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Research Paper

Water erosion risk assessment using models ICONA and techniques RS & GIS (case study catchment basin Babavly of Siahkal)

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Abstract: Erosion phenomenon has always been considered one of the most important factors is the waste of land resources. In this study, we intend to study water erosion risk using GIS and RS techniques model ICONA in catchment basin Babavly Siahkal of Gilan. In this study, at first, slope layer of DEM map information and rocky surface layer of geological maps were extracted and classified. Two above-mentioned layers for soil erosion maps were overlapped. Then the map of the soil conservation from the overlap of land use layers and vegetation resulted from the soil adjusted vegetation index using ETM $^+$ images of 2000 and 2013 Landsat 8 were prepared. Finally, the erosion risk map from erodible overlapped layer and soil protection was obtained. The final erosion risk results showed that the classes of erosion risk, respectively, from 1298.21 and 4924.10 ha in 2000 to 1058.71 and 4015.63 ha in 2013 has been reduced in area. Also, the classes of risk of medium, high and very high erosion risk, respectively, from 3170.29,1550.26, 2154.21 ha in 2000 to 3348.54, 1907.01, 2761.42 ha in 2013 has been increased in area. Verification of the results with land facts and field visit indicates overall accuracy equal to 0.79 and 0.85 and kappa coefficient equal to 0.78 and 0.83in ETM$^+$ pictures of 2000 and Landsat 8 in 2013, which was acceptable. In order to reduce the erosion destroying process in studied catchment basin, prevention of land transformation and protection of forest and land zones, improving and infrastructure of mountainous communication nets and creating conducting nets in roads will be recommended.

Keywords: Water erosion, GIS, remote sensing, ICONA

Introduction

One of the most important natural resource of any country is soil. In order to guarantee continuing existence, human during its evolution history has used soil as a filed for agriculture products and food supplying (Refahi, 2003). In areas where erosion is not controlled, soil depth gradually decreases and loses its fertility. However, erosion is permanent phenomena and there will always be, but if it is less than the rate of soil formation, it is not critical. Soil erosion is one of the most important environmental, agricultural and food production issues in the world and has a devastating impact on all ecosystems and natural resources managed by humans (Anbarani, 1998). Zoning the rate of erosion and prioritizing areas is an effective step to protect the organization and operation of the soil. Today, although developed countries could solve their most of soil conservation problems, developing countries are in the first stages because its real extension require to knowledge people and mechanize agriculture and recognize different zones in order to determine their ability. In order to accomplish desired goals and zonation of erosion risk, data obtained from remote sensing and capabilities of GIS to generate the data needed to create a factor model ICONA thereby to obtain information on high-quality output and reliability updates will be pretty easy . Thus, remote sensing and GIS can be effective in developing management solutions and providing options for managers to be applied to the problem of erosion.

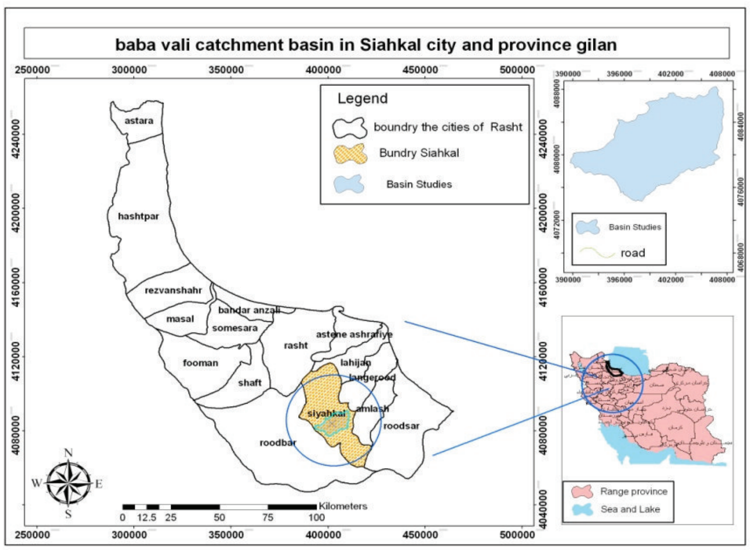
The fundamental problem of modern human life is to enhance the quality of life within the limitations and in harmony with the natural processes that form the foundation of life. In this respect, obviously without the use of new technologies, achieve the goal of improving the quality of life is not possible. Amongst, environment as body of development needs to attention and planning and the necessity of prevention of evitable damages to environment is to have proper information for assessing and decision making that applying modern technologies of remote sensing and geographical information will be useful in this regard.

Given the above issues, soil erosion risk assessment is essential to develop methods of preventing erosion for sustainable management of land and water resources (Vrieling et al , 2002). In order to estimate erosion, the first equation, which was proposed, was Xing equation in which the only two factors considered were the degree and slope length. Later Masgrio involved vegetation and climate factors in it. Then gradually formulas were prepared and made possible erosion prediction based on location data (Ronald et al, 1997). Wilson and Lorang,(2000) studied the GIS applications in order to estimate soil erosion and strudy limitations and finally demonstrated that geographical information system prepare excellent capabilities for improving and estimating soil erosion. Seddighi (2011) conducted the water erosion risk zonation using ICONA model based on RS & GIS technologies in catchment basin of Shiraz. His research results showed that ICONA model has well predicted the areas prone to erosion. Karimi and Amin (2012) determined the zonation of erosion risk of Syondra dam basin using ICONA model by RS technic and TM satellite imageries in 1987 and IRSp6 in 2010 in the period of 23 years and compared and calculated the type of land use during this period in ICONA model . Ehsani and Ghaffari Shirvan (2012) conducted water erosion risk zonation using satellite data and GIS and ICONA model in catchment basin of Hablehrod in Semnan. Their research showed that 48 percent of the erosion risk class is very low, 36 percent is low, 12 percent is medium and 4 percent is high. Bayramin et al (2003)conducted a study in the region of Pazar Turkey using ICONA model. Their study revealed that the meadows and moorland especially in steep slopes and foothills and mountainous areas encountered with high erosion risks and pastures require good management and user type , vegetation , rock, topographical conditions , rainfall and soil are the main factors that impact on soil erosion . Zaw Wan and Chan Chai (2008) conducted the soil erosion risk assessment using GIS and knowledge of farmers in arid and semiarid regions of the central region of Myanmar. In their erosion risk map was seen that about more than 75% of this region is in relatively low erosion risk. So the maximum erosion is a natural process that is ongoing in all parts of the land and is important in land surface change. But the foolish and cruel manipulation by human society to environment, the natural process of erosion has become so destructive intensity thatis added on a daily basis. This study offers a new model in study of erosion. We hope that it will be effective in maintaining our land areas. to keep our land area is effective .

