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Land Cover Change Dynamics Based on Intensity Analysis in Gorganrood Watershed, Iran

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ABSTRACT

This research investigates the transitions among the main Land Cover (LC)/Land Use (LU) categories in the upstream part of Gorganrood Watershed (GW) as a highly populated agricultural region that is reported to be facing considerable environmental changes in the form of deforestation, natural hazards, erosion, cultivation, and manufactured structures. Land cover maps for 1972, 1986, 2000 and 2014 were prepared, which included six LC classes: rangeland, forest, built-up, farmland, water, and bare land. Analyzing dynamics was conducted using multi-level intensity analysis followed by gain, loss, persistence, and transition exploration. Results shows that 1972-1986 interval was a fast period but changes were not stationary over the whole interval analysis level. At category level, bare land, built-up, farmland, and water categories were active gainers and changes were stationary. At transition level analysis, the transitions to built-up, bare land, forest, and water categories were stationary, from the rangeland and farmland categories. Generally, the surface occupied by farmlands increased at the detriment of rangelands and forests, and that it is the dominant LC/LU type in the watershed nowadays. In addition, the surface covered by built-up areas increased 11 times between 1972 and 2014. The results indicate that, LC/LU changes are associated with the overall population and economic growth and impact natural resources of the area, like similar regions in other developing countries.

Keywords: Change detection, Farmlands, Land use, Rangeland, Transition Matrix.

INTRODUCTION

Land Cover/Land Use (LCLU) change studies became an essential component of national and local organizations' strategies towards environment and natural resource management throughout the world (Minaei and Kainz, 2016; Thilagavathi *et al*., 2015). LCLU change as an important component of global environmental changes is a progressive, widespread and accelerating process that is mainly driven by anthropogenic derangements and natural phenomena, and which, in turn, affects humans, environment, biodiversity, and so on (Berakhi *et al*. 2014; Huang *et al*., 2012; Saeedimoghaddam *et al*., 2017; Shafizadeh-Moghadam *et al*., 2017b).

As a result of population growth, urbanization, agriculture, and built-up area expansion, different types of Land Cover Changes (LCC) are taking place at intensive levels in the entire world, especially in developing countries (Adhikari *et al*., 2014; Chapin Iii *et al*., 2000; Dingle Robertson and King, 2011; Shafizadeh-Moghadam *et al*., 2017a). Gorganrood Watershed (GW), as a highly populated agricultural region, is not different, and experienced artificial surface growth and numerous devastation and disintegration in natural resources like forests (Minaei and Kainz, 2016). These changes affect 600,000 residents and a high diversity of flora, fauna as well as endangered species in Golestan National Park (a UNESCO heritage site) under different LCC related influences.

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Over the past two decades, most of the studies with the aim of understanding the historical LCLU changes in the world, and specially in Iran, foucsed on simple analysis of the change matrix. For example, Nadoushan *et al*. (2017); Soffianian and Madanian (2015) investigated the LCC in Isfahan region. Fathian *et al*. (2016) did it in eastern subbasins of Lake Urmia. In Al-Saady *et al*. (2015) study, they investigated LCC in Zab River norhtwest of Iran. Mirzaei *et al*. (2015) studied Zagros forests and Minaei and Kainz (2016) investigated the LCC in the GW, etc. Stating the net change alone is fraught with danger of noticeably miscalculating the total change, and it is not satisfactory to provide quantitative and systematic signals of LCLU changes (Huang *et al*., 2012; Manandhar *et al*., 2010). Additionally, traditional transition matrices provide only limited information and fail to illustrate the intensity of the LCLU conversions (Manandhar *et al*. 2010). Hence, there is a necessity for a detailed method to study LCC changes in order to distinguish systematic conversions (Manandhar *et al*. 2010). Intensity Analysis developed by Pontius Jr *et al*. (2004) was the first introduced methodology for detailed analysis of LCLU changes. The multi-scale intensity analysis (Aldwaik and Pontius Jr, 2012) is performed according to a top–bottom approach that includes three levels, i.e. interval, category, and transition, and detects which changes among categories are stationary or not (Mallinis *et al*., 2014; Pontius Jr *et al*., 2013).

Nevertheless, as it can be inferred from the studies we have just described, no previous study has investigated patterns, dynamics, and processes of LCC in the GW and changes in the last 40 years are still unclear and not completely understood. Understanding LCC processes and patterns is essential in exploring the complex relations among human's life and the environment from local to global scales (Akinyemi *et al*., 2017). Hence, it is desirable to take a subsequent step beyond just mapping LCC to conduct a comprehensive LCLU change detection research using Intensity Analysis framework in order to detect the principal signals of changes in the region during three time intervals. In this study, we attempted to: (1) Detect the quantity of the gains and losses, (2) Analyze the spatio-temporal dynamics of LCC changes, and (3) Detect stationary changes in the GW.

