Environmental Sciences Vol.19 / No.1 / Spring 2021

259-276

Analyzing the spatio-temporal correlation between the changes in land use and groundwater quantity in Hamedan-Bahar Plain (Iran)

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Received: 2020.04.18 Accepted: 2020.09.10

Rafiemehr, H. and Kozegar Kaleji, L., 2021. Analyzing the spatio-temporal correlation between the changes in land use and groundwater quantity in Hamedan-Bahar Plain (Iran). Environmental Sciences. 19(1):259-276.

Introduction: Groundwater is considered the most important source for various uses in arid and semi-arid regions. Thus, evaluating the effects of human activities such as changes in land use/cover on groundwater resources plays a vital role in sustainable water management and, therefore, spatial planning. Accordingly, the need to integrate land use planning and water resources management is widely emphasized. In addition, perceiving the spatio-temporal relationship between land use changes and groundwater resources is crucial for the sustainable management of the plains in Iran. The present study aimed to assess this relationship in the Hamedan-Bahar Plain.

Material and methods: In the study, the land use maps of 1989, 1997, 2005, 2013, and 2018 were prepared from Landsat satellite images, categorized, and evaluated with respect to accuracy. Further, six uses including irrigated and dry agricultural lands, rangelands and elevations, man-made areas, gardens, and surface water resources were extracted and classified. Furthermore, the distribution maps for groundwater depth were prepared through kriging for five years based on the piezometric data. Finally, the correlation and relationship between land use changes and groundwater depth fluctuations were determined by the REGRESS method.

Results and discussion: The land use maps demonstrated an increase in the share of rangelands and elevations (9.68% in 1989 to 40.85% in 2018) and their conversion to dry agricultural lands. Additionally, the share of man-made and irrigated agricultural lands increased from 1.27 to 2.45% and 5.32 to 6.25% during the timespan, respectively. The trend of changes in groundwater level was more evident in the flatbed of the plain, in which groundwater level was less than 1800 m and important habitats and irrigated agricultural lands were available.

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http://dx.doi.org/10.52547/envs.29307

In addition, the average annual depletion of groundwater level for a 29-year time span was 0.91 m, and the minimum and maximum of the R–value related to five study periods was obtained 0.36 and 0.40 based on the REGRESS method, respectively. Further, the role of managerial factors should be considered as well as the relative relationship between groundwater level changes and land use. Furthermore, the correlation between the decrease in groundwater level and land use in each period relatively increased compared to the previous one by representing an R-value of 0.40 during 1989-2018, which can explain almost 16.2% of their changes. Due to the water resource scarcity, land use should be planned based on the scale, power, and extent of plains and watersheds in order to attain a sustainable regional water system.

Conclusion: The results of the study can play an important role in understanding the importance of groundwater resources and emphasize the necessity of paying more attention to the effects and changes of land use on groundwater in arid and semi-arid regions. Additionally, the results indicated the sensitivity of groundwater, as the most important water resource in the plains located in arid and semi-arid regions, to the types of variations. Decreasing rangelands, gardens, aqueduct, and surface water-dependent thickets as well as expanding dry and irrigated agricultural and man-made lands are regarded as some of the factors reducing groundwater level in the region. It is worth noting that these factors should be integrally evaluated with respect to other factors such as irrigation systems, water pricing, cultivation pattern, agricultural economics, and an increase in runoff.

Keywords: Land use change, Groundwater quantity, Hamedan-Bahar Plain, REGRESS

Introduction

Groundwater is considered a major source of drinking water worldwide and plays a vital role in maintaining the ecological value of many regions (Mishra *et al*., 2014, Adimalla and Li, 2018). About two billion people depend on groundwater supplies around the world (WWAP, 2015). The total volume of groundwater in the past 40 years was not estimated newly and rigorously although fresh groundwater storage and its temporal distribution are regarded as critical components in hydrological and climatic processes (Gleeson *et al*., 2016). In addition, the actual estimation of the human activities' effect on groundwater systems is important for establishing a reasonable utilization program of regional groundwater resources (Schwarts *et al*., 2003). Various quantities and intensities are extracted in different regions and the maximum quantity has been reported in some regions such as Pakistan, China, Iran, Bangladesh, and India (Foster *et al*., 2013; Foster and Cherlet, 2014). Further, groundwater is considered a primary factor to protect human ecosystems in dry and semi-dry lands (Calow *et al*., 1997; Eastman, 2012, Adimalla and Wu, 2019). Furthermore, evaluating the impacts of human activities (for instance, changes in land use/cover) on groundwater resources plays a vital role in developing and establishing the aimed plans of groundwater extraction (Sato and Iwasa, 2011; Schwartz and Zhang, 2003). Therefore, the mechanism of changing land use/cover in the watershed affecting the hydrological process has become an important field in the development of hydrology (Hoff, 2002; Bhat, 2018). The effect of land-use changes on the hydrological cycle and protection of groundwater systems, especially discharge and recharge areas, should be significantly highlighted (Pucci and Pope, 1995, Ainiwaer *et al*., 2019). Thus, numerous studies were conducted for identifying the impacts of changes in uses caused by human activities on groundwater resources in the world. Batelaan *et al*. (2003) found that the synergy of hydrological modeling and vegetation mapping proves advantageous and reveals some ecological differences in a watershed in Belgium. Xu *et al*. (2005) assessed how groundwater resource extraction influences agricultural land use in the Hebei Plain in China. Sun *et al*. (2008) assessed the long-term impacts of projected changes in climate, population, land use/cover, and groundwater availability on regional water in the USA. They claimed that a projected increase in population greatly stressed water supply in metropolitan areas and could lead to water scarcity-related problems, irrespective of climate change (Sun *et al*., 2008). Additionally, Lerner *et al*. (2009) reported the dependency of the amount of water demand on land use in the East Midlands of England. They suggested that human activities may affect access to groundwater resources due to the changes in the water-saving rate (Lerner *et al*., 2009). Yun *et al*. (2011) analyzed the hydrological processes and rechargeability of various land use types in the Guishui River Basin, China, by indicating a decrease in the annual-lumped groundwater recharge rate in the order of forest, cropland, grassland, and urban land. Taghipour (2012) evaluated the land use changes related to the reduction of groundwater resources in Khanmirza, Chaharmahal and Bakhtiari Province, Iran, through statistical models based on the regression analysis and found a significant relationship. According to Wagner *et al*. (2013), urbanization results in improving water yield and decreasing evapotranspiration, while evapotranspiration increases by enhancing cropland. Mishra *et al*. (2014) reported that the pattern of land use change demonstrates the rate of groundwater recharge in India. They argued that identifying and examining land use changes over time and their spatial-temporal distribution are considered essential for managing and planning the groundwater resources appropriately. Further, Nasrollahi *et al*. (2014) found a decrease in groundwater resources because of replacing rangelands with agricultural ones by investigating the effects of land use changes on groundwater resources in Gilangharb Plain, Iran by using satellite images. Brauman *et al*. (2015) assessed the impact of plausible shifts in watershed land use on hydrological services in the Kona coast of Hawai'i Island. They demonstrated the greater impact of transitions between native and plantation forests on aquifer compared to that between pasture to each type of forest (Brauman *et al*. 2015). According to Ghazavi and Ebrahimi (2016), land-use change influences different water balance components (recharge and discharge) significantly. An increase in agricultural areas results in improving annual discharge, as well as annual recharge from irrigation water (Ghazavi and Ebrahimi, 2016). Pourandara *et al*. (2018)

