Research Article
Assessment Fargas and BLM Models for Identification of Erosion Degree and Critical Sediment Sources (Case Study: Aghbolagh Drainage Basin, Hashtrood City)

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Abstract: The identification of the different areas in drainage basin (as a natural planning unit) for occurring the sedimentation and its severity in different phases of basic studies has been always one of the most important purposes of the natural resources experts. For achieving to this purpose some experimental models has been presented that Some of them have high efficiency and others have weaknesses. Fargas and BLM models are used in this research and they are run in Aghbolagh drainage basin in Hashtrood town, East Azarbayjan province with 7.8 km^2 area. Fargas model includes only two factors, the rock type erosivity and drainage density in the every rock unit, whereas BLM model includes seven factors; the surface erosion, the litter cover, the rock cover on the surface, the affection of destruction on the surface, the surface rill erosion, the affection of the sedimentation due to the water flow and the amplification of gully erosion. The objective of this research is the handling of these two models for different phases of basic studies in the study area. The results of two models showed, in Fargas model 3.67% area of the basin has high erosion, 14.26% area of the basin has severe erosion and 81.04% has very severe erosion and in BLM model 42.97% area of the basin has moderate erosion and 24.93% has high erosion, therefore 52.85% of the study area in Fargas and BLM models has concurrence in the erosion severity.

Keywords: Azarbayjan, drainage density, erosion severity, lithology

INTRODUCTION

Erosion is the wearing away of the land surface by running water, wind, ice, or other natural or anthropogenic agents that abrade, detach and remove geologic parent material or soil from one point on the earth's surface and deposit it elsewhere, including such processes as gravitational creep (Soil Science Society of America, 2001).

Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function (Lu *et al*., 2005; Santhi *et al*., 2006; Miller *et al*., 2007). When land is distributed at a destructive activities like construction site or agricultural land use, the erosion rate accelerate dramatically, some of the most spectacular landscapes are produced, the movement of soil off the disturbed area is increased and its impacts on the nature is intensified.

Erosion prevention measures are more effective than the reactive control of sediment. Identifying erosion problems at the planning stage and noting highly erodible areas, helps in selecting cost effective, environmentally sensitive erosion control measures (Clean Water Services, 2008).

The critical sediment source area identification at regional level, as a main factor to determine the sediment production intensity, is made by some methodologies that usually need thematic information of several variables which are not frequently available in form of existing maps at the required scale and/or for the complete study area. In some cases, some models have been developed in order to estimate soil erosion at very detailed level (Fargas *et al*., 1997).

Major types of erosion like rill, gully, stream and channel are some variables which can be assumed as criteria for erosion and sediment production intensite form which gully erosion has attracted more attention due to more sediment production and limited research recent years (Poesen *et al*., 1988, 2003).

As there is a strong correlation between the length and volume of the gully (Cheng *et al*., 2007), it is suggested that gully length is a significant and useful index to estimate the volume of gully erosion especially in large scale surveying of gully erosion because it is easier to measure the gully length from historical evidence such as aerial photos or remotely sensed images (Cheng *et al*., 2007; Hughes *et al*., 2001).

