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Comparison of EPM and geomorphology methods for erosion and sediment yield assessment in Kasilian Watershed, Mazandaran Province, Iran

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Abstract

Evaluation of Sediment yield in watershed scale is considered so important for implementation of soil conservation, watershed management, environment, dam construction and water resource management. Using empirical model is one of the approaches of evaluating Sediment yield. This research in Kasilian watershed evaluates Sediment yield by using Geomorphology method and EPM model with Arc View GIS soft ware. In Geomorphology method four effective factors including slope, lithology, erosion faces and land use were used and information layers were made by combining (over lay) them, then homogen unites were produced. Finally sediment yield were evaluated in each one of them. EPM model which was used in Yugoslavia for the first time used four factors including slope, lithology, landuse and erosion condition in each one of hydrological units and by using annual mean of precipitation and temperature, also sediment ratio, evaluates sediment yield. After evaluation and comparison it was found that the amount of sediment yield in Geomorphology method was 3.6% less (1197 ton/year) and EPM model was 4.8 times more (5322 ton/year) than field observation, (1243 ton/year).

Keywords: Kasilian; EPM model; Geomorphology method; Erosion; Sediment yield

1. Introduction

Due to lack of sediment gauging station in some catchments, For anticipating and evaluating of catchment's erodibility within catchment's programming and making priority in soil conservation For evaluating erosion and sediment yield, it is necessary to take help from quantitative and qualitative models.

By using erosion models we are able to locate erodable area then put them on priority to soil conservation programs and have them under control, but major problem is their calibration and reliability which should be done with high precision.

One of these models is Erosion potential method (EPM) which originally was developed for Yugoslavia by Gavrilovic (1988).

The method has been tasted in some catchments area in Iran, and it is appeared that out-put results are compatible with field observation. (Nadjafi 1994, Maleki 2003, Khaleghi 2005, Zia Abadi 2006). Application of Geographic Information System (GIS) and Remote Sensing (Rs) techniques in erosion and sediment yield assessment have been developed recently (Hill, 1993, Floras and Sgouras 1999, Tangestani 2001, Maleki 2003, Zia Abadi 2006).

Combination of those mentioned above make the results more compatible, and present research in Kasilian is an example in application of GIS techniques, spatial data management and modeling for assessing erosion severity and sediment yield.

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2. Material and Methods

2.1. Study Area

The Kasilian Watershed (53^o 18` - 54 $^o$ 30` E, 35^o 58` 30``-36^o 07`N) is a part of the great basin of Talar River, and covers an area of a bout $68km^2$, to southeast of Mazandaran province, North of Iran.

The relief of the area decreases from high mountain (3163 m) in southeast to river bed (1087) in Center. The climate changes from humid to cold humid, with annual mean of rainfall 809 mm. The Kasilian watershed has north trend. The most part of it is occupied by Shemshak formation (Siltstone) and after that by Quaternary alluvium.

More than 70% of Kasilian watershed is occupied by forest. The main soil type is Brownish with Acidic PH and then Yellowish pedozol.

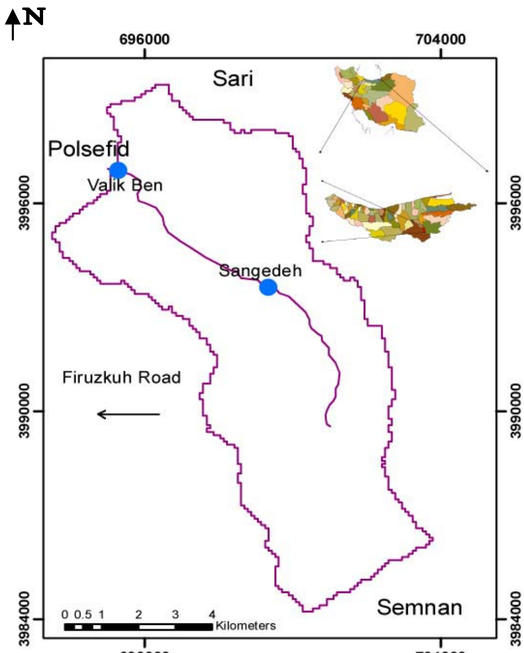


Fig.1. Geographical location of the Kasilian sub – catchment area in Iran - Mazandaran province

2. 2. Processing of EPM model and methods

1. Reconnaissance of study area for several times.
2. Extract the boundaries of watershed with doing observation, maps (Topographic map in 1/50'000 scale, 2004 -Geological map in 1/250'000 and 1/100'000 scale – 2001.