evaluated the effects of land use changes on groundwater recharge in Malaparamba, India by using the swimming model. They mentioned the dependency of groundwater recharge on rainfall patterns and land use changes and higher groundwater recharge in forest lands compared to the agricultural ones. The large-scale changes in groundwater reservoirs occur because of varying LULC, hydro-geomorphic features, and extensive groundwater exploration activities over the past decade in the Lucknow area of the Ganga plain (Verma *et al*., 2019). Based on reviewing the previous literature, land use change can modify hydrological processes at temporal and spatial scales, especially in the arid regions. The changes in land use, along with climatic, social, environmental, and economic factors, result in endangering water resources (Foley *et al*., 2005; Zhang *et al*., 2001).

Yet, a need for integrating land use planning and water management and developing integrated policies is emphasized (Carter, 2007; Arnold, 2006). The close relationship between two items is not widely highlighted in management actions through comprehensive politics despite its consideration from the past. Land use activities and water resource development and management are interdependent (Waldea and Gebremariam, 2017). Agricultural expansion, urbanization, deforestation, and human daily activities result in changing land use/cover temporally and spatially, which may influence water flow pathways and water balance (Rawat and Manish, 2015).

Thus, these resources respond to land use changes with delay, considering the immense volume of groundwater (Partnership, 2014). Iran possesses a critical situation with respect to water resources in spite of having one of the most advanced water management systems in the Middle East, similar to other counties in the region (Madani, 2014). Further, the lack of attention to land use changes results in the gradual loss of the balance of lands in Iran. Groundwater is considered the most important water resource for agriculture, industry, and human consumption in Hamedan, similar to other regions in Iran, (Kord and Moghadam, 2014).

Hamedan-Bahar Plain has become one of the agricultural hubs in Iran, especially with the production of water-consuming crops such as watermelon, potato, and cucumber during the past few decades (Ghasemi-Nejhad and Marofi, 2011). Naturally, the relative economic prosperity resulted in expanding man-made lands such as cities and villages in the plain. Additionally, the trend of converting rangelands to dry agricultural ones has intensified because of developing agricultural machinery. The above-mentioned factors have led to extensive evolutions in the cover of land use during the past few decades.

Thus, perceiving the relationship between land use changes and groundwater quantity is regarded as an important step for understanding the issue and comprehensive management. In the present study, the Hamedan-Bahar Plain was selected due to the critical situation of its groundwater resources because of extracting groundwater excessively and changing land use severely. The study aimed to examine the spatio-temporal relationship between land use changes and groundwater quantity in the Hamedan-Bahar

Plain for 29 years since no study, to the best of our knowledge, was conducted in the plain in this regard. In fact, the trend of changing land use and its effects on groundwater level was precisely assessed as time-series in the plain for the first time. The results of the study can be used for the principled planning of land in order to utilize groundwater resources sustainably, especially in Hamedan. Therefore, the question raised by considering the objective of the present study is related to the effect of the trend of land use changes on groundwater level in the Hamedan-Bahar Plain during the past three decades.

Study area

Hamedan-Bahar Plain, as the studied region, is located in the center of Hamedan County (Figure 1). In addition, the region is considered as a part of the Namak Lake basin with respect to the division of the drainage basin. The Namak Lake basin is regarded as a part of the Central Plateau basin of Iran and is limited by the drainage basins of Sefidrood and the Caspian Sea in the north, Karkheh and Maghreb in the west, Zayandehrood in the south, and Rig Zarrin and Namak desert in the east. Further, this basin is located between the longitudes of 48.8 to 52.3 E and latitudes of 33 to 36.22 N, the elevation of which is between that of Central Alborz and Zagros. Furthermore, the region is placed beneath the south drainage basin, drainage of Qom and Gharachay rivers, and Arak and Kashan deserts (Water Statistical Yearbook of Iran, 2013-2014). The population and area of Hamedan-Bahar Plain are 774074 (Statistical Center of Iran, 2018) and 2463 km^2, respectively (Hamedan Regional Water Company, 2015). The important demographic centers of the cities such as Hamedan, Bahar, Lalejin, and Salehabad are situated in this region.

