The estimation of erosion and sediment by using the RUSLE model and RS and GIS techniques (Case study: Arid and semi-arid regions of Doviraj, Ilam province, Iran)

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ABSTRACT: Nowadays, soil erosion is expressed as one of the important topics of watershed management at national and international level. The estimation of soil reduction risk and its spatial distribution is one of the important factors for the successful assessment of soil erosion. The purpose of this study is prediction of annual loss potential of soil and sediment load. The soil reduction due to erosion can be obtained by using prediction model like the Universal Modified Equation of Soil Erosion (RUSLE). In this research, the RUSLE model is used for estimation the erosion and sediment yield in Doviraj watershed located in Ilam province, Iran. The RUSLE factors are included R, K, LS, C and P that are calculated from data of rainfall, region soil map, Digital Elevation Model (DEM) and remote sensing techniques, respectively. The mean values of R, K, LS, C and P factors were equal to 209.04MJ mm h⁻¹ha⁻¹, 0.51 Mg ha⁻¹ha⁻¹MJ⁻¹mm⁻¹, 10.16, 0.53 and 1, respectively. The mean annual sediment yield was calculated as 273.6 ton/ha/year in the study area that was close to the measured value from Doviraj sediment gauging station (253.42 ton/ha/year). The calculated sediment value is 7.96% more than that of the measured sediment value (observed) (based on calculating the relative error). Therefore, there is no significant difference between rate of the observed and calculated sediment. Also the results showed that measurement of remote sensing techniques and GIS can be used for evaluate and calculate the rate of erosion and sedimentation.

Key Words: soil erosion, RUSLE model, remote sensing, GIS, Ilam province.

INTRODUCTION

Erosion and sediment production are one of the important problems at the country watershed management. Erosion and its consequences, with intensification of the man exploitation of nature from the early twentieth century, are entered owns negative effects on the vital ecosystem (Lu et al., 2001). The main reason is population increase and overuse of land (Ahmadi, 1999). The scientific plans for soil conservation require to accurate information about the factors that caused erosion. According to the causative factor of erosion at each location, the accuracy of this information causing that take place the appropriate protection operations with it. Accurate information from the erosion is very low in Iran and also was observed very differences between the observations and calculations. Being young the research of this field and lack of long-term measurements of erosion is prevented to achieve the reliable numbers (Arab Khadri, 2005). As regards that the measurement of the watershed water erosion rate were done in the hydrometric stations and sediment survey, the absence of these stations creates problems for calculation the soil erosion rate at the watershed surface. The estimation close to reality of the erosion and sediment value in an area always has been considered by researchers. The lack of the accurate statistics of erosion and sediment value in many countries, the use of erosion and sediment calculation models is inevitable (Ahmadi, 1999).

The watershed of Doviraj River is one of the largest watersheds of Ilam province. There is a reservoir dam in the output of this watershed. The outburst of this river in the wet seasons leads to create the destructive floods in downstream lands and Mosiyan fertile plain. Therefore, the study of erosion and sediment yield of this watershed has the great importance. Several models have been presented for the calculation and management plans development of soil erosion that the most important of these models, can be refer to: Universal Equations
of Soil Erosion (Wischmeier and Smith, 1978), Water Erosion Prediction Project (Flanagan and Nearing, 1995), Soil and Water Assessment Tool (Arnold et al., 1998) and European Soil Erosion Model (Morgan et al, 1998). During the recent 40 years, USLE model due to the simple calculations, has been mostly used for the estimation of potential soil erosion and different management operations effects (Kinel, 2000), and subsequent, the new version of USLE model has been developed with name of the Revised Universal Soil Loss Equation (RUSLE) that does more precise estimations of R, K, C, P factors and soil erosion (Renard et al., 1991; Van Remortel et al., 2004). Due to the capability of Geographic Information System (GIS) and Remote Sensing (RS) in geospatial data analysis; RUSLE/USLE models are combined with GIS and RS (Ouyang and Bartholic, 2001; Lufafa et al., 2003). Other advantages of using the GIS and RS techniques, is the possible of soil erosion estimation and erosion geospatial distribution with the acceptable cost and accuracy at the large areas (Mill ward and Mersey, 1999; Wang et al., 2003). For example, by combining RS techniques, GIS and this model, the network (distributor) soil erosion potential can be estimated (Mill ward and Mersey, 1999). Boggs et al. (2001) estimated the soil erosion risk based on RUSLE revised model, DEM data and land units map. Bartsch et al. (2002) used the GIS techniques for calculation the required factors of RUSLE for determination of soil erosion risk at Camp Williams. Considering the limitations of previous studies, Wilson and Lorang (2002), studied the GIS applications for soil erosion estimation and proved that the GIS provides the extraordinary ability for improvement and soil erosion estimation. Wang et al. (2003) have attempted using the geocentric data, Landsat images (TM) and DEM for soil erosion prediction by geo statistical methods. These researchers showed that these methods give significantly better results than that of the traditional methods. Arekhi and Niazi (2010) used the RUSLE model, RS techniques and GIS for soil erosion estimation and sediment yield of Ilam dam. The results are shown that the mean of annual sediment yield was calculated as 14.75 ton/hectare/year in the study area which is close to the obtained value of sedimentation station of Ilam dam (16.58 ton/hectare/year). The result of this research also showed, LS factor with correlation coefficient of 0.77 has been the maximum effect for the annual soil erosion estimation by the RUSLE model. This study proved the effectiveness of RS and GIS for quantitative estimation of soil erosion values, sediment yield and also erosion management.

