# Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 8 (8): 1495-1502, 2008
ISSN 1812-5654


# The Effect of Land Suitability to Reduce Erosion Risks, Using GIS (Case Study; Boushehr Province, Iran)

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**Abstract:** Soil erosion normally occurs at a very high level in most parts of Iran and can become a problem when human affects such as agricultural activities disturbed the ecological balance. Problems with erosion have become more apparent in recent decades owing to changes in land use, field sizes and soil management patterns. This study aims to find the relations between land management such as slope gradient with land use pattern and the erosion reduction in Jam and Riz basin. The materials used in this study included the basic maps of topography, geology, recent land use and IRS data that prepared the required information layers to assessment of erosion. The types of especial erosion calculated by the empirical method for the mentioned basin. The land use coefficient (Xa) was applied in the used model of EPM (Erosion Potential Model) to forecasting the effect of the land type to reduce the erosion. The results of this study indicated that the rangeland products a rate of especial erosion about 3074.8 ($m^3/km^2$ year) and the cropland products a rate of especial erosion about 1714.4 ($m^3/km^2$ year) which are respectively have minimum and maximum role in erosion for the study domain. In conclusion optimum land management reduced erosion in the study area up to 58.3%.

**Key words:** Land use, erosion, land management, EPM, GIS, Jam and Riz basin

## INTRODUCTION

Erosion is one of the most significant forms of land degradation (soil truncation, loss of fertility, slope instability), greatly influenced by land use and management (Rey, 2003; Bini *et al*., 2006). Soil forming environments and erosion processes is a much-debated question when studying the relationship between human impact and environment change (Ballantyne and Wittingtone, 1999; Vanniere *et al*., 2003). The impact of human activities (farming, agro pastoral burning) on mechanical erosion is well-established (Higgitt *et al*., 1991; Lageras and Sandgren, 1994; Passmore and Macklin, 1994; Thornes, 1987). Other parameters, permanent or unvarying (size of watershed, lithology and relief) and variable factors (climate, hydrology, vegetation cover) have an effect on sediment yield and erosion rates (Meade, 1988; Milliman and Syvitski, 1992). Sediment yield also depends on dynamic agents such as gravity on slopes and running water (Maede *et al*., 1990). Land transformation is most in rural areas where expansion of unsustainable agriculture practices are contributing to an unprecedented rate of land degradation (Guzman, 1991; Van der Zaag, 1992; Vazquez-Garcia, 1993; Aide and Cavelier, 1994; Aide *et al*., 1995; Landa *et al*., 1997). For example, agricultural land use is one of the most important factors that have shaped historic landscapes in Europe (Black *et al*., 1998; Correia, 2000; Van Oost *et al*., 2000; Bickik *et al*., 2001; Van Rompaey *et al*., 2002; Sun *et al*., 2003; Bakker *et al*., 2004, 2005). Increasing agricultural exploitation of landscapes and associated land use changes have often led to soil quality degradation and loss of soil by erosion (Szilassi *et al*., 2006). Soil losses and sediment yields from cropped areas have been estimated several times greater than native forest (Neil and Fogarty, 1991). Conversion of landform range to agriculture has created and continues to produce, many on and off site problems for rural people living in watersheds which one of the most destructive and insidious processes occurring because of this anthropogenic activity, is soil erosion (Changhuan and Lixian, 1992; Miller, 1993; Morgan, 1995; Lal, 1997; Landa *et al*., 1997). The potential for surface runoff and soil erosion is accelerating by land use and cultivations. Therefore, the modeling of land use changes is important with respect to the prediction or soil degradation and it is on-site and off-site consequences. Many land use changes studies have shown that almost all land use changes are clearly by human activities (Turner *et al*., 1990; De Koning *et al*., 1998; Thornton and Jones, 1998).