Martial mad Methods

2-1-Location:

Babavali catchment basin with 13140.33 ha is under Polroud basins located in mountainous location of Siahkal and in political divisions is belonged to Deilaman of Siahkal (in the south middle of Gilan and the lowest out point of basin with 1239 high from sea level in the south of Siahkal. The basin is located in between 49^0 45' 35'' to 49^0 57' 55'' east longitude and 36^0 48' 36'' to 36 56' 36'' north latitude. North and West of the Great catchment basin of Shalman are limited from the South East of Shakhdaran basin , from the North East and East to Garmaroud basin and from the South to Shahroud basin.



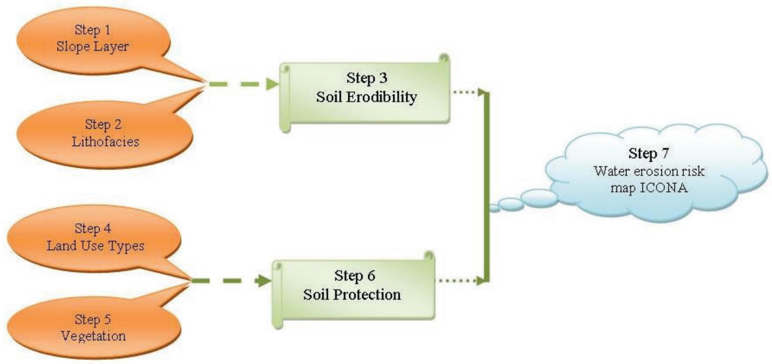
Map (1) - Babavaly catchment basin in Siahkal of Gilan

2-2-The images used in this research:

The use of satellite imaginaries has many advantages such as photography in different areas of electromagnetic spectrum from visible to ultra-red, having wide view in order to study large-sized phenomena, time repetition and ability of land separation fitted with studied purposes. Because of the wide view , allowing even greater speed and accuracy of processing and the cost is possible. The images used in this study are 8 Landsat images on 9 June 2013 and ETM imaginaries of 7 Landsat on June 30 , 2000.

2-3-Method:

As mentioned in the study background, ICONA model is presented by the Spainscientific Society of Conservation of Nature. The model was applicable in European countries and most of middle east areas. Among most of effective ways for predicting erosion using RS and GIS, simulation of the model in European countries, middle east regions and other regions with same weather conditions were accepted (ICONA, 1991; Bayramin , 2003). Factors affecting the model are slope, Lithofacies (Geology), land use, vegetation Cover. Each of these factors as geographical information systems and software layers digital remote sensing preparations a reprepared for entry into the model. Finally, areas susceptible to water erosion risk are determined.Flowchart of the above layers is shown in graph (1). Layers preparation is as follows:



Graph No. (1) - The conceptual ICONA model

2-3-1-Slopelayer:

To obtain a slope class, digital information of 1:25000 maps of the mapping organization was used. This information includes the height points, contour curves and catchment basin area and then the DEM map was obtained. To this end, DEM was provided with the appropriate resolution and slope maps were obtained in in GIS software and categorized in group that is shown in table (1) and map (2).

table (1)-Slope classes based on ICONA model in Babavaly catchment basin

Class	Slope Range %	Label
1	0-3	Flat and gentle
2	3-12	Medium
3	12-20	Steep
4	20-35	Very steep
5	>35	Extreme

2-3-2-Lithofacies layer (geology):

In studies of erosion and soil conservation, Geologic and lithological characteristics of the basin due to its effects on erosion is important . Various units of the basin geology degree of sensitivity varied. The map indicates the type of stone surfaces , stone or soil parent material or sediment samples with emphasis on chemical and mechanical resistance against corrosion. Soil protection and Watershed Management Research in the field (2004), Classification and formation of hard deposits and erosion took place country and category formations Alborz,Cope Dagh and Azerbaijan were performed and the sensitivity to erosion. However, Feiz Nia et al (1386), susceptibility to erosion and sediment catchment basin geological creation of Gorgan in GIS environment using USLE negative and did. They rock resistance to erosion of the rock type, hardness, combination, weathering and sediment production are divided according to climate. According to a survey done after receiving a 1:100,000 map Lithofacies(Geology) Geological and Mineral Exploration Geo- referenced maps and cut the basin of the map, the boundaries between map units and stone surfaces compared Babavaly catchment basin plan consulting geologist and expert opinion and perception of the field will Reset. The boundary of the digital ground units. Then, based on the strength of rocks in different climates Feiz Nia technique, ICONA model, Soil Conservation and Watershed Management Research Institute and carried out by experts to classify region.