The purpose of this research is the modeling of soil erosion rate and sediment yield of Doviraj watershed by combination of the RUSLE model, GIS and RS.

**METHODS**

*Characteristics of the study area*

The Doviraj watershed is located at the geographic range of 47° 16' - 47° 40 eastern length and 32° 34' -33° 05 north latitude in south of Ilam province, west of Iran. This watershed is beside the Karkheh River and limited to the heights of Kabir Kouh at north. The Black and Kase Mast mountains are the most important mountains of watershed. The area of study region is 118837.77 hectare and the maximum and minimum elevations of the study area are 2163 and the 177m above sea level respectively. The Ilam-Khuzestan road is located at the east to west direction and south of watershed. Figure 1 is shows the location of the study area at Ilam province and Iran.

![Figure 1. The location of the study area](image)

**MATERIALS**

The early studies are included the interpretation of topographic maps(1:500000), land capability map (1:80000), the study of rainfall statistics of weather stations, examination of detailed study report of Doviraj watershed of Ilam, the satellite image ETM+(2007) and ArcView 3.2,Envi 4.8,Ldrisi ands, ArcGIS 9.3 and ILWIS3.3soft wares.
THE RESEARCH METHOD

Universal Soil Loss Equation (USLE) and its revised version (RUSLE) are used for prediction of soil erosion and design of protective programs (Renard et al., 1991; Sadeghi et al., 2004). The RUSLE model is a water erosion estimation model that related to the following six erosion factors (Wischmeier and Smith, 1978) (equation 1):

\[ A = R \times K \times L \times S \times C \times P \]

In this equation, A is mean soil erosion at area level (ton/hectare/year), rain erosivity factor MJ mm ha\(^{-1}\) h\(^{-1}\) y\(^{-1}\) (R), soil erodibility factor Mg ha h ha\(^{-1}\) MJ\(^{-1}\) mm\(^{-1}\) (K), slope length factor (L), slope degree factor (S), management operations and coatings factor (C) and protective operations (P). L, S, C and P values are no unit. In this study, the general method is involved using of RUSLE model in GIS area. Next paragraphs also explains how to estimate R, K, C, P and LS factors that obtained from rainfall data, soil maps, processing of satellite images(C and P factors) and Digital Elevation Model.

Rain erosivity factor

Rain erosivity is defined as the rain compressional power in incidence of erosion (Lal, 1990). The most common index of the rain erosivity is R factor which is related to USLE and RUSLE models. The study of scientific papers showed, in many parts of the world, R factor has high correlation with soil erosion (Ferro et al., 1991; Renard and Freimund, 1994; Wischmeier and Smith, 1978; Yu and Rosewell, 1996). The R factor for different periods is obtained from the product of rain kinetic energy (E) in the maximum of 30-minute rainfall intensity \( I_{30} \). Since the rainfall graph and shower detailed data (intensity of rainfall) are available rarely on water stations, mostly monthly and annual mean values of rain is used for estimation of R factor in USLE and RUSLE models (Renard and Freimund, 1994; Yu and Rosewell, 1996; Ferro et al., 1991). For determination of R factor, after determination of index stations at the study area, monthly and annual rainfall was reconstructed at these stations and the study period. Figure 2 shows 12 stations which are used in this study. In the next stage, by using the following equation, the Fournier index and R factor for all stations are obtained. Fournier index (F) value from equation (2) is obtained (Renard and Freimund, 1994):

\[ F = \frac{\sum_{i=1}^{12} p_i^2}{\sum_{i=1}^{12} p} \]  

