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Effects of Land use Change and Erosion on Physical and Chemical Properties of Water(Karkhe watershed)

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ABSTRACT: Karkhe watershed (KW) with more than 5 million hectares recently encountered many problems in the natural, social and man-made habitats. Unsuitable use of land, soil erosion and lack of rainfall are the most destructive factors in this watershed affecting the whole region fundamentally. As expected, these problems have caused a considerable fall in biodiversity in fauna and flora, a decrease in volume and quality of water resources in watershed and a rise in probability of destructive floods. In this study the changes in land use levels and erosion were assessed in 5 sub-regions of Karkhe watershed in two periods of time '1988 and 2002' using images of LANDSAT. In addition, the effects of these manipulations on the physico-chemical qualities of water such as, cation and anion concentration, acidity and salinity were quantified. The results show that erosion changes in Karkhe Watershed are inconsiderable from 1988 to 2002. The extent of urban area and irrigated agricultural lands in Karkhe sub-regions (Gamasiab, Gharresu Kashkan) are around 1000 and 2000 km2 respectively, the decrease in river discharge around 121.6 m^3/s , is the most effective factors for the reduction in acidity(from 7.9 in 1988 to 8.1 in 2002), an increment in salinity (from 1.6 mg/L in 1988 to 3.6 mg/L in 2002 as average amount of SAR in all sub-regions of watershed) and the high density of the anions (from 8.1 mg/L in 1988 to 16.4 mg/L in 2002) and cations (from 8.8 mg/L to 16.5 mg/L) in Karkhe River.

Key words: Watershed, Acidity, Water quality, Salinity, Cation, Anion

INTRODUCTION

Population increase and soaring rate of natural resource exploitation not only have caused forest encroachment, range destructions, extension of cultivation lands and cities, and improper use of surface water flow but also are responsible for the decrease in environmental quality of riverine water, increase in the erosion and sedimentation, and dam destructions by high sediment density in their tanks (Sthiannopkao.*et al*., 2007). Xiana and Crane (2007) and also Milesi et al.(2003) suggested that anthropogenic developments also produced regional impacts on ecosystem structure and functionality. Land cover change due to the urban development during the 1992–2000 period, reduced annual net primary productivity of the southeastern United States by 0.4%. Land use and land cover (LULC) change associated with the urban development is considered one of the most disturbing processes because it brings about dramatic changes in the natural energy and material cycles of ecosystems and influences weather patterns, soil erosion, local climate conditions, biodiversity, and water resources (Kalnay and Cai , 2003). Soil erosion that mostly occurs due to land use change is a widespread environmental problem threatens man in the developing countries. Each year, 75 billion tons of soil is removed in the globe due to erosion with most coming from agricultural land. An average

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rate of soil loss for Asia is also 138 t ha- year- (Sadeghi *et al*., 2009). It has therefore economic, political, social and environmental consequences due to both on-site and off-site damages. Repeated satellite images and/or aerial photographs are useful for both visual assessment of natural resource dynamics occurring at a particular time and space as well as quantitative evaluation of land use/land cover changes over time (Takle and Hedlund, 2000). Analysis and presentation of such data, on the other hand, can be greatly facilitated through the use of GIS technology (ESCAP,1997) A combined use of RS and GIS technology, therefore, can be invaluable to address wide variety of resource management problems including land use and landscape changes (Gutman *et al*., 2002).

Spies et al. (1994) showed annual land use change, such as forest disturbance rates of 1.2% on public, non-wilderness lands, 3.9% on private lands, and 0.2% in wilderness. For western Oregon annual forest disturbance rates due to clear cutting between 1972 and 1995 ranged from 0.5–1.2% overall with nearly a 20% total forest impact and also report destructive effect on quality of water on river due erosion. Sivertun and Prange's 2003 study used GIS to identify high risk water pollution areas owing to land use change in the watershed draining into a small fjord-like bay in southeast Sweden. The bay has a narrow opening to the Baltic Sea and the water quality in the bay is highly dependant on the quality of the water from the surrounding watershed and it was found that the extension of urbane area and soil erosion caused decrease in water quality. He (2003) used the Agricultural Nonpoint Source pollution model (AGNPS) with an Arc View interface to look at the effects of land use change on water pollution in the Dowagiac River Watershed in southern Michigan. It was found that surface runoff decrease and soil erosion increase were most responsible factors in water quality decrease.Karkhe watershed is the biggest soil embankment in the Middle East, thus important enough to receive a special attention.

All of the forests and ranges in Karkhe watershed have shown negative ecological trend because of improper use and management. Therefore, if we want to rehabilitate them, we should inevitably consider a fundamental change in the way they are managed and used. According to the deputy of watershed management, Jihad-agriculture in Iran, in 2004 the main problem in this region is the existence of erosible geological land formations which account for more than 79% of the whole watershed thus producing sediment at around 1.5 millions m^3/y, that pours directly in to the Karkhe embankment tank. Thouvenot et al. 2004 stated that land use and water resources are unequivocally linked. The type of land and the intensity of its use have a strong influence on the receiving water resource. Increases in soil erosion and salinization due to the poor land use practices cause major problem for water resources. Soil erosion due to land use changes and the delivery of eroded sediments to river channels cause many environmental problems and can impose substantial financial burdens on society. Soil erosion has numerous detrimental on-site impacts on arable land, including the loss of topsoil and fertilizers, decreased crop yield and accessibility (due to the formation of gullies) in the short-term and decreased soil productivity in the long-term (Ward *et al*.,2009).The delivery of sediments eroded from agricultural areas is also responsible for the supply of nutrients, pesticides, and heavy metal contaminants into river channels which can have an impact on the water quality of rivers especially when they have low discharge rate due to lack of rainfall (Doomen *et al.*, 2008). Sediment delivery also impacts on channel and floodplain morphology (De Moor *et al.*, 2008), the ecological functioning of floodplains and sediment deposition rates in reservoirs and ponds (Richards *et al*., 2002 and Ward, 2008).