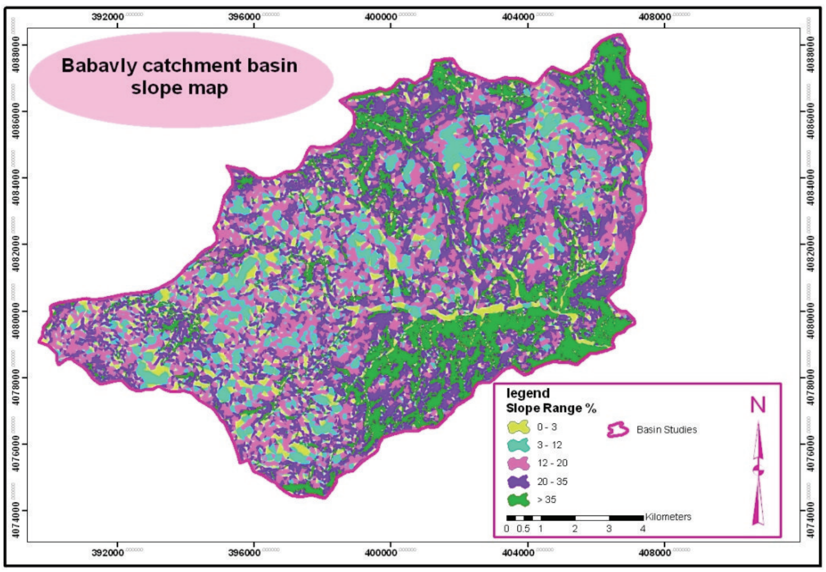
Table (2) - lithofacies classes of Babavly catchment basin of Siahkal

Abbreviation	Weight in erosion	Age	Facies
Pgkv	1a	Paleogene	Pyroclastic deposits, lava basic
Pgkt	2b	Paleogene	Acidic and andesitic tuffs, tuff siltstone
JK^1	3c	Late Jurassic to Cretaceous start	Medium and fine-textured layer of thin limestone and gray to light gray with dark slumber laminations

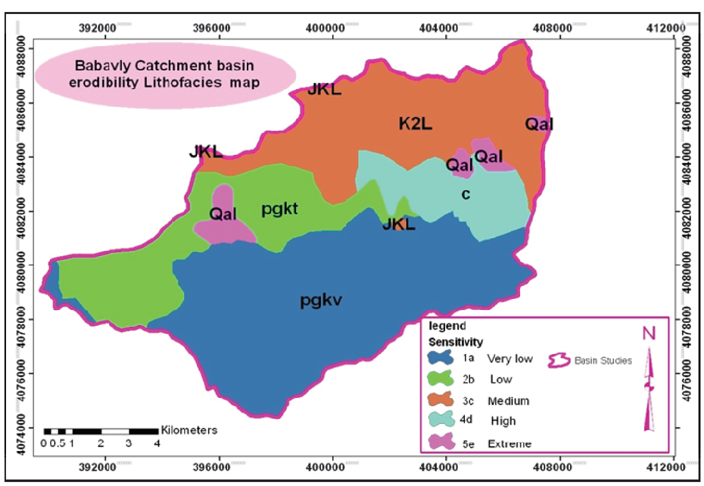
K2[1]	3c	Upper Cretaceous	Thin-to thick-bedded gray limestone Laminations of clayey and silty limestone gray, bright green and barely layers of sandstone and chert and limestone conglomerate
C	4d	Eocene	Genetic conglomerate with a matrix polymer clay Taqrmz dark purple-red sandstone, siltstone thin layers of tuff and lava basic rarely
Q^{al}	5a	Quaternary	Alluvial (Face, Qlvhsng, sand, gravel, clay, silt, quartz)

2-3-3- Soil erodible factor

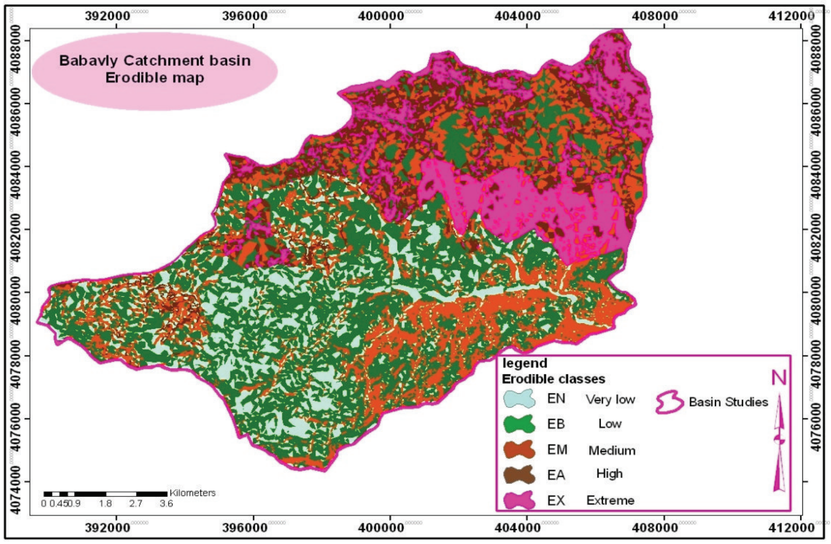
In this model, the mapping layer of soil erosion and slope, Lithofacies overlap and the potential for erosion risk mapping and surface erosion, respectively. Ground and surface erosion are given in the following table. For example, dense rock erodible class (compact) is class (1a) and a slope of less than 3%, minimum or (EN). Or classes without sediment / soil with a slope greater than 35% adherent maximum class erodible or (EX) are. Erodible fields in the table (3) are given. Erodible Index Table (4) is given.



