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Investigation the driving forces of land-use change in northeastern Iran: Causes and effects

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ABSTRACT

Land-use change is the most important causes of disturbances in the natural environment. This process increases the severity of natural disasters such as floods, dust storms, etc. Moreover, it leads to major unnatural events such as water, soil and air pollution and land subsidence. The objective of this study was to determine land-use change trends, causes, and driving forces of changes in Taybad-Bakharz region, Iran, for two times period (1977–2001, 2001–2016). According to the results, the studied areas were classified into five land-use classes including; residential area, cropland, salty land, rangeland, and barren land. The barren lands and rangeland had the highest percentage of area in 1977, which covered 85.5% of the area in equal proportion. Irrigated and rainfed agriculture increased during both periods. The percentage of agricultural areas reached from 7.8% in 1977 to 9.7% in 2001, and 14.3% in 2016. Due to continuous growth in population from 50,000 in 1977 to 160,000 in 2016, the residential area's growth had been dynamic during two periods and increased from .14% to .4%. It was clearl that a major land-use change had occurred in Taybad-Bakharz region. During 40 years, the capable lands converted to the agriculture lands. Three factors that have been led to increasing agriculture areas are technology and agricultural machinery entry, deep well drilling industry, and wet years that encouraged people to cultivated lands.

1. Introduction

Land-use change is the most important causes of disturbances in the natural environment. This process takes place under the influence of economic incentives. Land cover changes occur naturally over time and as well as or more affected by human activity. Therefore accurate information about land cover changes in order to knowledge improving, monitoring, and reporting of these changes is required (Gómez et al., 2016). Land-use change models are an important tool for comprehensive environmental management. These models through scenario analysis help to identify critical locations are subject to change. The Conversion of Land Use and its Effects at Small regional extent (CLUE-S) model has made for the analysis of land use in small-scale (watershed or region) with appropriate spatial resolution. The model was structured to provide conditions for a comprehensive analysis of land-use change associated with socio-economic and biophysical stimulating factors (Verburg et al., 2002). Most of the models used remote sensing and geographic information system to determine changes in land use.

(Haque and Basak, 2017) determined Land cover changes using GIS and remote sensing techniques in Tanguar Haor, Bangladesh. They analyzed NDVI, NDWI and CVI indices for 30 years. Their results showed that more than 40% of the area's land cover has been changed. Deep Water bodies were less, forest and highland vegetation were gone and wetlands converted to the cropland. Islam et al. (2017) considering land-use changes by using Landsat TM and Landsat 8 OLI/TIRS images in Chunati (Bangladesh) from 2005 to 2015. The results showed around 256 ha has been added for degradation of forest areas during 10 years and the yearly rate of progress was 25.56%. Additionally, 159 ha of naturally forested land had been changed to other land uses with the yearly rate of change of 15.88%. Karakus et al. (2015) determined land-use/cover change and land use potentials in Sivas city (Turkey) from 1987 to 2002. They reported the city was developed towards northeast, south, and southwest. The majority of the population were living in areas that have the highest quality for agriculture. Comparison of Markov models and satellite imagery in Tiruchirappalli, India, during 8 years well shown the spatial-temporal trend and developmental pattern of land use changes and confirmed the efficiency of this two methods for determining and identifying land-use changes (Kumar et al.,

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2013).

Land-use change can occur in many forms in different parts of the world (Reba and Seto, 2020); therefore, urbanization and the growing numbers of buildings in the rural region of China known as the most important factor of land use change. Peng et al. (2017) assessed Regional ecosystem health response to rural land-use change in Lijiang City, China. They showed land-use change had taken place nearly 30% in urban and rural areas from 1986 to 2000, and reduction of ecosystem health was clear.

Harvey et al. (2017) reported Rapid land use change by coastal wind farm development in Australian. Redondo-Vega et al. (2015) studied the effect of land-use changes eventuates from mining in the Northwest Mountains of Spain during the 50 years. The most important land-use change was relevant to the topography drastic changes caused by mining, and this change is irreversible. This Area occupied by slate mines (69%), coal mines (44%) and gravel quarries (8%). the gravel quarries Almost located in 44% of agricultural land. Land-use changes are nowadays the second greatest contributor to atmospheric carbon dioxide after fossil fuel combustion (Fuchs et al., 2013).