Over the past few decades, the vital resources of almost entire watersheds in Iran have been subject to rapid deterioration resulting from expanding anthropogenic activities. The Iran Forest and Rangeland Nationalization Act of 56 (on fixing and controlling of governmental national lands) was effective in reducing land use conversion and restoring many of resources. Despite its progress, overexploitation and mismanagement of watershed resources still remain as major threats to the watersheds in Iran. This is a major challenge because of its complex nature and the existence of diverse and varied land uses within the watersheds (Farahpour *et al.*, 2004).Due to the limitation and lack of fresh water resources in the entire world, specially in the located in dry parts of the earth and susceptible to drought such as Iran, governments have established a lot of irrigation and flood control facilities and dams (like Karkhe embankment) in order to keep and improve the proper use of these valuable resources.According to Luo et al. 2008 and Lin et al. 2007 land change and its effects on ecological systems have received worldwide attention since the 1990s.

A lot of efforts were made to understand the process, trend and driving forces of land change patterns and the resulting ecological consequences. However, the extent of the research on land changes, especially in forests and ranges, due to urbanization and destructive impacts such as increasing erosions and siltation and decreasing water quality, still seems to need much more attention.Thus, the primary objective of this study was to investigate the effects of land use changes on forests and ranges and the quality of Karkhe river water and its environmental characteristics. Therefore, the most important factors that affect the quality of water due to the change in the land use and erosion patterns in Karkhe watershed during two different times, namely 1988 and 2002 were probes.

MATERIALS & METHODS

Karkhe watershed is located in the west of Iran, south-west of Zagros Mountains.Its longitude and latitude are (46°, 06' to 49°, 10' E) and (30°, 58' to 34°, 56' N), respectively. According to the Iranian general hydrological classification, Karkhe watershed is a part of Persian Gulf watershed (Fig.1). Karkhe river networks include 5 sub-regions such as:"Gamasyab, Gharresu, Saymareh, Kashkan, Soufli-Karkhe".Each of these main branches is made by joining other sub-branches and these sub-branches are generally fed from different areas. Generally,its total slop and the shift of surface flow in Karkhe watershed are from north to south.

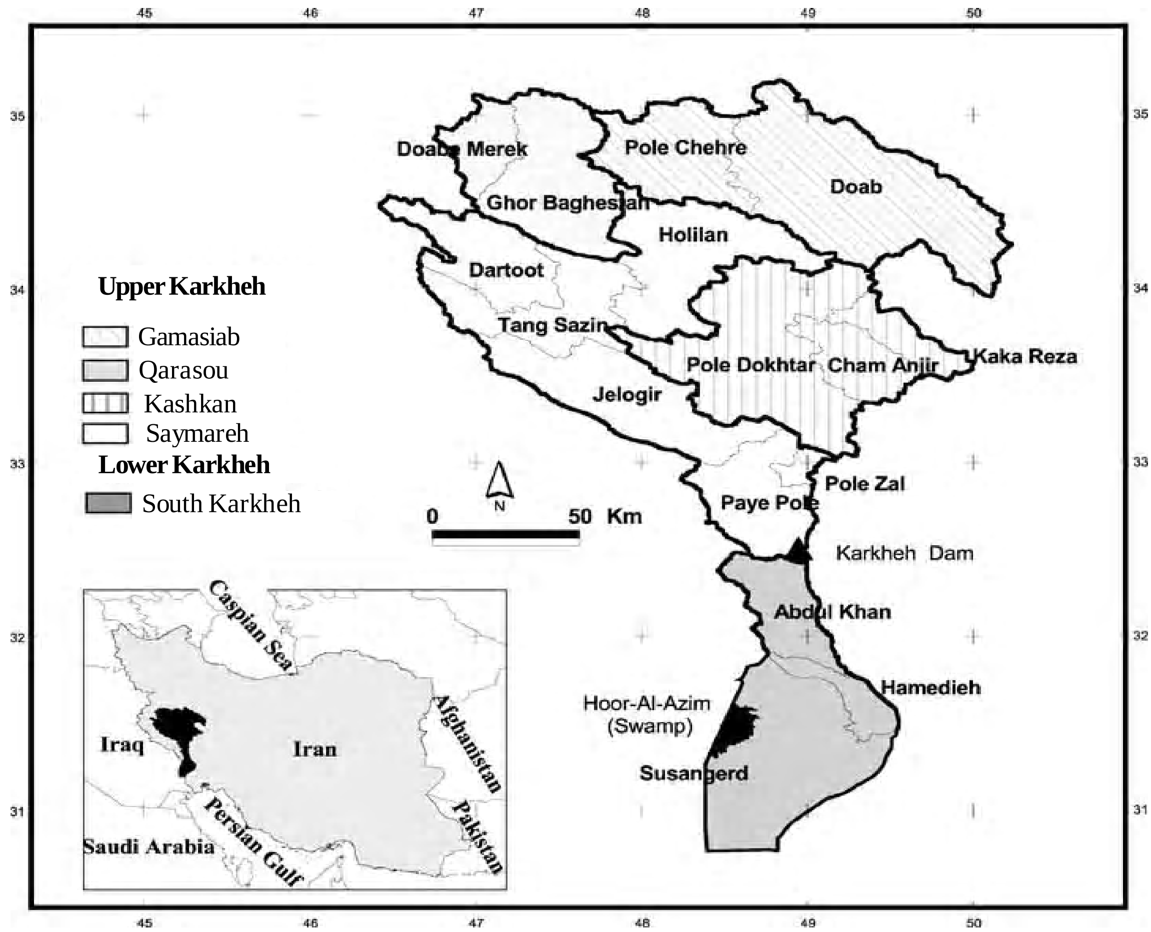

Fig. 1. location of Karkhe watershed in Iran indicating Upper and Lower Karkheh and their respective sub-catchments

In order to conduct an appropriate investigation into the environmental effects of land- use and erosion in the past and present, having a good understanding of the vital role of water resources of the watershed was critical in terms of both qualitative and quantitative measures. Therefore, in the first step, five sub-regions namely Gamasiab, Gharresu, Saymareh, Kashkan and Soufli-Karkhe, were determined on satellite images. The second step was the enhancement of digital spectral bands by “panchromatic band” with 15 meter separation ability for image processing and interpretation. Land use maps were drawn by TM 1988 and ETM+2002 digital (numeric) data and Arc GIS software under hybrid supervised classification method in the third step (Eosat, 2002). Meanwhile, physicochemical quality of five sub-regions in 2 periods of time, i.e., “1988 and 2002”, was assessed with SPSS software. Furthermore, the physical and chemical characteristics in hydrometric stations along the Karkhe river length, supplied by” Deputy of watershed management of Jihad agriculture in 2004" were investigated, and the precision and accuracy of collected data was controlled. Fig. 2 shows the flowchart of used method was illustrated.