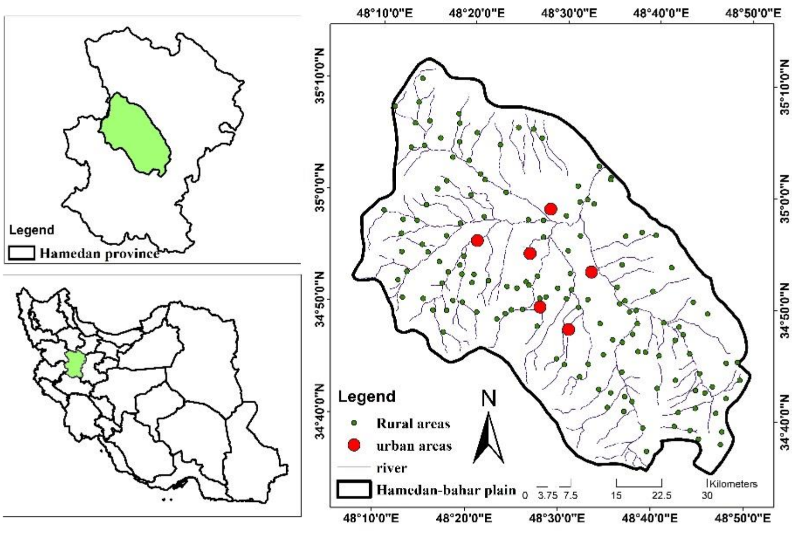

Fig. 1- Location of the region under study

The region possesses an important economic and agricultural position. In addition, 89.5, 2.9, and 7.6% of total groundwater consumption in the province are related to agricultural, industrial, and drinking water sectors, respectively (Hamedan Regional Water Company, 2015). Figure 2 displays the trend of groundwater level during 1991-2018, by representing the decrease in the mean groundwater level for the whole Hamedan-Bahar Plain from 1734 to 1719 m.

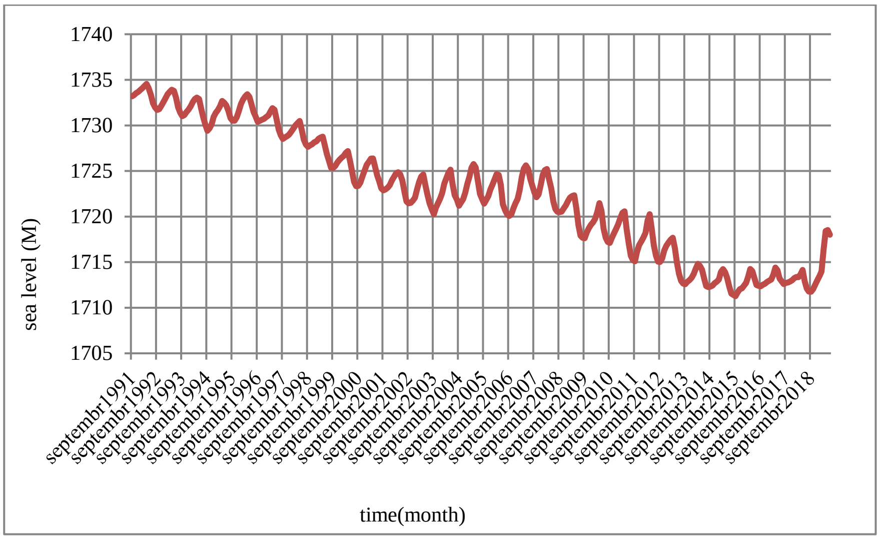

Fig. 2- Groundwater hydrograph of the Hamedan-Bahar Aquatic Plain during 1991-2018 (Hamedan Regional Water Company, 2019)

Due to the water crisis in the Hamedan-Bahar Plain, the Ministry of Energy reported the plain as a forbidden one to control and prevent from escalating the crisis during 1982-1983. Well digging is not allowed in the forbidden plains because of causing a reduction in their groundwater level.

Material and methods

Figure 3 illustrates the general trend of the present study. The land use maps of 1989, 1997, 2005, 2013, and 2018 were prepared. In addition, the six uses of irrigated and dry agricultural lands, gardens, man-made areas (such as urban-rural and industrial), arid ones (such as rangelands and uncultivated land), and surface water resources were extracted and categorized by using the satellite images. The satellite images were selected based on the criteria involving possessing identical resolution level, lacking cover cloud more than 5% of image and season or imaging at the same time (Schwartz and Zhang, 2003; Shrestha, 2006). The images used in the present study belonged to Landsat 4,5,7 and 8 (Table 1) and were taken at the end of an eight-year presidential term. Using such an approach can help to assess management efficiency in the region.

Table 1. Characteristics of the used Landsat images

No.	Satellite name / Landsat band composite	Supervised by	Date of taking the images	President
1	Landsat 4 and 5 / Bands: 1, 2, 3, 4, 5 and 7	TM	1989/05/14	Ali Khamenei
2	Landsat 4 and 5 / Bands: 1, 2, 3, 4, 5 and 7	TM	1997/07/26	Akbar Hashemi Rafsanjani
3	Landsat 7 / Bands: 1, 2, 3, 4, 5 and 7	ETM+	2005/07/24	Mohammad Khatami
4	Landsat 8 / Bands: 1, 2, 3, 4, 5, 6 and 7	ETM+	2013/07/27	Mahmoud Ahmadinejad
5	Landsat 8 / Bands: 1, 2, 3, 4, 5, 6 and 7	OLI	2018/07/22	Hasan Rouhani

