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Longterm Land use Change Detection in Mahidasht Watershed, Iran

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ABSTRACT

Changes in land use are considered as significant factors by decision makers which can be precisely evaluated by Geographic Information System (GIS) and Remote Sensing (RS) techniques. However, land use alteration should also be evaluated for monitoring and curtailing the land degradation, especially deforestation and degradation of rangelands. The present research was then carried out in the Mahidasht Watershed, a western semi-arid region in Iran for evaluating land use change during 1955- 2017, using aerial photos (1955) and Landsat satellite images (TM 1989, ETM 2002 and 2017). The main land use types of the study watershed including agriculture, forest and, rangeland and mix land use boundaries were mapped for each period (1955, 1989, 2002 and 2017). Results showed that forests and rangelands suffered from accelerated destruction during 1955– 2017 period. The reduction rate in areas of forests and rangelands were 87 and 147 ha/y. In contrast, the area of rain-fed agriculture and mixed land use (mixed of the forest- rangeland, and rangeland- rain-fed) that are more vulnerable to degradation hazard were increased by 500 ha per year. Rill and gully erosion features were obviously found in converted areas, especially in the rain-fed lands, indicating siltation and other environmental problems such as deforestation and carbon dioxide emission. In addition, irrigated lands were increased by 59.8 ha annually due to enhancing groundwater extraction through water well drilling. Currently, excessive water extraction has resulted in a negative balance of groundwater table leading to water scarcity in this area. The mix land use were found more vulnerable to soil erosion and deforestation problems.

Keywords Forest Converting; Irrigated Lands; Mixed Land use; Rangeland Degradation

CITATION LINKS

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Introduction

Population increase and demand for food production as well as improper land resources management cause anthropogenic land use changes like converting forests and rangelands to croplands, which are vulnerable mainly to degradation factors. Furthermore, the arable lands available in many parts of the world like Asia are very limited due to severe population pressure. It is found that the arable land availability has reduced per person from 0.4 to 0.2 ha during 1770- 2009, worldwide [1]. In Iran, 37% of farmers are stakeholder having less than one ha of agriculture land. Whilst, about 16% of them are landless [2]. Land use change consequently causes reduction in land vegetation cover that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect the climate and biosphere [3]. Land use monitoring is very essential for a better understanding of landscape dynamics, proper land management and decision improvement [4].

Extensive land use changes in the semiarid regions have raised concerns over its impacts on soil and water resources in addition to the looming climate change effects. Consequently, analysis of land use change is considered as elementary in planning and land management at the catchment scale [5]. In Iran with population growth, most parts of forests, rangelands, and agricultural areas are being converted to rain-fed lands, urban areas, industry, and mining sites as well as roads and gas nets construction leading to environmental degradation and socioeconomic problems [6, 7]. However change in land use negatively affects the livelihood of rural inhabitants and food security and social rights [8, 9]. It also becomes apparent that the majority of the world poor population will continue to live in rural areas and their livelihoods depend on sustainable agriculture until 2040 [10]. Earth resource satellites data are very applicable and useful for land use/cover change detection studies [11]. Remote Sensing (RS) has been widely used in updating land use/cover maps [12] in association with GIS that provides suitable platform for data analysis, update, and retrieval [13].

The spatial configuration of land use is an important determinant of many ecological and socio-economical processes [14]. A better understanding of the determinants of the spatial configuration of land use is necessary to assess the impact of possible, future developments on environment, economy, and society at large. Land use change becomes more significant for experts and decision makers as the main environmental problem around the world which has been evaluated in many countries. It is carried out using better and more accurate techniques such as RS and Geographical Information System (GIS). RS through aerial photos and satellite images can be used for land use monitoring over time. The proposed approach, which uses a combination of RS and GIS techniques, is an effective tool that enhances land use monitoring, planning, and management at the catchment scale. These techniques are used extensively and despite their short history, they are increasing researches on land resources focusing on environmental issues such as land degradation, deforestation and agricultural activities in different scales and objectives [15]. Aerial photos for Iran were prepared in 1955 at the 1:55,000 scale and were used for evaluation of forests, rangelands and soil erosion for the first time in Faculty of Natural Resources, Tehran University, Iran. Satellite images were used for assessment of natural vegetation within watersheds in Kabir Kouh in Ilam Province. Satellite images analysis indicated that forest areas were reduced from 108.2ha (1989) to 98ha (2002) [16]. During recent years increasing arable land, dam construction and urbanization are reported in semiarid regions of Iran [17].