(2)

In this equation pi is the average rainfall in month i and p is the average annual rainfall (mm). In this study, by using equation (3 and 4), Fournier index was calculated for all station and then with substitution Fournier index (equation 5) in the following equations that proposed by Renard and Freimund (1994) for the regions with lack of shower detailed data (intensity of rainfall), R factor value estimated for index stations.

\[ R - \text{factor} = (0.07397 \times F^{1.847}) / 17.2 \]  

(3)

If mm F<55 mm

\[ R - \text{factor} = (95.77 - 6.081 \times F + 0.4770 \times F^2) / 17.2 \]  

(4)

If mm F ≥ 55

Figure 2.Location of the meteorological stations in the study area
Soil erodibility factor

Soil erodibility factor (K), is soil erodibility rate per rain erosion index unit that is measured in the standard plot and often determined by using soil characteristics (Parysow et al., 2003). In the standard plot, the measurement of erosion is dependent on several soil characteristics including: soil texture, the rate of soil organic matter and permeability (Wischmeier, 1971), but in this study due to the level and information accuracy, the Ericsson triangle alignment chart is used for determining the soil erodibility factor (Figure 3). After soil testing and soil texture determination for the sampling points the K factor values was extracted by the Erickson graph and the mentioned method and K factor map prepared by ARCGIS 9.3 software for the study watershed.

Figure 3. The alignment chart of soil erodibility factor

The slope length and slope degree factors

The L and S factors in RUSLE model, present the topography effect on soil erosion. The increase of slope length and slope degree increases the water flow rate at ground surface and causes the acceleration soil erosion (Haan et al., 1994). Based on studies, pure soil erosion is more sensitive to changes at the slope degree against the slope length (McCool et al., 1987). The slope length is the distance between the high point of start downhill and the point of minimum slope and this point the sediments are deposited (Wischmeier and Smith, 1978). The topography special effect on soil erosion is estimated by LS factor (unit less). Due to the importance of the slope length and degree on soil erosion by changing the water flow rate in ground surface (Haan et al., 1994), its stress and variability were considered at the study area. The integrated effect of these factors was calculated by the equation (5) in the topographic factor (Mushtak, 2003).

\[(5) \text{LS} = (\text{Flow accumulation} \times \text{Cell size}/22.13)^{0.4} \times (\sin (\text{slop} \times 0.01745)/0.09)^{1.3} \times 1.6\]

For preparation of the map of LS topographic factor, first the Raster map of Flow accumulation was prepared by Arc Hydro Extension, DEM map and the ARC GIS 9.3 software. Using the ARC GIS 9.3 software, the LS factor and the output map was prepared (Figure 4).

Figure 4. Watershed slope map (degree)
The vegetation management factor

The management factor of vegetation is indicative the planting effect on agricultural management and effect of tree, shrub, grass and groundcovers on soil erosion reduction. By increasing the vegetation, soil erosion is reduced. Benkobi et al. (1994) and Biesemans et al. (2000) reported the vegetation factor with slope degree and slope length has more sensitivity in soil erosion and sediment generation. In the RUSLE model, vegetation factor is usually determined by empirical equations (Wischmeier and Smith, 1978). But most used of the vegetation growth index is Normalized Difference Vegetation Index (NDVI) that obtained by Remote Sensing technology. NDVI is one of the most popular vegetation indices that is defined by infrared \( IR^2 \) and near-infrared \( NIR^1 \) bands as equation (5) (Mather, 1999).

\[
NDVI= \frac{(NIR+IR)}{(NIR-IR)}
\] (5)

This index is introducing solar energy reflection from the earth surface which represents the types of vegetation. The NDVI values have fluctuation between 0 and 1. When the measured spectral response from the earth surface is very similar, NDVI values are close to zero. The normal vegetation (with photosynthesis activity) in near-infrared wavelength (NIR) (Landsat Band 4) has more reflection in comparison with visible spectrum (Red, Landsat Band 3); therefore, the NDVI values for green vegetation will be positive. The regions with little or no vegetation such as urban areas and arid lands usually show NDVI values between +0.1 and –0.1. Clouds and water resources show negative or zero values. The Normalized Difference Vegetation Index (NDVI) used for calculation of the ground spectral data and its results showed that this index has the high correlation with ground biomass (Lin, 1997). For mapping the Doviraj watershed, first Modis pictures of Landsat satellite at 24/6/2007 was prepared. The necessary preprocesses such as radiometric and geometric corrections on the images were performed by using the ENVI 4.8 software. Followings, the NDVI index was extracted by Idrisi15software.