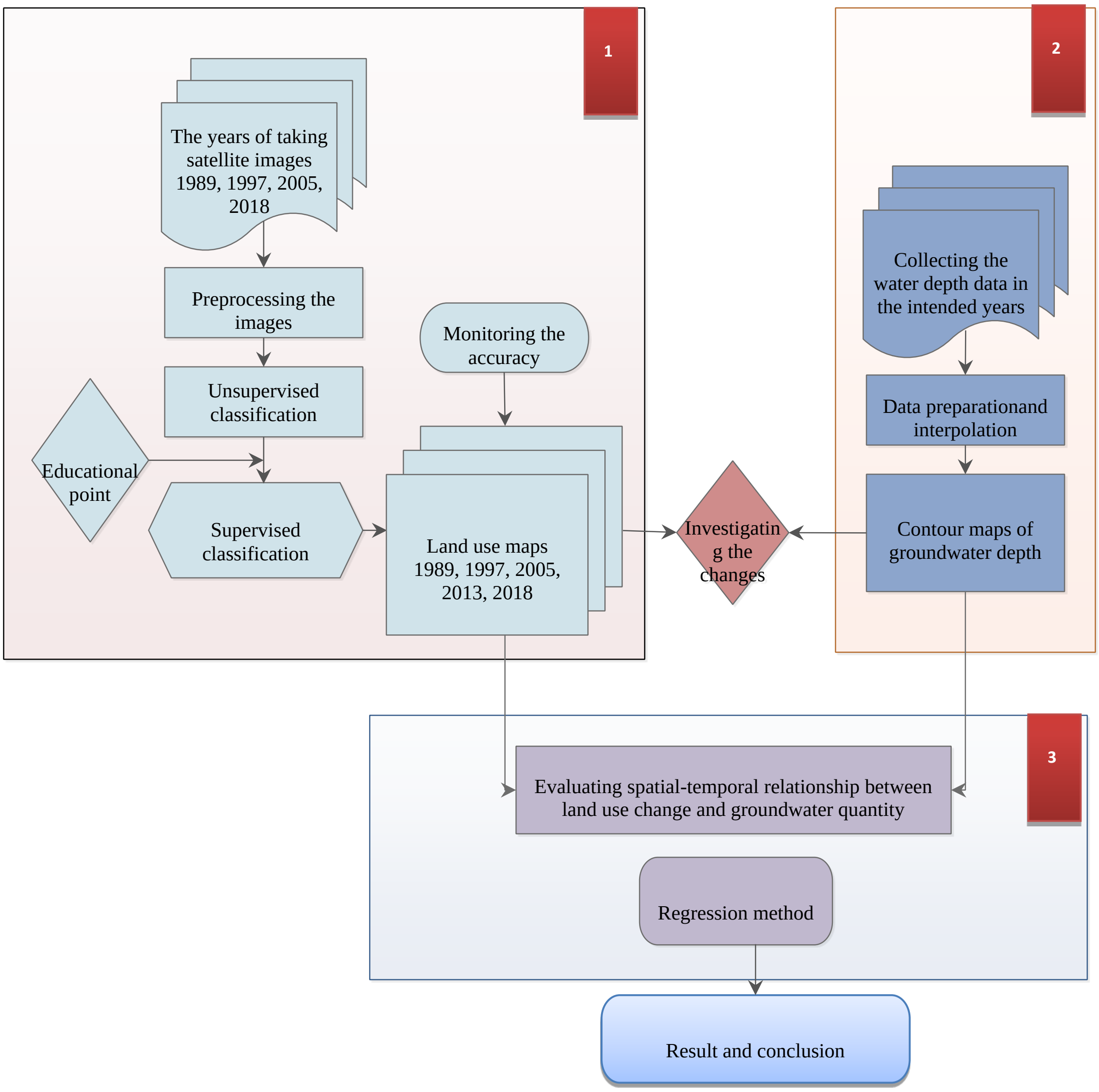

Fig. 3- A flowchart of the research process

The satellite images were pre-processed, processed, post-processed, and classified in order to extract the uses (Part 1, Figure 3). The images were modified geometrically (for unifying the reference of images by ground control points such as road intersection, etc.) and atmospherically (for eliminating or minimizing atmosphere effects such as the existence of cloud and fog) by the Haze Reduction module in ERDAS Imagine 2014 for preprocessing. In addition, various bands were merged based on reviewing the sources in order to prepare information. Further, the histogram equalization of the ERDAS image was applied to adjust image contrast. Furthermore, the images were categorized as supervisory in ERDAS to achieve general knowledge on land use classifications in the region, and the results were used as a useful tool for identifying educational samples. In this regard, field sampling was performed by using GPS, the results related to unsupervised classification, Google Earth, and previous knowledge about the region. Then, samples were entered into ERDAS. Additionally, the images were separately categorized supervisory in ERDAS based on the educational samples of the previous step by using the Maximum Likelihood method.

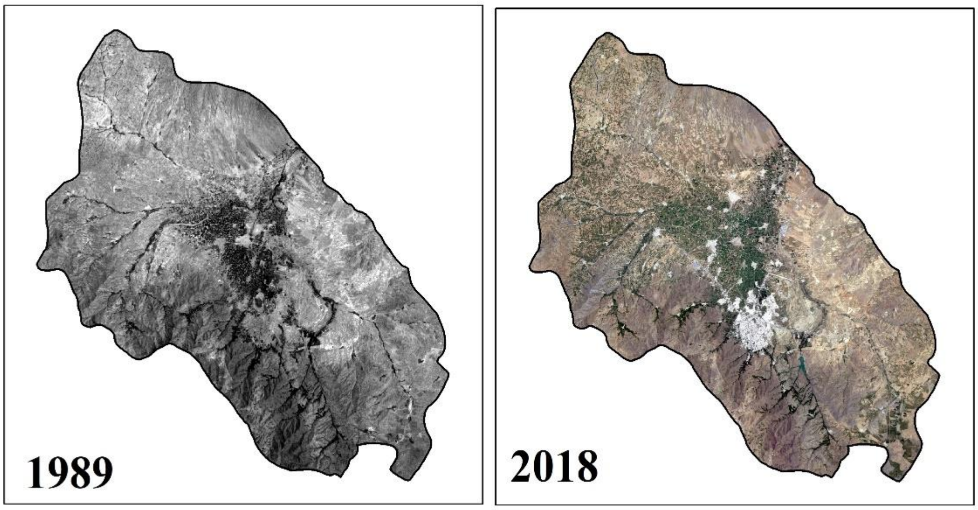

Fig. 4- Satellite images of the region in 1989 and 2018

At this step, the primary maps of land use were obtained, modified, and prepared for six time spans. After classifying the images, accuracy was assessed, land use layers were compared in IDRISI Selva software by using the cross-tabulation method, and finally, land use changes were extracted. The second part in Figure 3 examines the trend of the quantitative changes in groundwater. The information related to groundwater depth was provided from Hamedan Regional Water Company. Further, the zoning maps of groundwater levels related to 1989, 1997, 2005, 2013, and 2018 were prepared in ArcGIS 10.5 by using the kriging interpolation method, which indicated the changes in the groundwater depth. Regarding the last part in Figure 3, the regression analysis-based statistical models were utilized for perceiving the relationship between land use changes and groundwater quantity. To this end, the REGRESS module in IDRISI Selva was applied. The model evaluates the relationship between two layers as linear regression (Kord and Moghaddam, 2014). In fact, the REGRESS method investigated the linear regression between dependent and independent variables, in which land use changes and groundwater quantity were respectively considered as independent and dependent variables in the study.