In another study, Fatchs et al. investigated historic land changes in Europe. They stated that very nearly 700 000km2 (15.5%) of land cover in Europe has changed over the period 1950–2010.

Deforestation, farming, overgrazing, and hydraulic terraces were identified as the most important land-use change practices, which can affect the regional climate in the Mediterranean environment (Goyal et al., 2019). Silva et al. (2016) analyzed Drivers of land change in the Paraíba Valley, Brazil, between 1985 and 2011. Their results showed in the primary time of change (1985–1995), Topography and Land suitability for agricultural were generally persuasive factors of destruction. eucalyptus plantations was an important factor in forest recovery between the periods of 1995–2005 and 2005–2011 and socioeconomic drivers, for example, farm credit and economic development play important roles in forest recovery. Dissanayake et al. (2017) considered climate change cause and effect on land cover and land use in South Asia. Their study results showed climate change was a trigger for other land use changes.

According to the literature review of land-use change, in most studies, different tools have been suggested to determine land-use changes. Also, the future of land has been predicted as regard to the past and present conditions of land-use. Few studies explicitly acknowledge interactive effects of land use change, the driving forces, and causes in a social-ecological system. Bhattacharya et al. (2020) showed that the land use change and land cover alteration (positive and negative) were not the only factors affecting groundwater potential level. Indeed, different parameters (hydrological, pedagogical, etc.) are not controlled not only by the process of land use change but also there are several factors that have to be considered. Therefore, in this study, the process of land use change, driving forces (Political decisions, technology development, etc.), causes and effects of changes are considered in a social-ecological system to apply in comprehensive and desirable management for future. This study was done in Taybad-Bakharz region (As a representative of the arid and semiarid regions of Iran) located eastern north of Iran during 40 years (1977–2016).

2. Materials and methods

2.1. Study area description

Iran is located in arid and semi-arid regions of the Earth with a population of 83 million people, in which over 30% of the people's livelihood is related to farming (Statistical Center of Iran). Taybad-Bakharz as arid and semiarid areas of Razavi Khorasan province, Iran (Fig. 1). Taybad-Bakharz included a region of 4800 km^2, the region's population is 160,000 at present, Over 70% of rural people's livelihood grant through livestock and the rest (30%) are living from farming. Precipitation varies between 100 and 250 mm, Desert border areas are

Fig. 1. Location of the Study area.

experiencing less precipitation. Temporal and spatial variations of rainfall are very high. Mean yearly temperature is around 16°C, during the day in summer, temperature goes up 42°C. And yearly actual evapotranspiration changes from 2000 to 2500 mm. The wind velocity ranges from 5.3 to 6.8 m/s, with the maximum occurring in May at about 6 m/s. Moreover, over 120 days per year have wind.

2.2. Driving forces of land use change

During the last 50 years, Taybad- Bakharz region has been faced with a population growth. At the present, this region has a total resident population of 160,000. 50% of the population is rural whose their livelihoods entirely depend on agriculture and animal husbandry. In the past, water for agriculture and animal husbandry was supplied by Qanats. However, since 1960, this region has experienced a major conversion with technology development and the arrival of drilling industry along with Land Reform Law (the division of land between farmers), in which the large part of rangeland converted to the agriculture. Finally, necessary conditions to make drastic changes in land use over Quaternary sensitive formations was provided.

2.3. Land use and land cover data

At first, Landsat satellite imagery was downloaded for the years 1977, 2001 and 2016, according to the following characteristics from the site of https://earthexplorer.usgs.gov (see Table 1).

Then the quality of satellite images was investigated for the presence of geometric and radiometric errors, such as striping, Atmospheric Interference, skewing on Scanline and projection distortion. To identifying The Earth's surface condition well, the false color composite (bands 7,4,1)was prepared for each satellite image(Khoi and Murayama 2010). To investigation changes in land use/land cover, land use map was prepared for three different times (1977, 2001, and 2016). To prepare the final land use maps supervised classification method/ Maximum Likelihood algorithm (using all the spectral bands except 6th band) was used. For this purpose, the topographic maps of National Cartographic Agency (at the scale of l: 25000), aerial photograph at the scale of 1:20000 and the regional land use maps were used. In order to verify the accuracy of land use maps, the NDVI index was calculated. The equation is as follows:

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad (1)$$

Where NIR is the near infrared band value and RED is the red band value. NDVI value change between "+1 to -1". Towards '+1' means denser and greener vegetation. '0' means no vegetation and '0 to -1' describe other land use types.