MATERIALS AND METHODS

Study Area

The study area is located in the northeastern part of Iran and covers an area of 5,500 km^2 (Figure 1). It is located

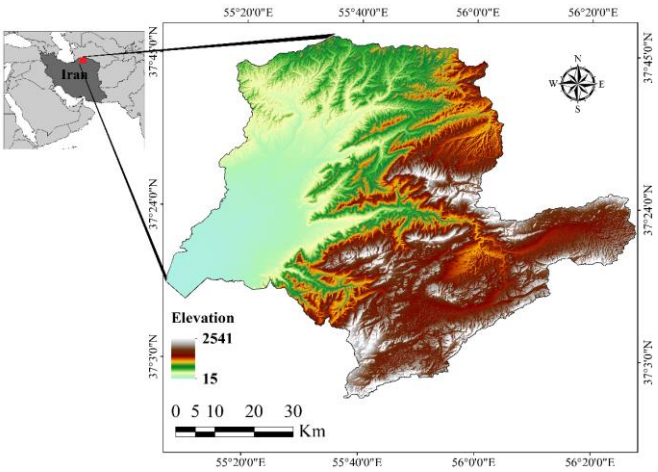

Figure 1. Study area in the northeast of Iran

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between 36° 57'-37° 47' N and 55° 08'-56° 25' E. It contains the upstream portion of the GW at elevations that range from 15 to 2,541 meters above sea level (Minaei and Kainz, 2016). This region is very important from several viewpoints: include valuable agricultural lands, approximately 600,000 residents, and Golestan National Park with rich and old forests, a high diversity of flora and fauna, as well as endangered species that can suffer from LCLU changes (Delbari *et al*., 2013; Minaei and Irannezhad, 2016; Minaei and Kainz, 2016; Statistical Center of Iran, 2006).

Data Sources and Processing

In order to select the appropriate remote sensing images, various factors such as the complexity of the study area, its coverage, the objective of the study, the user's requirements and data availability must be considered (Lu *et al*., 2014). Based on these factors, Landsat images were chosen. Four multi-temporal cloud free L1T Landsat MSS, TM, ETM+ and OLI/TIRS images (Path/Row 162/34) from 1972 to 2014 distributed by the Land Processes Distributed Active Archive Center (LP DAAC) were used as the core data for LCLU classification. In addition, to support the classification (interpretation, delimiting training sites, post-processing, and so on), the auxiliary data listed in Table 1 along with the main Landsat data were used.

In order to detect LCC based on the characteristics of the study area, the following six classes including built-up, farmland, bare land, rangeland, forest, and water were extracted. Following the classification process, accuracy assessments were conducted based on the overall accuracy, quantity, and allocation disagreements statistics. Overall, accuracy ranged from 89 to 95%, quantity disagreement from 2.1 to 6.6%, and allocation disagreement from 2.1% for 2014 to 2.7% for 2000. Although, based on these accuracy assessments conducted over the generated LC maps, the results were acceptable, authors tried to increase the quality of the classification as much as possible through a post-processing phase that incorporated the auxiliary data.

LCLU Change Analysis

For this research, the Post Classification

Table 1. Characteristics of data used for LCLU change detection.

Name of dataset	Acquisition date	Resolution	Full area coverage	Source
Landsat/MSS	1972/09/20	60 m	Yes	LP DAAC (earthexplorer.usgs.gov)
Landsat/TM	1986/05/19	30 m	Yes	
Landsat ETM+	2000/07/20	30 m (Pan 15)	Yes	
Landsat OLI/TIRS	2014/07/19	30 m (Pan 15)	Yes	
Aster	2001/07/18	15 m	No	
CORONA	1970/05/27	~ 2.1 m	No	
QuickBird	2005	0.6 m	No	Department of Geography, Ferdowsi University of Mashhad
DEM (Aster)	1970	30 m	Yes	Golestan Province Natural Resource and Watershed Management Administration
Aerial photo		~ 1.9 m	No	
Topographic map			No	
GIS thematic maps			Yes/No	

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Comparison (PCC) change detection method was applied. It is the most efficient method of change detection that identifies changes between pre-determined classes (Madugundu *et al*., 2014; Shalaby and Tateishi, 2007). More specifically, PCC has been found to offer precise indications of LCC and it is frequently rated among numerous other methods, such as principal component analysis and image differencing (Dingle Robertson and King, 2011). In addition, PCC enables to determine "from-to" class changes using a change matrix (Madugundu *et al*., 2014). Furthermore, the distinct classification conducted for each image alleviates the influence of multi-temporal effects caused by sensor or atmospheric differences (Madugundu *et al*., 2014; Shalaby and Tateishi, 2007). In order to apply PCC on our maps, firstly, we changed the maps' resolution to the most appropriate one (15 m). Then, cross-tabulations were applied on the 1972, 1986, 2000, and 2014 LC maps on a pixel basis to create overall change maps and matrices of changes. In addition, gains, losses, persistence, and transitions between categories were analyzed to comprehend the characteristics and coverage of the LCLU changes (Abino *et al*., 2015).

Intensity Analysis

Huang *et al*. (2012) and Mallinis *et al*. (2014) argue that even though "from-to" change matrices and the measures of gain, loss, swap and persistence generate relevant information, they do not let to consider all time points concurrently and thus they do not support a good understanding of the land surface change process. The multi-scale intensity analysis (Aldwaik and Pontius Jr, 2012) is performed according to a top–bottom approach that includes three levels, i.e. interval, category, and transition (Mallinis *et al*., 2014; Pontius Jr *et al*., 2013; Minaei *et al.* 2018).