Results and discussion

The present study assessed the trend of changing land use during a 29-year time span and extracted and categorized the six uses including irrigated and dry agricultural lands, gardens, man-made areas (such as urban-rural and industrial), arid lands (such as range and uncultivated land), and surface water source. Figure 5 and Table 2 display the area and percentage of each use.

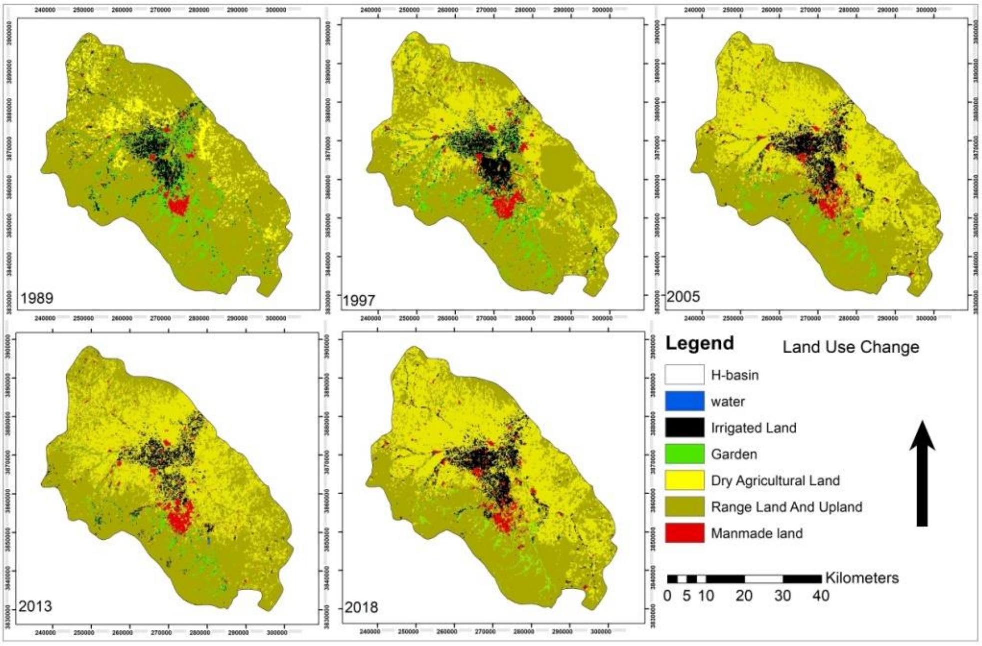

Fig. 5- Maps of classified land uses in the studyperiod

Table 2. Area (km^2) of different land uses in the study region

	1989	1997	2005	2013	2018
Rangelands and arid lands	1889.59	1420.32	1185.87	1398	1190
Dry agricultural lands	241.2	679	1018.37	880	1017.27
Gardens	192.54	162.62	58.83	42	58.3
Irrigated agricultural lands	132.68	165.6	156.54	106	155.78
Man-made areas	31.77	45	56.74	56.98	61
Surface water resources	0.34	0.44	1.11	0.9	1.1

Based on the results of land use maps, a decrease was observed in rangeland and upland from 75.59 to 47.8% in 1989 to 2018, respectively. In addition, rangelands were plowed and converted to dry agricultural ones. Consequently, their share increased from 9.68% (1989) to 40.85% (2018). Further, the share of gardens declined from 7.73% in 1989 to 2.34% in 2018, which can be related to the expansion of man-made lands to small gardens. Furthermore, the share of man-made and irrigated agricultural lands increased by 1.27-2.45% and 5.32-6.25% during the time span, respectively. Regarding irrigated agricultural lands, the slight changes in the area and quantity, as well as a large change in cultivation pattern towards high-demand crops such as potato and watermelon may be considered as the most remarkable issue in these lands. Finally, creating small dams around some dams such as Ekbatan resulted in enhancing the use of surface water resources from 0.013 to 0.044%.

Table 3 indicates the extent of the variations in different land uses in greater detail. Further, these numbers are related to the overlap of layers in different years in IDRISI software and most of the changes occur because of converting rangeland and elevations to dry agricultural ones.

Table 3. Conversions of land use (km^2) during the study period

	1989-97	1997-2005	2005-13	2013-18
Rangelands and uplands to dry agricultural lands	482.21	436	195	747
Rangelands and uplands to man-made land	30.17	11.84	12.36	24.79
Gardens to irrigated agricultural lands	54.49	37.9	7.37	52.7
Garden to man-made lands	5.31	6.7	1.6	8.49
Dry agricultural lands to irrigated lands	2.53	16.19	19.48	2.5
Dry agricultural lands to rangeland and uplands	78.31	137.9	362.8	33.79
Rangelands and uplands to irrigated agricultural lands	36.7	14.68	22	42
Irrigated agricultural lands to garden	28.32	3.75	0.9	4.85
Dry agricultural land to garden	1.25	-	-	-
Rangelands and uplands to garden	49	8.82	12.94	16.53
Irrigated agricultural land to dry land	21.12	33.76	41.36	34.77
Garden to dry agricultural land	16.69	19.48	-	29.4
Irrigated agricultural land to rangelands and uplands	10.34	37.49	53.51	31.77
Garden to rangelands and uplands	32.43	54.19	22.87	64.7
Dry agricultural land to rangeland and elevations	78.31	137.9	362.8	33.79
Dry agricultural lands to man-made lands	2.58	4.5	9.2	1
Irrigated agricultural lands to man-made lands	1.6	4.9	2.77	3.95