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However, biophysical conditions of the land, such as soil characteristics, climate, topography and vegetation determine largely the spatial pattern of land use and land use changes (Veldkamp and Fresco, 1996). Li *et al.* (2002), in addition to introducing vegetation factors, soil, rainfall and land use as a main influential factors on erosion concluded that erosion in plough lands is 48 to 53%, in river basin is 22 to 25% and in pastures is 33 to 34%. Roose (1998) found that the amount of soil erosion in intact forests is lower which about 0.004 to 0.5 ton in hectare is yearly. However, erosion in forests turned to agricultural land is about 750 ton in hectare yearly. Palis (1990) states, proper actions for soil and water conservation, decrease the erosion and water wastage about 2 to 1000 and 1.3 to 21.7 times, respectively. Chandler and Walter (1998) studied the effect of five kinds land use in runoff creation and concluded that forest lands, turned lower than 3% of annual rainfall to surface runoff. Mulch farming converted about 13%; plough lands about 17%, cultivated lands about 31% and spoiled pasture about 76% of annual rainfall to surface runoff. Bodnar *et al.* (2006) in a study entitled ex-post evaluation of erosion control in Southern Mali, compared the erosion situation in a rural area from 1988 to 2003, so, in 2003 the farmers installed the stony rows on their lands and cultivated grass bands. Then started to plant in a direction was a perpendicular to a slope. This comparison showed that special reduction happened to gully erosion volume about 87% in farmland; this is, from 58 to 8 $m^3$. Annual evaluation represented, the erosion value, depleted to 77%. That means, it reached from 42 to 10 ton in hectare, yearly. Methods for estimating sediment yield were first developed for the analysis of the effects of agricultural practices. The first model used was the Universal Soil Loss Equation or USLE (Wischmeier and Smith, 1965, 1978). The commonest models now being used are USLE (Mati *et al.*, 2000; Erskine *et al.*, 2002), MUSLE (Modified Universal Soil Loss Equation), WEEP (Water Erosion Prediction Project), RUSLE (Revised Universal Soil Loss Equation), (Millward and Mersey, 1999, 2001; Raghunath, 2002), PSIAC (Pacific Southwest Interagency Committee) (Nelson and Rasele, 1989; Heydarian, 1996; Clark, 2001) and EPM (Erosion Potential Method) (Tangestani, 2001). Gavrilovic (1988) originally developed the EPM model for Yugoslavia. The method has tested in some catchment areas in Iran and it is concerned that output results are compatible with field observation (Sadeghi, 1993; Refahi and Nematti, 1995). Applications of Geographic Information Systems (GIS) and remote sensing techniques in erosion and sediment yield assessment have been developed recently (Hill, 1993; Mezosi and Mucsi, 1993; Floras and Sgouras, 1999; Mohammed Rinos *et al.*, 2001; Rafaelli *et al.*, 2001; Shrimali *et al.*, 2001; Bissonais *et al.*, 2002; Lin *et al.*, 2002; Sahin and Kurum, 2002; Yuliang and Yun, 2002; Martinez-Casasnovas, 2003; Tangestani, 2006; Modallaldoust, 2007; Modallaldoust *et al.*, 2008). Remote sensing techniques assist the evaluation of erosion processes and the generation of land use maps, while the integration of such data layers with the generation of erosion - severity and sediment yield maps can readily be performed by the use of the analytical tools of GIS. In this study EPM model and analytical GIS tools used to the land management for erosion hazards reduce of the study area. Land use changes related to the slop factor is able to reduced the rate of erosion to 58/3 percentage.

## MATERIALS AND METHODS

Jam and Riz basin is located in 25 km toward North Kangan and Jam town and 220 km from Southern part of Boushehr Port. The geographical location of the study area is indicated 51°, 48', 31.7" E. to 52°, 25', 14" E. and 27°, 44', 28" N. to 28°, 14', 55" N (Fig. 1).

Jam and Riz basin is surrounded with Zard kouh range in north and Sarkhan Mountain in North Eastern, Haft Chah, Takhteh Siah and Charm Ayne in Southeastern, Kachhar in South and Sarcheshme in Southern West. The only surface streams of Jam and Hramiaki flow in this area which is by end of spring after conjunction together are formed the main stream of Baghan and finally as the main branch joined to the Mond river. The area of the basin was estimated as 90919.2 ha using Arc GIS 9.2 software. The highest elevation of the study area shows 1414 m and its lowest elevation is 57.764 m from the sea level. Annual precipitation investigation shows that maximum precipitation in Baghan station have been 724.5 mm and minimum value in Ghantareh station have been 82 mm. The study of coefficient of variation represents disorderly rainfall in the region. Seasonal distribution of rainfall in the region, clears that rainfall regime is base on Mediterranean regime. It means, more than 60% of annual precipitation is in winter and summer with only 1% annual precipitation is driest season. Monthly precipitation regime represent that maximum rainfall happens in January and December, respectively. June and July are month with lowest rainfall. The methodology used in this study involved the effect of land management to reduce erosion risks using GIS, with the primary data obtained from topographic maps; Land sat ETM+ data, aerial photographic interpretation, field survey and earlier studies (Natural Resources of Boushehr Province, Iran, 2006). Information on soils, surface geology, land use, land slopes and climatic (mean annual rainfall and temperature) were used to assess the erosion severity. Derivation of the factors required by the EPM model is documented in the literature (Gavrilovic, 1988), however,