After the inverse linear transformation of the training samples, the relation between C and NDVI be created as equation (6):

\[
C = \frac{1}{2} (1 - NDVI)
\] (6)

Therefore, the C value in each cell can be calculated. Since the C factor values are between zero and one, zero value will be devoted to pixels with the negative values and one to pixels with the more than one value. Figure 5 shows the relation between NDVI values and C factor and the types of ground covers. In this study, the C factor map was prepared based on NDVI. In fact, this factor completely has the reverse relation with NDVI.

![Figure 5. The relation between NDVI and C factor for the types of ground covers (Arekhi and Niazi, 2010)](image)

Protective operations factor

Cultivation on slope lands needs to protective operations for soil and water conservation. These operations cause reducing the sewage rate below the threshold of erosion and thus reduce the water erosion power and its carrying capacity. The protective operation is included contour cropping, terracing system, covered waterways, etc. The P factor is the ratio of eroded soil in conditions protective operations to created erosion in normal conditions (plowing toward slope) (Renard et al., 1997). In this study also the tension of protective operations types included contour farming, terracing system, covered waterways and other protective effects compared with standard conditions governing on the study plots of soil erosion (Renard and Freimund, 1994), in factor analysis of lands management. For estimation the lands management factor the standard table and also the proposed values from the India central institute of soil and water conservation were used which the...
results are given in table 1. Since any management and corrective operations have been in study area, the P value is considered.

<table>
<thead>
<tr>
<th>Slope (%)</th>
<th>Contour Farming</th>
<th>Strip Cropping</th>
<th>Terracing</th>
<th>No Safe guard Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>1-2</td>
<td>0.6</td>
<td>0.3</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>2-7</td>
<td>0.5</td>
<td>0.25</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>7-12</td>
<td>0.8</td>
<td>0.3</td>
<td>0.12</td>
<td>1</td>
</tr>
<tr>
<td>12-18</td>
<td>0.8</td>
<td>0.4</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td>18-24</td>
<td>0.9</td>
<td>0.45</td>
<td>0.16</td>
<td>1</td>
</tr>
</tbody>
</table>

**Determination of sediment delivery ratio**

In order to determine the erosion rate in watershed surface, the measurement and data of (erosion plots) should be available. But since there is no these information in this watershed and also many watershed of country, the deposition rate of watershed can be estimated by using the erosion delivery ratio to watershed erosion value.

Erosion delivery ratio is a coefficient which gives the amount of eroded materials in watershed that are transfer to the watershed outlet. In order to estimate this ratio, due to the lack of statistic and numbers of erosion situation and sediment watershed, generally used of empirical methods and relations that for this purpose exposed by deferent researchers at world.

These exposed relations are too many and each of them is determinable based on several of watershed parameters. Some of these relations determine the sediment delivery ratio (SDR) based on watershed area and the others based on combination of watershed parameters such as area, slope average of watershed, main waterway slope and other parameters depending on situation and characteristics of the study region.

According to the role of watershed area increase in reduction of flood flow energy and runoff, many exposed relations are based on watershed area. This factor is very good application in cases where watersheds area is large but for the small watershed other factors involved such as watershed slope, main waterway slope and other parameters.

Here, several important estimation relations for SDR is given and based on them the watershed erosion delivery ratio are estimated:

1. Del Vanoni (1975):
   \[ SDR = 0.4724 A^{-0.125} \]
   \[ A = \text{watershed area (km}^2\text{)} \]
2. Exposed model by USDA (1972):
   \[ SDR = 0.5656 A^{-0.11} \]
   \[ A = \text{watershed area (km}^2\text{)} \]
   \[ SDR = 0.3740 A^{-0.2382} \]
   \[ A = \text{watershed area (km}^2\text{)} \]

**RESULT**

**Rusle-Factors**

The Fournier index and rain erosion values were calculated by using (5), (6) and (7) equations during 23-year statistic period (1987-2010) for 12 stations. Calculated values for Fournier index and R factor showed in Table 2. First based on the relation between slope and rainfall (Figure 7) and then based on the relation between rainfall and R factor (Figure 6), the average annual rainfall map and R factor of Doviraj watershed obtained by IDW interpolation method in ARC GIS 9.3software, respectively (Figures 8 and 9). The average R factor fluctuates between 107.41 to 276.38 \(MJ mm h^{-1} y^{-1}\) and its average value and deviation is 209.04 \(MJ mm h^{-1} y^{-1}\) and 38.17, respectively. The rain erosion was high in north-east and south-west of the study watershed having higher altitude which is showed with blue color. In other words, the reduction of R factor had a close relation with elevation and rain reduction from north to south.