Map (2) - Slope map of the study area based on the ICONA model



Map (3)- sensitive map to Lithofacies erosion



Map (3)- Erodible map of Babavaly catchment basin

table (3) -Ground and surface erosion

Slope class	Lithofacies Class				
	1 (a)	2 (b)	3 (c)	4 (d)	5 (e)
1	1 (EN)	1 (EN)	1 (EN)	1 (EN)	2 (EB)
2	1 (EN)	1 (EN)	2 (EB)	3 (EM)	3 (EM)
3	2 (EB)	2 (EB)	3 (EM)	4 (EA)	4 (EA)
4	3 (EM)	3 (EM)	4 (EA)	5 (EX)	5 (EX)
5	4 (EA)	4 (EA)	5 (EX)	5 (EX)	5 (EX)

Table (4) -Erodible index table (ICONA)

Class	Label	Description
1	EN	Very low
2	EB	Low
3	EM	Medium
4	EA	High
5	EX	Very low

2-3-4-Land use Layer area of study:

Today, the most common method for mapping changes is to use of remote sensing technologies(Lefskyand & Cohen, 2003).Evaluation is the process of identifying and distinguishing between change status of a user or process is different when(Lu et al,2004).The images used in this research is to make another map area, Landsat8 of 9 on June 2013 and the Landsat7 image of 30 June 2000.

-Preprocessing images

In this study, the geometric correction of the images, extracted drainage and road map of 1:25000 scale mapping and matching them with scenes from Rice Research Institute in the province. Institute for Geo- referenced image, the geometric error of a few pixels were observed. Given the proper resolution PAN band Landsat (15 m), the image of this band relative to other bands and then correct the 1:25000 maps of 2013 and the bands of image geometric correction method in 2000. A total of 20 ground control points for geometric correction panchromatic band was selected from waterways and roads. RMSE error in the band of 0.19 was obtained. Both stages of the process of transforming a polynomial and nearest neighbor method were used for sampling again. It is explained RMSE error of 0.25 for the images and for images in 2013 to 0.4 in 2000, respectively.

- Choose the best bands combination:

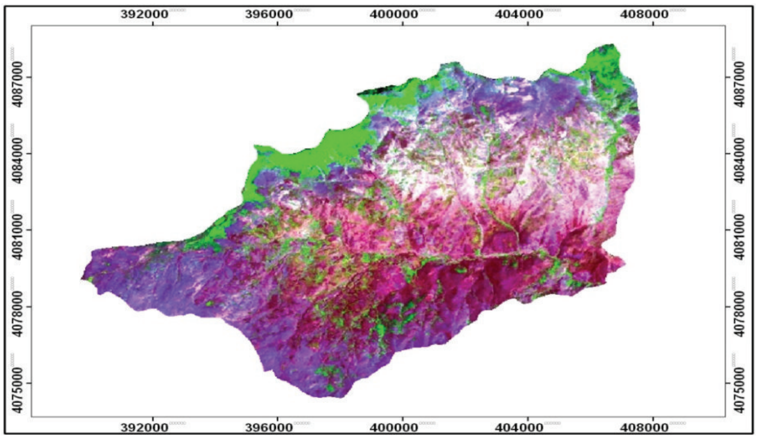
In the remote sensing data, the initial calculation of statistical indicators is essential. These calculations include the mean, standard deviation, correlation matrix, and variance,co-variance in each band. To determine the best combination, OIF index was used. OIF levels based on variance and correlation between different bands are obtained as follows:

$$OIF = \frac{\sum_{j=1}^{3} SDj}{\sum_{j=1}^{3} |CCj|}$$

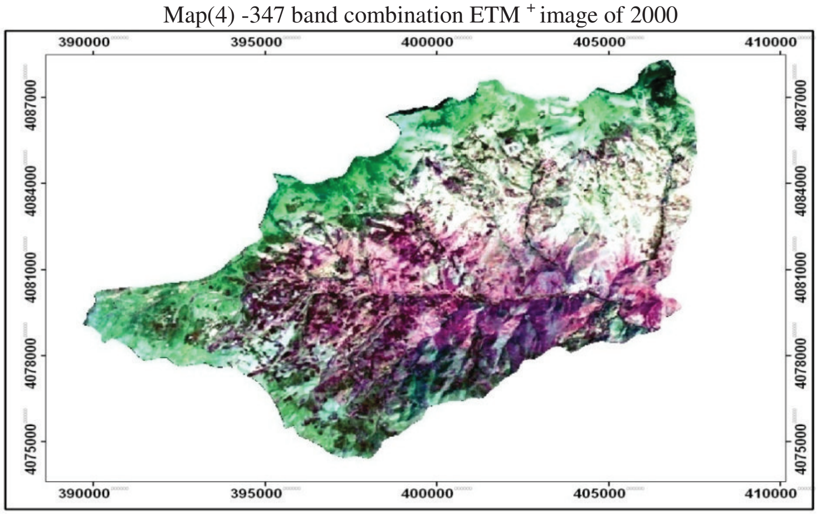
$\sum_{j=1}^{3} SDj$ Total standard deviation of three bands

$\sum_{j=1}^{3} |CCj|$ Total absolute correlation between the dual-band tri bands (Chavez et al, 1986; Alavi Panah , 2006).

After determining the lowest or highest sum of the correlation between bands and band pixel values of the standard deviation relative to each other, good of the algorithm In voice greatest the band and defining of the most favor able combined the least amount of has been applied by redundancy(Ahani ,1387;Seddighi, 2011).Best band combinationETM $^{+}$images in this study for2000,combining for347 and Landsat8 images, the combination of 367was selected.