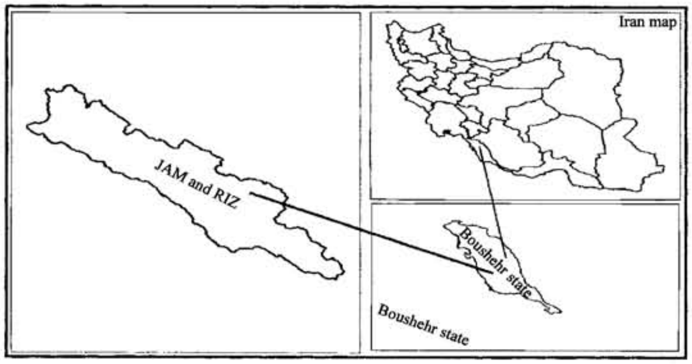


Fig. 1: Geographic location of Jam and Riz watershed

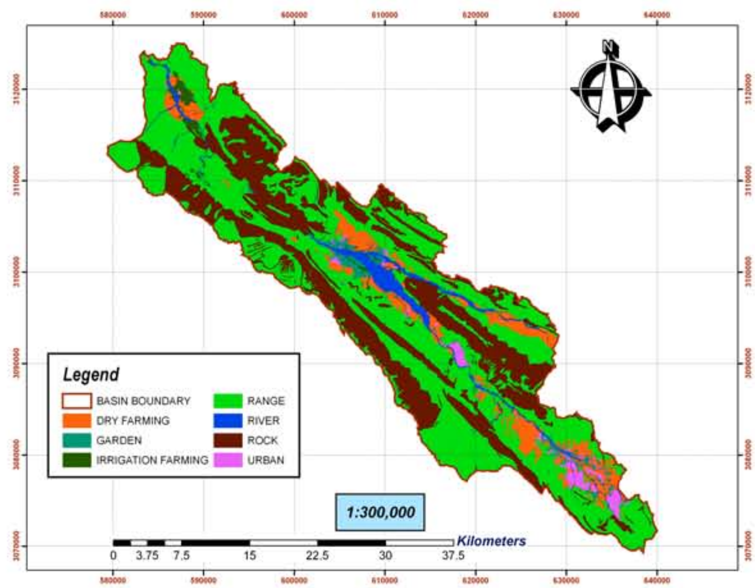


Fig. 2: Recent land use of Jam and Riz basin (Modallaldoust, 2007)

the recent development of GIS and remote sensing technologies permits a more accurate estimation of some of the factors. The following sections describe the some techniques used to generate the data layer and to evaluate the erosion factors for EPM model based on the data layer.

**Land use:** To determine the Xa-factor value utilized by the EPM method, land use map was generated by the use of Land sat Enhanced Thematic Mapper (ETM+) data in 2002 and Indian Remote Sensing (IRS) in 2004 (Fig. 2). Several enhancements and classification techniques were used, in conjunction with ground-truth data obtained from field excursions in 2006 and 2007, to delineate training areas of known land cover categories for the Jam and Riz basin. A maximum likelihood supervised classification (Campbell, 2002) was then performed using bands 1, 3, 4, 5 and 7 to recognize the unique spectral signatures associated with those land features. Small changes in land use had occurred between the time of collection of the satellite data and the field surveys. The land use coefficient (Xa) corresponding to each land use class was estimated by the use of EPM Guide Table (Gavrilovic, 1988). This model classifies land uses into 10 categories and evaluated the coefficient Xa from 0.1 (for high-density woodland) to 1.0 (for badlands). The study area classified to six categories and the land use coefficient was evaluated for each map class (Table 1).