Since disturbed lands in watersheds are significant source of sediment, a systematic rating of their potential for erosion would be useful in soil conservation planning. Most importantly mapping and assessment of
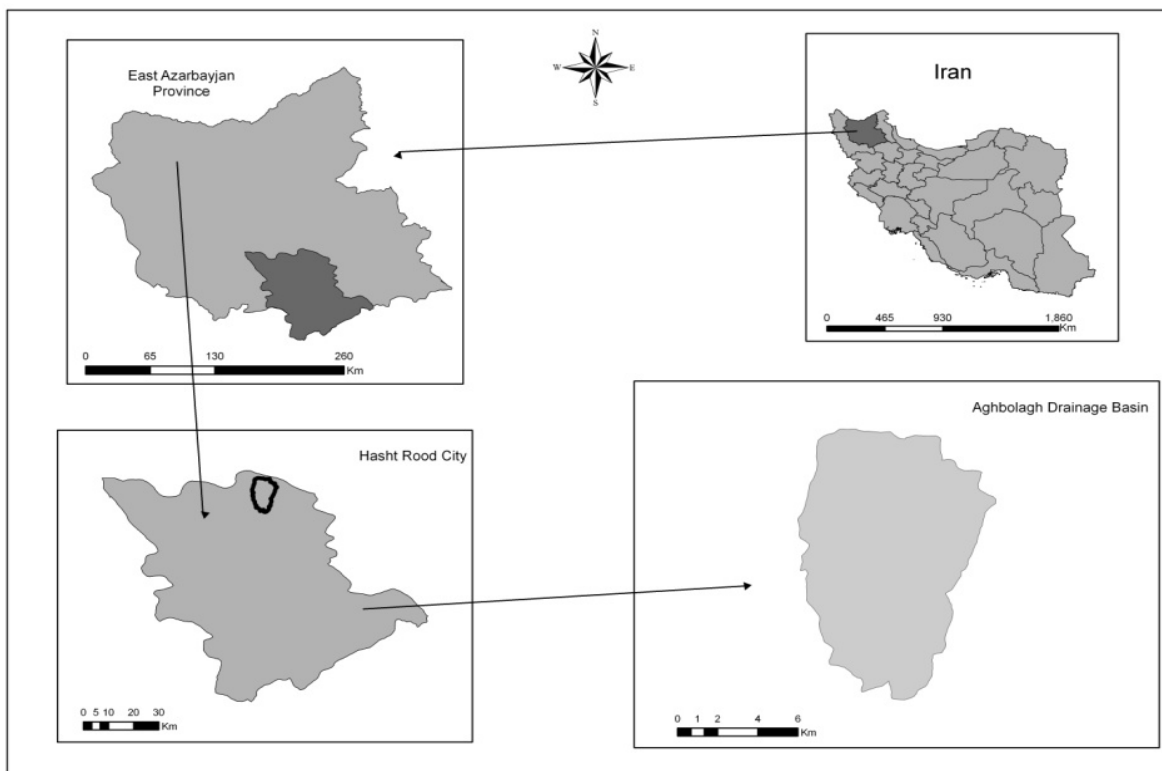
Fig. 1: Study area location

erosion prone areas enhances soil conservation and watershed management. The Maps allowing identification of preferential areas where action against soil erosion is more urgent and or where the remediation effort will have highest revenue (Esther, 2009). Soil erosion research was carried in the study area, based on different factors such as lithology, erosion types, steep slopes, drainage pattern and land use, to ensure the status of land and watershed management scenarios and offset the effects of erosion and sedimentation ratio.

Study area: The catchment of Aghbolagh with area of 78.2 km^2, occupies the northern of the Hashtrood City and is situated between 37° 28′ 51″ N-37° 36′ 39″ N and 46° 59′ 59″ E-47° 05′ 36″ E (Fig. 1). The maximum and minimum elevations of the study area are 2110 and 1668 m above sea level, respectively. This area with average precipitation of 325 mm, is located in cold semiarid area. The main land use is agriculture without irrigation which covers about 82% of the study area.

Geology of the study area is rather simple without any complicated tectonic activities. Igneous rocks beside sedimentary rocks are the main lithology, but most of the region, about 81%, is covered by unconsolidated conglomerates, sandy marls and alluvial sediments. This composition is one of the main important factors for high potential of erosion.

METHODOLOGY

A qualitative assessment methodology was used to identify the critical sediment resources of the study area which already has been developed by Fargas *et al.* (1997). They used this technique for the watershed of the Joaquin Costa reservoir (NE Spain), with a surface of 1500 km^2. The validation was carried out by means of photo-interpretation and field works, which gave a liability of 78.5%. The parameters of this method are from different reliable sorces, the lithology is rated be erosion indexes, adapted from FAO (1977), the value of drainage density are rated according to an erosion class (Bucko and Mazurova, 1985) and the sediment emission risk class is based on Fargas *et al.* (1997).

