Investigation of the possibility to prepare supervised classification map of gully erosion

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Abstract: This study was done to investigate the possibility providing gully erosion map by the supervised classification of satellite images (ETM+) in two mountainous and plain land types. These land types were the part of Varamin plain, Tehran province, and Roodbar sub-basin, Guilan province, as plain and mountainous land types, respectively. The position of 652 and 124 ground control points were recorded by GPS respectively in mountain and plain land types. Soil gully erosion, land uses or plant covers were investigated in these points. Regarding ground control points and auxiliary points, training points of gully erosion and other surface features were introduced to software (Ilwis 3.3 Academic). The supervised classified map of gully erosion was prepared by maximum likelihood method and then, overall accuracy of gully erosion map was computed. Results showed that the possibility supervised classification of gully erosion isn't possible, although it need more studies for results generalization to other mountainous regions. Also, when land uses and other surface features to increase in plain physiography, it will be decreased the classification of accuracy.

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1. Introduction

Gully erosion causes damages to vulnerable agricultural lands, water pollution by soil particles and chemicals, and mudflows which may affect urban areas (Poesen & Hooke, 1977). In contrast to the effort during the last decades to investigate sheet (inter-rill) and rill soil erosion processes, relatively few studies have been focused on quantifying and/or predicting gully erosion (Martinez Casasnovas, 2003). Gullies can develop as enlarged rills, but their genesis is generally more complex, involving sub-surface flows and sidewall processes (Bocco, 1991). The geographic distribution of gullies is one of the most important information required for soil conservation. Large gully systems have received much attention from researchers using modern geospatial analysis (Mohammadi-Torkashvand, 2008; Zinck *et al.*, 2001; Martinez Casasnovas 2003; Martinez Casasnovas *et al.*, 2004).

The possibility to use the aerial photographs for soil mapping has been known for a long time (Goosen, 1967). Commonly they were used to support conventional geomorphological methods (Stromquist, 1990), and also for direct identification of sheet, rill and gully erosion (Frazier *et al.* 1983; Stromquist *et al.*, 1985). But it should be regarded that field survey and photo interpretation for gully erosion mapping at the national scale is time consuming and expensive (Raoofi *et al.*, 2004). The extension of the use of modern spatial information technologies, such as geographical information systems (GIS), digital elevation modeling (DEM) and remote sensing, have created new possibilities for research as a key for gully erosion mapping (Martinez Casasnovas, 2003) that is economical due to low costs as well as quickness (Raoofi *et al.*, 2004).

Gully erosion is a serious problem in many parts of the world, and particularly in Iran, because of climate, lithology, soils, relief and land use/cover characteristics. In Isfahan province as a pilot design, Rahnama (2003) investigated the possibility of preparation of soil erosion features map by aerial photograph interpretation and concluded similar results. He recommended satellite imagery and GIS for this aim. Sirvio *et al.* (2004) have investigated gully erosion hazard assessments in Taita Hills, SE-Kenya, applying airborne digital camera orthomosaics and GIS for small-scale studies and field measurements for large-scale studies. Detection of distribution and intensity of gully erosion and main factors affecting gully erosion were investigated within Taita Hills and changes during the last 50 years.

Raoofi *et al.* (2004) categorized rill and gully erosions in Taleghan basin-Tehran province by using visual interpretation of images derived from the fusion of ETM+ bands and Cosmos image. Also a map of ground truth from eroded regions was provided by using Cosmos image as well as visual interpretation and field observations. Measurements had indicated an approximate 80 percent accuracy for the categorization. Allan James *et al.* (2007) investigated the ability of the ALS (Airborne Laser-Scanning) topographic data to identify headwater channels and gullies for two branching gully system in frosted areas and to extract gully morphologic information. Regarding results, at the gully network scale, ALS data had provided accurate maps- the best available- with robust detection of small gullies except where they are narrow or parallel and closely spaced. Mohammadi Torkashvand and Nikkami (2005) concluded that the integration of three data layers (land use, rocks erodibility and land units) in GIS is a suitable method in providing erosion features map such as gully erosion. Mohammadi Torkashvand (2008) differentiates photomorphic units on satellite images as homogenous units with the view of gully erosion and introduced it with data layers integration as the best methods in providing gully erosion map. The aim of this paper is to prepare soil gully erosion map by the supervised classification of satellite images in two lands type including mountainous and plain physiographies.

2. Materials and Methods

Satellite images of ETM$^+$ sensor (year 2004) was used for supervised classification of gully erosion. For investigation of the possibility supervised classification of gully erosion, 3 lands type were considered including:

1. A square-form part of bare low lands in Varamin plain, Tehran province, with 14094 ha located between 51°43′ E and 52°00′ E, 35°14′ N and 35°20′ N (basin 1),
2. Above lands (low lands) mixture with cultivated lands located between 51°44′ E and 52°02′ E, 35°15′ N and 35°21′ N with 29303 ha area (basin 2),
3. The Roodbar sub-basin, Guilan province, with 102,898 ha located between 49°15′ E and 49°51′ E, 36°43′ N and 37°02′ N (basin 3) has been considered as a basin in mountainous land type. Land uses were agriculture lands, rangelands, forests, woodlands and olive orchards. This basin is a part of Alborz mountains strain.