At the interval level, the variation of the size and the rate of change amongst time intervals is assessed. In other words, at this level, the observed annual change intensity S_t [Equation (1)] during each time interval [Y_t, Y_{t+1}] is compared to a uniform annual change U [Equation (2)], during the entire extent of the study (Huang *et al*., 2012; Mallinis *et al*., 2014; Pontius *et al*., 2013). (equetion1&2)

At the category level, for any time interval, the variation of the intensity of change between categories is measured, so that active and inactive categories can be identified in each interval (Huang *et al*., 2012; Mallinis *et al*., 2014). G_{tj} represents the intensity of a category's annual gross gains as the percentage of the additional surface covered by the LCLU category at the end of the time interval [Y_t, Y_{t+1}], compared to the overall surface covered by this category at *t+1* [Equation (3)]. Conversely, the intensity of a category's annual gross loss, denoted L_{ti}, is calculated as the percentage of the surface no longer covered by the LCLU category, compared to the overall surface covered by this category at the beginning of the time interval [Equation (4)] (Huang *et al*. 2012; Mallinis *et al*. 2014; Pontius Jr *et al*. 2013). Afterward, the interval-specific uniform hypothesized intensity of change (S_t) is compared to the intensities obtained from the equations. This S_t intensity would exist, if the overall interval change intensity is equally distributed throughout the studied area (Mallinis *et al*., 2014). (equetion3&4)

At the transition level, the variation of the

$$S_t = \frac{Area\ of\ change\ during\ interval\ [Y_t, Y_{t+1}]}{(Duration\ of\ interval\ [Y_t, Y_{t+1}]) * (Area\ of\ study\ region)} 100\% \quad (1)$$

$$U = \frac{area\ of\ change\ during\ all\ intervals}{Duration\ of\ all\ intervals * (Area\ of\ study\ region)} 100\% \quad (2)$$

$$G_{tj} = \frac{Area\ of\ annual\ gain\ of\ category\ j\ during\ interval\ [Y_t, Y_{t+1}]}{Area\ of\ category\ j\ at\ Y_{t+1}} 100\% \quad (3)$$

$$L_{ti} = \frac{Area\ of\ annual\ loss\ of\ category\ i\ during\ interval\ [Y_t, Y_{t+1}]}{Area\ of\ category\ i\ at\ Y_t} 100\% \quad (4)$$

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intensity of the transition between LCLU categories during each time interval is measured. More specifically, it involves two processes, whereby (1) The intensity of transitions towards a specific "gaining" LCLU category, and (2) The intensity of transitions from a particular "losing" category is being considered (Aldwaik and Pontius Jr, 2012; Huang *et al*., 2012; Mallinis *et al*., 2014).

Equation (5) gives the declared intensity with which category *n* acquired gains over category *i* (denoted R_{tin}). R_{tin} equals W_{tn} [Equation (6)] if category *n* obtains gains of equal intensity from each of the other categories (Mallinis *et al*., 2014; Pontius Jr *et al*., 2013).

Moreover, at every level, the intensity analysis process assesses the stationarity of the patterns through time intervals (Aldwaik and Pontius Jr, 2012; Mallinis *et al*., 2014). Stationarity has a distinct definition for each of the above-mentioned level of the intensity analysis process. At the interval level, stationary means that the observed annual change intensity is equal to the uniform annual change for all time intervals. At the category level, stationary means that a category's gain or loss is either greater or lower than the Uniform Intensity (UI) line in all intervals. Then, at the transition level, the same term means that gains or losses of a category either target or avoid a specific category in all time intervals (Aldwaik and Pontius Jr, 2012; Huang *et al*., 2012). A more detailed description and explanation of the intensity analysis process can be found in Aldwaik and Pontius Jr (2012), Aldwaik and Pontius Jr (2013), Huang *et al.* (2012), Mallinis *et al.* (2014), and Pontius Jr *et al.* (2013).

RESULTS AND DISCUSSION

LCLU Change Analysis

LCLU Status and Dynamics between 1972 and 2014

The results of the classification process conducted for each year provide an overall estimate of the LC distribution in the study area. As it can be seen in Figure 2, the area covered by different class varied during these years. Overall changes include quantity change and allocation change (as the sum of exchange and shift). Figure 2 presents that most of the change during each time interval is quantity difference. Exchange (change between two classes) is larger than shift (LC change among more than two classes) during the first two time intervals but the status changed. Generally, overall change is stronger and fastest in the first decade and reduced to 2000-2014 as the slowest change period.