Aerial photograph in 1/55.000 Scale 1976, Satellite image – land sat (ETM+) – 2003). And for more certainty compare with boundaries which produce by Geo HMS Software.

3. Climatic study and providing Isoterm and Isohyet map, (T).
4. Hydrological study including Surface and ground water (H).
5. Geological investigation and produce lithology map (Y).
6. Geomorphological study with field survey and providing Geomorphologic map and erosion faces, (φ).
7. Remote Sensing and extract land use map, (Xa).
8. Plant Survey and provide vegetation map.
9. Soil study and provide soil map.
10. Producing Homogen unites with using land use, geology, slop and erosion faces map.
11. Evaluating erosion and sediment yield with erosion potential model and Geomorphology method in Hydrology unites and Homogen unites, (both).

The Erosion Potential Method calculates coefficient of erosion and sediment yield (Z) of a Sub-catchment's area by following equation:

$$Z = Y.Xa. (\varphi + I)^{1/2} \qquad (1)$$

Where Y is coefficient of rock and soil resistance to erosion ranging from 2 to 0.25, Xa is a Land use coefficient, ranging from l.o to o.o5, φ is the coefficient, observed erosion processes ranges from 1.0 to 0.1, based on the severity of erosion.

The factor I is the average land slope in percent (Gavliloric, 1988) Erosion severity is classified according to values of Z, areas with > 1.o 'severe erosion' and those with Z < 0.19 have very slight erosion. Sediment production is estimated as

$$WSP = T. H. \pi . Z^{3/2} \qquad (2)$$

Where W is the weight and WSP is the average annual specific production of sediments per km^2 in m^3/year, T is a Temperature coefficient, calculated as

$$T= (t/10 + o.1)^{½}$$

With t, the mean annual temperature in degrees Celsius (^oC) Z the coefficient of erosion calculated from equation (1).The other factors which are required by the EPM model are documented in literature (Gavrilovic, 1988).

The process in Geomorphology method is the same but all are in Homogen unites

3. Results

In present research after field observation information layers were produced in Arc view and Arc GIS: land use (Xa) litho logy (Y), slope (I) and erosion faces (φ) then we overlaid them and Z Factor obtained, (equation 1) in each Geomorphology and Hydrology unites. Erosion map were produced following that. Finally with using the other factors in every Homoge unite, (Geomorphology method) and sub – watershed, (EPM model) obtained and at last WSP, GSP and GS calculated.

The results show that changes in land use due to development strategies exposing erosive factors include erosion–sensitive geological formations consisting largely of alluvium (Quaternary), poor vegetation and dry farming which in study area are main factors in making sediment available annually for erosion and transport.

These sensitive areas are concentrated in north and near to outlet. In the other places with sensitive formation because of the high density of vegetation the erosion is negligible.

In south of Kasilian also due to poor vegetation and low temperature snow channels developed.

In total we have 5 class of erosion

1. Very slight surface erosion
2. Slight surface erosion
3. Surface and Rill erosion
4. Snow channel
5. Exposed rock (Bed rock).

The correlation between erosion potential categories derived from EPM model, and the erosion coefficients of rocks, topographical slope classes, and land use type we calculated in each Hydrology and Homogen unites.

It is evident from the table that the areas with severe erosion potential correspond to agriculture land with sensitive formation, Quaternary alluvial which is sensitive to erosion. (Table 1&2)

Also we can find that the areas with high erosion are those with topographic slope between (10-30) percent. The areas with least erosion potential in Kasilian watershed are exposed rocks which were classified as Bed Rock and high dense forest. After calculating erosion potential the other factor, WSP, GSP, GS were calculated as given in literature (Gavrilovic 1988), (Table 1&2).

4. Conclusion

After considering all factors it seems that, erosive factors are:

a. land use b. litho logy c. Slope

As expressed before, changes in land use cause to develop erosion. Litho logy and slope after land use respectively, accelerated erosion.