Nowadays, GIS and RS with developed relevant software are common and necessary tools for experts and managers to achieve better and more accurate planning on how to use lands. Because these techniques can enable us to determine with much ease the specifications of environmental planning. These techniques are also a valuable tool for studying soil erosion in Iran. An investigation by Srivastava and Gupta, showed that during 1994-2000 about eight square kilometers of natural resources were converted to urban areas [18]. Land use change in Catmando Valley, Nepal, was estimated during 1989-2005 using satellite images. The results showed a 14% reduction in agricultural areas and adversely an increase of 17% in urban and rural areas [19]. The same investigation in Qazvin Province showed that from 1990 to 2010 about 44,845ha of agricultural lands were converted to non-agricultural lands, of which, 32,033 and

10,243ha were respectively transformed to urban areas and infrastructures [20].

The present study aims to assess the trend of land use change in Mahidasht Watershed, Kermanshah, Iran. The land use change evaluated for 1955 -2017 period using aerial photos (1955) and satellite images (TM 1989, ETM 2002 and 2017). In addition, the border and areas of agriculture, forests and rangelands were distinguished and interpreted for each period (1955, 1989, 2002 and 2017).

Materials and Methods

The study area: This study was conducted at the Mahidasht Watershed, located in Kermanshah Province, west of Iran. It is the upper catchment of the Karkheh River Basin (KRB) within the Zagros Mountain Chains (Figure 1). This watershed with an area of 1493.3km^2 lies between 34° 02' 25" and 34° 31' 28" N and 46° 33' 16" and 47° 23' 05" E, comprising plains, hilly and mountainous areas with forests, rangelands and agricultural lands. The mean annual precipitation and temperature are 481mm and 17.7°C, respectively. The minimum and maximum altitude above the sea level is 1360 and 2774m. The dominant plant species in forests and rangelands are *Quercus brantii* and *Astragalus parrowianus*, respectively [21].

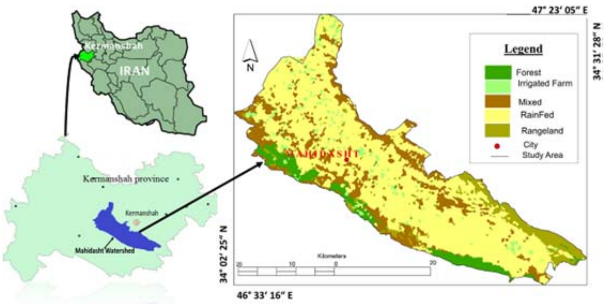

Figure 1) Location of Mahidasht Watershed in Kermanshah province, Iran

Methodology: The purpose of this study was to determine the status of land use change in different periods in Mahidasht Watershed. Land use alteration during 1955-2017 was evaluated for forests, rangelands, rain-fed, and irrigated lands. The maps of land use were prepared for 1955, 1989, 2002, and 2017 years, using aerial photos (1955) and Landsat satellite images (TM 1989, ETM 2002 and 2017). The maps and borders of each land use were verified in the field and digitized using GIS (ArcGIS; version 9.1). Then, the change in the area of each land use type was analyzed and mapped through GIS (Figure 2). Furthermore, the aerial photos (1955) were interpreted using relevant stereoscope tool in the lab and classified into different land use areas. Satellite images (TM 1989, ETM 2002 and 2017) were first corrected and then a land use map was obtained using the ArcGIS software. Taking 50 ground control points from the maps, the images were geometrically corrected before applying image merging and classification. Satellite images indicating land use were classified into distinct areas using vegetation indices (NDVI). This was followed by significant fieldwork in the study areas. The classification of land use included, forest area, rangeland, rain-fed land, irrigated land, and mixed lands. In the end, four land use maps were prepared separately for each period and then land management status and land use change factors were analyzed.