In order to data and satellite imagery processing, ENVI 4.8 and R (raster, sp, rgdal and LSRS packages) software were used.

2.4. Groundwater depletion estimates

Groundwater depletion estimates for Taybad-Bakharz region is based on water levels in 34 monitoring wells during 10 years. Inverse Distance Weighted algorithm (IDW) was used to interpolate Groundwater Depletion (GWD). IDW assumes that each measured point has a local influence that diminishes with distance. Data processing was carried out in R software (gstat and sp packages).

Table 1
Data type and technical properties of satellite images used in this study.

Year Produced	Satellite type	Image Date	WRS Path/ Row	Spatial Resolution	sensor
1977	Landsat3	13 May	158/36	60m	MSS
2001	Landsat4	13 May	158/36	30m	TM
2016	Landsat8	25 May	158/36	30m	OLI and TIRS

2.5. Groundwater quality changes

The groundwater quality changes were considered using Electrical conductivity (EC), Total Dissolved Solids (TDS), acidity (pH) and Sodium Adsorption Ratio (SAR) parameters in two periods (1977–2001,2001-2016). These parameters directly or indirectly are affected by land-use changes and may be transformed by boundary displacement in fresh and salt water. Parameters such as EC (μS/cm) and TDS (mg/L) apply to determine salinity, SAR (mEq/L) and pH is known as standard diagnostic parameters for the sodicity and acidity, respectively. The Inverse Distance Weighted algorithm was used to interpolate these parameters.

3. Results and discussion

3.1. Land-use changes

Land use maps for the years 1977, 2001 and 2016 using Landsat satellite images were acquired as shown in Fig. 2. Given to the maps the study area's land uses were sorted into following 5 groups including (1) Residential area, (2) Cropland, (3) Salty land, (4) Rangeland and (5) Barren land. The results showed barren lands and rangeland had the highest percentage of area in 1977 which covers 85.5% of the area in equal proportion. This percentage is almost constant in 2001 with 10% diminish in the rangelands. There are no significant changes in 2016 and this proportion is similar 2001. Then the largest percentage of changes in barren lands and rangeland occurred in the period of 1977–2001. The area of Salty land during two periods was constant with a bit change in the second period. This land use covers 6.5% of the area. Irrigated and rainfed agriculture increased during both periods. This increment during the first and the second periods was 2% and 5% respectively.

In fact, the percentage of agricultural areas reached from 7.8% in 1977 to 9.7% in 2001 and 14.3% in 2016. Due to continuous growth in population from 50,000 in 1977 to 160,000 in 2016, the residential area's growth had been dynamic during two periods and increased from .14% to .4% (Fig. 3). The percentage of rangeland areas decreased from 42.7 (1977) to 32.2 (2001) and 29.3 (2016).

As a supervised classification method, NDVI helped to accurately identify the vegetation. Fig. 4 is the thematic change of NDVI in 3 times (1977, 2001 and 2016).

Thematic change of NDVI helped to visualize the typical dynamics of the changing land cover within different time periods (1977–2001 and 2001–2016). This analysis also justified the typical behavior of each land cover types over time periods. As you can see, variations in land uses are largely similar to the classification method. The results indicated that the increasing in agricultural lands was noticeable, which was consistent with a number of previous studies (e.g. Silva et al., 2016). Similar to the previous studies (e.g. Peng et al.,2017; Karakus et al., 2015), we found that the residential areas had been increased. Our results about land use change trend do not contradict the previous studies (e.g. Haque and Basak, 2017).