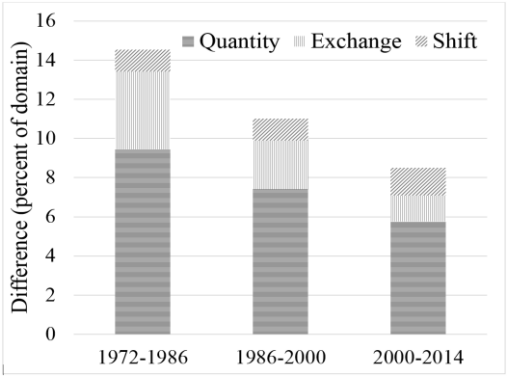

Figure. 2. Overall changes during 1972-2014

Table 2 and Figure 3 indicate that in 1972, 1986, and 2000, rangeland was the dominant land cover with ~60, 50, and 45% of the total area, respectively. Rangeland followed by farmland and forest were the most prevalent land cover from 1972 to 2000. The chart illustrates that there is a significant difference between 2014 and the previous years, whereby farmland replaced rangeland as the dominant land cover (40 percent).

The Figure 3 shows that there has been a steep decrease and increase in the rangeland and farmland classes, respectively. The area covered by the less prevalent built-up and water classes increased too. Built-up surface area increased by 11 times since 1972,

$$R_{tin} = \frac{Area\ of\ annual\ transition\ from\ i\ to\ n\ during\ interval\ [Y_t, Y_{t+1}]}{Area\ of\ i\ at\ Y_t} 100\% \quad (5)$$

$$W_{tn} = \frac{Area\ of\ annual\ gain\ of\ category\ n\ during\ interval\ [Y_t, Y_{t+1}]}{Area\ of\ not\ category\ n\ at\ Y_t} 100\% \quad (6)$$

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reaching approximately 9,000 hectares, and water surface, which covered 1,200 hectares in 2014, experienced a 57 times increase since 1972. Finally, while bare lands experienced some fluctuations, their surface remained approximately the same over the 42 years period.

Of note is that all previously mentioned changes are those that occurred within one class. The changes from one LC class to another are presented in Tables 3 in the form of observed annual transition matrix and Figure 4 for LC gains, persistence, and losses. From 1972 to 2014, rangelands as the most prevalent class were largely converted into farmlands (~2,900 ha yr^{-1}) and forest (~580 ha yr^{-1}) in the North and South of the Golestan National Park. The latter conversion could be related to the establishment of the Golestan National Park in 1976 and the provision of different energy resources for the local population. Furthermore, during these years, more than 492 ha yr^{-1} of forest surface that were mostly located near built-up areas and flat regions were also converted to farmlands. It should be mentioned that, while the rangeland category suffered the largest losses, it gained approximately 488 hectares per year from forests. The farmland surfaces were mainly converted to built-up (approximately 166 ha yr^{-1}) and water (~27 ha yr^{-1}) surfaces. These changes were concentrated in the part of the region that is covered by plains. However, the expansion of built-up areas was not only at the detriment of farmlands; it takes 30 ha yr^{-1} from ranges and less than 1 ha yr^{-1} from forest during 1972 to 2014. Similarly, Amini Parsa and Salehi (2016), Nadoushan *et al*. (2017), and Langroodi *et al*. (2015) report built-up areas expansion and vegetation cover decreasing from past to present in different regions of Iran.

Figure 4 shows the gain, persistence, and loss of each category in percent in three intervals. The size of a category at $time_1$ is the sum of its persistence and loss. The size of a category at $time_2$ is the sum of its persistence and gain. For example, range accounts for 60 percent of the domain in 1972 and 51 percent in 1986. In support of Table 3, the Figure 4 presents that the great

Table 2. Summary of surface covered by each class (in ha and percentage) for the different years.

LCLU class	1972		1986		2000		2014	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Bare land	4,404.78	0.70	4,084.52	0.65	5,759.80	0.92	4,305.24	0.69
Built-up	819.07	0.13	2,646.88	0.42	5,050.67	0.81	9,057.29	1.45
Farmland	125,379.09	20.02	182,633.27	29.16	224,809.31	35.90	255,753.59	40.84
Forest	122,614.20	19.58	119,333.86	19.06	106,020.83	16.93	106,267.82	16.97
Rangeland	372,998.45	59.56	317,440.78	50.69	284,351.40	45.41	249,663.40	39.87
Water	20.57	0.00	96.95	0.02	244.28	0.04	1,188.97	0.19

Table 3. Observed annual transition matrix (ha) over the 2000 to 2014 period.

	Bare land	Built-up	Farmland	Forest	Range	Water
Bare land	-	0.21	11.2	0.03	122.05	0
Built-up	0	-	0.58	0.001	0.04	0.18
Farmland	0.02	166.11	-	12.15	102.81	27.5
Forest	0	0.41	492.8	-	488.87	0.09
Rangeland	131.11	30.22	2906.56	580.79	-	1.68
Water	0	0	1.6	0	0.05	-