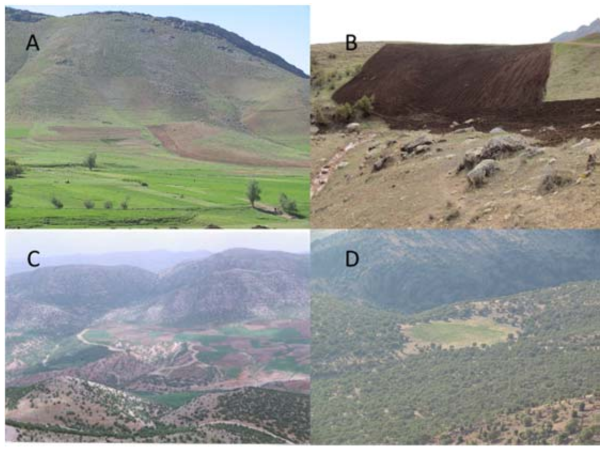

Figure 2) Various landuse and land cover degradation in the study area: (A) converting rangeland to steep slope rain-fed land; (B) up-down the slope tillage practice using moldboard plow in converted rangeland; (C) fragmenting and scattering the virgin plant diversity through improper agricultural activities and forest clearance; (D) converting the forest at the gentle slope to agricultural lands.

Findings

The results of land use change analysis four periods from 1955 to 2017 indicated that severe converting of forest and rangelands to agricultural lands was occurred in Mahidasht Watershed that are described as follows:

Change in the Forest Area: The dominant species in this forest are *Quercus brantii*, *Amygdalus orientaalis, Acer monspessulanum and Crataegus aronia*. This investigation showed that the forest has been reduced from 13928.4ha in 1955 to 8520.4ha in 2017 which is annually an average 87ha reduction in the forest area. The area of the forest in 1955, 1989, 2002 and 2017 had been 13928.4, 10135.2, 9384.4 and 8520.4ha, respectively (Table 1). The deforestation occurred mainly due to population growth, increase in agricultural machinery and ineffective official control as well as land prices.

Table 1) Landuse area during four years 1955, 1989, 2002 and 2017 in the Mahidasht Watershed, Iran

Landuse	1955		1989		2002		2017	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Forest	13928.4	9.3	10135.2	6.8	9384.4	6.3	8520.4	5.7
Rangeland	22031.6	14.8	17685	11.8	13907	9.3	12897.7	8.6
Rain-fed lands	94383.6	63.2	102081.2	68.4	97480.4	62.3	96445.9	64.6
Irrigated lands	1520	1.0	1887.3	1.2	3383.9	2.3	5226.4	3.5
Mix landuse	17467.2	11.7	17542.1	11.8	25175.1	19.8	26240.4	17.6
Sum	149330.8	100	149330.8	100	149330.8	100	8520.4	100

Change in the Rangelands: As shown in Table 1, the respective change in rangelands for 1955, 1989, 2002, and 2017, had been 22031, 17685, 13907 and 12897ha. However, it was observed that rangelands were reduced annually 147ha during 62 years (Table 1). Field surveys verified that some parts of rangelands which were converted to steep rain-fed agricultural lands were observed in the vicinity of agricultural lands with the slope of 10-25%. In this process, farmers changed borders between their land and rangelands and converted some parts of rangelands to rain-fed areas which were subjected to unsuitable tillage practice (Up-down the slope plowing) with consequent soil erosion and siltation hazard (Figure 1).

