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Armed conflict and land-use changes: Insights from Iraq-Iran war in Zagros forests

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ABSTRACT

The role of armed conflicts on land use/cover changes (LUCC), especially in Zagros forests of Iran, remains ambiguous after 30 years of the Iraq-Iran war. Our goal in this study was to assess LUCC in Sardasht related to the Iraq-Iran war in a 22 year period (1976–1998). LUCC of Sardasht city was evaluated using Landsat satellite image time series of MSS and TM data. We classified multi-temporal Landsat imagery using Random Forest classifier, then Land Change Modeler (LCM) was used to change detection and analysis. Change detection results showed that during 1976–1998, 5363.37 ha of forest areas were declined and converted to the croplands, rangelands and built-up areas. The highest decrease of forest areas was in periods of before (1976–1984) and after the war (1988–1993 and 1993–1998), 1331, 1734, and 2066 ha, respectively. While, during the war (1984–1988), only 54 ha decrease has taken place in forest lands of Sardasht. Also, increasing in other land uses during this period was significantly less than other periods. Calculation of annual rate of deforestation showed that the period of 1993–1998, has the highest rate of degradation in forest areas with a rate of −0.45%. While, during and before the war, it was −0.01% and − 0.20%, respectively. With the start of the war, residents of the region migrated to safe areas. The result of this migration was reducing forest conversion to other land uses. Trends in deforestation and forest degradation intensified after the end of the war. The causes of this destruction were destroying regulatory and control infrastructure on forests and natural resources in addition to the return of the inhabitants and an increase in demand for food and agricultural development. Moreover, after the war, the attention of the government was towards supplying the needs of human societies. Therefore, not enough attention was paid to monitoring and controlling over the degradation of natural resources. It is therefore necessary to reduce residents' dependence on natural resources through accurate and detailed planning and to increase their participation in forest conservation. In this regard, conservation programs should be continued strongly.

1. Introduction

Awareness of land use/cover patterns in a region is a necessary prerequisites for the planning and implementation of effective land use/cover policies and sustainable regional development plans (Andersen et al., 2017; Van Khuc et al., 2018). Land cover is defined by the attributes of the earth's land surface and subsurface, including natural vegetation cover (like forests and rangelands), soil, water resources (surface and groundwater), croplands, and human structures (Lambin et al., 2003). Land use also refers to human economic and social activities on the earth surface. Land use and land cover are related to each other and we must consider both of them together (Campbell and Wynne, 2011).

Several factors cause land use/cover changes (LUCC) with different rates and scales including: biophysical factors, technological and economic changes, and organizational and political activities (Geist and Lambin, 2002; Groeneveld et al., 2003). Moreover, climate change and disturbances could exceed the ecological resilience of vegetation cover, resulting in a loss of forest cover and shifts to non-vegetative ecosystems (Seidl et al., 2016; Sohngen and Tian, 2016). Such effects could increase the existing pressure on people's livelihood and food security urging expansion of current croplands by forest clearing (Bele et al.,

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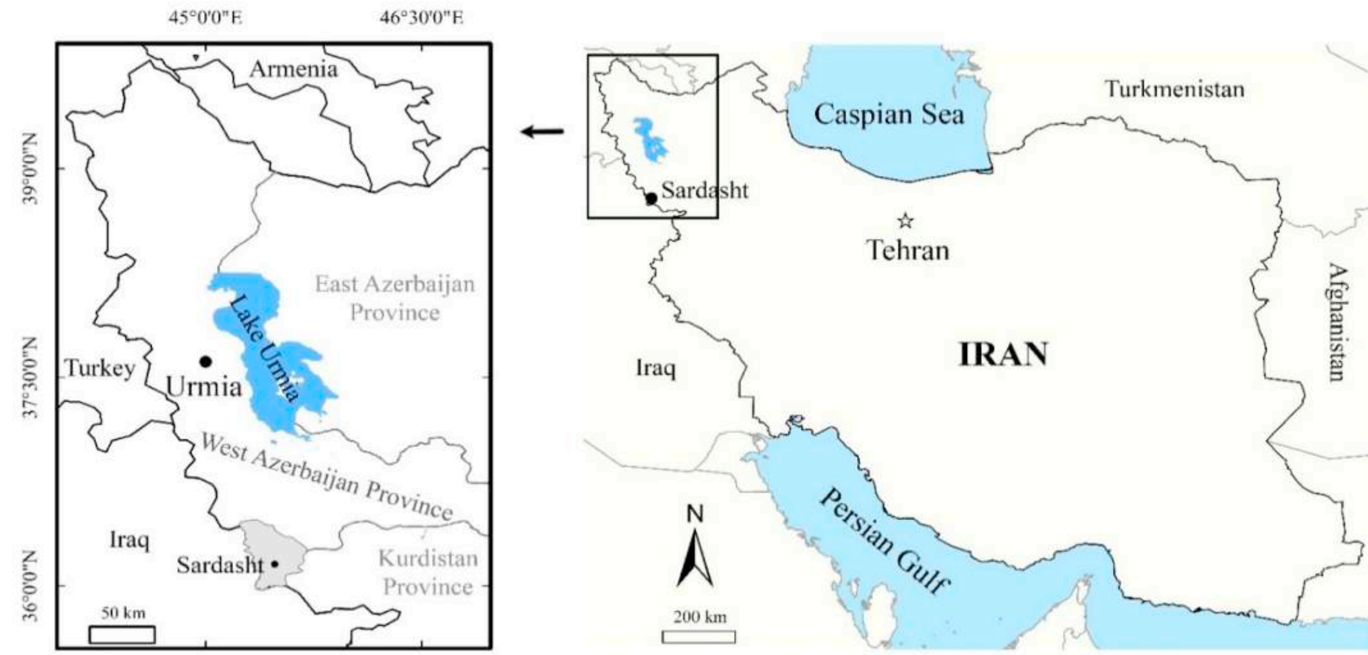


Fig. 1. Geographical location of Sardasht city.