The BLM methodology is also applied for evaluation the sediment risks. Totally seven criteria are considered in this technique and the results were classified according to five major erosion classes.

Finally the results of above mentioned methods were evaluated in comparison with each other and the similarities were identified.

DISCUSSION

Two main methodologies, Fargas and BLM models which have been proved useful for erosion assessment and soil conservation planning, were used to identify the erosion intensity, areas with different risk, sediment production and critical sediment resources recognition.
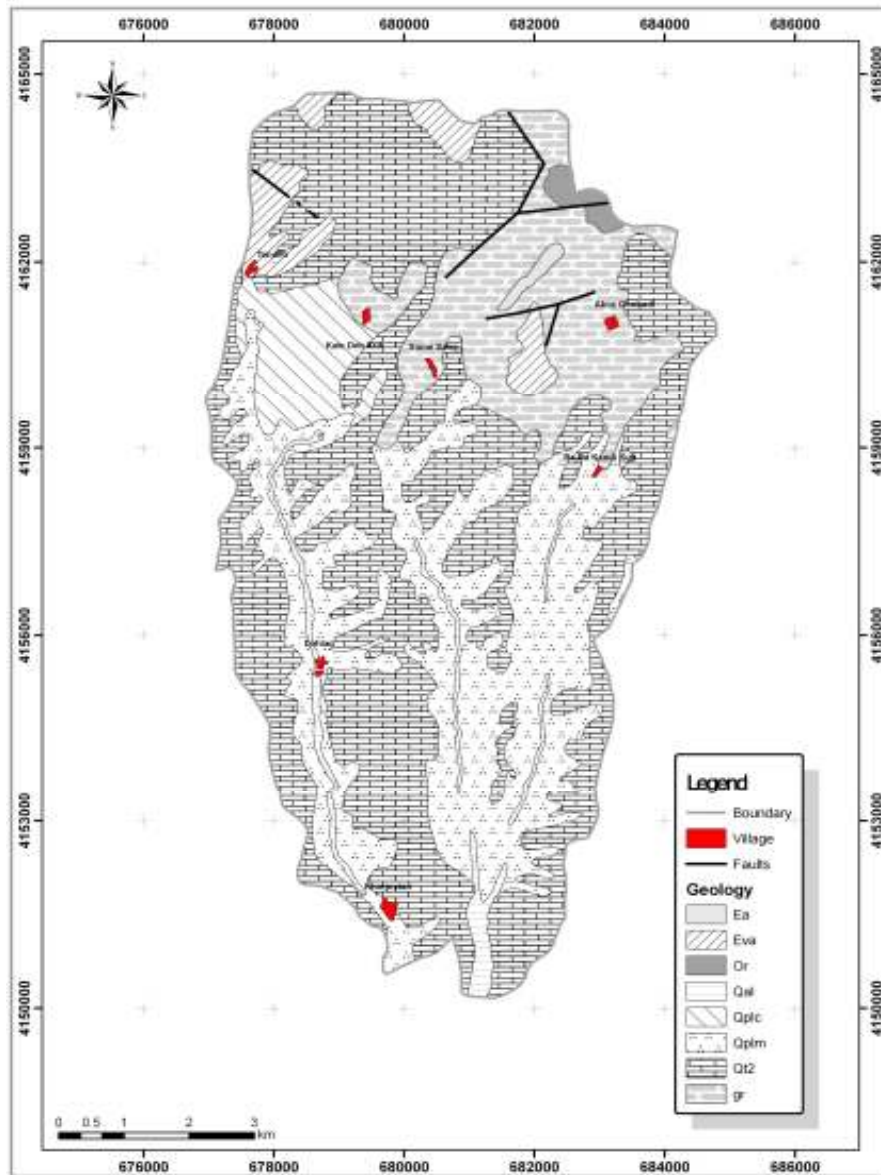
Fig. 2: Geology map of study area

Fargas model: The Fargas model is based on the delineation of homogeneous units with respect to drainage density and lithology (Fargas *et al*., 1997). So, the geological information is one of the principal factors of this model for which the geology map has been prepared (Fig. 2). As shown in the geology map and Table 1, Q^{t2} unit composing of terrace alluviums with high resistance degree (FAO, 1977), covers about 46.5% of the study area, whilst the hard rocks of gr, O_r, E_{va} and E_a have frequency of 14.26, 0.68, 3.67 and 26.09%, respectively. Qpl^c, Qpl^m and Q^{al} are other soft lithology units with 4.7, 27.56 and 2.21%, correspondingly.