Map(4) -347 band combination ETM $^{+}$ image of 2000



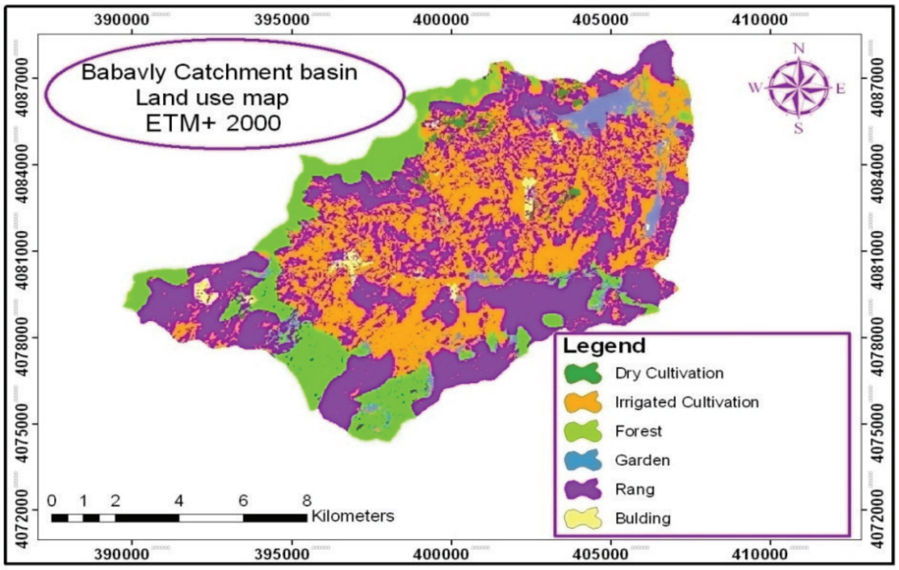
Map(5) -367 band combination of Landsat 8 of 2013

Table (5) -Land USE class:

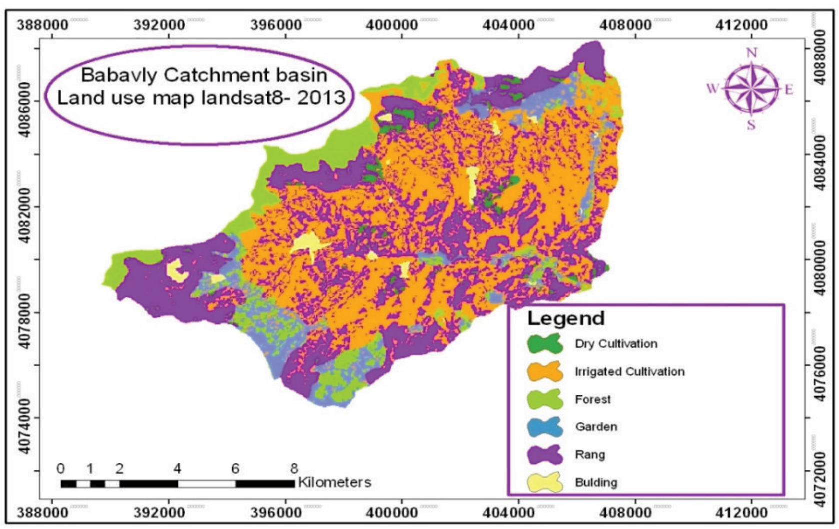
Class	Land use name
1	Dry Cultivation
2	Irrigated Cultivation
3	Forest
4	Garden
5	Range land
6	Bulding

-Image classification:

For classification, supervised classification method and the maximum likelihood algorithm were used. In this way, the regions are used for training and education as the basis of classification (Alavi Panah ,2006). The maximum likelihood algorithm is the most common method of classification (Mather, 2005 :315). This method is more accurate than other existing methods for classification, a small amount of variance and correlation values for different spectral bands, are calculated for all samples from the property to communicate a pixel to the classification of the Department of or samples spectrum is also used .within each of the classes as much as possible to support a resolution better user classes (Jensen ,2005 : 125). The land classification based on spectral reflectance, classification accuracy assessment was conducted. Existing applications of Babavaly catchment basin are as follows:



Map(6) – land Use of 2000 of ETM $^{+}$ image



Map(7) - land Use of 2013 of Landsat image 8

- Classification accuracy assessment

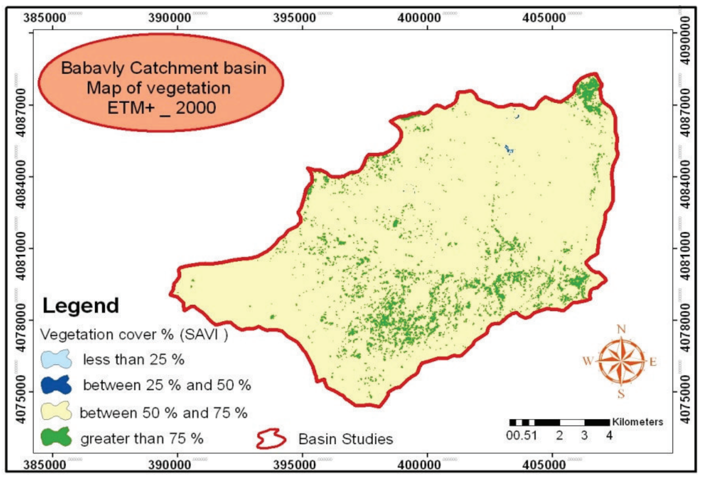
Table (6)- Kappa coefficient and overall accuracy of the ETM $^{+}$ image of 2000	
overall accuracy	Kappa coefficient
0.8949	0.8889

Table (7)- Kappa coefficient and overall accuracy of the Landsat8 image of 2013	
overall accuracy	Kappa coefficient
0.8804	0.8750