3.2. Groundwater depletion changes

During these periods, 288 deep and semi-deep wells drilled in the region. These developments Along with mismanagement in groundwater discharge led to a wide part of rangeland Placed under cultivation process. Given that there was no productivity in barren lands and this land use included badlands, salty land, and rocky surfaces. Then a large part of the rangeland converted to the agriculture. Qanats dried in most areas. These circumstances encouraged the government and people to drilled deep wells to supplied water for drinking, agriculture and animal

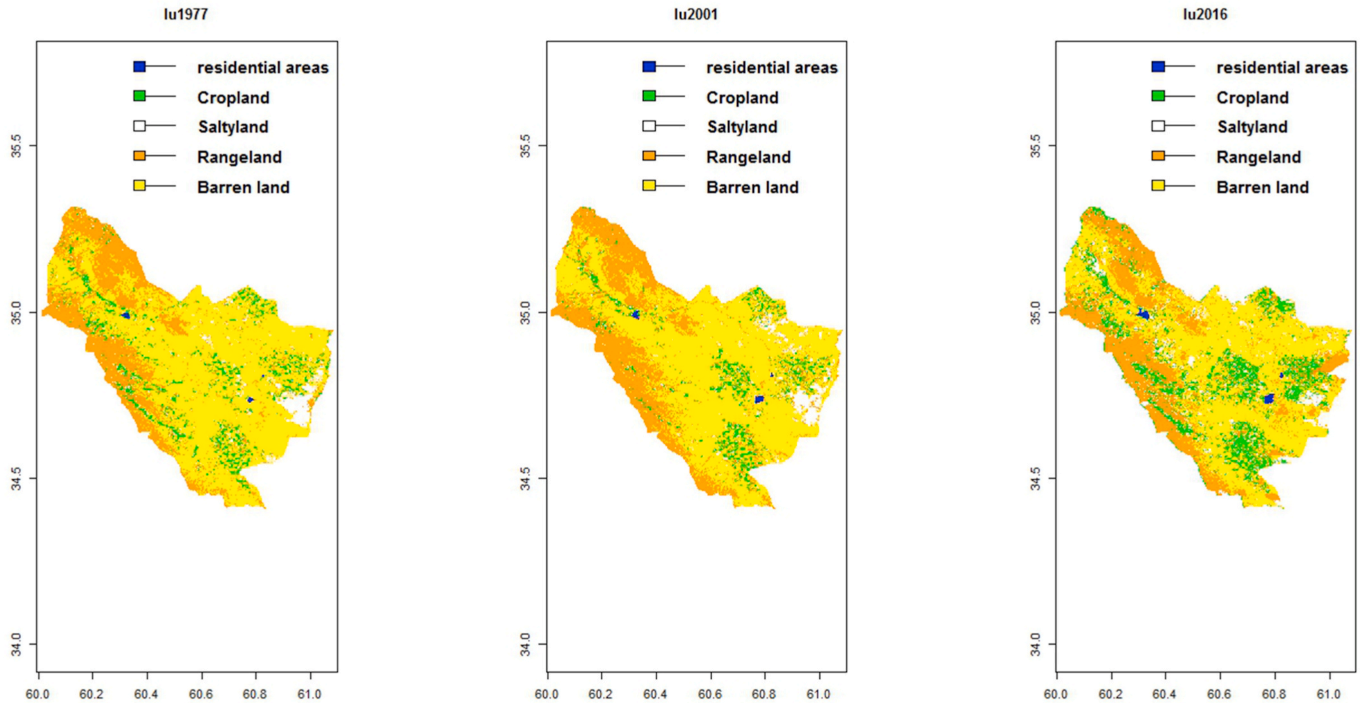

Fig. 2. Maps of land-use changes.