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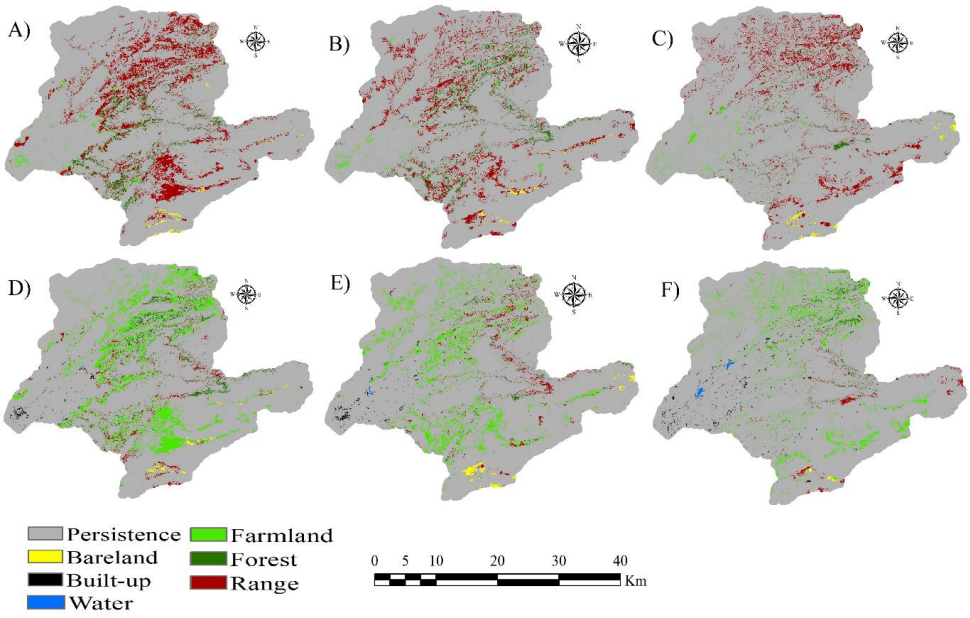

Figure 3. LCLU persistence, gains and losses over time: (A) Losses from 1972 to 1986, (B) Losses from 1986 to 2000, (C) Losses from 2000 to 2014, D) Gains from 1972 to 1986, (E) Gains from 1986 to 2000 and (F) Gains from 2000 to 2014.

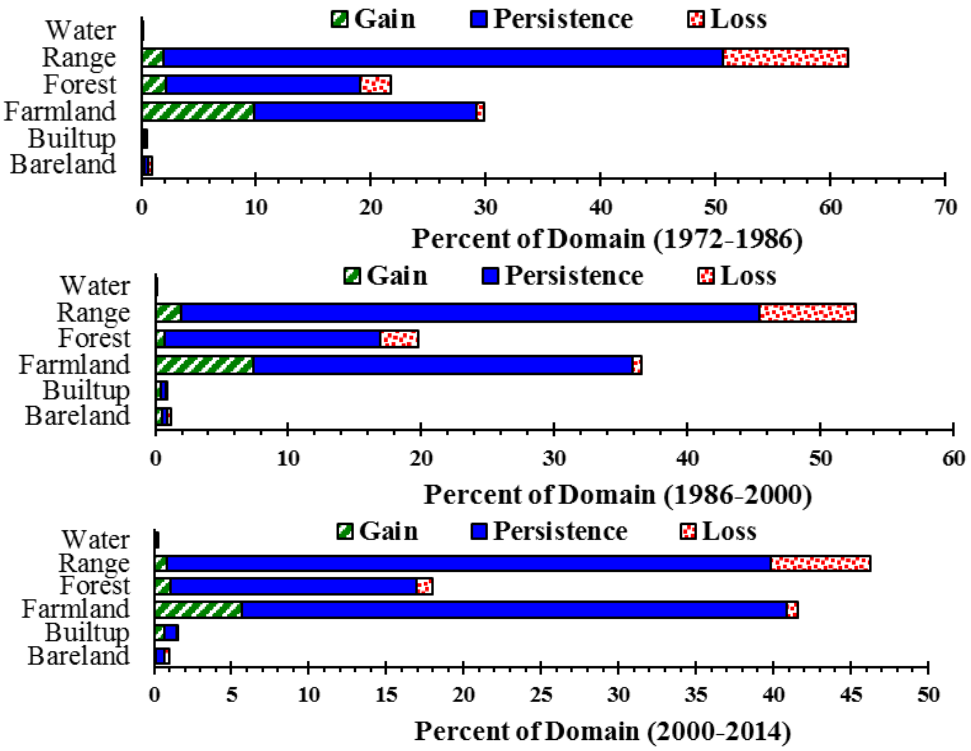

Figure 4. LCLU classes' surface gains, persistence, and losses by category in percent 1972-1986, 1986-2000, and 2000-2014.

losers are range and forest categories and the

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farmland is the biggest gainer. As shown in this figure, the major inter-class transitions percent for all three intervals include the gains from farmlands at the detriment of rangelands. Of note is that, while analyzing places where LCC occurred is important, it is also relevant to identify areas where no changes occurred (areas characterized by persistence) (Abino *et al*. 2015). The figure reveals that the percentage of unchanged areas covered by rangelands and forests decreased during these 42 years. Meanwhile, the persistence of the other categories (built-up, water, farmland) and, generally, the entire of the basin tend to have more stable land covers.