2015). Sudden and rapid changes that take place by warfare and armed conflicts can be added to these factors (Baumann and Kuemmerle, 2016; Baumann et al., 2015). However, less attention has been paid to how warfare can affect the environment (Ordway, 2015).

Over the past decades, 80% of armed conflicts and wars have occurred directly in forest areas with high biodiversity (Hanson et al., 2009; Ordway, 2015) and has been led to an increase in the rate of deforestation (Baumann and Kuemmerle, 2016; Gbanie et al., 2018; Gorsevski et al., 2012; Köthke et al., 2013). However, there is also some case studies that show armed conflicts contributed to forest recovery and expansion due to displacement of people through immigration from unsafe areas, depending on the nature and location of combat zone (Ordway, 2015; Stevens et al., 2011). In fact, unsafe conditions can lead to migration and decreasing the destruction activities. Other studies have also shown that after fighting ends due to refugees return (Ware, 2005), population resettlement, croplands expansion (Stevens et al., 2011) and reconstruction and new built-up areas (Xiao et al., 2006) have led to an increase in deforestation activities.

Evaluating the changes of spatial and temporal patterns of land use/cover by satellite imagery provides great opportunity to discover causes, effects and consequences of changes compared to the patterns related to direct and indirect human activities for scientific community (Cardille and Foley, 2003). In this regard, the spectral data of multiple sensors of Landsat is often used to land use/cover classification in regional scales (Judex et al., 2006; Lu and Weng, 2007) due to Landsat's long archive and being free of charge (Manandhar et al., 2009). Using Landsat satellite image time series can be considered for change monitoring caused by armed conflicts and warfare in a long-term period.

Iranian Zagros forests covers 11 provinces of Iran with a total area of 4,749,000 ha (20% of total forests in Iran) (Roozitalab et al., 2018), considered as a key strategic area for many economic and political reasons and play a critical role for improving climate condition, water supply, economic and social balance of the region. Zagros forests are divided in three classes due to differences mostly between climate and species: 1) northern Zagros, 2) central Zagros, and 3) southern Zagros. Sardasht city is located in northern Zagros with 91,117 ha forest area which estimated Iranian Forests, Range and Watershed Management Organization (FRWO). Unfavorable political, economic and social conditions in this forest area have caused rural population resident in or near forest land to meet their livelihood needs strongly depend on forest resources, which have led to the more degradation of forest areas (Henareh Khalyani et al., 2012; Henareh Khalyani et al., 2013).

During the Iraq-Iran war (1980–1988), this region was affected by the destructive effects of war like the other parts of Zagros in the West of Iran. As a case, four crowded parts of Sardasht city has been attacked with seven 250-kilograms of Sulfur Mustard bombs on June 28, 1987, which 4500 people exposed to mustard gas in the target (Malekari et al., 2013), and caused many human and environmental incidents and migration of Sardasht people to other areas (Ghasemi et al., 2008; Pourfarzam et al., 2009).

After four decades from Iraq-Iran war, no research has been done so far on the evaluation of effects of war on LUCC in Zagros forests. This war has always been considered as an influential factor in the psychological and social dimension of human beings during, in the short term and afterwards of it. In the years of the occurrence of war and then, attention to natural resources and the need for protection of it reduced inevitably, especially in the boundaries regions, due to the government's involvement with the issues and consequences of the war and standing other important issues in the priorities, Therefore, it seems that this issue has led to changes in land use/cover and vegetation, along with the direct and indirect effects of war on forests and natural resources in and around the combat zones. As a result, it is essential to understand the direct and indirect effects of armed conflicts on ecosystems (Stevens et al., 2011; Sutherland et al., 2009). Therefore, the main goal of this study is evaluating LUCC of Sardasht city before (1976–1984), during (1984–1988) and after (1988–1993 and 1993–1998) Iraq-Iran war. Specifically, we attempt to answer three research questions:

1. How was the extent of changes in land use/cover precipitated by the Iraq-Iran war in Sardasht city?
2. Did the war affect population changes and people's migration?
3. Whether land use/cover changes before and after the war were the same?

2. Methods

2.1. Study area

Our study area was the landscape surrounding Sardasht city located in southwestern of West Azerbaijan Province in Iran, between 45°13′48″ to 45°42′00″ E longitude and 35°57′36″ to 36°28′12′′ N latitude, with a total area of 138,183 ha (3.8% of the province) in a height range of 591 to 2683 m above sea level (Fig. 1). The average annual precipitation of region is 724 mm that winter and summer are the seasons of the most and least annual rainfall, respectively. Wet season in the study area is typically considered to begin in the latter part of October until late April (includes October, November, December, January, February, March and April), and dry season usually begins from late May and continues until late September (Beygi Heidarlou et al., 2015). The average maximum and minimum temperature of Sardasht are 21 °C and 6 °C. Based on last population census of Iran in 2016, the population of this city was 118,849 residents (Beygi Heidarlou et al., 2019).