The K average is fluctuate between 0.20 and 0.59 in the study area and its standard deviation is 0.51 mm\(^{-1}\)Mg ha h\(^{-1}\) MJ\(^{-1}\) and 0.05, respectively. Figure 10 shows spatial distribution of soil erosion.

The topographic map of the study area is used to create the slope length and slope degree (LS) map. The LS factor calculated by equation 8 and use of watershed DEM map and considering interaction between
topography and water flow aggregation (Figure 11). As the figure 11 shows, the LS factor value is fluctuating between 0 and 277.72 at pixel level in study area and its average is 10.16.

The C factor map was prepared based on NDVI (Figure 12). In fact this factor completely has the reciprocal relation with NDVI. The C factor value fluctuates between 0 and 0.66 and its average is 0.53. The C factor map show that the higher value of this parameter is located on no vegetation regions and its minimum on regions with dense cover that is specified with lighter color.

Figure 13 shows the P factor. Since in the study watershed any management and corrective operations are not organized, the value of P unit was considered. The statistics of R, K, LS, C and P factors are exposed in Table 3.

Table 2. Calculation and estimation of F and R for rainfall stations

<table>
<thead>
<tr>
<th>Station name</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Altitude (m)</th>
<th>Rainfall (mm)</th>
<th>R (MJ mm ha⁻¹ h⁻¹ y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdanan</td>
<td>725825</td>
<td>3652033</td>
<td>916</td>
<td>588.6</td>
<td>302.9</td>
</tr>
<tr>
<td>Anjereh</td>
<td>703786</td>
<td>3662645</td>
<td>1155</td>
<td>531.9</td>
<td>259</td>
</tr>
<tr>
<td>Srabbagh</td>
<td>754105</td>
<td>364375</td>
<td>844</td>
<td>529.9</td>
<td>257.6</td>
</tr>
<tr>
<td>Seyahgav</td>
<td>754200</td>
<td>3639778</td>
<td>765</td>
<td>515.2</td>
<td>246.7</td>
</tr>
<tr>
<td>Mormori</td>
<td>751455</td>
<td>3624910</td>
<td>524</td>
<td>497.7</td>
<td>233.9</td>
</tr>
<tr>
<td>Hezarzni</td>
<td>730628</td>
<td>3646596</td>
<td>795</td>
<td>486.3</td>
<td>226.1</td>
</tr>
<tr>
<td>Vargarmeh</td>
<td>760196</td>
<td>3649183</td>
<td>445</td>
<td>464.5</td>
<td>210.9</td>
</tr>
<tr>
<td>Dashchamran</td>
<td>738063</td>
<td>3661569</td>
<td>614</td>
<td>442.9</td>
<td>196.5</td>
</tr>
<tr>
<td>Shahedalidashti</td>
<td>691986</td>
<td>3629138</td>
<td>365</td>
<td>302.1</td>
<td>113.3</td>
</tr>
<tr>
<td>Mosiyan</td>
<td>723874</td>
<td>3600210</td>
<td>151</td>
<td>233.1</td>
<td>79.5</td>
</tr>
<tr>
<td>Tmtmab</td>
<td>706113</td>
<td>3625714</td>
<td>241</td>
<td>229.2</td>
<td>77.7</td>
</tr>
<tr>
<td>Sadat</td>
<td>739623</td>
<td>3596876</td>
<td>159</td>
<td>228.6</td>
<td>77.5</td>
</tr>
</tbody>
</table>

Figure 6. The relation between altitude and rainfall

Figure 7. The relation between rainfall and R factor
Figure 8. The average annual rainfall map of Doviraj watershed

Figure 9. The R factor map of Doviraj watershed

Figure 10. The K factor map of Doviraj watershed
Figure 11. The LS factor map of Doviraj watershed