Change in the Rain-fed Lands: As shown in Table 1, the respective change of rain-fed agriculture in 1955, 1989, 2002, and 2017 was 94383.6, 102081.2, 97480.4 and 96445.9ha mainly converted to rain-fed land. Thus, this study showed that rain-fed lands have been increased 66ha yr^{-1} during 47 years. Field verification explored that the rangeland and forest areas were converted to steep rain-fed agriculture in vicinity of agricultural lands with the slope of 10-25%. In this process, farmers changed borders between their lands and rangelands or forests and converted some parts to rain-fed areas each year. The area of rain-fed lands has increased from 94383 in 1955 to 102081 in 1989 which adversely resulted in a reduction in forest areas from 1989 until 2002 (97480.4ha; Figures 3 and 4).

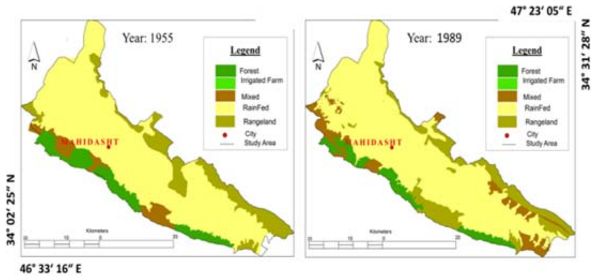

Figure 3) Landuse areas in 1955 and 1989 in Mahidasht Watershed, Iran

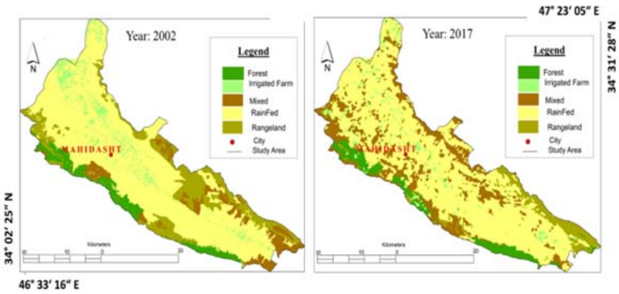

Figure 4) Landuse areas in 2002 and 2017 in Mahidasht Watershed, Iran

Change in the Irrigated Lands: The respective change in irrigated lands in 1955, 1989, 2002 and 2017 was 1520, 1887.3, 3383.9, and 5226.4ha indicating 59.8 ha/yr increase in this land use type (Table 1). Field survey showed that the rain-fed area was converted to irrigate lands in plain areas with the slope of 0-2% due to excessive groundwater extraction through drilled wells during recent years resulting in the reduction of aquifer water.

Mixed Land use: Mixed areas include the pieces of fragmented rain-fed lands within forests or rangelands which are also impossible to consider as forest, rangeland, or agricultural land which represent the illegal land use changes and forest paths formation in the study area. The mixed land use and its increase are more related to land degradation, especially deforestation, overgrazing, and improper plowing.

The results also revealed that areas of rangelands and forests were decreased during 1955-2017 period and mainly converted to agricular and mixed land uses (Diagram 1).

Comparing the percentage of land use in 1955 to 2017 in Mahidasht Watershed shows that the area of forests and rangelands has dramatically reduced Figure 4).

As results indicated, the rate of forest conversion was more severe in the 1955 to 1989 period than other periods. There was 27.2% reduction in forest areas during 1955-89 indicating mean annual 0.8 % (Table 2).

Mixed lands as the degraded lands have increased from 0.45 in period 1955-1989 to 43.5% in period 1989-2002, showing considerable change in land use over time. The results (Table 2 and Diagram 2) showed that the most land degradation and land use change occurred during this time period 1989 to 2002. Diagram 3 also shows that the largest increase in irrigation agriculture is for the period 1989 to 2002.