2.2. Selecting time periods

We selected five-time points (1976, 1984, 1988, 1993 and 1998) for LUCC detection analysis based on accessibility to Landsat satellite imagery and chemical bombardment of Sardasht and three surrounding cities between 1984 and 1988 (i.e., Piranshahr, Mahabad and Baneh). Piranshahr and Baneh were bombed in 1984 and Mahabad were bombed in 1986. Subsequently, to identify the effects of Iraq-Iran war on land use/cover of Sardasht, four different time periods including: 1976–1984, in order to change detection before the war, 1984–1988, to change detection during the war; and 1988–1993 and 1993–1998, which captured post-war short-term and medium-term of LUCC.

2.3. Image classification

Pre-classification (analysis of transformed images from two different times without image classification) and post-classification (the analysis of thematic classifications from two different time images) methods are the two main approaches for change detection analysis (Peiman, 2011; Yuan et al., 2005). The most commonly techniques used in pre-classification method include some vegetation indices (e.g., NDVI, NDWI, and MNDWI), change vector analysis (CVA), principal component analysis (PCA), band combination (BC), and principal-component transformation (PCT), etc. (Haque and Basak, 2017). On the other hand, post-classification technique is the most widely used one for change detection analysis based on thematic satellite image classification acquired in different times (Jensen and Lulla, 2005). This technique evaluates the change in land use/cover based on a detail categorized classification of land use/cover, and it includes aerial difference calculation, image differencing, image rationing, image regression, etc., (Haque and Basak, 2017).

In this study, for the post-classification method, due to the long archive of Landsat images and their spectral and spatial resolution are well suited for mapping land use/cover (Baumann et al., 2015; Irons et al., 2012), we used multi-temporal Landsat imagery (Ioannis and Meliadis, 2011) for mapping land use/cover based on seasonal coverage and cloud cover (Baumann et al., 2015; Vittek et al., 2014) (Table 1). The only cloud-free and usable image data for the region in 1976, available on July 23th this year.

For the time points Sardasht images, four land-use classes were generated: (1) forest (canopy more than 5%, according to definition of FRWO), (2) croplands, (3) rangelands and (4) built-up areas. For each of these classes, we collected training data (Eastman, 2006) using field visit and visually interpreting of Landsat images for 2017 (Song et al., 2015; Svatonova, 2016) and studied time periods images (Baumann et al., 2015). Then land use/cover attribution of each point confirmed using high-resolution imagery in Google Earth whenever possible, and used to classify Landsat imagery using a nonparametric random forests classifier (Foerster et al., 2016; van der Linden et al., 2015; Waske et al., 2012). Also, we applied majority filter to eliminate single pixels, which indicates an inappropriate classification (Farhadifard et al., 2017).

Table 1
Details of used imagery for the study area.

Year	Data type	Sensor	Path/Row	Acquisition date	Season
1976	Landsat 2	Multispectral Scanner (MSS)	168/35	23 Jul	dry
1984	Landsat 5	Thematic Mapper (TM)	168/35	24 Jun 27 Aug	dry dry
1988	Landsat 4 and 5	Thematic Mapper (TM)	168/35	10 May 22 Aug	dry dry
1993	Landsat 5	Thematic Mapper (TM)	168/35	16 May 19 Jul	dry dry
1998	Landsat 5	Thematic Mapper (TM)	168/35	15 May 19 Sep	dry dry

2.4. Estimating thematic accuracy of land use/cover maps

The thematic accuracies of the land use/cover maps calculated using confusion matrices (Card, 1982; Olofsson et al., 2013; Tsendbazar et al., 2016). It was conducted based on a stratified random sampling of 40 points for each class. Also, using Google Earth imagery land use/cover of each point by interpreting the Landsat images were checked (Baumann et al., 2012). In the accuracy assessment, we built confusion matrices from sample counts by accounting for the class proportions of the land use/cover maps (Card, 1982). The area-weighted accuracy assessment (overall accuracy) and class-specific accuracies were derived using the method described by Olofsson et al. (2013). The variance and confidence level of the accuracies were calculated using the equations for stratified random sampling based on a 95% confidence interval (Card, 1982; Olofsson et al., 2013).

2.5. Change detection

For change detection and analysis of land-use in Sardasht during time periods, TerrSet Land Change Modeler (LCM) (Eastman, 2015; Eastman and Toledano, 2018) was used, which is an empirically parameterized land change projection tool developed to support a wide range of planning activities. The LCM is a tool for assessing and designing land cover changes and analyzing land use (Eastman et al., 2005; Gontier et al., 2010). This model is capable to extract LUCC at different time periods and scenarios by combining biological, physical and socio-economic factors which affect the land-use changes (Beygi Heidarlou et al., 2019; Liu et al., 2017). Land use/cover maps for 1976 with 1984, 1984 with 1988, 1988 with 1993, and 1993 with 1998 were used for change analysis before, during and after the war. Gains, losses and net changes for each class and transition from one class to other type of classes in study area in studied time periods detected and analyzed (Eastman, 2015).

2.6. Annual rate of change

Rate of changes for each time periods (e.g., before, during and after the war) were calculated using the formula below:

$$dn = [S_2/S_1]^{\frac{1}{n}} - 1$$

Where dn is annual rate of change, S_1 and S_2 are land cover in time

Table 2
Confusion matrices of the land use/cover maps for 1976, 1984, 1988, 1993 and 1998. Accuracy measures are presented with a 95% confidence interval. Land cover class 1 is forest, 2 is croplands, 3 is built-up areas and 4 is rangelands.