RESULTS & DISCUSSION

Water quality influences the growth and health of human populations and as well affects ecological health of watershed systems. Historical water management, however, often focused on watershed development and economic activities at the expense of water quality (Kose, Baskent, 2002) while improvements in water quality were achieved through careful planning and regulation Protecting the health of watershed ecosystem is therefore a critical issue facing watershed regulatory bodies and managers. A critical factor

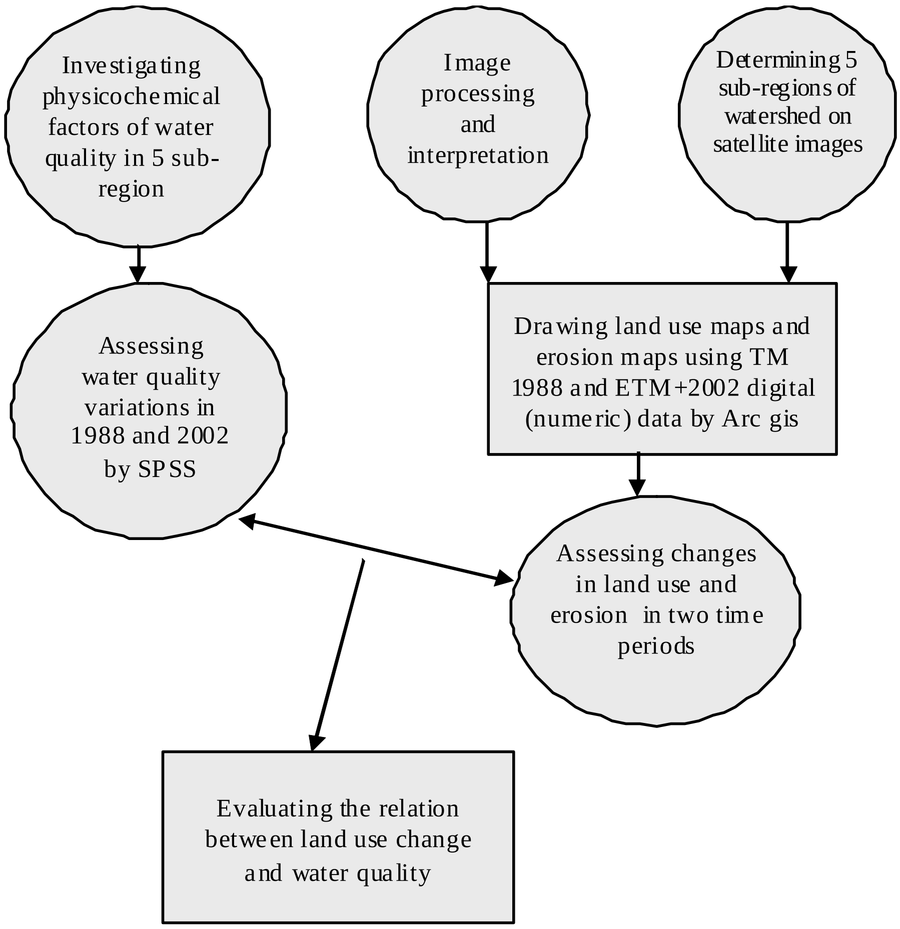

Fig. 2. The flowchart of method used in the research

in watershed-based approaches in Iran is the ability to prioritize land and to target programs and policies at areas with maximum benefits. Since various environmental and socio-economic conditions may lead to conflicts among stakeholders, strategies and policies that are fragmented in scope may not be effective for sound watershed management. Frequently, compromises are necessary in order to obtain overall optimal land and water use throughout the entire watershed.Such effort involves the government and other stakeholders in an organized and concerted process.Consequently, An assessment of land use and erosion change patterns that incorporates individual system components within a general framework, instead of examining or presenting them in isolation, is useful for providing a broad and comprehensive analysis. This allows gaining economic efficiency by allocating limited resources to those areas that contribute or have potential to impair watershed health.Land use and its change patterns are essential factors that affect decrease in the water quality of this area. The following demonstrates the nature and range of these factors:

Fig. 4 shows the kinds of land use changes over the Karkhe watershed region.Fig. 3 and 4 showed that the changes in unusable or bare lands, fair ranges, poor ranges and fair forests were significant .For instance, an increase in the area of unusable lands in Gamasiab and Soufli-Karkhe sub regions is around 3000 km^2, and a decrease in the area of fair ranges (around 3000 km^2)and transferring to poor ranges and unutilized lands is a sign of destruction in these regions.Results showed that, the area of city lands in some sub-regions known as Gharresu Saymareh Kashkan and Soufli-Karkhe has increased from 600 to 1600 km^2 in years 1988-2002. Additionally, the area of gardens and irrigated agricultural lands in "Gamasiab " has decreased from 1000 to 500 km^2 and the area of these lands increased 12000 km^2 in average in "Kashkan and Soufli-Karkhe. These studies showed that two sub-regions "Gamasiab and Soufli-Karkhe" had different land use change patterns during the period of 14 years .However, in the whole watershed the total average extension of irrigated agricultural land and gardens was 1000 km2.