**Slope:** Land slopes were calculated using 1:25000 topographic maps produced by the National Cartographic Center of Iran. Interpolation Tool in Arc GIS9.2 used the original digital data in Microstation Design (DGN) format to build up a DEM (Digital Elevation Model) of the study area (Soleimani and Modallaldoust, 2008). A raster grid cell of 50H50 m was generated and was applied to produce

Table 1: Land use coefficient (Xa) used in EPM model

| Land cover | Xa (recent land use) | Xa (after management) |
|---|---|---|
| Rock | 0.6 | 0.6 |
| Rangeland | 0.65 | 0.5 |
| Dry farming | 0.9 | - |
| Irrigation farming | 0.9 | 0.2 |
| Garden | 0.7 | 0.3 |
| Urban and industrial area | 0.0 | 0.0 |

Table 2: Slope classes and the assigned I- factor of classes, used in EPM model

| Slope class | Slope (%) | I-factor |
|---|---|---|
| 1 | 0-5 | 0.025 |
| 2 | 5-10 | 0.075 |
| 3 | 10-20 | 0.150 |
| 4 | 20-30 | 0.250 |
| 5 | 30-40 | 0.350 |
| 6 | 40-50 | 0.450 |
| 7 | >50 | 0.600 |

the DEM. The slopes were reclassified into 7 categories ranging from 0-5 to >50%. The mean value of each slope class was assigned in decimal system (Table 2), to determine the *I*-factor (Gavrilovic, 1988). For suitable management, the land with less 15% slope as irrigation farming and more 15% slope as rangeland selected. Therefore estimated land use index was calculated for land and again was calculated the amount of erosion and sediment.

## RESULTS AND DISCUSSION

The results imply that after proper management, the whole erosion of basin has decreased up to 58.3% (Table 3, 4). The amount of special erosion for Jam and Riz current situation is about 2327.4 $m^3$ kmG$^2$ per year. If the management were appropriate, this amount will decrease up to 970.4 $m^3$ kmG$^2$ per year. This difference for all basin is equal to 1357 $m^3$ kmG$^2$ per year, which with considering total area of basin, erosion will deplete up to 1233773.5 $m^3$, yearly. On the other hand, according to sediment delivery ratio, which is 44% for whole basin, the sediment of whole basin decreases 542860.4 $m^3$ per year, which is notable. This means, the amount of basin erosion and sediment will decrease 2.4 times.

Referred to Fig. 2 and 3 that are presenting recent land use and after management it can be resulted that two major types of the changes happened such as dry farming to irrigation and rangeland to irrigation farming. The area with dry farming is concentrated in three main sections of upslope, middle part, down slope and through the main channels of the watershed. These mentioned types of the land used are suitable for the agricultural activities (Makhdoum, 2007). According to the filed investigation and extracted data from different sources, the land use conversion from dry farming to irrigation farming causes a sensible reduction of special erosion

Table 3: Erosion condition according to recent land use of Jam and Riz basin

| Type of land use | Area (%) | Area (ha) | Special erosion $\frac{m^3}{km^2.y}$ |
|---|---|---|---|
| Urban and industrial area | 2.1 | 1899.6 | - |
| River | 3.6 | 3300.0 | - |
| Rock | 30.2 | 27499.8 | 1532.0 |
| Garden | 1.8 | 1599.8 | 2132.1 |
| Irrigation farming | 0.9 | 840.0 | 1714.4 |
| Dry farming | 7.5 | 6800.0 | 2062.5 |
| Range land | 53.9 | 48980.0 | 3074.8 |
| Total | 100.0 | 90919.2 | 2327.4 |

Table 4: Erosion condition according to land use after management of Jam and Riz basin

| Type of land use | Area (%) | Area (ha) | Special erosion $\frac{m^3}{km^2.y}$ |
|---|---|---|---|
| Urban and industrial area | 2.1 | 1899.6 | - |
| River | 3.6 | 3300.0 | - |
| Rock | 30.2 | 27499.8 | 1532.0 |
| Garden | 1.8 | 1599.8 | 2132.1 |
| Irrigation farming | 22.3 | 20241.5 | 423.2 |
| Range land | 40.0 | 36378.5 | 937.9 |
| Total | 100.0 | 90919.2 | 970.4 |