LC Intensity Analysis

Figure 5 shows the interval-level intensity analysis results. Each bar that extends to the right from the middle axis is the observed change intensity (Zhou *et al*., 2014). Each bar that extends to the left from the middle axis is the change area and shows the commission and omission errors, too. Change area and commission of change error have solid shades to indicate that their union is observed change. Omission of change error has a partially hatched pattern to indicate that omission of change error is observed persistence that is hypothesized change (Aldwaik and Pontius Jr, 2013). In terms of the right side of the middle axis, if

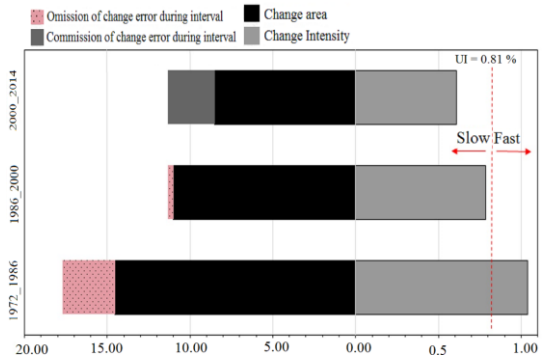

Figure 5. Intensity analysis for three time intervals (1972-1986, 1986-2000 and 2000-2014) level changes.

an interval's bar ends before the uniform line, then, the change is relatively slow for that interval; if an interval's bar extends beyond the uniform line, then, the change is relatively fast for that interval (Zhou *et al*., 2014). The threshold of Uniform Intensity (UI) is 0.81 percent, and 1972-1986 was the time interval with the highest intensity. Then, the intensity decreased during the two following time intervals to reach 0.61 percent in 2000-2014. This means that changes were not stationary over the time of this interval analysis.

The next step in the intensity analysis process takes place at the category level. At this level, the UI values for the first, second, and third time intervals were 1.04, 0.79, and 0.61 percent, respectively (Figure 6). During all three periods, gains benefiting to the bare land (~3 to ~1%), built-up (~5 to ~3%), farmland (2.40 to 0.99%), and water (almost stable) categories were relatively active compared to *UI* values. In contrast with these classes, gains concerning the forest and rangeland categories were relatively dormant compared to the *UI* values and this condition was reinforced over time. According to the stability (or stationarity) criteria stated by Aldwaik and Pontius Jr (2012), the bare land, built-up, farmland, and water categories were stationary in terms of gains. The results are in line with those of Soffianian and Madanian (2015) and Zhou *et al*. (2014) about built-up, bare land, farmland and water gains in China; and Enaruvbe and Pontius Jr. (2015) for water and built-up categories in Nigeria, which experienced active gains.

Also, loss intensity is presented in Figure 6. During the first time interval, the bare land and rangeland categories are actively losing surface, while other classes are relatively dormant in terms of loss intensity. During the 1986-2000 periods, the forest and water categories joined the rangeland and bare land categories, bringing the number of actively losing classes to four, whereas the built-up and farmland categories remained dormant. The bare land, rangeland, and water categories were relatively actively

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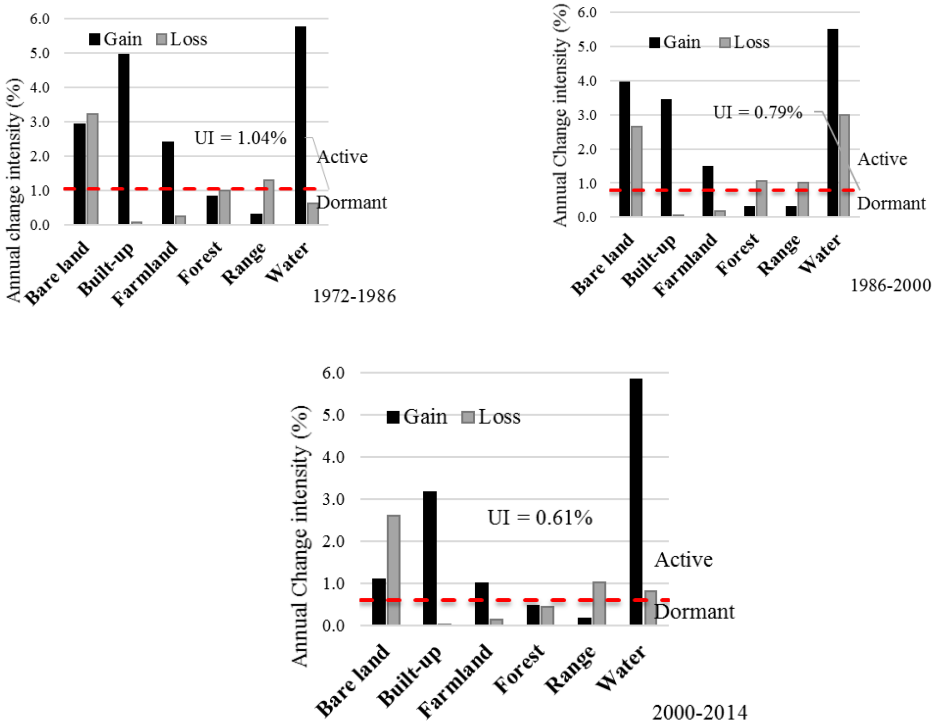

Figure 6. Category intensity analysis for three time intervals: 1972-1986, 1986-2000 and 2000-2014. Columns show intensity of annual gains and losses within each category.

losing area during the third time interval. During this interval, the forest, farmland, and built-up categories were relatively more dormant, in that order. Nevertheless, as a result of the category-level intensity analysis of losses, the bare land and rangeland categories were found to be stationary. The bare land changes are consistent with those of Nadoushan *et al*. (2017) in Isfahan and Zhou *et al*. (2014) in coastal area in south of China.