The drainage density is another main factor of this model. An erosion class can be attached to an elementary catchment depending on its drainage density

(Bucko and Mazurova, 1958; in Stroosnijder and Eppink, 1993). Figure 3 shows the drainage density of the field and Table 2 shows the erosion class based on drainage density for different parts of the study area.

Despite this model is based on these two parameters, considering the fact that slope degrees and slope length are reflected in the drainage density (Horton, 1945), the mentioned slope parameters are also affect the model result. Furthermore, various lithology units by their different permeability control the runoff generation (Del Val, 1989).

The value of the coefficient to determine the sediment emission risk class, for each lithologic unit, is obtained multiplying the erosion class according the drainage density and the weighting factor of the lithology according to the resistance of materials
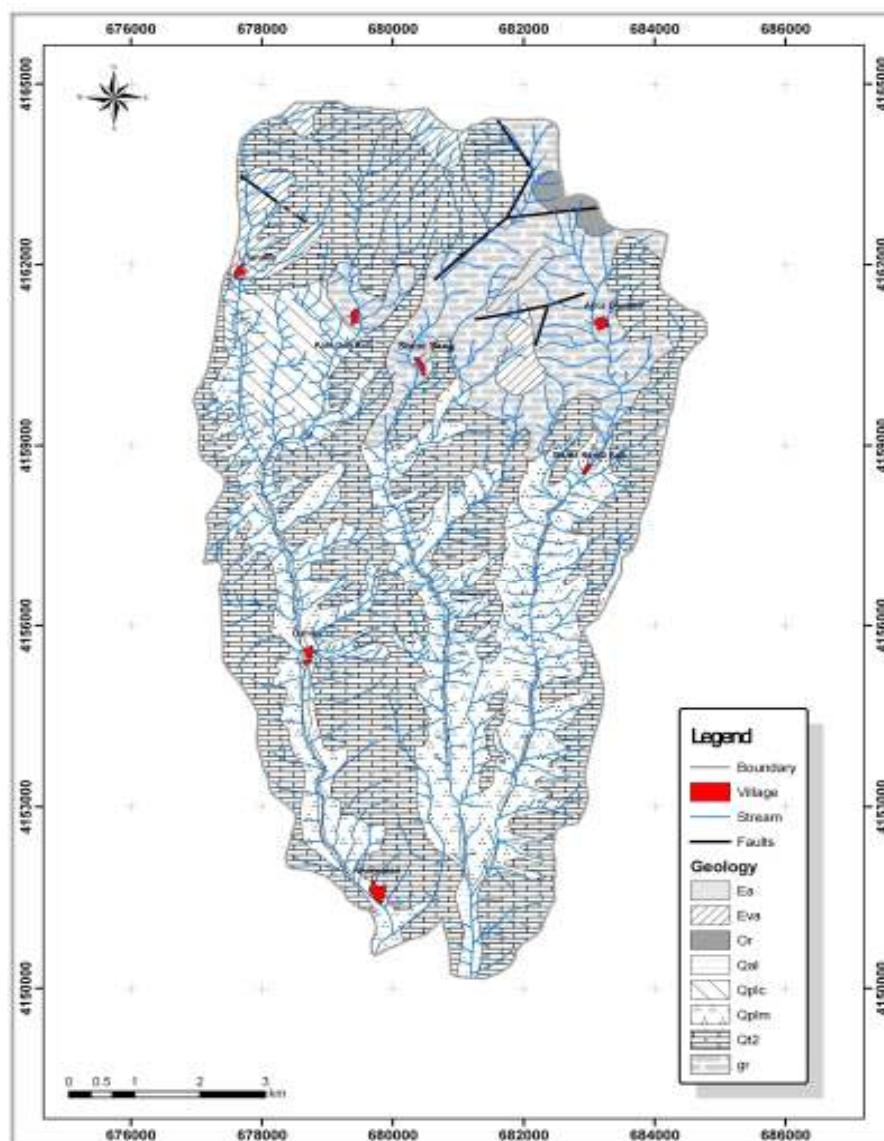
Fig. 3: Drainage density of study area