In Kasilian watershed after overlaying land use, slope, litho logy and erosion faces, 28 Homogen unites were derived.

With using Geomorphology method, appeared that highest erosion potential correlated to Homogen unite (H – unit) number 12 which covers north and center of sub-watershed number 3, where: 1=0.5 φ= 0.4 Y=1.2 Xa=0.4 Y and Z=o.5.

As you see litho logy has the most impact.

Moderate erosion correlated to: H-unites number 2,8,11 which located on southern of sub-w number 1, north, and center and eastern of sub-w number 2, north and eastern of sub –w number 3, western of sub – w number 10 and north and western of sub-w number 11.

Slight erosion in: H- unites number 19, 13, 6. 7, 20, 14, 1 0, 24, 25, 26 and 23.

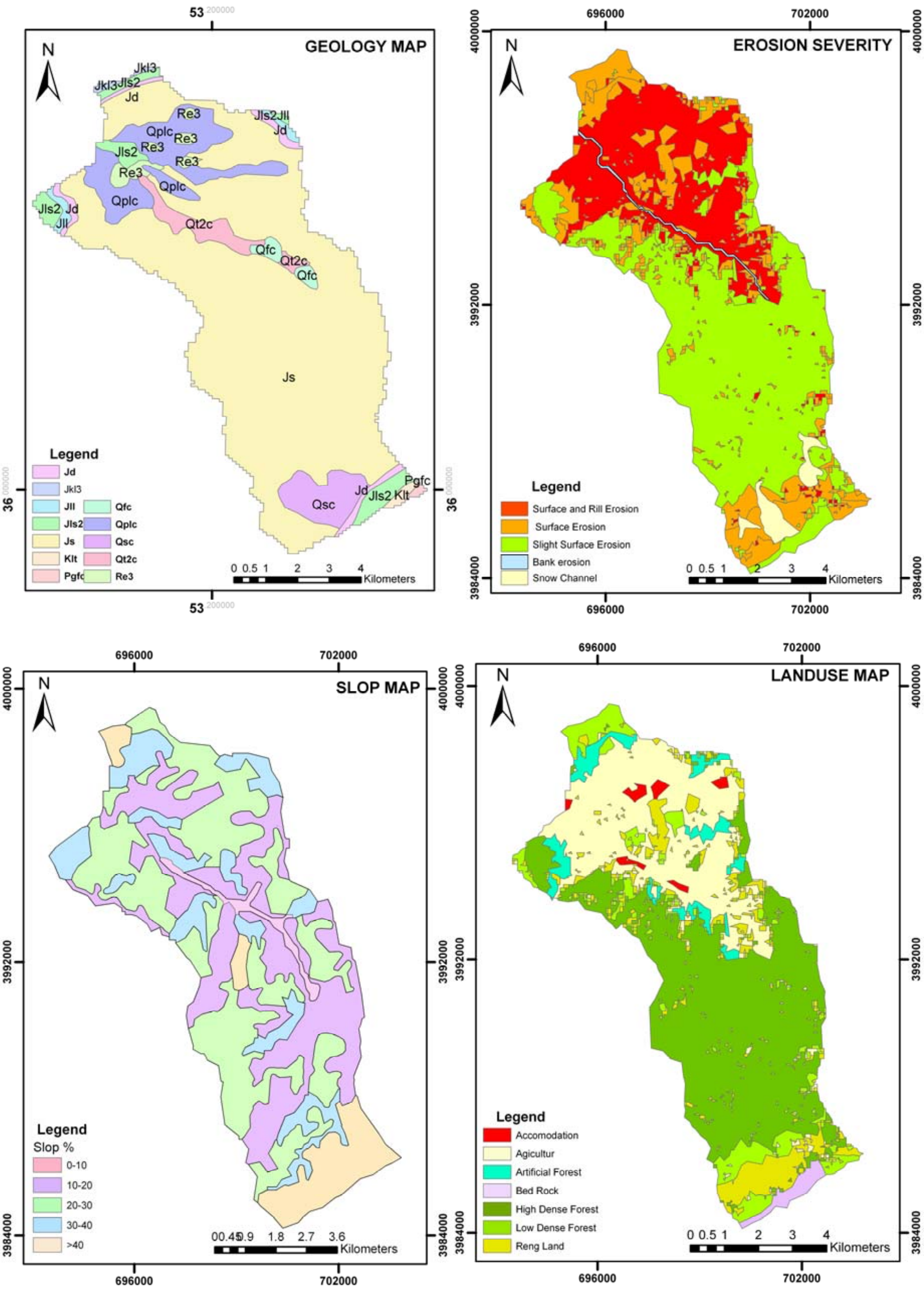
The most sediment yield correlated to: H-unit number 7 where Z =0.34 WSP=473.3 GSP=59.1 and GS= 499.4