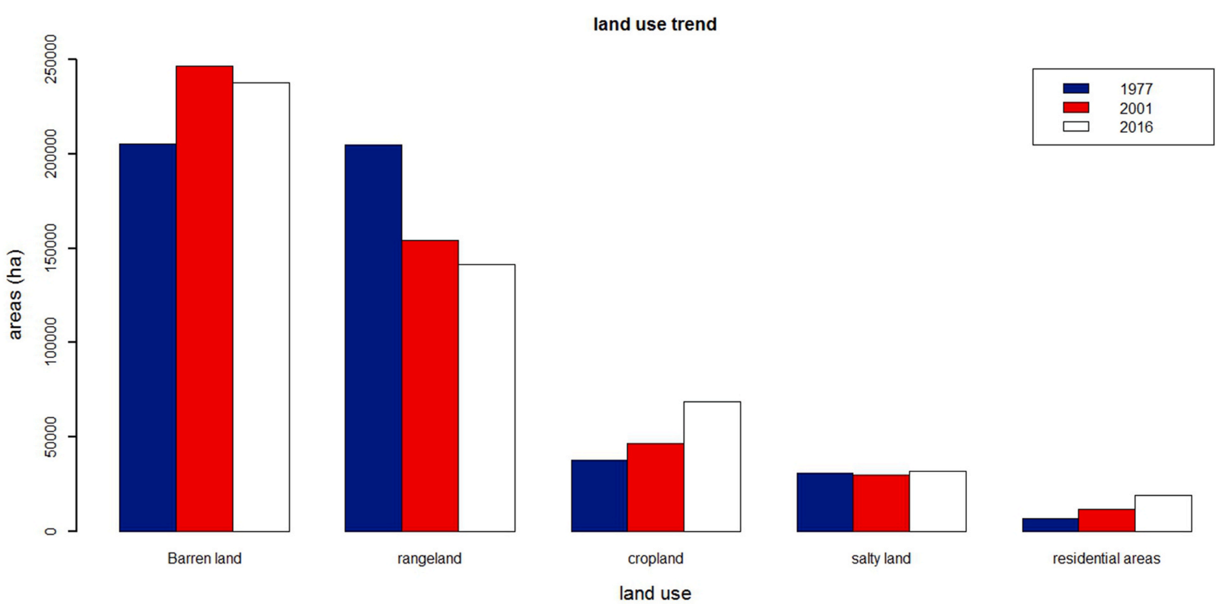

Fig. 3. Land-use change trend.

husbandry. These practices caused the agriculture reached to the highest possible level in 2016.

Agricultural levels growing, increased production so that crops such as melons, wheat, barley, sugar beet, cotton, and crocus)saffron(was produced at a large scale. This increase in production, leading to declining in groundwater level (Fig. 5) so that during the second period, the southern half of the region experienced 1.5-m depletion per annual. Fig. 3. According to the land use maps, there is three important irrigated agriculture in the region that experience the maximum amount of water depletion. When summing up the GWD estimates of the Taybad-Bakharz region depletion for the last years, The blue part in groundwater depletion map (Fig. 3), with 25-m water depletion known as the largest GWD and high-risk area. This depletion essentially relevant to the Excessive groundwater discharge in Desert border areas where are experiencing less precipitation. In the northern part, there are fewer deep wells and water depletion is low.

Due to the proximity of fresh and saltwater aquifers in this area, a sharp annual depletion and high evapotranspiration, Displacement possibility in fresh and saltwater boundary are very high. So that some freshwater wells completely salted and agricultural eliminated. This Displacement Approximately is irreversible. Given that land use changes occurred at its peak, then increasing in the residential areas will be the most important changes in this region. And this change is taking place in the urban areas, It's predicted with the decreasing in rural incomes and