from 2062.5 to 423.2 $m^3$ kmG$^2$. According to (Fig. 2), we can observe that lands with dry farming and rangelands have located in margin of river of low slope areas. These lands have the greatest amount of erosion and sediment, have been identified as a crisis and dangerous areas because of erosion and sediment creation and should be controlled. On the other hand, because these lands are in low slope of plain and are close to Baghan River, they have capability of turning to farm land. However, according to (Fig. 3), the farming pattern of these lands and able to change and results can be predicted after management. As you see in (Fig. 3), after management and changing farming pattern, great part of lands through the main channel and low slope plains have turned to irrigation farming. Irrigation farming in current land use map have area about 840 ha which have almost allocated 9% of basin area to themselves. Due to their little extent, they have high erosion about 1714.4 $m^3$ kmG$^2$ yearly. In fact, as in Fig. 2, parts of this irrigation farming of basin are not located in proper zones, which by adequate management, that these lands must convert to range lands. Results indicate after changing the land use, the extent of irrigation farming will decrease up to 20241.5 ha, i.e., about 22.3% of total basin area. There fore, because these lands are located in suitable place, the erosion resulting these lands decrease up to 423.4 $m^3$ kmG$^2$ per year. By this method, the area of basin=s rangelands, which have allocated about 53.9% of total area, decreases and reaches to 40%. This area depletion means omission of unsuitable and erosive areas. So that, by changing unsuitable ranges lands to livestock grazing, the erosion have been decreased from 3074.8 to 937.9% per year.

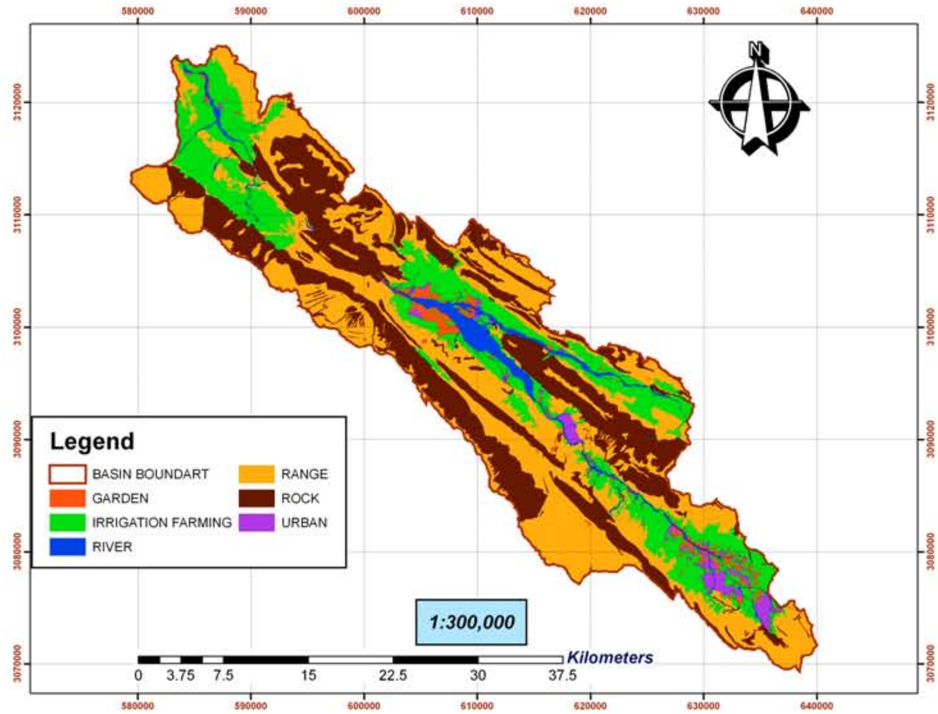


Fig. 3: Land use map after management, Jam and Riz basin

Finally, observing tables and mention to figures, it can be concluded that the pattern of dry farming in under studied area is not adequate and must be removed. Changing cultivation pattern with proper management is a process can be accomplished easily and needs new methods and public intention for more and better application of resources. As you saw in results, alteration and reformation of land use in the field of reducing the erosion amount will be effective. Therefore, in order that management be applicable, using following cases are important:

- Necessity of changing the kinds of land use or take actions for prevention of same unwanted alters in lands. Residents of area must accept this subject. By this way, the most appropriate pattern can be accessible.
- Public and policy makers= intentions to carry out legal performances in the field of enacting and executing laws. Without adjusting with executive organizations and policy makers= support, the plan would fail.

Following suggestions are results from this research:

- Before any changes in land use, current map of land application must be compared with land use planning map in which lands capabilities and symmetry factors are regarded and then changes in land use be performed.
- Systematic and integrated planning must be done for training and development of change methods and optimized land use.
- Changing land use, which has formed according to land potential and capability, must be prevented.

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