These changes are considered significant with respect to the maintenance of the balance in groundwater resources since arid lands result in intruding surface water and recharging groundwater resources due to high permeability. However, agricultural and man-made uses have a high tendency for consuming groundwater resources, along with preventing water intrusion. As shown in Table 4, the maximum and minimum groundwater depth in the Hamedan-Bahar Plain was determined as 40.4 and 2.4, respectively. Additionally, an increase in the maximum depth during the last decades represents a decrease in groundwater reserves. Based on the results, mean groundwater depth increased during 1989-2018 and the general trend of groundwater depth indicated the constant reduction of water reserves. Further, the difference between mean depths in the Hamedan-Bahar Plain was obtained as 29.6 in the time span.

Table 4. Trends related to the changes in minimum, maximum, and mean groundwater depth (m) in the studied years

Year	Minimum	Maximum
1989	2.4	40.4
1997	2.7	38.86
2005	1.86	54.95
2013	3.3	75.7
2018	2.5	70

Source: Hamedan Regional Water Company (2019)

Figure 6 displays the spatial variations of groundwater levels. As shown, the values of groundwater level more than 2300 m are related to the high slopes such as mountains and rough terrain although the role of groundwater is insignificant. In addition, the result of Regional Water Company data on groundwater level from piezometric observation wells in the whole area was obtained by interpolating kriging in GIS software. Further, changes were more evident in the flatbed of the plain with groundwater level lower than 1800 m and important habitats and irrigated agricultural lands.

As already mentioned, the REGRESS method assesses the linear regression between dependent and independent variables. The model provides a regression equation and a correlation coefficient. In this regard, land use changes and groundwater depth were respectively considered as independent and dependent variables in the present study. Further, the values of their correlation are provided in Table 5 and Figure 7, by indicating the higher values in the Hamedan-Bahar Plain during 2013-2018 compared to other years.

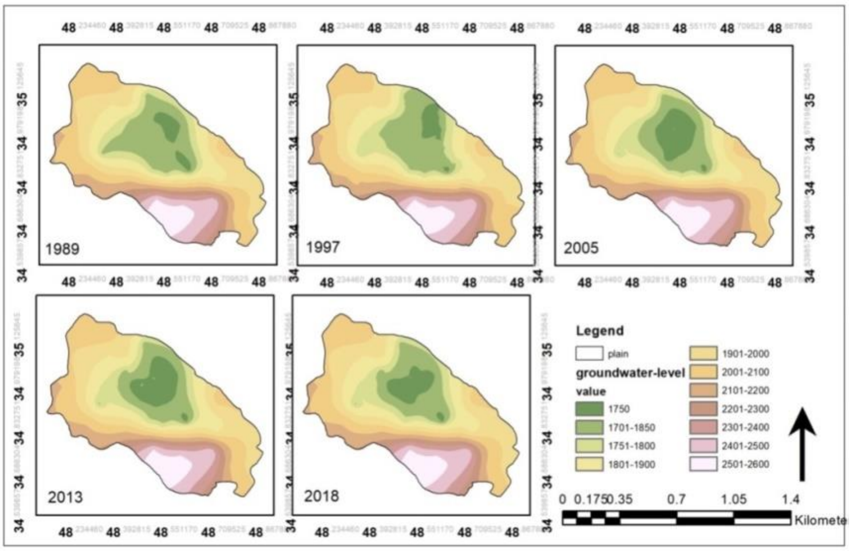

Fig. 6- Groundwater depth maps in the study period

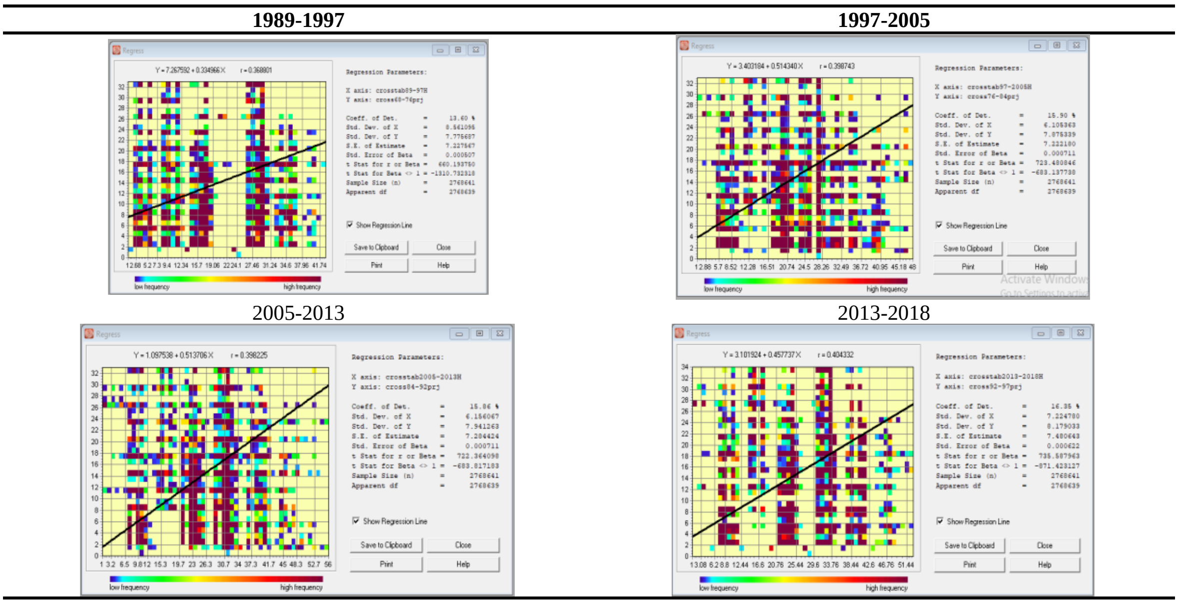

Fig. 7- Relationship between land use change and groundwater depth in Hamedan-Bahar basin during the study period