Sensitivity and types of erosion were main factors for zoning of the watershed, Figs.5 and 6. The most common types of erosion in this area were surface, rill and gully erosion respectively (SRG).According to the map, these types of erosions, (SRG), were common in this watershed. Also, some regions in this watershed didn't show any type of erosion. The Figs 5 to 6 depicted the erosion change patterns in the 5 sub-regions during the 1988-2002. According to these Figs, the sub-regions of this watershed showed mostly extreme and mild types of erosion with total area of 39600 km2 in 1988 and 40368 km2 in 2002 occurred in Saymareh, Gamasiab, and Gharresu and Soufli-Karkhe and the amounts of soil erosion in the whole area of each sub-region in 2002 were 25, 5.15, 5.12 and 5 million tons and in Kashkan with the lowest level of erosion was 2 million tons. In addition, paltry erosion was the most prevalent kind of erosion to dominant about 6630 km2 (around 74% of area of of this sub region) in 2002.

According to the Fig. 5 and 6 there was not any significant difference in amount of erosion in area during 14 years .Moreover, the amount area of Badland declined around 120 km2 (from 4000 km2 in 1988 to 3880 km2 in 2002) due to the construction of Karkhe Dam.Figs 7 to 12 shows the results of an investigation into the water quality of rivers in 7 stations like Do-ab station located in Gamasiab sub region, Baghestan station located in Gharesu and Jelogir and Pai-pol, Hamidie located in Karkhe River," kanale vasleye stations" located in seymareh and" Hovayzeh station" located in Kashlan in two periods 1988 and 2002.

The results showed that the range of changes in some factors like SAR (sodium absorption ratio), TDS (total dissolved inorganic solids), cations and anions content, EC (electrical conductivity) and pH were completely obvious in both periods (1988 and 2002). All in all, a long range of changes in these factors implied an increase in the water pollution of studied rivers in both periods of time which was showed in Table 2.The results of investigations in physical, chemical and hydrological statistics of Karkhe river in sub-regions stations by "SPSS" software showed a significant difference with 95% confidence level ($p<0.05$) in both periods of 1988 and 2002. Despite

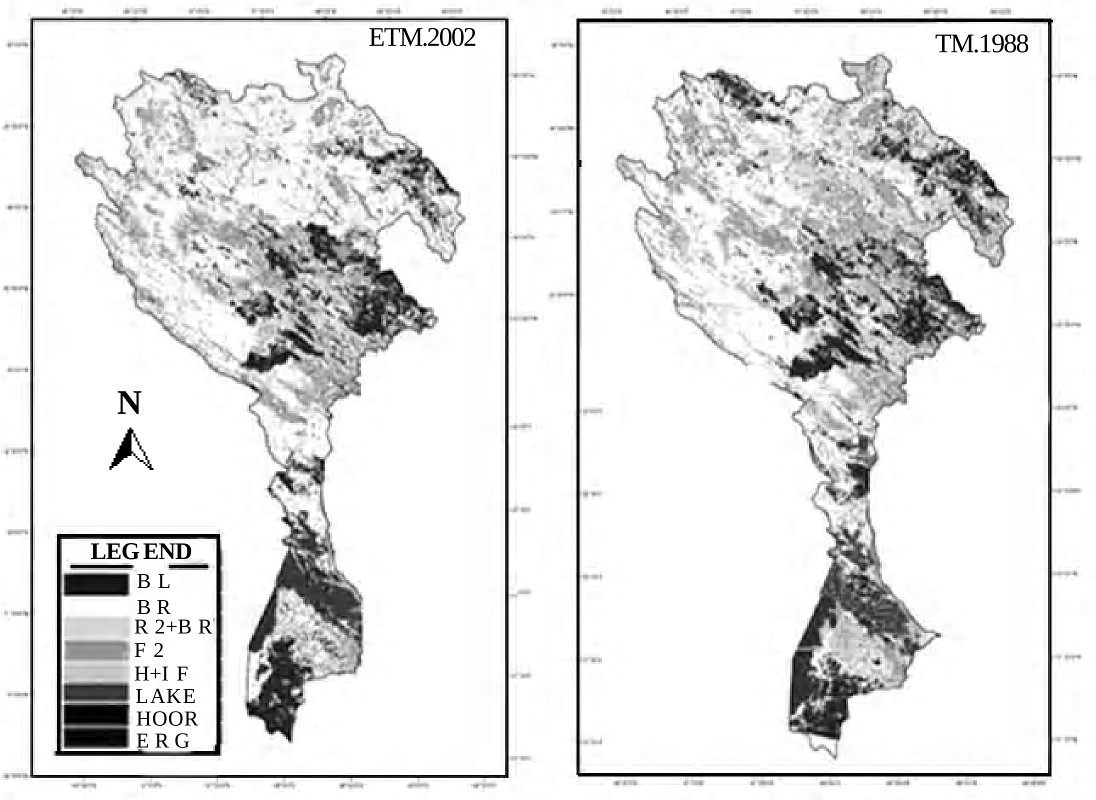

Fig. 3. land use Map and its changes in Karkhe watershed

Fig.3 shows the map of land use and its changes in Karkhe watershed in 1988 and 2002 using TM and ETM images, respectively. *Legend of fig.3. According to the standards of country's forests and ranges organization)*

BL: rock lands with less than 50% canopy.

BR: unutilized and fallowed lands that include ploughed land and areas that have lost their flora.

BR+R2: fair ranges and unutilized and followed lands. (R2 includes fair ranges with 25% to 50% canopy with no any external species on them.

F2: fair forest with 25%to 50% canopy and a mix of native and foreign species.

H+ IF: orchard site management and water cultivation .orchard management includes types of orchards and vineyard; water cultivation includes all of the cultivable lands irrigated by human.

LAKE: all of water area such as pools, natural and artificial lakes and wetlands.

HOOR: reed-beds that are like wetlands.

ERG: flowing sands.