Table 1: Resistance of geological units to erosion (modified from FAO (1977), in MOPT (1992))

Rocks and sediments	Geological units	Resistance index	Area (% of total area)
Hard rocks	gr	4	14.26
	O_r	1	0.68
	E_{va}	3	0.68
	E_a	2	3.67
Soft rocks	Qpl^c	6	4.70
	Qpl^m	9	27.56
Old alluvial deposits	Q^{t2}	8	46.50
Recent alluvial deposits	Q^{al}	7	2.21

Table 2: Erosion class on the basis of drainage density (modified from Bucko and Mazurova (1958), in Stroosnijder and Eppink (1993))

Class	Geological unit	Erosion degree	Drainage density (km/km^2)	Rating value
1	E_{va}	Very severe	4.34	10
2	E_a	Severe	1.76	8
3	O_r	Very severe	2.72	10
4	gr	Very severe	4.44	10
5	Qpl^c	Very severe	5.37	10
6	Qpl^m	Very severe	5.49	10
7	Q^{t2}	Very severe	3.04	10
8	Q^{al}	Very severe	13.85	10

(Fargas *et al*., 1997). Table 3 shows the calculated values and the erosion risk for different geological units of study area. The critical sediment source as well as its area in the detail scale for the study area, is available in the table. According to this table the erosion risk of slight, moderate, high, severe and very severe are, 0.68, 0.33, 3.67, 14.26 and 81.06% of total area, respectively.

Figure 4 shows the risk of erosion and critical sediment source of the area.

BLM model: BLM methodology, which was initiated by Bureau of Land Management (BLM) of the United State of America, is mainly base on the erosion types. Soil Surface Factor (SSF), which is the base for

Table 3: Sediment emission risk class (modified from Fargas *et al*. (1977))