2-3-5-Vegetation Map

For mapping vegetation, the vegetation indices were used. Vegetation indices can provide useful information on vegetation condition for us. Most bands are used in the calculation of vegetation indices ranging from red and near-infrared bands. The reason is that the high- energy absorption or reflection coatings with very low vegetation in the red and infrared part of the high energy reflections. This distinction can help us to vegetation covers in a single band images or color composites identification (Fatemi and Rezaee, 2005). This ratio expresses the fact that this subject luxuriant vegetation in the near infrared, the reflected light intensity and the wavelength of red light is absorbed by (Seddighi , 2011). In this study, the research project of Sobh Zahedi (2012), the best approach to classification was chosen based on L type . He in the formula considered the amount of SAVI vegetation, poor, moderate and good, respectively, 0.25, 0.5 and 1. After reading the book Babavaly watershed basin planning studies and expert opinion has been prepared in 91 Babavaly scheme was diagnosed with moderate vegetation zone. However, the vegetation index NDVI is suitable for areas with dense vegetation and by external factors such as weather conditions, lighting, angle, and above all a reflection of bare soil are affected.

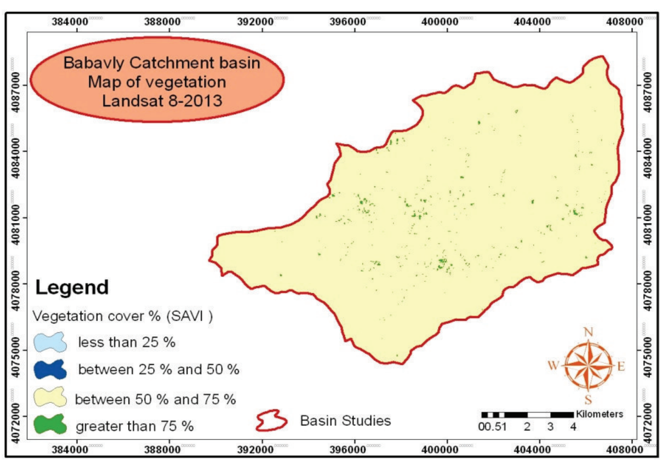
$$SAVI = \frac{(NIR - RED)(L + 1)}{NIR + RED + L}$$



Map (8) - Percentage of vegetation in 2000 based on ICONA model

Table(8)- Table of vegetation percentage classes

Class	Description
1	Vegetation cover less than 25 %
2	Vegetation cover between 25 % and 50 %
3	Vegetation cover between 50 % and 75 %
4	Vegetation cover greater than 75 %



Map (8) - Percentage of vegetation in 2013 based on ICONA model

2-3-6- Soil protection status

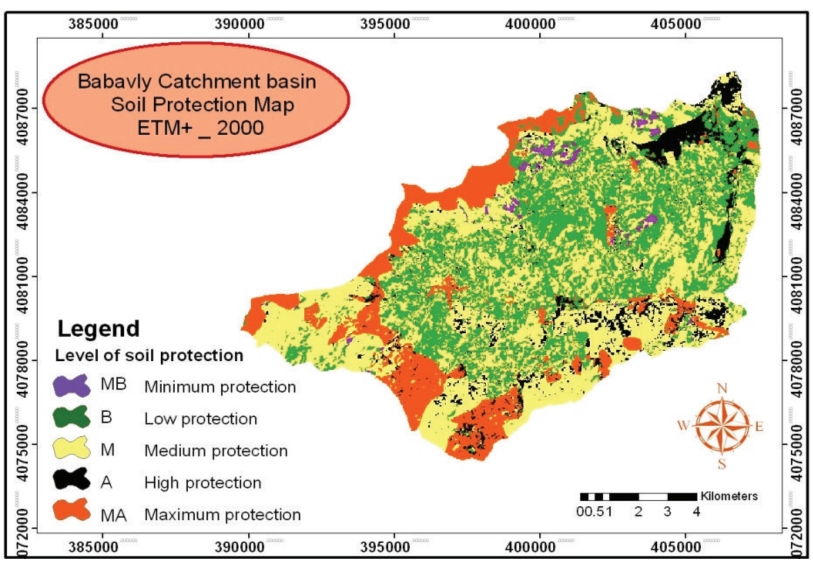
Among the important parameters involved in watershed protection of watershed is vegetation and existed type of use. Soil protection conditions vary at any time and according to the type of soil cover same time is expressed. ICONA model for the study of soil protection layer, cover layer and user layer overlap region, respectively. Soil protection Status Table (9) was estimated. For example, over 75% forests cover any areas of soil protection or too dry farming areas coverage 0-25 is considered among the areas with low protection. A class of soil protection in the table (10) is shown.

Table (9) – combining classes Land use and vegetation cover (ICONA model with study of the table inserted in thesis of Seddighi, 2012)

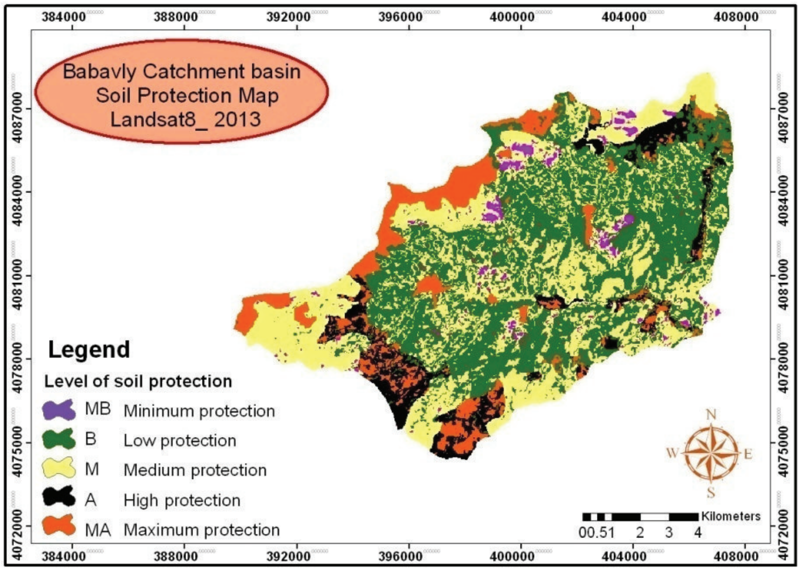
Land Use	Vegetation cover (SAVI) %			
	0-25	25-50	50-75	>75
Dry Cultivation	5 (MB)	5 (MB)	4 (B)	4 (B)
Irrigated Cultivation	5 (MB)	5 (MB)	4 (B)	3 (M)
Forest	3 (M)	2 (A)	1 (MA)	1 (MA)
Garden	4 (B)	3 (M)	2 (A)	1 (MA)
Range land	5 (MB)	4 (B)	3 (M)	2 (A)
Bulding	1 (MA)	1 (MA)	1 (MA)	1 (MA)