The analysis of the intensity at the transition level is more complex than the two previous levels. During the three intervals, some source and destinationgroups did not change: The transitions tobare land, built-up, forest, and watercategories were stationary from the rangeland (Intensitiesduring three dates= 0.03, 0.07, and 0.02%),farmland (0.09, 0.07 and 0.11 %), rangeland(0.26, 0.09, and 0.17%) and farmland (0.0,0.01, and 0.03%) categories, respectively. However, we focused on transitions towards farmland and built-up because they are the categories that varied over time and human's society tend to extend them as much as possible. So, for a better understanding of these processes, the intensity graphs are presented in Figure 7.

Figure 7 presents the active classes that were identified during the transition level analysis for built-up and farmlands. The built-up category mostly gained surface area over the farmland and rangeland categories, and the intensity of the transition from both of these classes (combined) approximately increased over time, but the transition from farmland towards built-ups was greater. In addition, only transitions from farmland to built-up class were stationary. Transitions to farmland occurred from rangeland and water classes, but only the transitions from rangelands were stationary. During the 1972-1986 periods, only farmlands were converted into rangelands, but later, this category started to actively target the water class too.

The analysis of the transitions among all categories shows that, for the bare land category, transitions towards the rangeland

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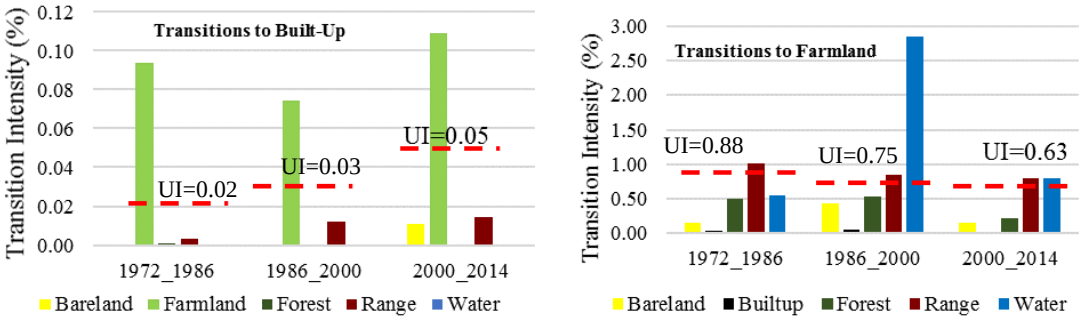

Figure 7. Transition intensity analysis towards the rangeland and farmland categories during the three intervals. Columns show the intensity of the annual transitions in related categories.

category were stationary, with intensities being at 0.04, 0.03 and 0.06 during the three time intervals, respectively. Transitions from the built-up category occurred only towards the water category during the 2000-2014 periods, and were not stationary. Transitions from the water category benefited to the farmland category and were stationary. The results of the transition intensity analysis from the rangeland, forest and farmland towards other categories, as illustrated in Figure 8, show that rangelands intensively and consistently lost lands to bare lands and farmlands. This process demonstrates stationarity, though the intensity of this change decreased. Forest losses towards farmlands were stationary, but the water and rangeland classes gained further surface area from it during the 1972-1986 and 2000-2014 periods, respectively. In other words, farmlands consistently gained surface from forests, but forests first lost surface towards water during the 1972-1986 periods, later towards rangelands during the 2000-2014 period, but towards no other class (than farmlands) in between. Besides, the