After running EPM model in 11 sub-w understood that highest erosion potential correlated to sub-w number 3- where Xa=0.4 Y=1.6 I=0.51 φ=0.345 and Z=0.418 least erosion potential correlated to sub-w number 9 with Z=0.065

Sub-watersheds with slight erosion potential are numbers: 1,2,10 and 11.

Table 1. Erosion severity and sediment yield in hydrologic units

Name	H	t	T	M	Z	WSP	Ru	GSP	GS
1	1344	10.7	1.08	695	0.322	430.6	0.47	202.3	1072.2
2	1349	10.7	1.08	697	0.316	419.87	0.46	193.1	1776.5
3	1267	11.1	1.1	661	0.418	617	0.22	135.7	407.1
4	1459	10.26	1.06	447.7	0.169	103.5	0.46	47.6	418.8
5	2063	7.03	0.91	997	0.117	114	0.69	78.6	378.8
6	2186	6.4	0.86	1046	0.157	175.7	0.75	131.7	1014
7	1942	7.6	0.92	947	0.078	59.6	0.61	36.3	272
8	1518	9.8	1.03	770	0.095	72.9	0.41	29.8	157.9
9	1568	9.6	1.02	791	0.065	42	0.54	22.6	153.6
10	1384	10.5	1.07	712	0.223	251.9	0.43	108.3	790.5
11	1440	7.3	1.06	736	0.295	392.5	0.48	188.4	471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Surface Erosion
Slight Surface Erosion
Bank erosion
Snow Channel
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SLOP MAP
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LANDUSE MAP
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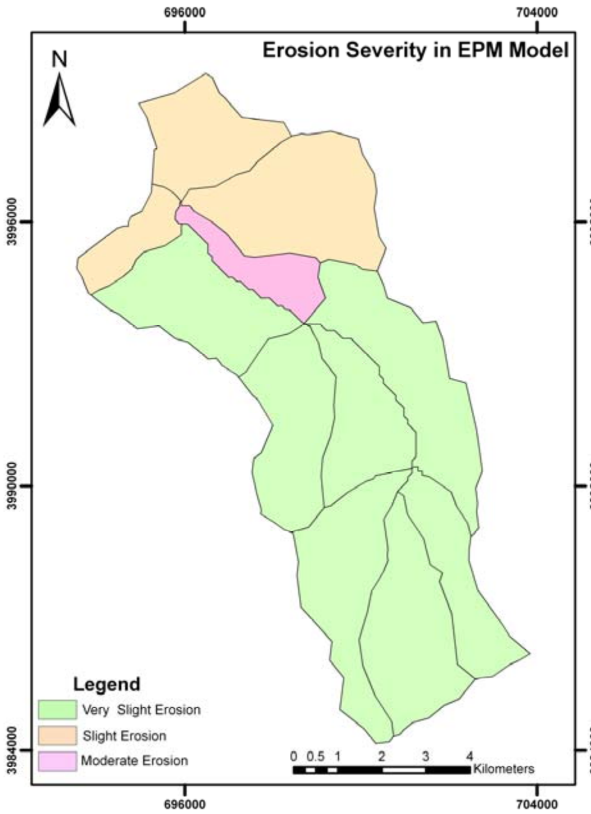
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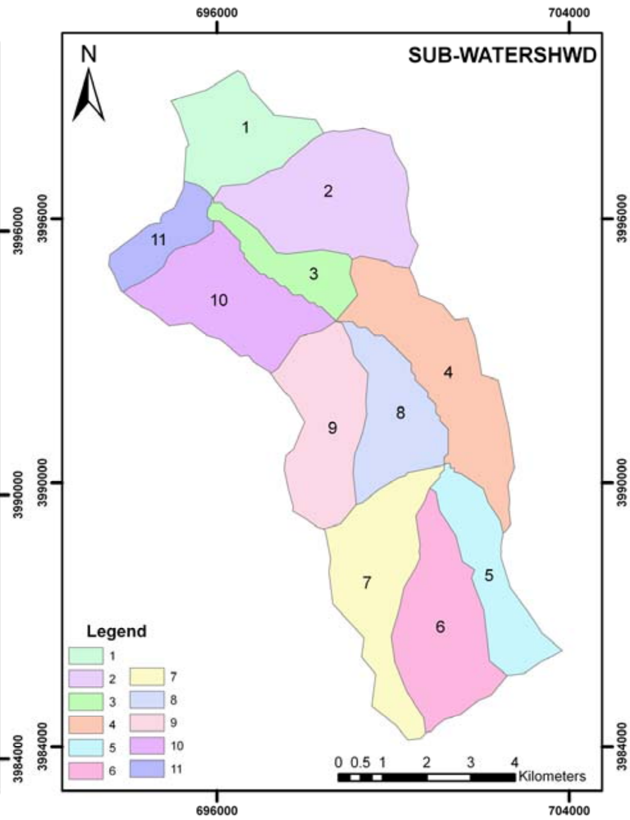
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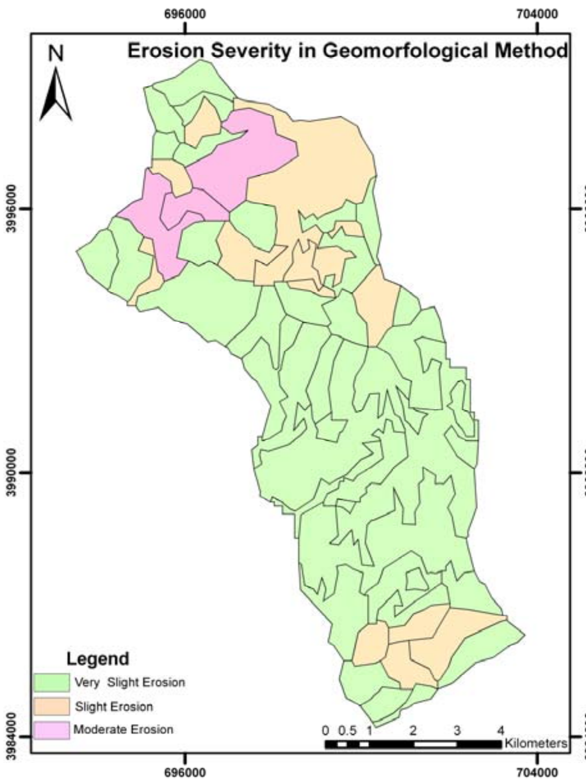
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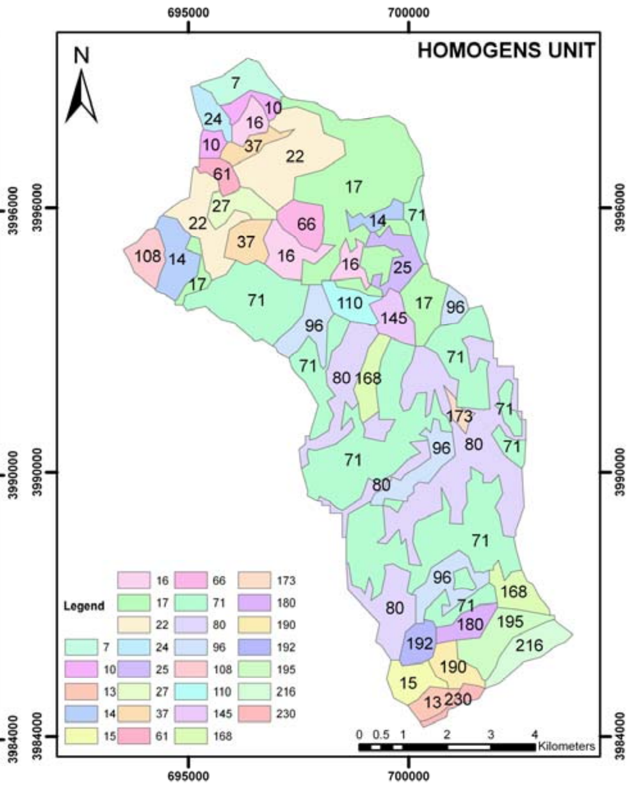
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Kilometers