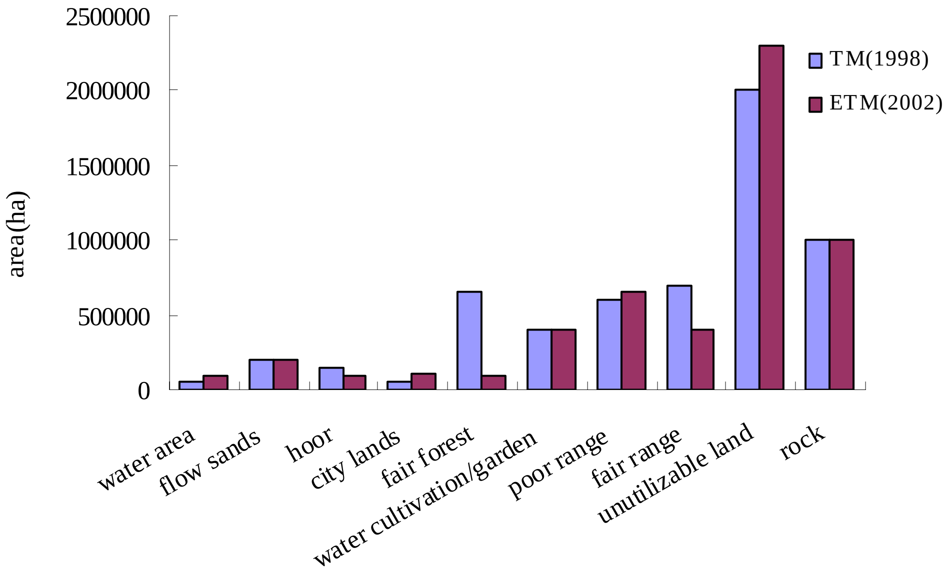

Fig. 4. Land use types and its changes in Karkhe watershed

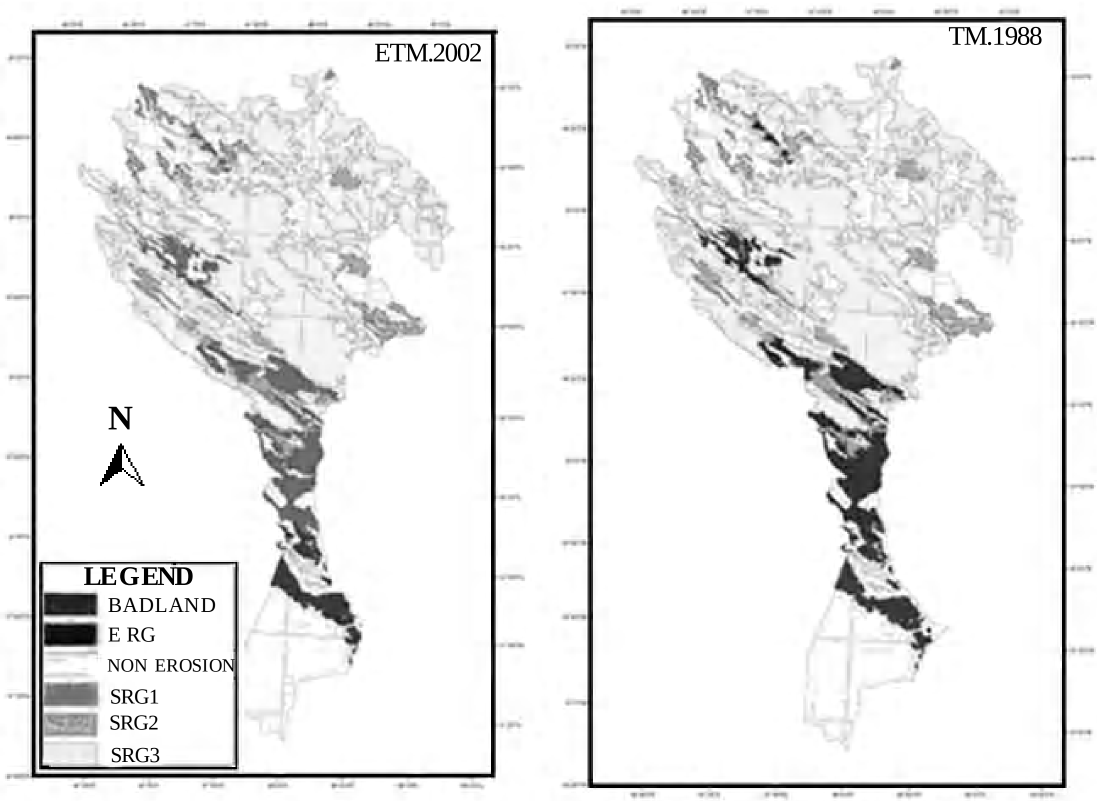

Fig . 5. Erosion Map and its changes due to land use in Karkhe watershed

The Legend of fig.5.According to the standards of country's forests and ranges organization

Badland: the lands suffering the most severe erosion in this area.

ERG: running and unstable gravels in this area.

None erosion: the lands free from erosion.

SRG1*: lands with surface, rill, and gully erosions.

SRG2: lands with surface, rill, and gully erosion.

SRG3: lands with surface, rill, and gully erosion.

"*NOTE: in these lands the increase in numbers is a sign of intensity of erosion."