Image processing included radiometric correction, selecting best bands for making color composite with regard to the O.I.F. [1], making principal components 1, 2 and 3, resampling spectral bands and principal components to the panchromatic bands, georeferencing by the nearest neighbour method, making different color composites using the spectral bands, and linear stretching and filtering in different stages for preparation of color composites. All color composites were compared and the best color image was selected for the distinction of gully erosion. From DEM, a hill shade layer was prepared and overlayed on a color composite that obtained 3-D view possibility. Investigations show the possibility visual distinction of more gullies such as small and medium gully erosion on the satellite image is not possible, therefore, by using optimum index factor, 3 bands that had least common information were selected. Therefore, bands 5, 3 and 1 were combined to make a color composite 531 RGB, of course, at first these bands extended by linear stretching.

The position of 652 and 124 ground control points were recorded by GPS respectively in mountain and plain land types. Soil gully erosion, land uses or plant covers were investigated in these points. Regarding ground control points and auxiliary points, training points of gully erosion and other surface features were introduced to software (Ilwis 3.3 Academic). The supervised classified map of gully erosion was prepared by maximum likelihood method and then, overall accuracy of gully erosion map was computed.

3. Results and Discussion

It should be regarded that the visual detection of large gullies is not difficult on images, but there is a problem in distinguishing small gullies. Previously, it had been talked that processing ETM$^+$ images for distinguishing gully erosion intensities were done, but this processing was not caused to detect the small and medium gullies. Hajigholizadeh (2005) also for providing surface, rill and gully erosion maps in five basins in Tehran province, Iran, by using images visual interpretation, concluded that recognition of surface, rill and small gully erosion is very difficult with due attention to images resolution. An applied hypothesis in this study was the possibility of satellite images classification regarding spectral reflexes for detection of gully erosion. This hypothesis can be considered with regards to gully sidewalls angle and change in its spectral reflex than environs. Table 1 shows the results of the supervised classification of gully erosion in plain physiography. In basin 1 that is a homogenous plain with bare lands, accuracy was 85.9%. When these lands were accompanied with cultivated lands (basin 2), accuracy decreased to 59.4%. Decrease in accuracy is because of cultivated lands. This is caused to digital number interference between gullies and cultivated lands. DN difference between gullies and environs is very obvious in a homogenous plain.

[1] Optimum Index Factor

With the current availability of high-resolution satellites such as IKONOS and QuickBird options for detecting and monitoring individual small-scale features have increased, although not yet reported in literature. The visual interpretation provided usually good results and despite of intensive development of numerical interpretation approaches, it is still popular. It is used mainly for erosion mapping of large areas in third world countries (Tripathi and Rao, 2001; Sujatha *et al.,* 2000).

Table 1. Results of the supervised classification of soil gully erosion in plain land type

	Total classified pixels	Classified correct pixels	Accuracy (%)
Gully erosion in basin 1	456	392	85.9
Gully erosion in basin 2	687	408	59.4

Table 2 shows the supervised classification results of gully erosion and other surface features in mountainous physiography. The greatest accuracy is related to forest land use but this value is only 49.8% for gully erosion. Therefore, results denote to a low accuracy in providing gully erosion map that is not acceptable. Previous studies of Mohammadi Torkashvand (2008) indicated that the photomorphic units' map derived from processing satellite images had a 89.9% conformity than ground truth map of gully erosion.

Table 2. Results of the supervised classification of soil gully erosion and other surface features in mountainous land type (Roodbar sub-basin)

Surface feature	Total classified pixels	Classified correct pixels	Accuracy (%)
Gully	325	162	49.8
Agriculture lands	432	314	72.7
Range lands	1120	854	76.3
Forest	2587	2485	96.1
Plant cover	925	764	71.7
Urban	54	48	88.9
		Overall Accuracy: 85.0	

Raoofi *et al.* (2004) computed an accuracy 80% of gully erosion map derived from visual interpretation of Cosmos images than ground truth map. The highest spectral reflexes interference of gully erosion exists with range lands and then agriculture lands. From 325 ground control points (pixel) having gully erosion introduced to software, only 162 pixels had correctly been classified in supervised classified map; 102 and 42 pixels were also classified in range lands and agriculture lands categories, respectively.

Investigations in basin 3 (Roodbar sub-basin) indicated that gullies size in mountain regions are mostly not required size that their pattern be detectable on satellite image. Even when depth and sidewall slope of a gully be high until because of change in spectral reflex to differentiate its DN, again is not required size that be dominant feature at a pixel 28×28 m. We know that the spectral reflex of a pixel is a mean DN of its different features and when a feature is dominant, it influence pixel DN. Therefore, gullies are maybe detectable in a homogenous plain with very low change in slope and relief because of its DN difference than environ that is very obvious, but in mountainous regions with great variations in slope, natural relief, contrast and small size of gullies, there isn't this possibility for supervised classification of gully erosion. When we have a ground control point with distinct coordinate of gully erosion, this pixel isn't introducer of gully erosion, unless gully erosion is dominant in this pixel. Since gullies are linear features and generally distant (the classification of gully erosion is regarding gullies size and its distant), DN of a pixel is only not related to gully erosion.