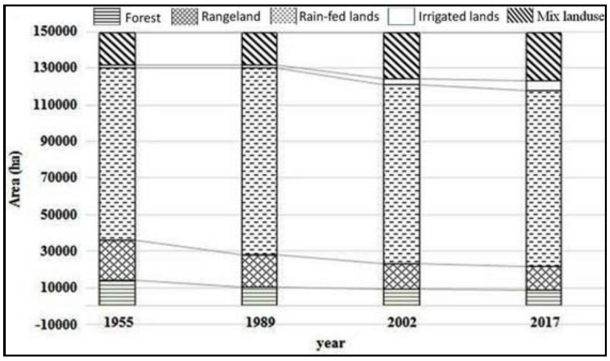

Diagram 1) Landuse area during the time period of 1955- 2017 in Mahidasht Watershed, Iran

Table 2) Landuse change over time in Mahidasht Watershed, Iran

Landuse	Landuse change (%)			
	- 1989 1955	1989- 2002	2002- 2017	1955- 2017
Forest	-27.2	-7.4	-9.2	-38.8
Rangeland	-19.7	-21.4	-7.3	-41.5
Rain-fed lands	8.2	-4.5	-1.1	2.2
Irrigated lands	24.2	79.3	54.4	243.8

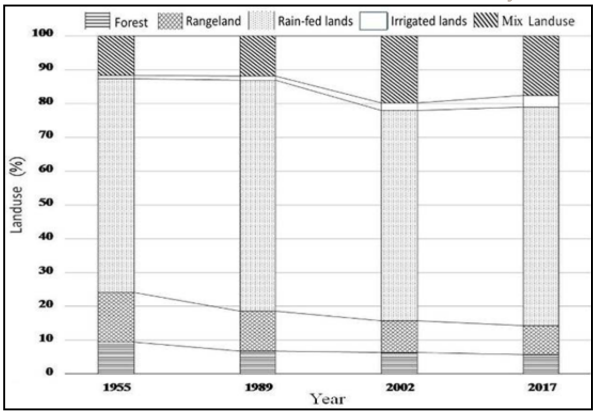

Diagram 2) Percentage Landuse area during the time period of 1955- 2017 in Mahidasht Watershed, Iran

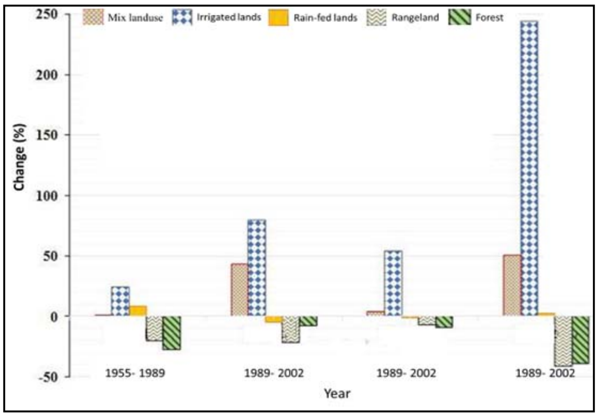

Diagram 3) Landuse change from 1955 to 2017 in Mahidasht Watershed, Iran

Discussion

The results showed that irrigated lands experienced an increase of 243.8% and 59ha/year during 1955-2017. The main reason for this trend is the increase in the number of wells in the study area. So, the number of drilled wells in 1955 increased from two (deep wells) to 2200 wells in 2017. The results also indicated a reduction of 64ha of forests and 81ha of rangelands between 1955 and 2002. Meanwhile, it was understood that during the same period a huge increase of about 500 ha in combinatory lands happened. In addition, due to the change of rain-fed lands to irrigation lands, we observed a decrease of 354ha per year of rain-fed lands between 1989 and 2002. Local inhabitants, particularly smallholding farms attempt to improve their livelihood through most land use change resulting in accelerated soil erosion [22, 23]. There is more severe on sloping lands, where the soil is unprotected [24]. The study by Sabzghobaee *et al*. revealed that during recent years 2841 ha of rangelands in the study area was converted to urban and industrial areas [25].