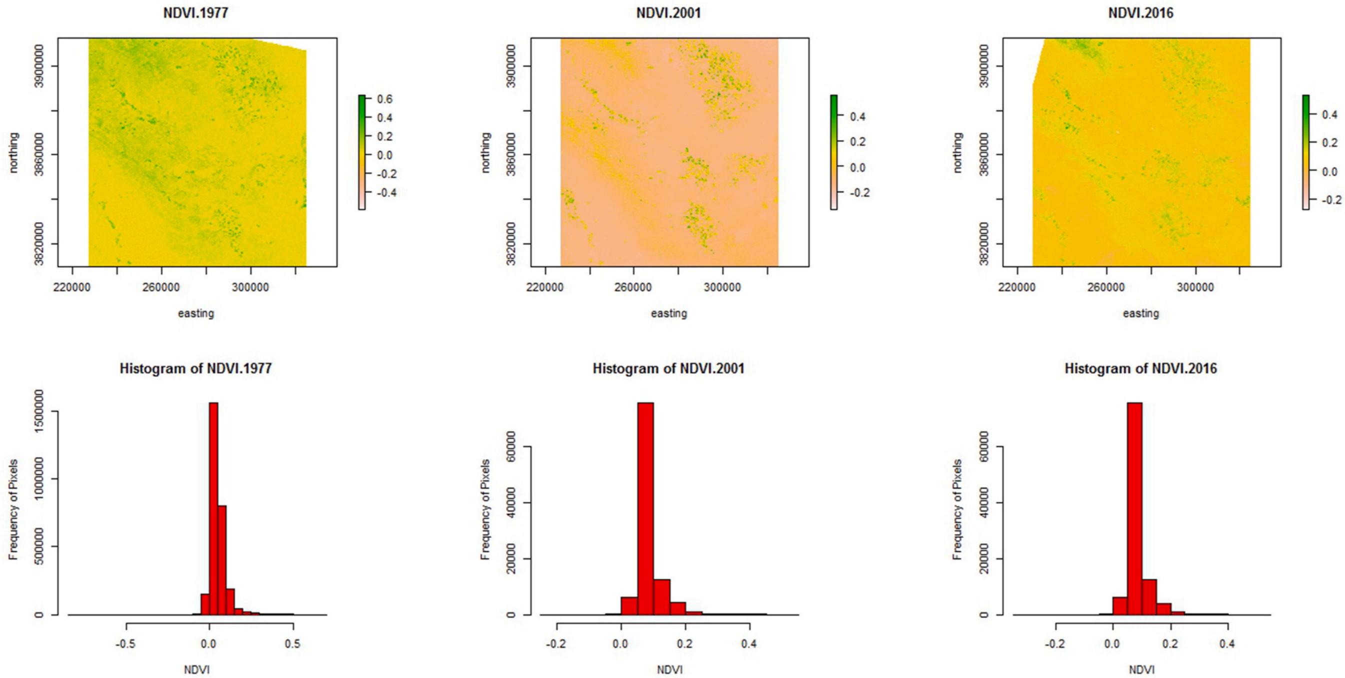

Fig. 4. NDVI changes for time periods.

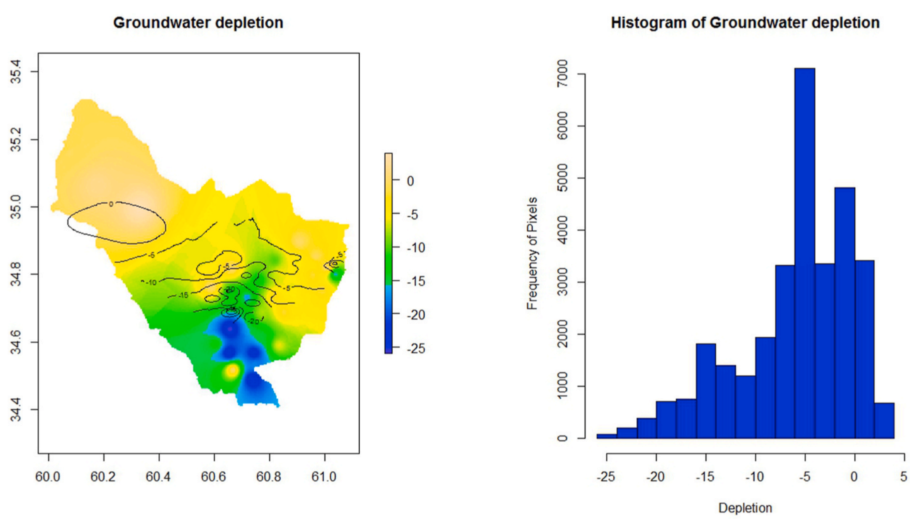

Fig. 5. Groundwater depletion.

the loss of their livelihoods, Villages will be haunted and migration will be begun.

3.3. Groundwater quality changes

The following results were obtained by analyzing groundwater quality parameters (Figs. 6 and 7): EC and TDS are growing in the southern part of the region. This displacement is towards areas with the highest water depletion (25 m). In the northern part, there is no change in all groundwater quality parameters because these areas are away from the desert border and fresh and saltwater boundary. Besides, there are fewer deep wells and water depletion in these areas.