1976		Reference classes				Total	User's	Producer's	Overall
		1	2	3	4				
Map classes	1	39	2	0	6	47	0.83 ± 0.08	0.99 ± 0.01	0.83 ± 0.08
	2	0	33	1	2	36	0.92 ± 0.05	0.48 ± 0.13	
	3	0	1	39	0	40	0.98 ± 0.02	0.54 ± 0.11	
	4	1	4	0	32	37	0.86 ± 0.07	0.69 ± 0.06	
Total		40	40	40	40	160			
1984		Reference classes				Total	User's	Producer's	Overall
		1	2	3	4				
Map classes	1	37	2	0	2	41	0.90 ± 0.02	0.99 ± 0.02	0.90 ± 0.04
	2	1	37	2	1	41	0.90 ± 0.03	0.57 ± 0.15	
	3	1	0	38	0	39	0.97 ± 0.01	0.46 ± 0.21	
	4	1	1	0	37	39	0.95 ± 0.02	0.87 ± 0.06	
Total		40	40	40	40	160			
1988		Reference classes				Total	User's	Producer's	Overall
		1	2	3	4				
Map classes	1	35	1	0	3	39	0.90 ± 0.03	0.98 ± 0.01	0.88 ± 0.04
	2	2	36	1	1	40	0.90 ± 0.03	0.64 ± 0.13	
	3	1	1	39	2	43	0.91 ± 0.01	0.61 ± 0.11	
	4	2	2	0	34	38	0.89 ± 0.05	0.80 ± 0.07	
Total		40	40	40	40	160			
1993		Reference classes				Total	User's	Producer's	Overall
		1	2	3	4				
Map classes	1	34	1	0	5	40	0.85 ± 0.05	0.96 ± 0.01	0.84 ± 0.07
	2	3	35	2	3	43	0.81 ± 0.07	0.62 ± 0.16	
	3	0	2	38	1	41	0.93 ± 0.03	0.53 ± 0.23	
	4	3	2	0	31	36	0.86 ± 0.05	0.70 ± 0.11	
Total		40	40	40	40	160			
1998		Reference classes				Total	User's	Producer's	Overall
		1	2	3	4				
Map classes	1	34	1	0	2	37	0.92 ± 0.03	0.97 ± 0.01	0.88 ± 0.05
	2	2	36	2	2	42	0.86 ± 0.06	0.63 ± 0.20	
	3	1	0	38	1	40	0.95 ± 0.03	0.57 ± 0.25	
	4	3	3	0	35	41	0.85 ± 0.06	0.85 ± 0.07	
Total		40	40	40	40	160			

period one and two, respectively, and n is number of years between time periods (Ellis and Porter-Bolland, 2008).

2.7. Demographic changes

In order to investigate the relationship between demographic changes and LUCC in Sardasht, the demographic information of Sardasht for years 1976, 1984, 1988, 1993 and 1998 besides migration statistics regarding to 1986–1996 were obtained from Statistical Center of Iran (SCI). We used AAGR (Average Annual Growth Rate) and population of Iran census years (i.e., 1976, 1986, 1996 and 2006) to estimate population for the studied years using the following equation:

$$r = \sqrt[n]{\frac{P_n}{P_o}} - 1$$

Where AAGR rate of population is r, population at the end and the beginning of the period are P_n and P_o, respectively, and number of years between the two time periods is n.

3. Results

3.1. Thematic accuracy assessments of the land use/cover maps

The confusion matrices of the land use/cover maps are provided in Table 2. The results shows that each of the five land use/cover maps were in general highly accurate. The 1984 land use/cover map had the highest overall accuracy (0.90 ± 0.04) with a 95% confident interval, followed by the 1988, 1998, 1993 and 1976 land use/cover maps.

3.2. Change analysis

Spatial pattern and the total surface of land use classes in Sardasht for 1976, 1984, 1988, 1993 and 1998 are presented in Figs. 2 and 3. During the entire study period (1976–1998), forest areas decreased by 5363.37 ha. Also, additions to croplands, built-up areas and rangelands were 2124.27, 395.01 and 2766.87 ha, respectively.