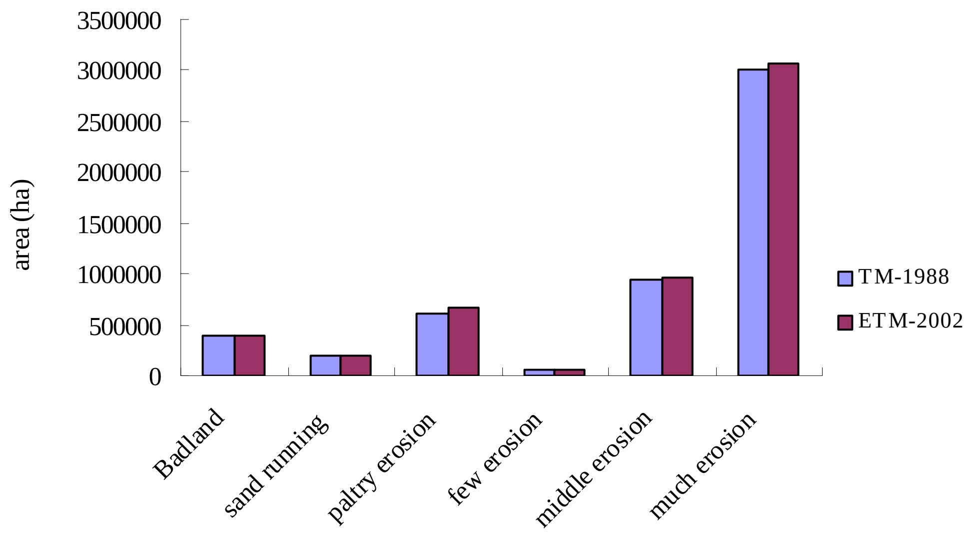

Fig. 6. Erosion types and its changes in Karkhe watershed

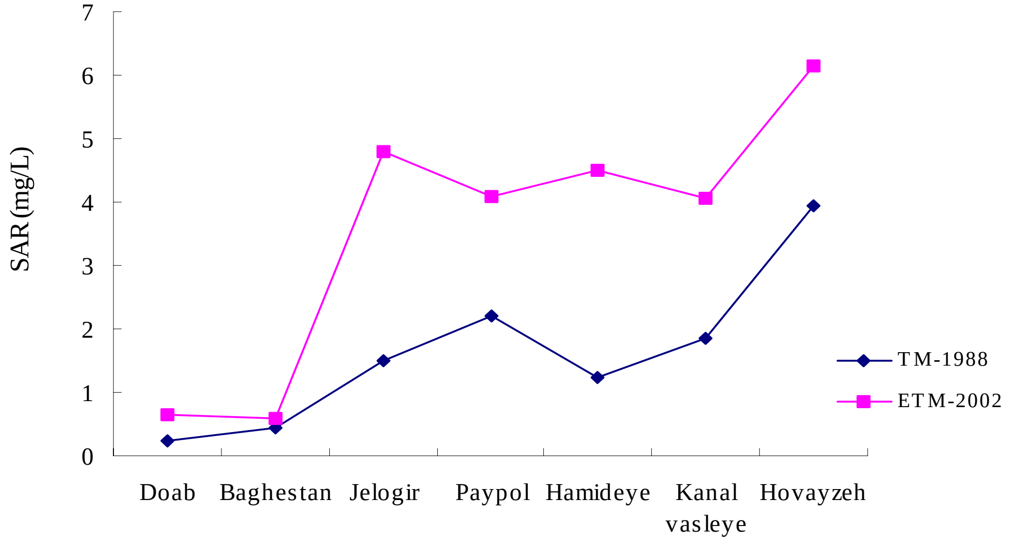

Fig. 7. changes in SAR(Sodium absorption ratio) from 1988 to 2002
(Deputy of watershed management of Jihad agriculture, 2004)

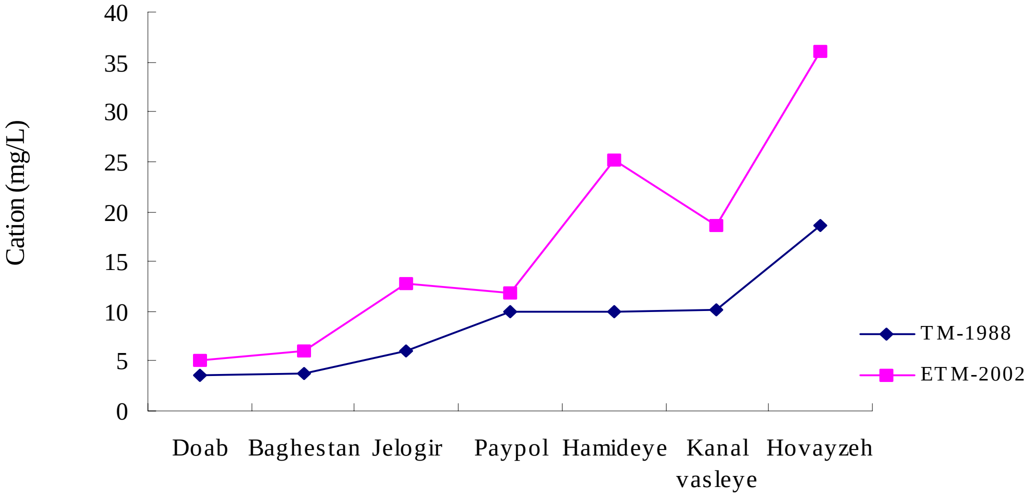

Fig. 8. change s in cations FROM 1988 to 2002
(Deputy of watershed management of Jihad agriculture, 2004)

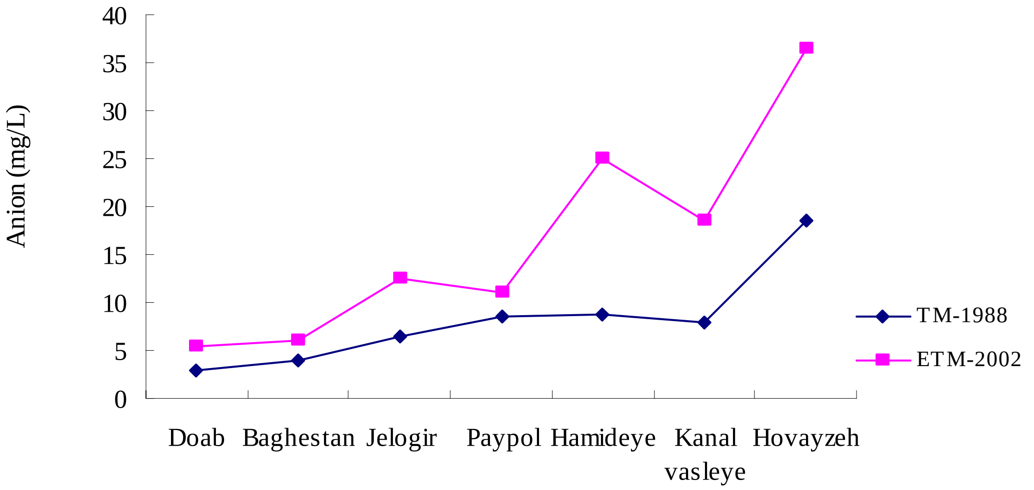

Fig. 9. Anion changes from 1988 to 2002
(Deputy of watershed management of Jihad agriculture, 2004)