The results of the regression analysis demonstrated a relative intensity regarding the correlation between land use changes and a decrease in groundwater level during the time spans (Table 5). Additionally, the value of regression in the years of 1989-1997, 1997-2005, 2005-2013, and 2013-2018 were respectively obtained as 13.6, 15.9, 15.86, and 16.35, by representing a linear trend with relative growth for the effect of land use changes on the groundwater level. Further, converting rangelands and gardens to irrigated, dry agricultural and man-made lands was the general trend of changing land use, which constantly occurs in all time spans except 2005-2013. In addition, the value of regression was less than that of its next and prior timespans. Then, the correlation between groundwater level and land use was measured in a general time span for specifying and understanding the situation.

As shown in Figure 7, the correlation between land use and underground water changes was 0.40 during 1989-2018. Based on the results of the regression test, a relative increase was observed in the intended correlation in both periods compared to the previous one due to the periodic enhancement in manipulating nature by humans. In addition, the correlation was determined as 0.4 during a 29-year period and almost 16.2% of the variations in groundwater level can be explained by land use changes.

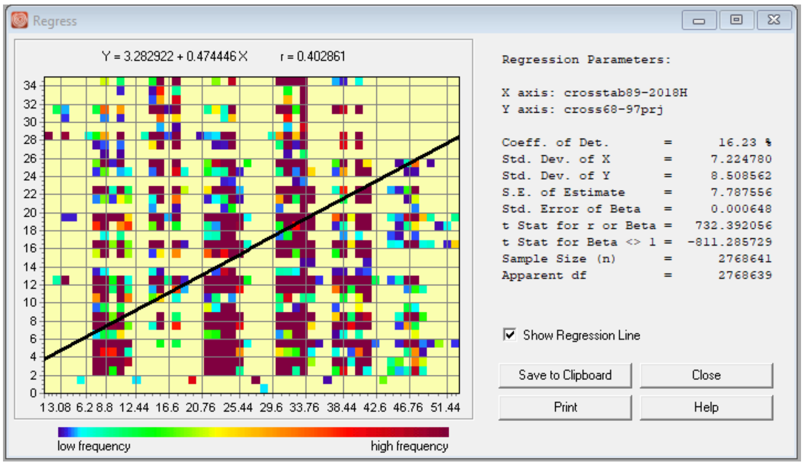

Fig. 8- Relationship between land use and groundwater depth changes in Hamedan-Bahar Plain during 1989-2018 based on the REGRESS method

Based on the results, a direct relationship was observed between groundwater changes and land use, which was increased in each time span compared to the previous one. In addition, the share of irrigated agricultural lands in the whole region improved from 5.3% (132.68 ha) to 6.25% (155.78 ha) during 1989-2018. However, the quantitative expansion of irrigated agricultural lands cannot be the main reason in this regard. Based on the land use change model, extending dry agricultural lands, which often become rangelands, was regarded as an important reason for changing land use, the share of which was enhanced from 9.68% in 1989 to 40.85% in 2018.

Considering the results of the study during a 29-year period, approximately 16.2% of varying groundwater levels in the study area can be explained by land use changes. Further, the maximum effect was obtained during 2013-2018, the result of which indicated a 16.35% decrease in groundwater level due to land use changes. During the study period, the area of irrigated agricultural lands represented a 1.5-fold increase from 106 ha (4.2%) to 155.78ha (6.25%).

The above-mentioned changes such as reducing rangelands and gardens, enhancing dry agricultural lands, and extending irrigated agricultural and man-made lands resulted in relating 16.3% of the 29.6 m decrease in groundwater level in the Hamedan-Bahar Plain to land use changes.

Other factors such as the agricultural economy of the region and the dependency of people on agriculture, especially cultivating high-water crops such as potatoes and watermelons, should be highlighted (Rouhani *et al.*, 2007; Ghasemi-Nejad Raeini and Marofi, 2011). Reducing the groundwater level in the studied plain led to negative impacts such as decreasing groundwater quality (Ghasemi *et al*, 2010) and endangering the economic future, especially in the agriculture sector (Seyedan *et al.*, 2017).

The results of the present study are in line with those of some other studies (e.g., Batelaan *et al.*, 2003; Yun *et al.*, 2011; Taghipour, 2012; Wagner *et al.*, 2013; Mishra *et al.*, 2014; Brauman *et al.*, 2015; Ghazavi and Ebrahimi, 2016; Verma *et al.*, 2019). The findings in the present study indicated that developing agricultural lands and man-made areas, and consequently, declining the rangelands are directly related to the decrease in groundwater depth. Therefore, remote sensing techniques and GIS, along with assessing spatio-temporal correlation, can facilitate and enhance managing and monitoring groundwater plans. This claim is supported by using remote sensing techniques and GIS, along with regression analysis-based statistical models.

Conclusion

The results can be used to select priority sites for land use and groundwater management since disregarding groundwater considerations in making decisions about land use change and managing land generally can lead to long-term consequences and costs based on drinking water security and sustainability of aquatic ecosystems, occupational safety of residents, widespread migration and national security in the forbidden plains. In contrast, the managerial measures regarding the relationship between land and groundwater uses can provide more benefits to groundwater resources at a relatively proportional cost in the area and prevent these issues, especially public dissatisfaction and security issues.

Based on the results, the following suggestions can be made.

- Considering the scale, boundaries, and power of the plains and basins for the future management of land use planning due to water resources scarcity.
- Organizing and planning modern agriculture by emphasizing on lower water consumption.
- Arranging cultivation patterns and avoiding cultivating agroforestry crops such as potatoes and watermelons.
- Preventing rangeland destruction and their conversion to non-irrigated lands.