Due to presented results in Table 3, forest areas decreased by

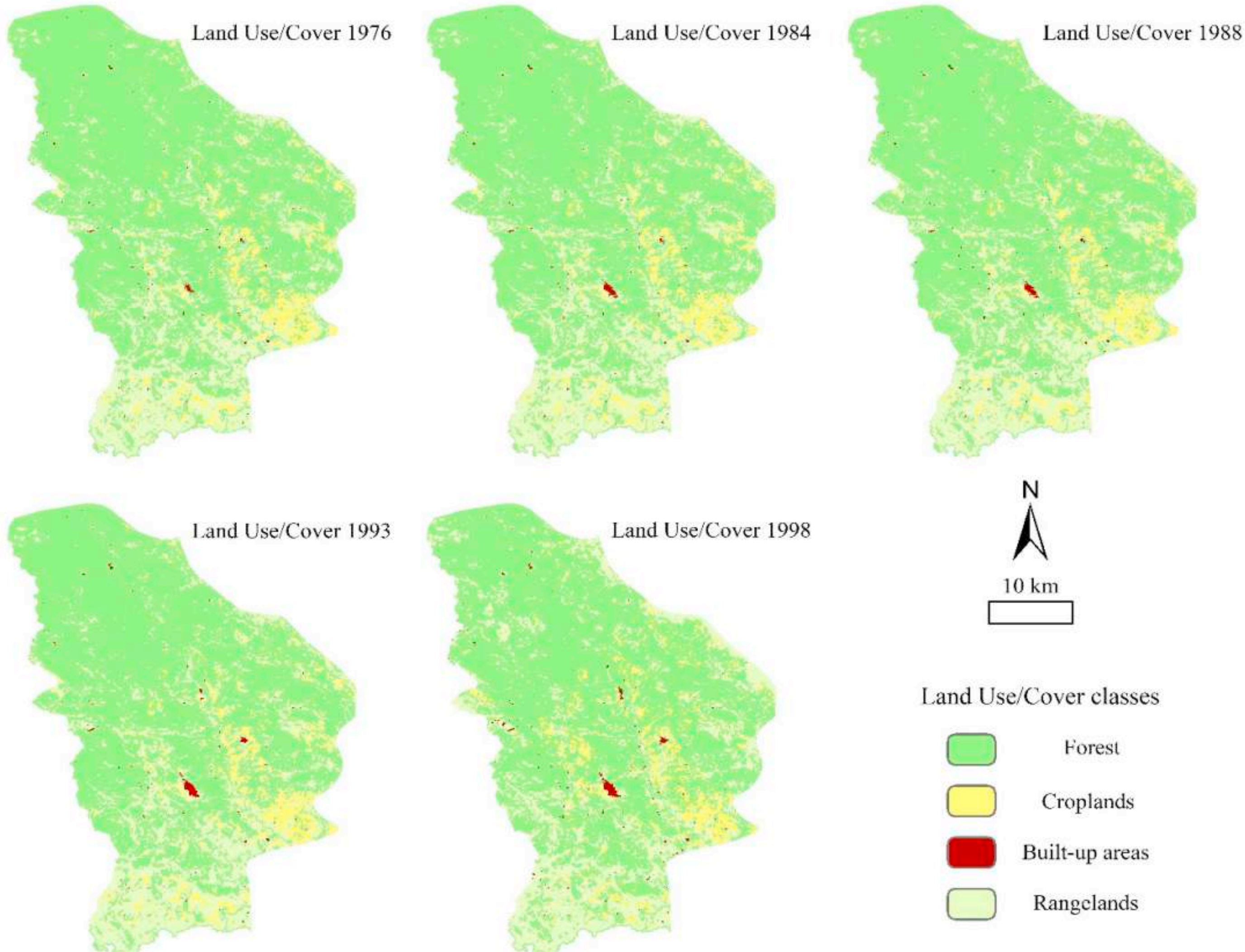


Fig. 2. Land Use/Cover maps of Sardasht city in studied years.

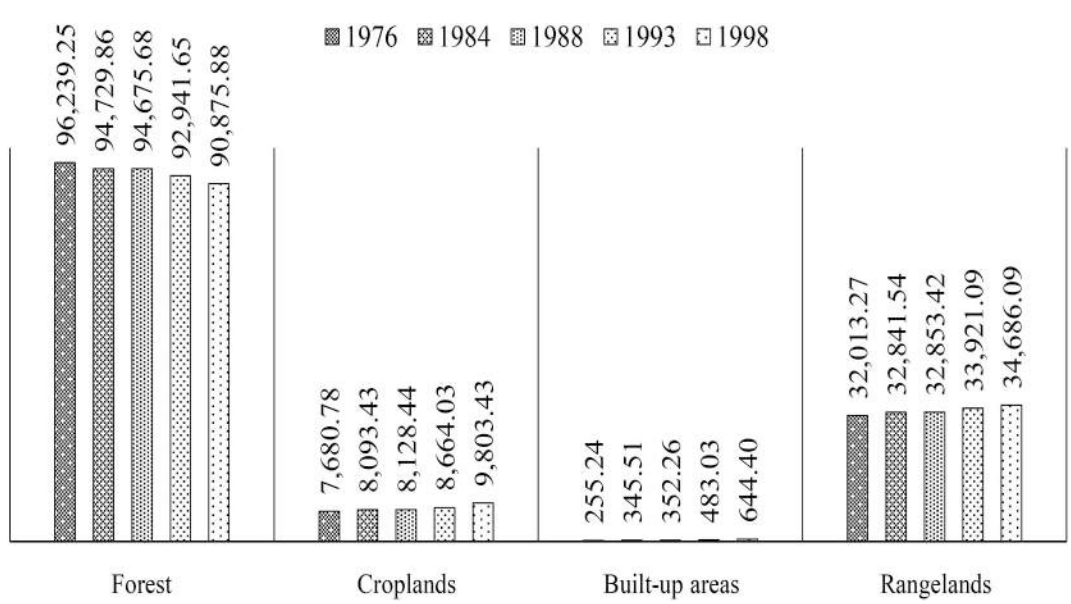


Fig. 3. Respective extents of land-use classes by hectare in Sardasht city.

Table 3
Losses, Gains and Net changes of each land-use types before, during and after Iraq-Iran war in Sardasht city.

Land use class	Pre-war (1976–84)					
	Losses		Gains		Net changes	
	Hectare	Change %	Hectare	Change %	Hectare	Change %
Forest	−1331	−1.39	0	0.00	−1331	−1.38
Croplands	0	0.00	413	5.10	413	5.1
Built-up areas	0	0.00	90	26.13	90	26.13
Rangelands	0	0.00	828	2.52	828	2.52
Land use class	**During the war (1984–88)**					
	Losses		Gains		Net changes	
	Hectare	Change %	Hectare	Change %	Hectare	Change %
Forest	−54	−0.06	0	0.00	−54	−0.06
Croplands	0	0.00	35	0.44	35	0.44
Built-up areas	0	0.00	7	1.92	7	1.92
Rangelands	0	0.00	12	0.04	12	0.04
Land use class	**Post-war (1988–93)**					
	Losses		Gains		Net changes	
	Hectare	Change %	Hectare	Change %	Hectare	Change %
Forest	−1734	−1.83	0	0.00	−1734	−1.87
Croplands	0	0.00	536	6.18	536	6.18
Built-up areas	−10	−2.86	141	29.16	131	27.07
Rangelands	0	0.00	1068	3.15	1068	3.15
Land use class	**Post-war (1993–98)**					
	Losses		Gains		Net changes	
	Hectare	Change %	Hectare	Change %	Hectare	Change %
Forest	−2343	−12.05	+277	10.05	−2066	−2.27
Croplands	−609	−35.04	1748	42.59	1139	11.62
Built-up areas	−3	−0.52	170	25.43	161	25.04
Rangelands	−120	−31.69	885	33.19	765	2.21