| Geological unit	Lithology	Resistance index	Area (% of total)	Drainage length	Drainage density (km/km^2)	Rating value	Coefficient value	Risk
E_{va}	Andesitic lava, tuff	3	3.67	12.49	4.34	10	30	High
E_a	Andesite, andesitic basalt	2	0.33	0.45	1.76	8	16	Moderate
O_r	Rhyolite	1	0.68	1.45	2.72	10	10	Slight
gr	Granite	4	14.26	49.60	4.44	10	40	Severe
Qpl^c	Unconsolidated conglomerate	6	4.71	19.77	5.37	10	60	Very severe
Qpl^m	Sandy marl	9	27.57	118.50	5.49	10	90	Very severe
Q^{t2}	Young terraces	8	46.46	11.00	3.04	10	80	Very severe
Q^{al}	Alluvium	7	2.32	25.10	13.85	10	70	Very severe
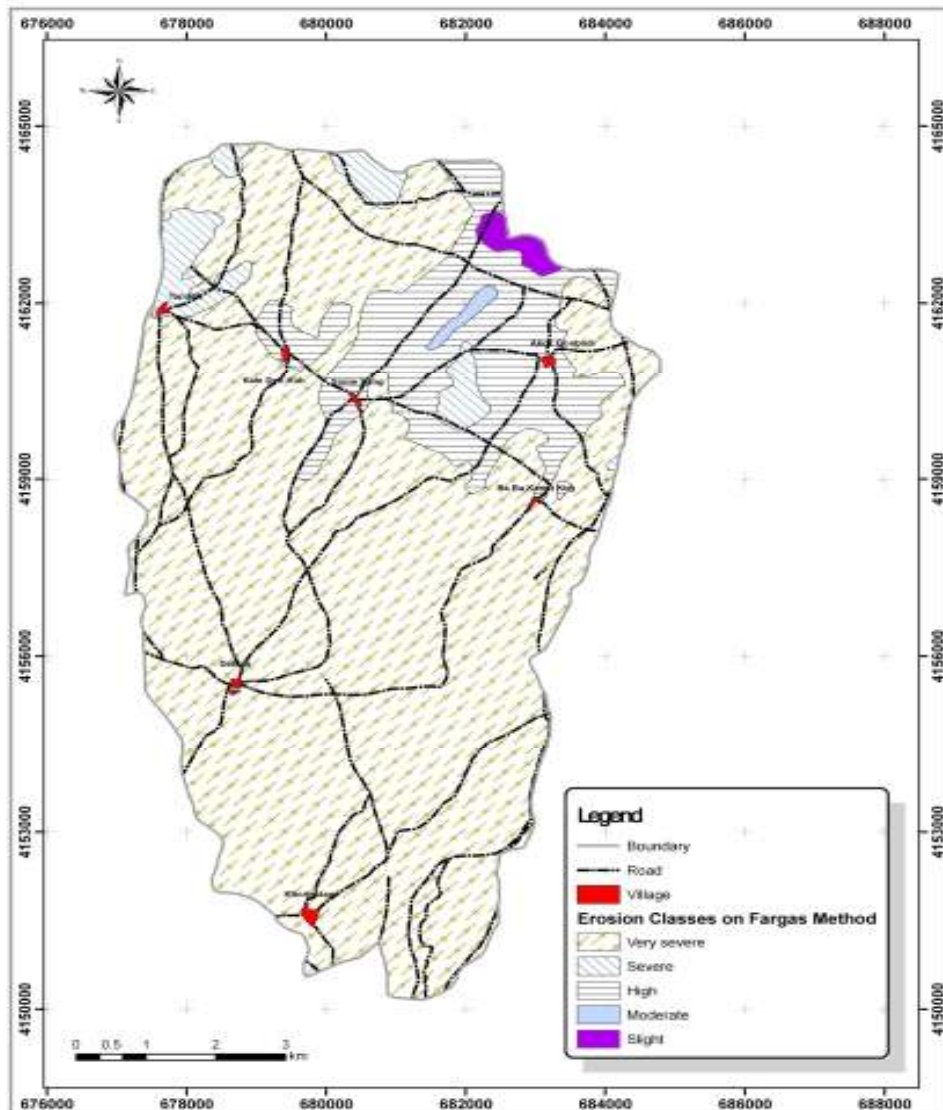
Fig. 4: Risk of erosion based on fargas method

Table 4: The erosion risk based on the 7 factors (bureau of land management)

Sum 7 factors score	Erosion risk
0-20	Low
21-40	Moderate
41-60	High
61-80	Severe
81-100	Very severe

assessment of erosion intensity, is resulted from seven factors including surface erosion variable from (0-14),

Litter on the surface (0-14), rock fragment (0-14), superficial degradation (0-14), rill erosion (0-14), runoff sediments precipitation (0-15) and gully erosion (0-15). The erosion risk of BLM method, is evaluated based on these factors, according to Table 4. Table 5 shows the erosion risk in the study area. Figure 5 and 6 show the erosion class and erosion risk in the area.