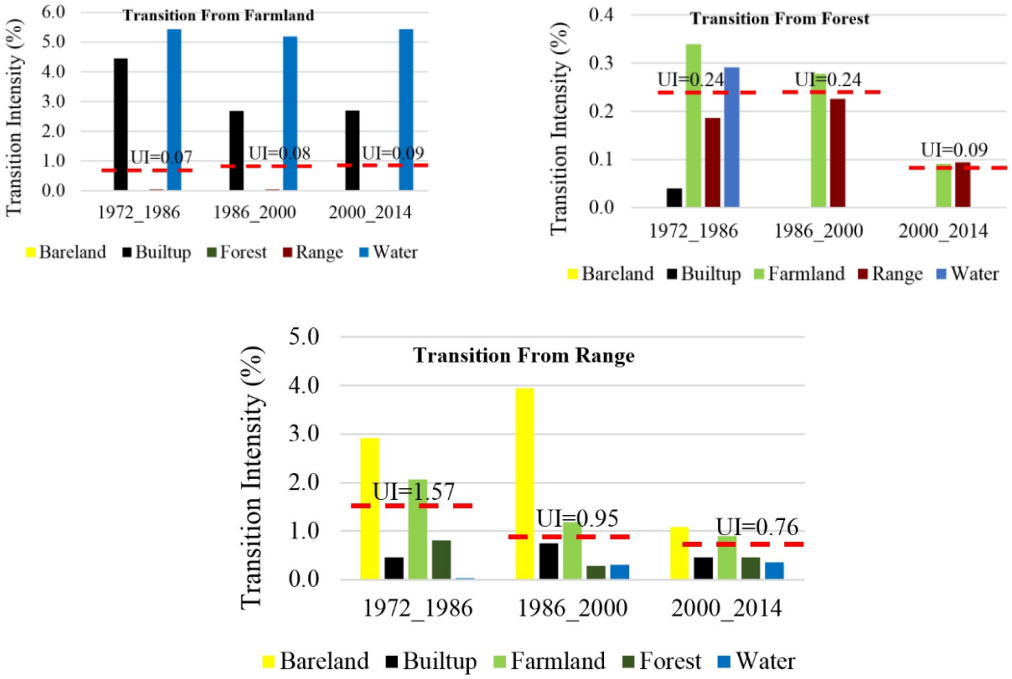

Figure 8. Transition intensity analysis from rangeland, forest and farmland categories during 1972-1986, 1986-2000 and 2000-2014. Columns show the intensity of the annual transitions in related categories.

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farmland class intensively and with stationarity lost area to the water and built-up categories. Built-up gain intensity decreased during the 1986-2000 periods, but increased again in 2000-2014, while water gains remained intense over all periods of time.

CONCLUSIONS

This study was conducted to determine the LCLU status and changes over a 42-year period (from 1972 to 2014) in the Northeast of Iran, using Intensity Analysis. This study has enabled revealing that in 1972, 1986, and 2000, the rangeland was the dominant land cover. Farmland and forest followed rangeland as the most prevalent land covers between 1972 and 2000; however, the status changed significantly and, in the last interval, farmland was the most dominant LC.

This study uncovered that forests suffered from a gradually decreasing change until 2000, but, from 2000 to 2014, they experienced a slow increase, perhaps due to some forest protection policies and afforestation in Iran. It also reveals that less prevalent built-up and water classes expanded too. More specifically, built-up areas expanded by 11 times their initial surface area since 1972, and gains are mostly from farmlands. Finally, while bare lands experienced some fluctuations, after 42 years, their surface remains approximately the same.

The investigation of intensities has shown that, at the interval level, the 1972-1986 interval was an active period of change compared to the uniform intensity. When examined at the category level, the built-up, farmland, and water categories actively gained surface area compared to the uniform intensity. Moreover, at the transition level, sources classes were mostly stable while only the rangeland, farmland, and, to a lesser degree, forest target categories changed.

The results of this study indicate that significant changes occurred in the regions that consequently affect the ecosystem and human life. The increase of the surface covered by farmlands and built-up areas as well as the decrease in the area covered by forests and rangelands could increase the likeliness of different types of natural hazards, especially floods, which are predominant in this region. Finally, the current study was the first work in this filed in Iran. The findings of this study suggest that, with this knowledge of LCLU changes, more appropriate plans and programs should be developed to manage the future of the watershed. Study results are useful and important for decision makers and mangers. It could be the basis for many future studies in case of environmental management and exploring drivers and so on. Nevertheless, this research faced some limitations, like access to socio-economic data and relationship assessment in case of climate change conditions, that could be investigated in the future works to further extend our knowledge and face the future with more efficient measures.

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پویایی تغییرات کاربری اراضی بر اساس روش تحلیل شدت در حوضه آبخیز گرگانرود، ایران

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چکیده

مطالعه حاضر به بررسی تغییرات در میان کلاس های پوشش اراضی/کاربری اراضی در سرشاخه های حوضه آبخیز گرگانرود به عنوان منطقه ای کشاورزی که با تغییرات محیطی قابل توجهی از جمله جنگلزدایی، مخاطرات طبیعی، فرسایش، کشاورزی و ساخت و ساز روبرو است، پرداخته است. نقشه های پوشش اراضی برای سال های ۱۹۷۲، ۱۹۸۶، ۲۰۰۰ و ۲۰۱۴ در برگیرنده شش کلاس تحت عناوین: مرتع جنگل، ساخته شده، کشاورزی، آب و زمین های بایر تهیه شدند. تحلیل تغییرات با استفاده از روش چند سطحی تحلیل شدت به همراه کاوش کسب ها، از دست دادن ها، بدون تغییرها و تغییرات انجام گرفت. نتایج نشان می دهد که در سطح دوره های زمانی، بازه زمانی ۱۹۷۲-۱۹۸۶ دوره تغییرات سریعی بوده اما این حجم از تغییرات در کل بازه زمانی پایدار نبوده است. در سطح تغییرات، تبدیلات به ساخته شده، بایر، جنگل و آب در مقایسه با کلاس های مرتع و کشاورزی پایدار بوده است .بطور کلی، سطوح کشاورزی همزمان با کاهش مراتع و جنگل ها افزایش یافته و در حال حاضر پوشش اراضی غالب منطقه را تشکیل می دهد. علاوه بر این، گستره پوشیده شده با کلاس ساخته شده نیز بین سالهای ۱۹۷۲ تا ۲۰۱۴ یازده برابر افزایش یافته است. نتایج نشان می دهد که همانند مناطق مشابه در کشورهای در حال توسعه، تغییرات کاربری اراضی با رشد جمعیتی و اقتصادی مرتبط می باشد و بر منابع طبیعی تاثیر می گذارد .

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