1734 ha (−1.75% change) in the first five years after the war (1988–1993). This reduction of forest cover in the second post-war period (1993–1998) despite an increase of 277 ha, continued to 2066 ha (−2.27% change). Decreasing in forest areas before the war (1967–1984) was 1331 ha (−1.38% change), while only 54 ha decrease (−0.06% change) occurred during the war (1984–1988) in Sardasht. During the first (1988–1993) and second (1993–1998) periods after the war, croplands was expanded by 536 ha (6.18% change) and 1139 ha (11.62% change), respectively. Also, at the same time periods expansion of built-up areas was 131 ha (27.07% change) and 161 ha (25.04% change), respectively. The highest increase in rangelands were also during 1988–1993 (1068 ha (3.15% change)).

Conversion from forest to croplands, 413, 35, 535 and 1748 ha, forest to rangelands, 828, 12, 1059 and 282 ha and forest to built-up areas, 90, 7, 141 and 35 ha were the major changes during 1976–1984, 1984–1988, 1988–1993 and 1993–1998, respectively (Fig. 4). Also, 603 ha of croplands converted to rangelands during 1993–1998. The highest transition from rangelands to built-up areas occurred in the same period (120 ha) (Table 4).

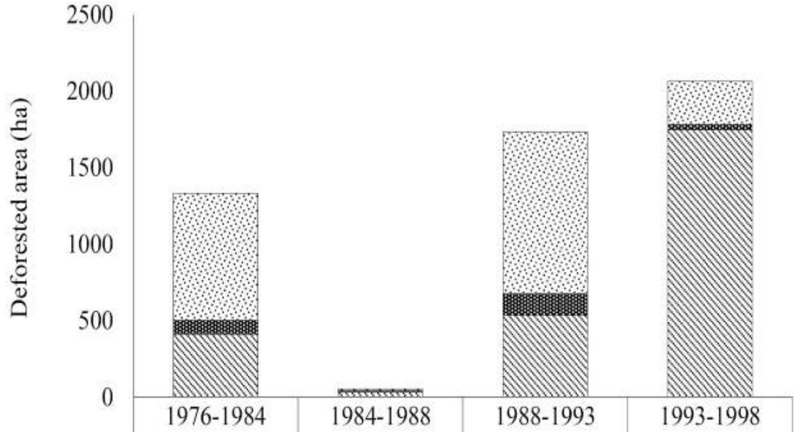
Our results show a high degradation of forest areas before (1976–1984) and after the war (1988–1993 and 1993–1998), with rates of −0.20%, −0.37% and − 0.45%, respectively, compared to during the war period (1984–1988), with rate of −0.01%. Development and expansion of other land uses during the war period also had a similar trend to degradation rate of forest areas, and changes rate of them in the pre-war and post-war periods was higher than during the war period (Fig. 5).

3.3. Population growth rate

Analysis of census information during 1976–1998 period indicated that population of Sardasht increased, from 54,338 in 1976 to 95,511 in 1998 (Fig. 6). Based on Fig. 6, the highest estimated AAGR (0.030%) was for of the pre-war period (1976–1984). It declined to 0.024% during the war (1984–1988), but increased to 0.028% after the war in the third period (1988–1993).

3.4. Distribution of immigrants based on their last residence

Between 1986 and 1996, 15,752 people entered the Sardasht or moved into the city. Based on census statistics of Iran (SCI) (Table 5), last previous residence of 17.25%, 9.37% and 4.91% of immigrants were other provinces of Iran, other cities in the province (West Azerbaijan) and abroad, respectively. While, last previous residence of 68.24% of immigrants was Sardasht that reflects returning of out-migrants to home (Sardasht) after ending the war.



	1976-1984	1984-1988	1988-1993	1993-1998
Forest to rangelands	828	12	1059	282
Forest to built-up areas	90	7	141	35
Forest to croplands	413	35	535	1748

Fig. 4. Conversion of forest to other land cover types in Sardasht before (1976–1984), during (1984–1988) and after (1988–1993 and 1993–1998) Iraq-Iran war.

4. Discussion

This study showed that armed conflict and warfare as one of the fastest drivers of changes, caused significant and drastic changes in land use/cover of Sardasht city. The obtained results from Fig. 3 and Table 3 showed that the degradation of forestlands significantly decreased during the war period and was lesser than pre-war and post-war periods. Other studies also showed the same effects of war. For instance Stevens et al., (2011) in exploring the effects of armed conflict on Nicaragua's Atlantic Coast showed that in the first 5–7 years of the conflict, reforestation was more than deforestation, but in the later years of the conflict due to the high density of migration and land reform, deforested areas almost doubled that which was reforested. The presented results in this research also indicate the high annual rate of deforestation before the warfare in Sardasht (−0.20%) (Fig. 5), which can be due to the modernization period (a set of development programs and actions) and social changes in Iran during 1972 to 1977 (Iman and Mohammad Pour, 2004). The process and modernization programs were officially started in the form of a set of social, political and cultural programs such as industrialization of the communities, compulsory settlement of nomads, and expansion of modern education since 1941 in Iran, which was also traditionally associated with the period of dependent capitalism and arrival of the elements and modernization processes to the Kurdish community of Sardasht that greatly affected their social, economic, cultural and political life and caused the transformation of the social and economic relations of the local communities of Sardasht, while at the same time also created comparative progresses at different levels of people's life. In that period, there was no reform in the agricultural sector, and farmers and local communities had minimal livelihoods, which could be one of the reasons for LUCC and forest loss and converting them to croplands, rangelands and built-up areas before