4. Conclusion

In general, results showed that the possibility supervised classification of gully erosion isn't possible, although it need more studies for results generalization to other mountainous regions. Also, when land uses and other surface features to increase in plain physiography, it will be decreased the classification of accuracy.

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References

1. Allan James, L., D. G. Watson, & F. H. William, 2007. Using LiDAR data to map gullies and headwater streams under forest canopy: South Carolina, USA. Catena, Article in Press, Corrected Proof.
2. Bocco, G. 1991. Gully erosion: processes and models, Progress in Physical Geography, 15 (4), 392–406.
3. Frazier, B. E., D. K. Mc Cool, & C. F. Engle, 1983. Soil erosion in the palouse: An aerial perspective. J. Soil and Water Cons., 38, 70-74.
4. Goosen, D., 1967. Aerial photo interpretation in soil survey. Soil Bulletin. 6. FAO, Rome.
5. Hajigholizadeh, M., 2005. Capability using high resolution satellite images in distinguishes some erosion features in Tehran province, Iran. In the Proceeding 3rd Erosion and Sediment National Conference, 28-31 August, 2005. Soil Conservation and Watershed management Research Institute, Tehran, Iran.
6. Martinez-Casasnovas, J. A., 2003. A spatial information technology approach for the mapping and quantification of gully erosion, Catena, 50 (2-4), 293-308.
7. Martinez-Casanovas J. A., M. C. Ramos, & J. Poesen, 2004. Assessment in sidewall erosion in large gullies using multi-temporal DEMs and logistic regression analysis, Geomorphology, 58, 305–321.
8. Mohammadi-Torkashvand, A., D. Nikkami, & M. Esfandiari, 2005. Investigation of methodology for preparing erosion features map, case study: Tehran Kan-Sologhan basin. In the Proceeding 3th Erosion and Sediment National Conference, 28-31 August, 2005. Soil Conservation and Watershed management Research Institute, Tehran, Iran.
9. Mohammadi-Torkashvand, A. 2008. Investigation of Some Methodologies for Gully Erosion Mapping. Journal of Applied Science, 8 (13): 2435-2441
10. Poesen J. W. A. & J. M. Hooke, 1997. Erosion, flooding and channel management in Mediterranean environments of southern Europe, Progress in Physical Geography, 21, 157–199.
11. Rahnama, F., 2003. International design for providing erosion features map in the part of Isfahan province, Iran. Workshop of modern technologies designs (GIS-RS) in soil conservation. 7-8 febrevery 2003. Soil Conservation and Watershed management Research Institute, Tehran, Iran.
12. Raoofi, M., H. Gh. Refahi, N. Jalali, & F. Sarmadian, 2004. A study of the efficiency of digital processing methods of satellite images to map and locate soil erosion, Iranian Journal of Agriculture Sciences, 35 (4), 797-807.
13. Sirvio, T., A. Rebeiro-Hargrave, & P. Pellikka, 2004. Geo-information in gully erosion studies in Taita hills, SE-Kenya, preliminary results. In the proceedings of the 15th Africa association of remote sensing of environment conference, 17-22 oct. 2004. Nairobi, Kenya.
14. Stromquist, L., 1990. A multilevel approach to soil-erosion surveys, Examples from the Lesotho lowlands, P. 1-12. In L. Stromquist (ed.) Monitoring soil loss at different observation levels-Case studies of soil erosion in the Lesotho Lowlands. UNGI Uppasala University, Uppasala.
15. Stromquist, L., B. Lunden, & Q. Chakela, 1985. Sediment sources, sediment transfer in a small Lesotho catchmaent- A pilot study of the spatial distribution of erosion features and their variation with time and climate. South Afric. Georg. J., 67, 3-13.
16. Sujatha, G., R. S. Dwivedi, K. Sreenivas, & L. Venkataratnam, 2000. Mapping and monitoring of degradaded lands in part of Jaunpur district in Uttar Pradesh using temporal spaceborne multispectral data. Int. J. of Remote Sensing, 21, 519-531.
17. Tabatabaei, S. M. R., 2000. Investigation of gully erosion changes trend in Khoozestan province by using GIS and satellite imagery. In the Proceeding 2nd Erosion and Sediment National Conference, 12-13 August, 2000. Soil Conservation and Watershed management Research Institute, Tehran, Iran.
18. Tripathi, N. K., & A. M. Rao, 2001. Investigation of erosion on Hope Island using IRS-ID LISSIII data. Int. J. of Remote Sensing 22, 883-888.
19. Zinck, J. A., J. Lopez, G. I. Metternicht, D. P. Shrestha, & L. Vasquez-Selem, 2001. Mapping and modeling mass movements and gullies in mountainous areas using remote sensing and GIS techniques, International J. Applied Earth Observation and Geoinformation, 3 (1), 43–53.

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