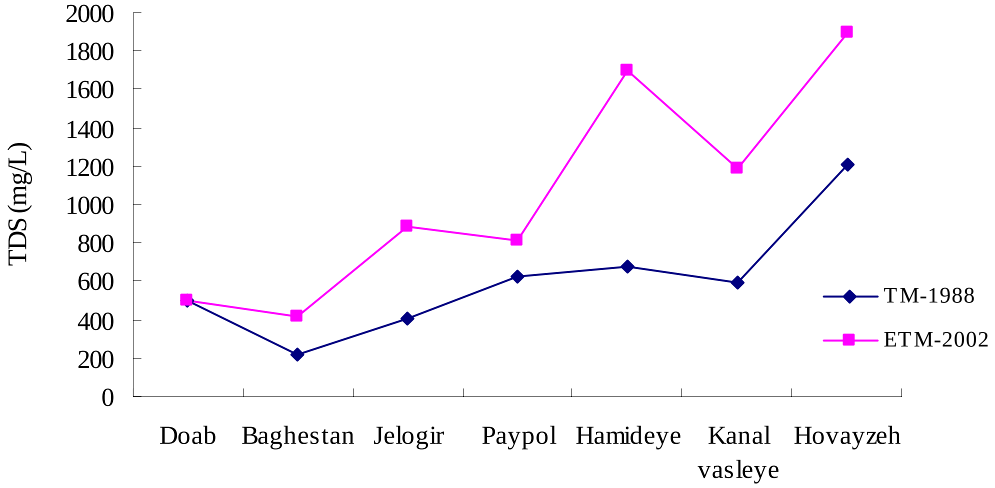

Fig. 10. Changes in TDS from1988 to 2002 (Total dissolved inorganic solids)
(Deputy of watershed management of Jihad agriculture, 2004)

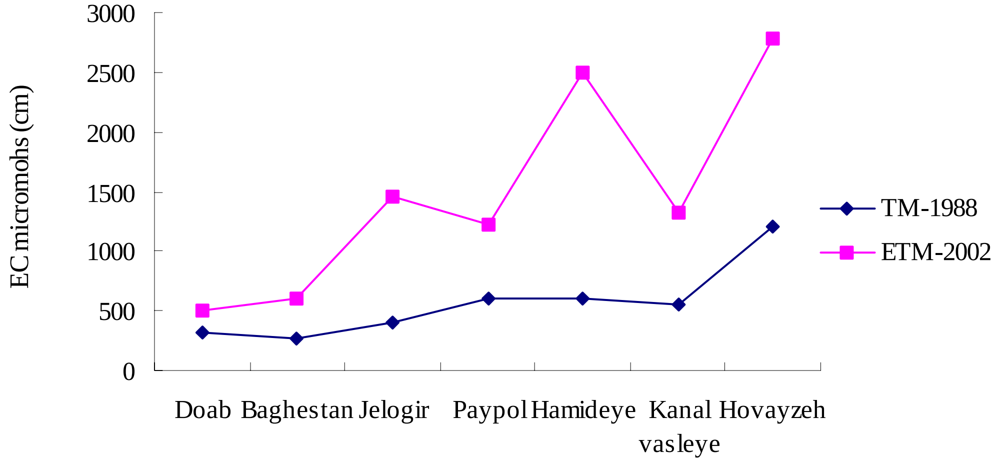

Fig. 11. Changes in EC from 1988 to 2002 (Electronic Conduction)
(Deputy of watershed management of Jihad agriculture, 2004)

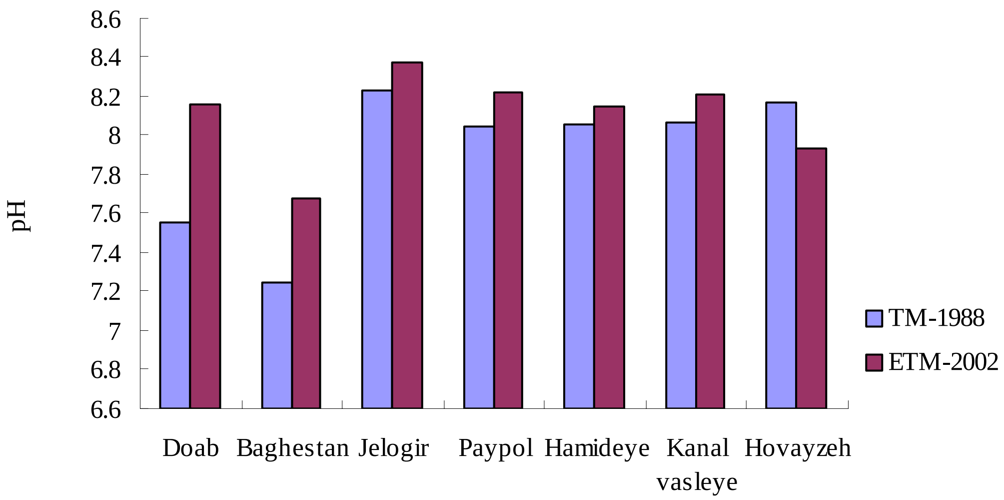

Fig. 12. Acidity Changes from 1988 to 2002 (pH)
(Deputy of watershed management)

of the rainfall in KW, an annual study of Karkhe river discharge as an effective factor on water quality, is necessary. As can be observed in Fig.13 below, the drought in 1999 - 2000 was completely obvious so that it caused fluctuations in water quality and a decrease in the annual discharge of Karkhe watershed around 121.6 m^3/s.The correlation between water quality factors and following figs showed a strong relation between SAR and EC with Karkhe River discharge at Pai-pol and Hamidie stations so that the more Karkhe river discharge at Pai-pol and Hamidie stations , the more amount of SAR and EC in 2002 in comparison with 1988. Therefore, the decrease in the river discharge worsens the drop in the water quality in drought seasons. Figs 7-12 below illustrate results of an investigation into the water quality of rivers at 7 stations and Fig. 13 shows discharge variation of the Karkhe River in 1999-2000 and annual average of discharge from 1954 to 2000. As can be seen from Table 2 there was a significant difference and increase in all factors of water quality in 1988 in comparison to 2002 which was a sign of rise in water pollution.Table.1 shows Karkhe watershed sub region characteristics (Ministry of Energy, 2001).