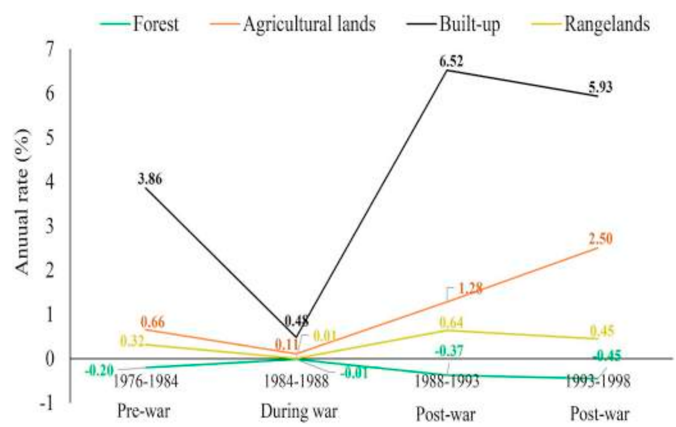


Fig. 5. Annual deforestation and expansion rates of other land-uses before, during and after Iraq-Iran war in Sardasht city.

the war in Sardasht. At this period, agriculture has been one of the important aspects of economic activity of societies (Iman and Mohammad Pour, 2004). It has always been assumed that the socio-economic conditions of the local people, especially food products and the state of food security and living adjacent to forest areas, will affect the conversion of forests to agricultural activities (Handavu et al., 2019; Bahadur, 2011). The establishment of some government institution and organizations such as municipality in 1950, using the first tractor in 1962, department of education in 1963, governorate in 1967, electrification in 1968, natural resources department in 1969, and the establishment of other departments, can be considered as the source of important developments that have been effective on qualitative and quantitative development of local communities of Sardasht and land

Table 4
Major changes between land-use types and their contributions to net changes (ha) before, during and after Iraq-Iran war in Sardasht city.

Transition between land-use types	Before the war	During the war	After the war	
	1976–1984	1984–1988	1988–1993	1993–1998
Agriculture to Built-up	0	0	0	6
Agriculture to Rangelands	0	0	0	603
Built-up to Agriculture	0	0	1	0
Built-up to Rangelands	0	0	9	0
Rangelands to Built-up	0	0	0	120

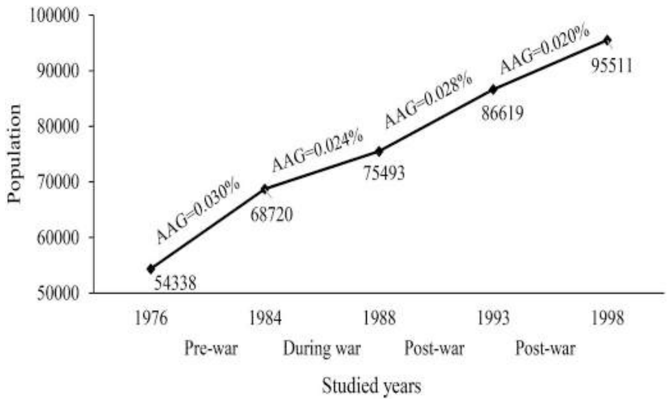


Fig. 6. Population statistics for the studied years in the Sardasht (AAG: Average Annual Growth).

Table 5
In-migration statistics during 10 years before the census 1996 based on their last previous residence (SCI, 1996).

Last previous residence		Residing in urban areas		Residing in rural areas		Total	Percent
		Male	Female	Male	Female		
Census place (Sardasht city)	City	0	0	652	576	1228	
	Village	2,393	2,281	2,421	2,426	9521	
	Total	2,393	2,281	3,073	3,002	10,749	68.24
Other cities in the province	City	496	375	299	154	1324	
	Village	22	18	61	51	152	
	Total	518	393	360	205	1476	9.37
Other cities from other provinces of Iran	City	1,064	191	1,168	90	2513	
	Village	41	17	111	36	205	
	Total	1,105	208	1,279	126	2718	17.25
Abroad		85	79	280	329	773	4.91
Not stated		9	5	5	17	36	0.23
Total		4,110	2,966	5,009	3,667	15,752	

transformations (Iman and Mohammad Pour, 2004) especially conversion of forests to other land use types like croplands.

Other processes that occurred before the war in Iran were the nationalization of rangelands and forests in 1962. The nationalization of rangelands for the Sardasht livestock community has led to the gradual destruction of the traditional livestock system and the limitation of grazing livestock and storage of forage for cold days of the year, and the livestock farmers, or even cowhands who have difficulty due to the limitation of breeding and grazing of livestock in rangelands due to the limitation of the state, and on the other hand, because of the region's mountainous nature, due to the lack of sufficient land for agriculture, they have turned to the destruction of the forests and cutting oak trees, and by this way they offset their lost economies. This is due to mismanagement subsequent to land nationalization, and natural resources allocation to urban and agricultural development in its modernization phase, which were inconsistent with the cultural norms and livestock production objectives of the indigenous people (Byakagaba et al., 2018; Msuya, 2015).