In the southern part, the salinity increased from 2000 μS/cm to 4000 μS/cm. According to Fig. 5 (histograms of EC), the pixels with high salinity values are growing.TDS parameter was similar to EC and almost had the same trend. PH range ((7.8–8.7) unchanged but during the second period, increasing in alkaline class was observed in all of the southern parts. Also, SAR has experienced changes in classes. And this change took place in the southern part of the region where situated on the edge of the desert.

Finally, this changes in groundwater quality parameters can be ascribed directly or indirectly to the fall in water levels and movement in fresh and saltwater boundary. Our results do not contradict the previous studies (e.g. Bhattacharya et al., 2020). Rather, we provided complementary insights into the relationship between land-use change and groundwater parameters. In particular, our results showed that a variety of groundwater parameters were associated with land-use changes. The results may be varied a bit when land-use change is assessed in different years (wet and dry years). However, the change may be not significant in total period.

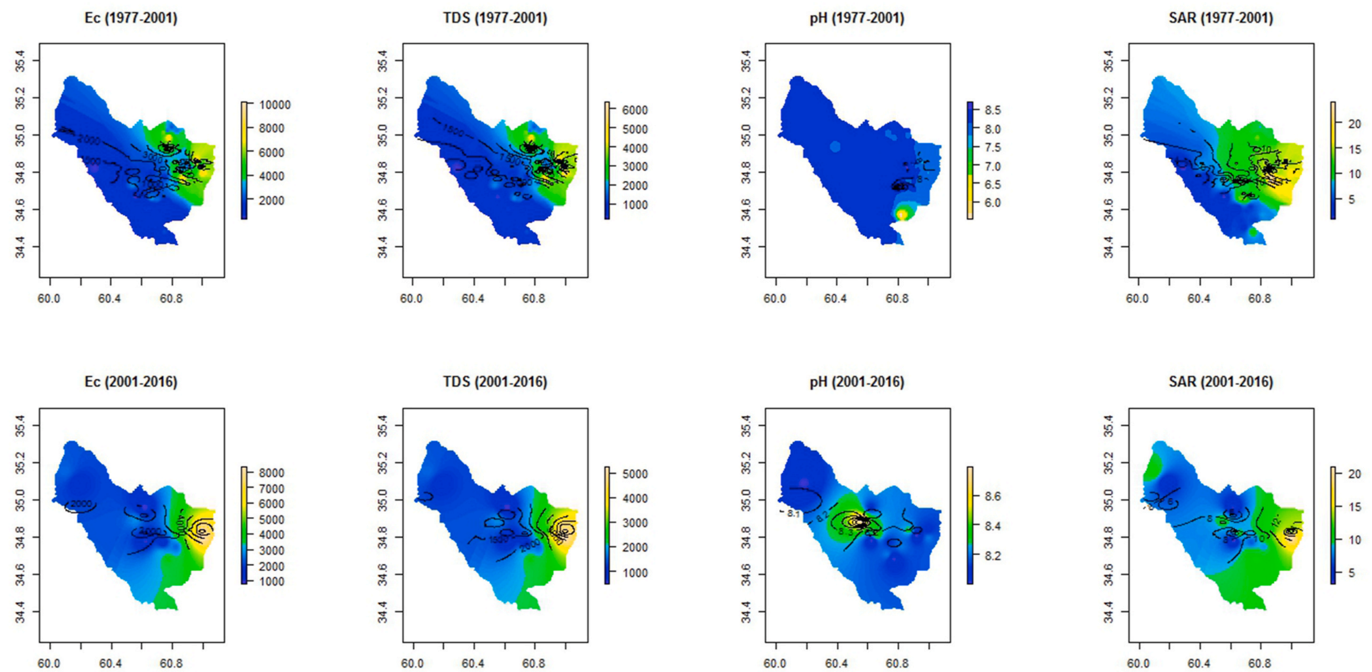

Fig. 6. Groundwater quality changes.