Table 1. Charectristics of Karkhe watershed subregions (ministry of energy,2001)

Main rivers	Hight maximum(meter)	Area (km^2)	Hight minimum(meter)
Gamasiab	3645	11459	1450
Gharresu	3351	5350	1300
Saymareh	3645	16411	150
Kashkan	3645	8955	500
Soufli-Karkhe	357	8589	3

Table 2.Average changes of water quality in all stations of sub regions
(Deputy of watershed management of Jihad agriculture, 2004)

The average in all stations in year	SAR (mg/L)	CATION (mg/L)	ANION (mg/L)	TDS (mg/L)	EC (micromohs/cm)	PH
1988	1.6	8.8	8.1	605	565.7	7.9
2002	3.5	16.5	16.4	1058.7	1483.5	8.1

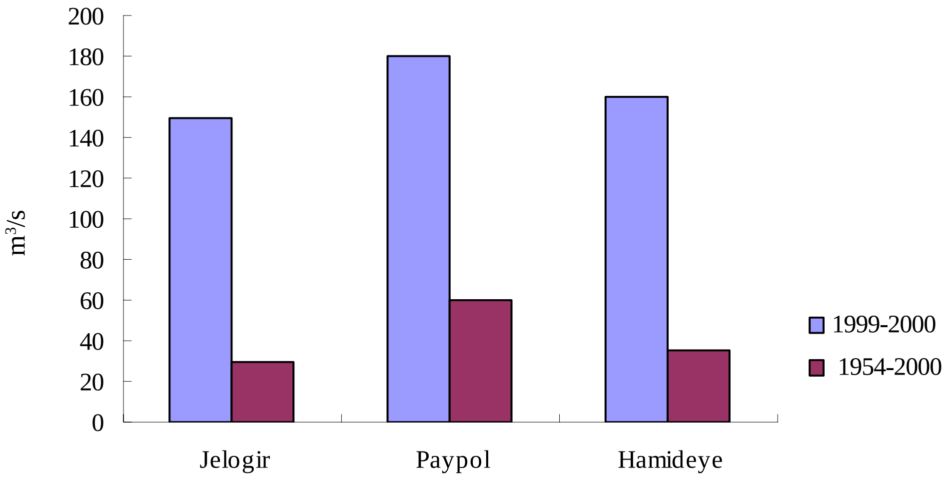

Fig. 13. Karkhe river discharge in 1999-200 and previous years (1956-2000)
(Deputy of watershed management of Jihad agriculture, 2004)

CONCLUSION

Results from all five sub-regions, including Saymareh, Gharesu and Kashkan, Gamasiab and sofli-Karkhe, showed that land use changes in two – Gamasiab and sofli-Karkhe – were the most significant and destructive which caused an increase in the area of unutilizable lands in these two sub-regions (from 16000 km^2 in 1988 to 18000 km^2 in 2002) due to degradation in the area of fair ranges and garden and irrigated agricultural lands as a result of population growth and natural resource exploitation and urbanization.

Therefore, the destruction of natural ecosystems of sub-regions was responsible for the most considerable effects on Karkhe river water quality due to their severe land use changes which proved Sthiannopkao et al. (2007) who stated that extension of cultivation lands and cities are also responsible for the decrease in environmental quality of water, increase in the erosion and sedimentation, and dam destructions by the accumulation of high sediment density (or high density sediment) in their tanks. Further, urban development and water irrigated agriculture has caused water pollution in Karkhe river signaled by the decrease in water acidity (pH from 7.9 to 8.1), increase in salinity (from 1.6 mg lit^- in 1988 to 3.6 mg lit^- in 2002 as average amount of SAR in all sub-regions of watershed) and anions content from 8.1 mg/L in 1988 to 16.4 mg/L in 2002) and cations (from 8.8 mg lit^- to 16.5 mg/L) in Karkhe River; specially in Gamasiab, Gharesu and Kashkan sub-regions which include several counties such as Kangavar, Nahavand,Bakhtaran, Eslam-abad, Khoramabad. This result proved Thouvenot et al. (2004) studies in 2004 who said that Land use and water resources are unequivocally linked increases in soil erosion and salinization due to the poor land use practices that cause major problem in water resources.

The decrease in river discharge in Karkhe River to around 121.6 m^3/s due to decline in rainfall was the most effective reason for water pollution and this conclusion was consistent with He, 2003 and Doomen et al. (2008) who stated that the delivery of sediments eroded from agricultural areas was also responsible for the supply of nutrients, pesticides, and heavy metal contaminants to river channels which had an impact on the water quality of rivers specially when they had low discharge rate due to lack of rainfall.The conflict between environmental protection and the economic development by different land uses within a watershed were challenges facing land use planners in many developing countries such as Iran, so this result proved Farahpour et al. (2004) who said that overexploitation and mismanagement of watershed resources still persist as major threats to watersheds in Iran.This is a major challenge because of their complex nature and the existence of diverse and diffuse contributing land uses within the watersheds.

According to the results of the erosion map and Figs, with comparison the amount of erosion in 1988 and 2002, despite the very small increase in erosion in 2002, there was no significant difference in erosion patterns of this watershed during 14 years. Recent droughts and the decrease of the “Karkhe River” discharge (from 163.3 to 41.6 m^3/s) directly influenced water quality decrease. Improper use of water resource in sectors as farming, industry (the source of chemicals, poisonous materials and heavy elements) and city development (about 500km^2 increases in urban area) caused increase urban and domestic sewage that had strongly impact on water quality decrease undoubtedly justifies an urgent need for precise investigations. We should apply a useful natural resource management and policy in two sub-regions of “Gamasiab and sofli-Karkhe” to mitigate undesirable land changes and destructions due to the poor land use practices and environmental pollution such as water quality degradation of rivers. All of the forests and ranges in Karkhe watershed showed negative ecological trend and degradation due to unsuitable use and mismanagement.Therefore, if we intent to rehabilitate them, It is worth noting that integrated land use management in the Karkhe watershed must be implemented in order to maintain good surface water quality and quantity for sustainable use as a source of water supply within the Karkhe watershed.Therefore, the necessity of applying “land use planning program which means reasonable use of land and compatible with its ecological capacity, should be put in the spot light.

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