According to Table 5 the study area could be dissection in 3 major erosion risk, including low,

Table 5: Erosion risk in the study area based on SSF calculation

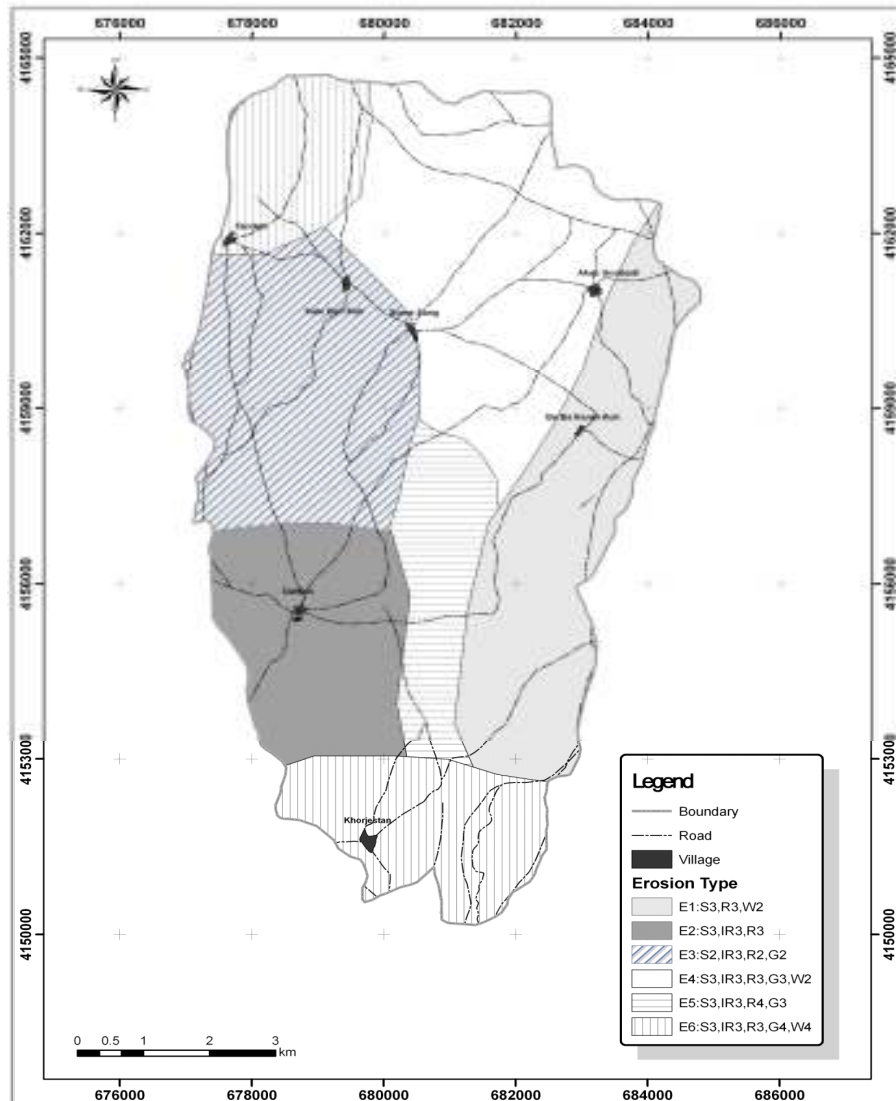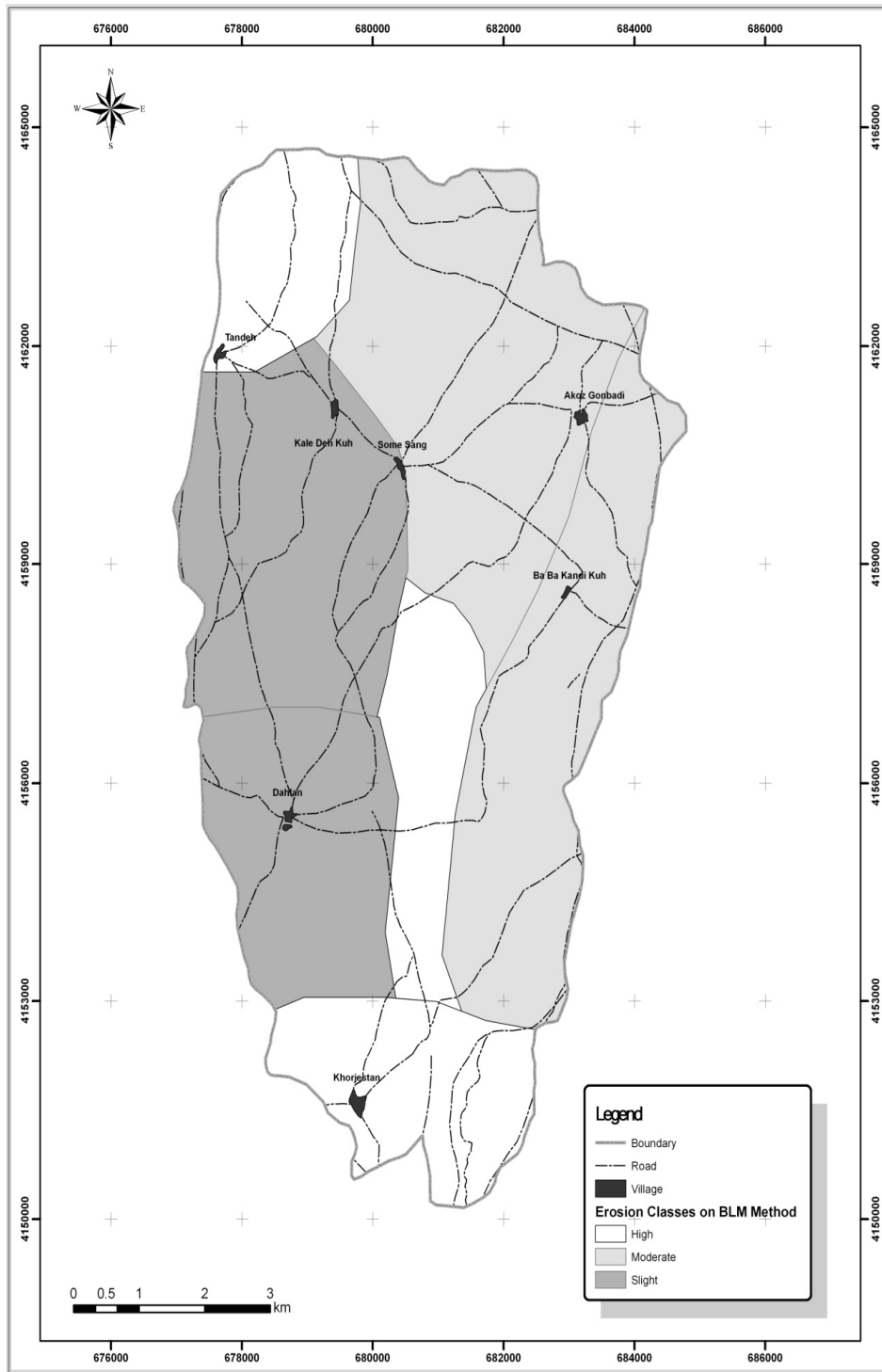| Class	Seven factors of BLM							Total score	Risk	Area (% of total area)
	F1	F2	F3	F4	F5	F6	F7			
E1	6	6	6	6	7	7	4	42	Moderate	18.59
E2	6	6	6	6	8	8	0	40	Low	13.12
E3	4	4	4	4	5	5	5	31	Low	18.98
E4	6	6	6	6	8	8	8	48	Moderate	24.37
E5	8	8	8	8	11	11	8	62	High	7.70
E6	8	8	8	8	11	11	11	65	High	17.22

Fig. 5: Erosion type

Fig. 6: Erosion risk based on BLM method

moderate and high with area of 32.1, 42.96 and 24.92%, respectively.

CONCLUSION

The erosion risk and critical sediment source are possible to identify at reconnaissance level, using both Fargas and BLM model. Here, these metods have been implemented in a GIS environment in order to automate the sediment emission risk maps. Despite the Fargas model which is based on drainage density and rock materials, the BLM is in accord with erosion types. The results of both models for the study area illustrate more similarities. The application of these methods can be

replaced by each other but as the Fargas model uses a few terrain variables, is preferred to BLM method, in case which there is limitation for available factors.

ACKNOWLEDGMENT

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