Table (10) -Classes of soil protection

Class	Label	Description
1	MA	Maximum protection
2	A	High protection
3	M	Medium protection
4	B	Low protection
5	MB	Minimum protection



Map (9) - Soil protection of Babavaly catchment basin ETM images of 2000



Map (10)- Soil protection of Babavaly catchment basin ETM images in 2013

2-3-7-The final map of erosion risk:

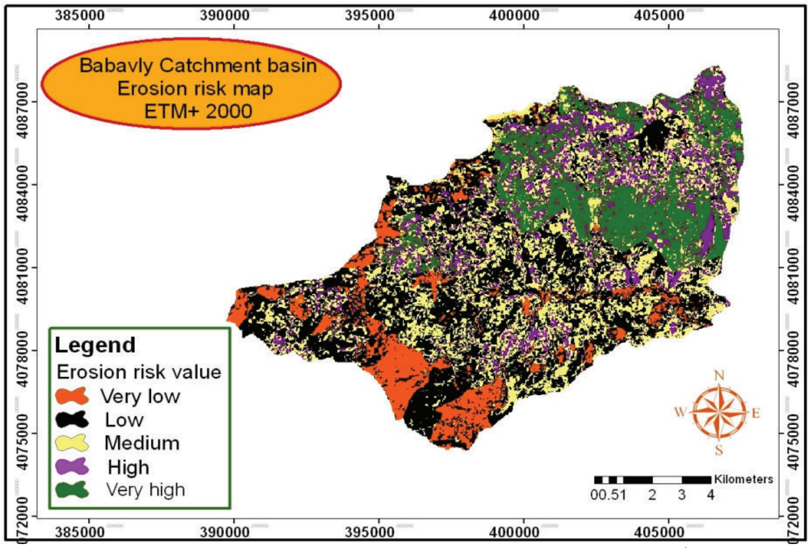
One important objective of this study was to assess and map the location of the erosion risk zone based on the degree of qualitative or risk level, so in the final stage, layer of soil protection and soil erosion layer to create soil erosion risk maps were overlapped .It can be expected that such soil protection areas where are in very good and good conditions that means they have good coverage and use) are less vulnerable to erosion and areas with high slopes and rock is susceptible to erosion; the greater is the risk of erosion. Soil erosion areas in the table (11) are presented. Erosion Class is shown in table (12).

Table(11)- Table of integrate soil conservation and erosion classes

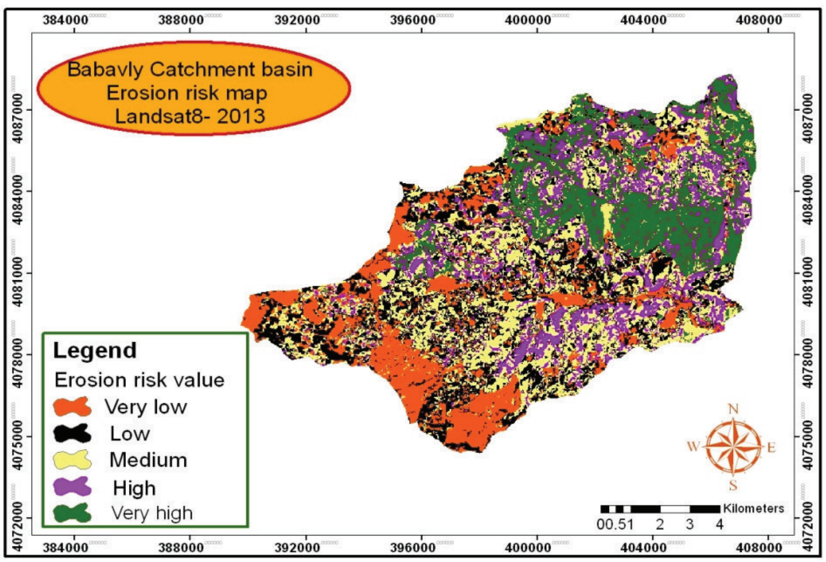
Erosion Risk		*Level of erodibility*				
		1 EN	2 EB	3 EM	4 EA	5 EX
Level of soil protection	1 MA	1	1	1	2	2
	2 A	1	1	2	3	4
	3 M	1	2	3	4	4
	4 B	2	3	3	5	5
	5 MB	2	3	4	5	5

