.977
	Validation	415.34	406.67	-2.0	40.836	0.984	0.981
EPM	Calibration	561.05	547.48	-2.4	145.784	0.976	0.903
	Validation	415.34	413.13	-0.5	81.323	0.931	0.927

Sensitivity analyses of the models were carried out to assess the variations in the models output with change in input parameters. For the WEPP model, effective hydraulic conductivity, rill erodibility and critical hydraulic shear stress values were most sensitive for soil erosion. For the EPM model, land slope, soil erodibility and soil protection were dominant in erosion process.

EPM model application at watershed scale

In this part, the EPM application at watershed scale is presented. Erosion and sediment yield (Z) rates for the Marmeh watershed as calculated in the traditional way are given in Table 4. Rates were calculated for 10 sub-watersheds (flow direction considered), using one value of each parameter for one sub-watershed. Ghalesefid and Chalsarbaz among of all sub-watersheds have the Maximum erosion rates and sediment yield (Z=0.91). The erosion distribution and erosion hazard areas in the Marmeh watershed are shown in Fig 6.

WEPP model application at watershed scale

WEPP watershed simulation for all flowpaths averaged over sub-watershed. The WEPP watershed delineation using the GeoWEPP considered some of the area in the upstream direction as drains to other watershed, a result of variation in the watershed delineation from GeoWEPP. The sum of erosion rates for the Marmeh watershed with this method were estimated 1226.5 ton/ha/y. The WEPP spatial map output as shown in Fig 7.

Table 4: Erosion and sediment yield rates for the Marmeh watershed

	Results for different sub-watersheds									
	Chlshekar	Chalsarbaz	Juchin	Kuhsiyah	Panjchah	Dehmard	Ghalesefid	Murmish	Dashtghand	Madalkani
Z	0.78	0.91	0.90	0.87	0.88	0.77	0.91	0.79	0.77	0.61
Ru	0.68	0.66	0.61	0.72	0.76	0.86	0.53	0.59	0.51	0.37
Wsp (m^3/km^2yr)	780.2	976.25	961.78	918.77	936.21	762.38	979.48	792.27	765.35	537.56
G(m^3/yr)	530.5	644.32	586.68	661.51	711.52	655.64	519.12	467.44	390.32	198.89

Comparison of the models

The result showed that WEPP simulated sediment yield better than EPM. All statistical criteria of the WEPP model for the calibration and validation periods including R_e, $RMSE$, R^2, and E_{NS}, were better than those of the EPM model. Shen et al. (2009) and Bhuyan et al. (2002) used WEPP, SWAT and WEPP, EPIC (the sediment yield simulation part is USLE or a modified version) to simulate sediment yield and test the capability of the models to simulate sediment yields. Their results indicated that WEPP predictions were better than those of the models.

The sediment yield that was estimated by WEPP had a different spatial method the one estimated using EPM. WEPP uses the steady-state sediment continuity equation to predict soil loss, while EPM sediment yield simulation is the factor-based, which means that a series of factors, each quantifying one or more processes and their interactions, are combined to yield an overall estimation of the soil loss. Additionally, limitations of the EPM estimation can be attributed to its dependence on many empirical factors, maybe not well suited to condition of the Marmeh Watershed.

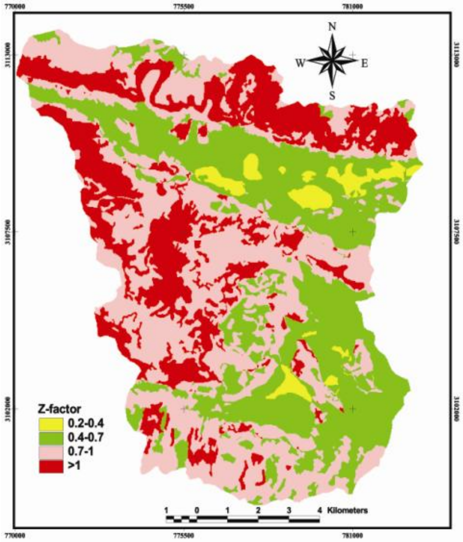


Figure 6. Erosion distributions using EPM model

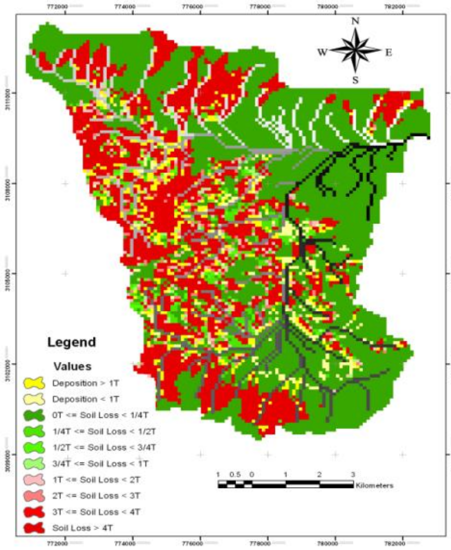


Figure 7.Soil loss variation using WEPP model

.CONCLUSIONS

Soil erosion and land degradation are two main problems of upland watersheds that contribute to the increase of sediment yield and decline of water quality. In this study, the empirical EPM and the physical WEPP were applied to estimate soil loss and sediment yield from Marmeh Watershed. Each model was used to hillslopes that were obtained by subdividing (ten sub-watersheds) the watershed. The simulation result for both models showed that soil loss and sediment yield rate is too high in the Marmeh Watershed. It also indicated that the greater the observed values, the smaller were the deviation values for both models and inversely. Statistical analysis showed that the WEPP model provided better estimations than the EPM model for soil loss and sediment yield. Consequently, it is suggested to replace the EPM model with the WEPP model used for watersheds in Iran.

ACKNOWLEDGEMENTS

The research was supported by the Islamic Azad University, Khorasgan branch, Isfahan, Iran. The authors are grateful to Dr. Shakeri for help with field works. Thanks are due to two anonymous reviewers for their useful comments on this manuscript.

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