Table 2. Erosion Seventy and sediment yield in Homogen unites

Name	H	t	T	M	Z	WSP	Ru	GSP	GS
1	1517	9.8	1.03	769.6	0.163	124.8	0.08	9.98	1
2	1324	10.8	1.08	686.3	0.159	147.5	0.036	5.31	4.2
3	2769	3.4	0.66	1264.6	0.149	150.7	0.046	6.9	3.6
4	1475	10	1.04	751.6	0.129	113.6	0.031	3.51	5.7
5	2384	5.4	0.8	1126	0.209	270.25	0.035	9.4	8
6	1282	11	1.09	667.9	0.384	548.2	0.079	43.3	88.7
7	1380	10.5	1.07	710.6	0.34	473.3	0.125	59.1	499.4
8	1284	11	1.09	668.8	0.46	714.1	0.069	49.2	231.2
9	1396	10.5	1.07	717.6	0.127	109.1	0.057	6.2	3.75
10	1381	10.5	1.07	711.1	0.309	410.3	0.089	36.5	34.6
11	1219	11.4	1.11	640.2	0.406	572	0.04	22.8	18.9
12	1202	11.5	1.11	632.6	0.5	772.5	0.069	53.3	74.6
13	1122	11.9	1.13	597	0.388	498.3	0.02	9.9	4.9
14	1306	10.9	1.09	678	0.308	396.6	0.067	26.5	23.8
15	1628	9.3	1.01	816.8	0.086	65.3	0.22	14.3	267.4
16	1625	9.3	1.01	815.5	0.076	54.1	0.17	9.1	97.3
17	1638	9.2	1	821	0.084	62.7	0.12	7.5	29.25
18	1715	8.8	0.98	853.4	0.078	57.2	0.057	3.25	3.25
19	1248	11.2	1.1	653	0.396	562	0.05	28.1	22.5
20	1286	11	1.09	669.7	0.335	444.4	0.03	13.3	10.6
21	1783	8.5	0.97	881	0.082	63	0.09	5.67	9.6
22	1425	10.3	1.06	730.1	0.067	42.1	0.026	1.09	0.25
23	2228	6.1	0.84	1063.7	0.208	266.1	0.045	11.9	8.3
24	2431	5.1	0.8	1144.8	0.335	557	0.099	55.1	44
25	2124	6.7	0.87	1021.8	0.213	247	0.062	15.3	9.9
26	2493	4.8	0.76	1169.3	0.259	367.7	0.08	29.4	41.1
27	2901	2.6	0.6	1328.5	0.128	114.5	0.08	9.1	10
28	2953	2.4	0.58	1348.5	0.069	44.4	0.09	3.9	1.2

Sub–watershed with negligible erosion potential are numbers: 4, 5, 6, 7, 8 and 9.

The most sediment yield correlated to sub-w number 2; where: Z=0.316 WSP=419.87 GSP=193.1 and GS: 1776.5.

After calculating and comparing total sediment yield with field observation, it was cleared that EPM overestimated about 4 times more, 5322 Ton/year and Geomorphology method was close to field observation, 3.6% less than that, 1197 ton/year. (Field observation was 1243 Ton / year) at last we found that:

- The coverage area of each erosion classes in both EPM model and Geomorphology method are compatible.
- Using EPM model with Geomorphology method showed more reasonable results.

Because the coefficients of rock resistance to erosion (Y) were primarily evaluated for Yugoslavia the coefficients were modified to represent the geology of Kasiliam watershed area using methodology proposed by Feiznia (1995).

- In EPM model actual sediment ratio is slope and in area like Kasilian which has relatively high slop, sediment yield will be overestimated. To avoid this problem (Hydrology units) should be smaller. In mountain area it is better to make Homogen unite.
- GIS is an effective tool for calculating the mathematical equations for erosion potential, and sediment yield and mapping models such as EPM model and Geomorphology method.

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