Figure 12. The C factor map of Doviraj watershed

Figure 13. The P factor map of Doviraj watershed
Table 3: The statistics related to RUSLE equation factors in Doviraj watershed

<table>
<thead>
<tr>
<th></th>
<th>R Factor</th>
<th>K Factor</th>
<th>LS Factor</th>
<th>C Factor</th>
<th>P Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>107.41</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Maximum</td>
<td>276.38</td>
<td>0.59</td>
<td>277.72</td>
<td>0.66</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>109.04</td>
<td>0.51</td>
<td>10.16</td>
<td>0.53</td>
<td>1</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>38.17</td>
<td>0.05</td>
<td>15.89</td>
<td>0.06</td>
<td>0</td>
</tr>
</tbody>
</table>

**Annual soil erosion**

The annual average of soil erosion was calculated by producing the erosivity factor (R), erodibility factor (K), topography factor (LS), management vegetation factor (C) and protection operation factor (P) in ARCGIS 9.3 software. The obtained map of this model is showed in figure 14. The soil erosion values are fluctuating between 0 and 18785.37 ton/hectare/year at pixel level in study region. The mean and standard deviation also determined as 607.98 and 1021.64 ton/hectare/year, respectively. In the next stage the annual soil erosion map was classified to 5 risk classes (Figure 15). The frequency of each risk class is showed in figure 16. Most of the study watershed (90%) has the erosion class of very little to little that these classes mainly located at north and south of watershed. About 0.36% of watershed was placed under high to severe erosion which are placed in north west- and north east- of the watershed.

![Figure 14. The average annual soil erosion map](image1)

![Figure 15. The classes of soil erosion map](image2)
Sediment yield

In this study, average values of sediment delivery ratio fluctuate between 0.23 and 0.49 and sediment yield average in watershed outlet between 139.8 and 297.9 ton/hectare/year (Table 7).

The rate of observed and calculated sediment in the watershed outlet was 253.42 (ton/hectare/year) and the estimated sediment value (average estimated sediment) is 273.6 ton/hectare/year based on RUSLE model by using the Vanoni erosion delivery ratio method. So, in this study the difference between estimated and observed sediment value is 20.18 ton/hectare/year by RUSLE model. In other words, the estimated sediment value is about 7.96% more than the measured sediment (observed) (based on calculation of relative error). Therefore, no significant difference observes between the observed and estimated sediment rate.

Therefore, since the estimated sediment yield value by Vanoni method (Table 4) almost was close to recorded sediment yield value in sedimentation station of Doviraj watershed, this method is introduced as a suitable method for calculation of sediment delivery ratio.

Table 4. The methods of sediment delivery ratio, the values of delivery and sediment yield in study watershed

<table>
<thead>
<tr>
<th>Methods of sediment delivery ratio</th>
<th>Delivery Ratio (average)</th>
<th>sediment yield (ton/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanoni</td>
<td>0.45</td>
<td>273.6</td>
</tr>
<tr>
<td>Boyce</td>
<td>0.23</td>
<td>139.8</td>
</tr>
<tr>
<td>USDA SCS</td>
<td>0.49</td>
<td>297.9</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION

Since Iran is faced to the water erosion problem and the measurement of water erosion rate of watershed occurs in hydrometric and sedimentation stations, the lack of these stations caused the problems for estimation of soil erosion rate at watershed level. For this reason, several empirical and physical equations suggested for estimation of soil erosion. Also the factors that these equations based on them can mention the rainfall rate, topography, soil type and vegetation. Universal Soil Loss Equation is the model which considers these factors in most parts of the world and especially Iran. In this research it is tried to use the technology and advances in computer science for erosion and sediment estimation. In this study quantitatively the soil erosion and sediment yield was evaluated using the network (distributive) by RUSLE model within Geographic Information System. The R, K, LS, C and P maps were combined together for creating the map of erosion risk and sediment yield in GIS and the spatial distribution of soil erosion and sediment yield was obtained. Very near results of estimated average annual sediment yield (273.6 ton/hectare/year) with the measured one (253.42 ton/hectare/year), showed the ability of integration of the RUSLE, GIS and RS for the estimation of sediment yield of Doviraj watershed in Dehloran city. The creation of database by the traditional methods is very time consuming, boring and impractical. In this study we tried to obtain information from remote sensing and use the capabilities of Geographic Information System for creation of required data of RUSLE model factors with high quality and easy updates capability.

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