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فصلنامه علوم محیطی، دوره نوزدهم، شماره ۱، بهار ۱۴۰۰

۲۵۹-۲۷۶

بررسی همبستگی فضایی زمانی میان تغییرات کاربری زمین‌ها و سطح آب زیرزمینی در دشت بهار همدان (ایران)

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تاریخ دریافت: ۱۳۹۹/۰۱/۳۰ تاریخ پذیرش: ۱۳۹۹/۰۶/۲۰

رفیعی مهر، ح. و ل. کوزه‌گر کالجی. ۱۴۰۰. بررسی همبستگی فضایی زمانی میان تغییرات کاربری زمین ها و سطح آب زیرزمینی در دشت بهار همدان (ایران). فصلنامه علوم محیطی. ۱۹(۱): ۲۵۹-۲۷۶.

سابقه و هدف: آب زیرزمینی به‌عنوان مهمترین منبع است، کاربری‌های گوناگون درمناطق خشک ونیمه خشک محسوب می‌شود. بنابراین ارزیابی اثرهای فعالیت‌های انسانی (به‌عنوان نمونه،تغییرات کاربری وپوشش زمین‌ها) برمنابع آب‌های زیرزمینی، نقش اساسی درمدیریت پایدار آب ودرنتیجه برنامه‌ریزی فضایی دارد. بنابراین نیاز به یکپارچه‌سازی برنامه‌ریزی کاربری زمین‌ها و مدیریت منابع آب به‌صورت گسترده‌ای مورد تأکید می‌باشد و درک ارتباط مکانی فضایی تغییرات کاربری زمین‌ها و منابع آب زیرزمینی، نقش حیاتی در مدیریت پایدار دشت‌های کشور دارد. این پژوهش با هدف بررسی ارتباط فضایی زمانی میان تغییرات کاربری زمین‌ها و منابع اب زیرزمینی در دشت همدان بهار انجام شده است.

مواد و روش‌ها: نقشه‌های کاربری زمین برای سال‌های ۱۹۸۹، ۱۹۹۷، ۲۰۰۵، ۲۰۱۳ و ۲۰۱۸ از تصویرهای ماهواره‌ای لندست استخراج و طبقه‌بندی شد و سپس مورد ارزیابی صحت قرار گرفت. شش کاربری، شامل زمین‌های کشاورزی آبی، دیمی، مرتع‌ها و ارتفاعات، زمین‌های انسان ساخت، منابع آب سطحی و باغ‌ها، استخراج و طبقه‌بندی شدند. همچنین نقشه‌های پراکنش عمق آب زیرزمینی با روش کریجینگ برای پنج سال از داده‌های پیزومتری تهیه شد. همبستگی و ارتباط بین تغییرات کاربری زمین و نوسانات عمق آب زیرزمینی توسط روش REGRESS صورت پذیرفت.

نتایج و بحث: نتایج نقشه‌های کاربری زمین‌ها نشانگر کاهش سهم زمین‌های مرتعی و ارتفاعات وتبدیل به زمین‌های دیمی می‌باشد به گونه‌ای که سهم این زمین‌ها از ۹/۶۸ درصد در سال ۱۹۸۹ به ۴۰/۸۵ درصد در سال ۲۰۱۸ رسیده است. سهم باغ‌ها کم وسهم زمین‌های انسان ساخت از ۱/۲۷ درصد در سال ۱۹۸۹ به ۲/۴۵ درصد در سال ۲۰۱۸ رسیده است. سهم زمین‌های کشاورزی آبی از ۵/۳۲ درصد در سال ۱۹۸۹ به ۶/۲۵ درصد در سال ۲۰۱۸ رسیده است. روند تغییرات تراز آب زیرزمینی نیز در بستر هموار دشت مورد مطالعه که کمابیش تراز آب در آن‌ها کمتر ۱۸۰۰ متر بوده است و نقاط سکونتگاهی مهم و زمین‌های کشاورزی آبی نیز در آن‌ها هستند، بیشتر نمایان می‌باشد. میانگین سالانه بلندمدت افت سطح آب زیرزمینی برای دوره ۲۹ ساله، ۰/۹۱ می‌باشد. براساس روش رگرسیون، مقدار R برای پنج دوره

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http://dx.doi.org/10.52547/envs.29307

مطالعاتی، حداقل ۰/۳۶ و حداکثر ۰/۴۰ به‌دست آمد. در کنار ارتباط نسبی تغییرات سطح آب زیرزمینی و کاربری زمین‌ها، نقش عامل‌های مدیریتی نیز باید مد نظر قرار گیرد. به‌گونه‌ای که همبستگی میان کاهش تغییرات سطح آب زیرمینی و کاربری زمین‌ها در هر دوره نسبت به دوره قبل خود افزایش نسبی داشته است. مقدار R بین تغییرات سطح آب زیرزمینی وکاربری زمین‌ها برای سال‌های ۱۳۶۸ تا ۱۳۸۹ ۰/۴۰ به‌دست آمد که براساس آن، ۰/۱۶ درصد ازتغییرات این دو متغیر در ارتباط باهم قابل تبیین می‌باشد. به‌دلیل کمبود منابع آب؛ برنامه‌ریزی کاربری زمین‌ها برای آینده باید در ارتباط با مقیاس، توان و محدوده دشت‌ها و حوضه‌های آبخیز انجام گیرد تا بتوان به سیستم پایدار آب منطقه‌ای دست یافت.

نتیجه‌گیری: نتایج تحقیق حاضر می‌تواند نقش مهمی در درک اهمیت منابع آب زیرزمینی در مناطق خشک و نیمه خشک داشته باشد و بر لزوم توجه بیشتر بر تأثیرهای کاربری زمین‌ها و تغییرات آن بر آب‌های زیرزمینی در این مناطق تأکید کند. این امر درکنارتوجه به دیگر عامل‌های مدیریتی می‌تواند منجر به توسعه پایدار در مقیاس دشت‌ها و حوضه‌های آبخیز شود.

واژه‌های کلیدی: کاربری زمین‌ها، آب زیرزمینی، دشت همدان بهار،REGRESS.