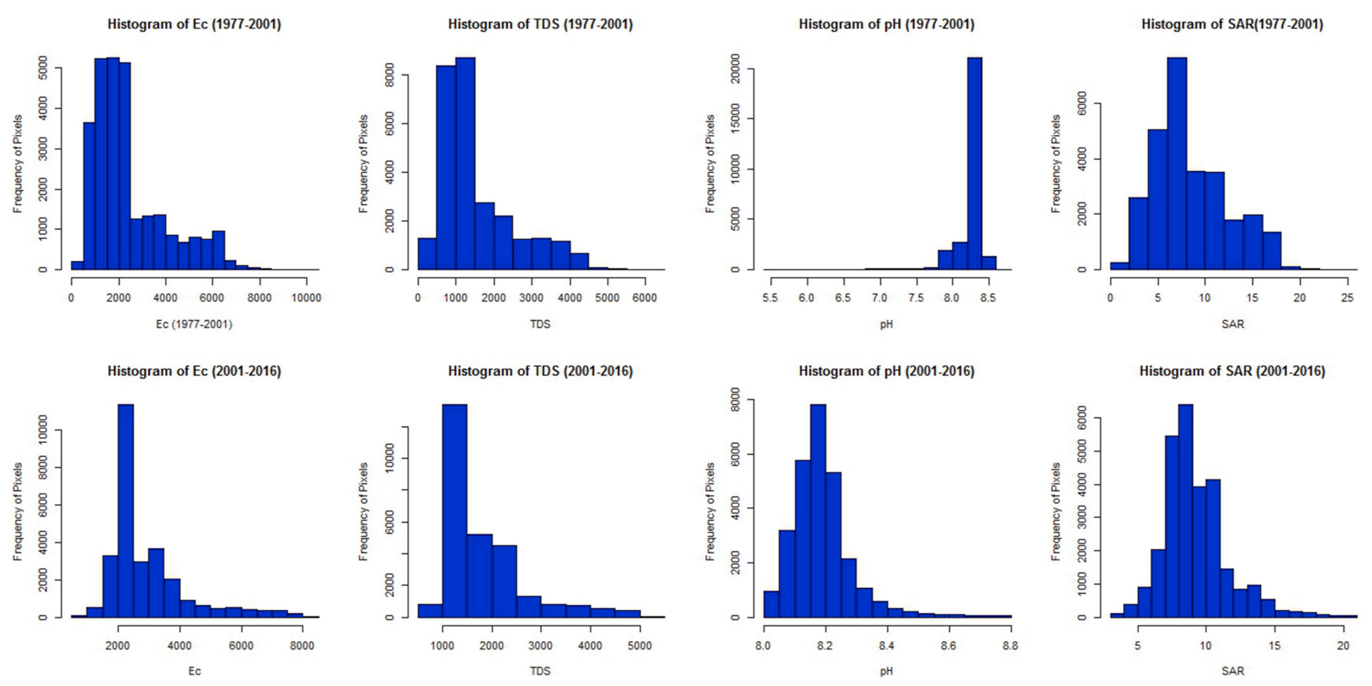

Fig. 7. Histograms of groundwater Quality Changes.

4. Conclusion

It is clearl that a major land-use change has occurred in Taybad-Bakharz region. During 40 years, the capable lands converted to the agriculture lands. Three important factors leads to increasing agriculture areas including technology and agricultural machinery entry, deep well drilling industry and wet years that encouraged people to cultivated lands. Currently, irrigated agricultural has the maximum possible extent and completely depends on the water discharge. Besides, the livelihoods of many families have been obtained from farming and crop activities. In the last years, the management actions at the regional level could partially control discharge, digging wells, and land use conversion. However, these management practices have not been successful, because aquifers are being depleted for many years, which increases the possibility of a disturbance in people's livelihood conditions due to decreasing in precipitation and the lack of aquifers recharge are continuing. It is predicted that agricultural growth in Taybad-Bakharz region will have a downward trend and will be stopped, and bare lands and dust storms will be formed unless comprehensive management actions are taken at the local and regional level. Due to incorrect policies in the past, the livelihoods of a large part of the population living in the region have become dependent on agriculture, which have been led to increasing ground water extraction. Decreasing groundwater level and increasing salinity will threaten the dependent population. Policymakers must develop alternative livelihoods at the regional level to overcome the human-environmental catastrophe. Besides, the process of rehabilitating destroyed rangeland must be quickly considered. Plowing poor rangelands should be banned in wet years, because these lands can be a major source of dust in dry years. Moreover, groundwater extraction must be minimized, and control policies should be tightened so that the severity of the risk is reduced.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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