The main factors responsible for changes in utilization of lands in Mahidasht Watershed were population increase, unemployment, and changes in living patterns. These factors have led to an increase in poverty, emigration of villagers and nomads to large cities, and destruction of resources. The results of a similar research Reis, in Rize, North-East Turkey reported severe land cover changes in agricultural areas, especially in tea gardens (36.2%), as well as in urban (117%), pasture (-72.8%) and forestry (-12.8%) regions between 1976 and 2000 [25]. It was observed that land use and land cover changes mostly occurred in coastal areas and in areas with low slope values [26]. The process of urbanization or its growth drives changes in land use/cover patterns, which also have adverse impacts on the ecology of the area, especially hydro-geomorphology and vegetation [27]. It is related to socioeconomic issues mainly lower income of stallholders, livelihood needs as well as improper agricultural activities such as heavy tillage practice and livestock grazing [28]. Based on local data, there were only five types of land use in 1955 and the majority of irrigated lands were supplied by surface and local spring waters. However, 1500 wells were drilled by 2017 of which 600 wells were illegally built-up. This situation negatively affected groundwater resources. Subsequently, aquifer height has fallen down from 6.7 to 21.3m above the surface during 1997-2011 [29]. Also, the average reduction rate in areas of forest and rangeland were 87 and 147ha/yr. In contrast, the area of rain-fed agriculture and mixed land use (forest-rangeland and rangeland-rain-fed) were increased annually by 500 ha. In the period from 1955 to 2017, the level of forests and rangelands decreased by 38.8 and 41.5%, respectively, and the levels of rain-fed, irrigation and Mix Land use, increased by 2.2, 243.8 and 50.2%, respectively. Moreover, Were *et al*. using satellite images to assess the rate of changes in vegetation cover in parts of Kenian forests during a 40 year period observed one percent decrease in forest areas annually. Meanwhile, they reported an increase in agricultural lands and urban areas by six and 16%, respectively [30].

Subsequently, this adverse change in areas of both forests and rangelands in Mahidasht Watershed cause land degradation mainly soil neutrinos depletion and organic carbon emission sharing the off-site impacts such as global warming. This cause severe degradation of vegetation cover and adversely increasing bare soil at hillslope of Mahidasht Watershed [31]. The study by Heshmati *et al*., in the upper part of Mahidasht Watershed (Merek sub-watershed), revealed the respective loss of 16, 0.17 and 4.3kg ha^{-1} y^{-1} of SOC (Soil organic carbon), N, P and K through 8.6tha^{-1} y^{-1} soil erosion impacting land use change, mainly converting forests to rain-fed lands [32]. They also revealed that these lands having soil containing smectite subject to deforestation and overgrazing can help promote soil erosion and depleting plant nutrients and SOC [33]. Furthermore, according to Chen *et al*., hill slopes in the area accelerate erosion severity [34]. Furthermore, the soil erosion intensity of the arable land was highly sensitive to the land slope.

The limitations of this research include low information about factors afflicting land use change as well as predicting the land use change in the future. However, for completing this research, a holistic study is suggested to analysis and prioritizing the effects of stakeholders on land use changes in Mahidasht watershed.

Conclusions

The results showed that converting the forests and rangelands to arable lands are the main land use alteration within the Mahidasht Watershed. Periodic comparing land use maps during the 1955-2002 indicated a reduction of 5544 and 8124.6ha of forests and rangelands to the rain-fed areas, respectively, indicating 13668.6ha (9.1%) reduction in their areas during 47 years. Natural resources (Forests and rangelands) in the vicinity of agricultural lands are more vulnerable to alteration and consequently as critical areas will be subject to improper agricultural activities and soil erosion hazards. Furthermore, a increase in irrigated areas through well drilling is also related to land use change, especially in rain-fed area. Finally, this land use change not only contributes to soil erosion and siltation hazards but negatively also can cause biodiversity issue, especially destruction of some vegetation species such as Quercus sp, Agropirom sp and Festuca sp. It is concluded that land use change is related to socioeconomic issues, the lower income of local people, livelihood needs as well as improper management and monitoring. This study explored that population increase, food demand and short term needs of local inhabitants resulted in considerable land use changes during 1955-2017.

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Conflicts of interests: The corresponding author has no conflict of interest.

Authors' Contribution: Gheitury M. (First author), Original researcher (45%); Heshmati M. (Second author), Introduction author/ Methodologist/ Assistant researcher / Statistical analyst (35%); Ahmadi M. (Third author), Methodologist/ Assistant researcher/ Statistical analyst (20%)

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