Rate of deforestation in Sardasht declined during the war to −0.01% (Fig. 5). Similar patterns have occurred during other wars, including in Nagorno-Karabakh conflicts (Baumann et al., 2015) and Bosnia-Herzegovina (Witmer, 2008; Witmer and O'Loughlin, 2009). People left or were pushed to leave the war-torn areas to protect their lives. The lack of security, immigration of people to safe areas, difficult access to other areas due to the mountainous area and the missing workforce all contribute to a decline in croplands expansion and forest degradation in Sardasht. As our results showed, this causal chain was also present in the case of Iraq-Iran war, where the people of Sardasht were forced to leave their hometown. Those who left the city during the war returned to their homeland after the ending of war, such that 68.24% of incoming immigrants to Sardasht previously lived in this city (Table 5). There is a significant relationship between population growth and forest loss (Malkamäki et al., 2016). Our findings are in agreement with a study by Ashraf et al. (2017). They noted that population changes, particularly population increase have a significant effect on the extent of forests. As other possibilities for farmers were limited, rural people continued forest clearing to increase their agricultural production and revenues (Beygi Heidarlou et al., 2019). This has been also proven with other evidence reported in the literature (Carr et al., 2005; Geist and Lambin, 2001; Bahadur, 2011). Baumann et al. (2015) in evaluating effects of Nagorno-Karabakh conflicts showed that socio-economic shocks and changes can lead to rapid changes in land use/cover, so that during 1988 to 1994, one million people were forced to migrate due to the heavy military activity of Azerbaijan and Armenia in that region, that one of the effects of this migration was non-development of agricultural lands due to their abandonment. Witmer and O'Loughlin (2009) and Witmer (2008) studies in the Bosnian and Herzegovinian war also obtained similar results and people were forced to leave their living area or to protect themselves. Eight years of Iraq-Iran war, air and artillery attacks led to financial and physical damages and a recession in the Sardasht livestock and farming sector (Iman and Mohammad Pour, 2004).

On the opposite side, Gibson and Campbell (2011) showed that croplands in Iraq changed after the war, and they encountered with a 20% increase as a result of imposing United Nations sanctions. Gbanie et al. (2018) also referred to the effect of the people's migration during the Sierra Leone war and showed that during the war agricultural activities were one of the most important problems of people to supply their foodstuffs. Also after the war, displaced people were reluctant to return to their primary residential areas, cause an increasing the demand for needed land for housing, and then protected forests decreased as well as other forests.

After the end of the war in 1988 and return of immigrant groups during the war to Sardasht (Table 5) and the need of the country to rebuild damaged areas by war and as a result of construction and development activities in the form of rural roads, electricity supply, water supply networks, establishment of rural schools and, most importantly, provide inexpensive agricultural machinery, have led to a major transformation in the socio-economic, agricultural, livestock, handicraft, transportation and education sectors in the country, especially in Sardasht (Agaei, 2007; Bagheri Dolatabadi and Ebrahimi, 2016). Deforestation rate in Sardasht after five (1988 to 1993) and ten (1993–1998) years of the war and continuation of the modernization process in Iran, increased to −0.37% and − 0.45%, respectively. During the first period after the war (1988–1993), 1059 ha and 535 ha of forests converted to rangelands and croplands (Fig. 4), respectively. Since the 1993, pressure on forests has increased considerably also owing to agricultural modernization and mechanization. In these time periods, overuse of machinery, intensive cropping and short crop rotations (Iman and Mohammad Pour, 2004) leads to more conversion of forests to croplands (1748 ha) versus conversion to rangelands (282 ha).

One of the main social consequences of war was the homelessness of people and stressful conditions due to the destruction of the cities and inhabitants of the people, which resulted in mass immigration from war regions (Vogel, 2007). The return of people to their homes and villages after the end of the war-affected economic activity and LUCC were initiated (Heidari et al., 2016). Imbalances in the social and biological environment have led people to the devastation of natural resources and forests blindly (Rimal, 2011). On the other hand, new technologies have changed the time and quality of agricultural operations and expanded the possibilities of agricultural mechanization, and because of the mountainous of the region and the economic weakness of the people in amends of a large part of post-war economic problems, cause to destroy the forestlands and converting them to croplands (2283 ha) during 1988 to 1998 (Fig. 4). Heilongjiang's experience also showed that the basic proximate cause of deforestation is cropland expansion (Shi et al., 2016). In the other study, Shi et al. (2017) found that built-up areas increased along with cropland expansion in the case of northeast China. Land-use change can be affected by development programs in a region and affect land sustainability in the long-term (Xie et al., 2007).

5. Conclusion

Warfare and armed conflicts are a large form of socio-economic shocks. With the onset of the war and increasing bombardment and conflicts in Sardasht, the residents of the area migrated to safer places (Iman and Mohammad Pour, 2004). This migration could be considered to be a cause to reduce the conversion of forest lands to other land uses during the war. After the end of the war and return of residents to Sardasht, the process of destruction of forest lands intensified. One of the possible reasons for this devastation after the end of the war, in addition to the return of the inhabitants and the increased demand for food and agricultural development, could be the destruction of the regulatory infrastructure and control over forests and natural resources during the war. Also, the government's attention was to provide housing facilities and to meet the demands of human societies, therefore, and forcefully did not pay enough attention to monitoring and control over the destruction of natural resources. Other studies also showed that the destruction process has not been reduced and continues to increase (Beygi Heidarlou et al., 2019; Beygi Heidarlou et al., 2020). Therefore, it is necessary to reduce the dependence of the inhabitants of the region to natural resources by carefully and accurately planning, increasing their participation in its conservation, and gradually reducing the process of destruction. In this regard, conservation plans should be continued more vigorously.

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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