Table(12)-Soil erosion risk classes

Erosion Risk	class
1	Very low
2	Low
3	Medium
4	High
5	Very high



Map (11)- Erosion risk of Babavaly catchment basin 2000 ETM $^{+}$ image



Map (12)- Erosion risk of Babavaly catchment basin 8 Landsat image, 2013

Results

In the classified slope map , about 48 percent of the land area has slopes greater than 20 percent. Slopes over 35 % in the North East and South- East basin is clearly visible (Map 2). The Lithofacies are classified as classes, class 1a , with an area of 5528.14 hectares is allocated to the highest area. The results of combining layers of slope and stone surfaces in layers, the erosion indicates this is the highest area in the classes, the erosion of the floor, EB (the erosion low) with an area of 37.35, the 4900.68 hectares of area covered and after class, EM (the average erosion) is of secondary importance . The land use map 2000 and 2013 can be seen in the period from 2000 to 2013 on a land area of dry land and water and in residential areas and gardens such as the 183.08 and 820.14 and 63.88 and 490.27 additional acres of forest lands , rangelands, the amount of 496.86 and 1063.26 acres has been reduced. The greatest amount of change occurred in the area of pasture land at a rate of 8.09 % of the irrigated area and the largest increase was observed in the amount of 6.24 % of the area. This can cause an increase in the rural population in the basin, the ecological principles of non- compliance and failure to comply with certain conservation laws, he said. But more than 75 % of the floor area of study represents a very good cover of the 699.02 acres in 2000 to a 12.78 acres converted and has been significantly reduced. Combining the results of land use and vegetation layers in the layer of soil protection in the period 2000 to 2013 shows that soil protection is very high and high and medium grade of 2065.89 and 758.85 and 4814.89 ha in 2000 to 1898.10 and 611.02 and 4554.90 hectares in 2013, has declined. A total of 58.42 % of the area of the 53.75 % reduction was observed in the area. The high protection class and too little protection from 3746.10 and 1711.35 ha to

3799.15 and 2250.36 hectares and a total of 41.58 % to 46.16 % of the area have increased. The organic matter content and soil physical properties and reduces impact protection and increased sensitivity to it. The average too much is added. In 2000, a very low erosion risk classes, the equivalent of 1298.21 hectares was estimated that the figure for 2013 to 1058.71 is reached. The low risk classes in 2000, 4924.1 acres have been reached to this figure for 2013 to 4015.63 hectares is an area of 908.47 hectares, equivalent to reducing the level indicated. The class of risk eroding middle much in 2000, respectively 3170.29 and 1550.26 and 2154 ha , which figures in 2013 to 3348.54 and 1907.01 and 2761.42 acres has been in a total surface of 1142.42 ha area has increased.

Conclusion

Having timely data necessary for the proper management of natural areas, One of the principles of natural resource management, land use change is about maps. Turning to the high cost and lack of timely preparation of these maps by ground operations in recent years, the use of satellite imagery as a way to have this Karmtrh . The results of the classification of digital images of the study area for mapping land use classification maximum likelihood of a company sets different bands showed that the best overall accuracy of classification image, ETM $^{+}$ 2000 and Landsat 8 , 2013 , respectively equivalent to 0.89 and 0.88, respectively , 0.88 and 0.87 respectively. Citing compared with investigations Mont Seroud and Limenz (1992), Delapian and Smith (1999) , (Estehman , 2004 : 746), the coefficients of overall accuracy and kappa Big Balance 0.7 in terms of accuracy, very good , and less than 0.4 as is weak , the results obtained from the use of satellite imagery to classify land uses in the basin , but Siahkal both individual users and the accuracy in terms of total accuracy and Kappa value , produced in association with has been outstanding .

According to the morphological and topographic basin catchment basin Babavaly a percentage steep terrain with extreme density (30 % <) , susceptible to water erosion and flood- prone areas , heavy rainfall in the area occurs mostly in spring phenomena leading to flooding and soil erosion in the catchment area is large . High-gradient watershed transformation unauthorized vegetation due to misuse and overuse of land erosion and flooding cause of the phenomenon , though of short duration rainfall is also one of the main factors . Since Babavaly basin hydrologic group , Group D, C is the slope of the basin, according to the map is fairly severe erosion in many parts of the basin are predicted and observed . The results of the research results (Akan , 2002) who stated levels causing flooding in watersheds is generally lands with slopes above heavy soils with hydrological groups C and D , and land vegetation is lower . Water holding capacity and permeability mapping of areas above or below than above the canopy of natural lands and is corresponded unrestored.

The model can well ICONA erosion in the watershed studies to estimate. The results (angular and Chan Chai, 2008 : 105) that evaluated the risk of erosion ICONA model did correspond. They stated that sensitive lands, especially rangeland, dry farming wasteland, generally on steep slopes and hilly and mountainous areas with a high risk of erosion.

The study area due to the steep topographic features and density, terrain, and climatic characteristics of the regime, snow, rain , frost and frequent rainfalls during the period of relatively severe and sometimes persistent, sensitive soils and rock units and how to use possesses land erosion surface forms , ditches , waterways and mass. Research in this study was similar to what is questionable compared to the previous map (2000) is .showed that the best overall accuracy of 2000 and Landsat ETM $^{+}$ image zoning 8 , 2013 , respectively, equivalent to 0.79 and 0.85, respectively , 0.87 and 0.83 respectively. It also calculates the statistical minimum percentage assured that classes grade very high sensitivity 2000 -level by 1 and 5 percent respectively 0.8981 and 0.9214 and for class -sensitive medium 0.4791 and 0.6982 % of the highest and lowest percentage of minimum sure . Also for 2013,classes, class sensitivity levels 1 and 5 percent respectively by 0.8914 and 0.9202 and for low grade 8227 / 0 and 0.7943 % of the highest and the lowest percentage were found to have the least confidence .

In the end, it can be noted that the use of satellite imagery in ICONA model also can reduce the cost of GIS sensible, orderly way to revise and improve the information. The remote sensing as a source of a lot of data required and the GIS as a system which manages , analyzes and presents this information are responsible for closely have found that combining these two techniques , the model ICONA accountable for assessing the risk of erosion blue.

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