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AN ANALYSIS OF THE LANDSCAPE STRUCTURE CHANGES AS AN ECOLOGICAL APPROACH TO ACHIEVE SUSTAINABLE REGIONAL PLANNING (CASE STUDY: LATIAN DAM WATERSHED)

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Highlights

- Monitoring past/present trends of landscape change with time series approach from 1987 to 2017.
- Fragmentation and patchiness increase in the vegetation class and the class of the bare land was predicted.
- An increment in the build-up class and patch homogeneity was predicted.

Abstract. The formation of modifications or conception in the landscape could possibly, be a procedure relative to its natural and non-disturbance process; and it could be hastened by the occurrence of disturbance regimes. The objective of this research is to survey the changes in a landscape structure, over a period of 30 years, to attain information, as to the current conditions of land use, utilizing landscape metrics in the watershed area of the Latian Dam, so as to analyze the results and the voids present, towards obtaining a specified sustainable regional planning for the abovementioned watershed. Land use was identified and reviewed by means of four Landsat satellite images for 1987, 1998, 2007, and 2017; and in this watershed, it was classified into four classes, (a) build-up areas, (b) vegetated areas, (c) bare lands and (d) water bodies. Subsequently, by taking advantage of 7 metrics at the landscape level and 8 metrics at the class level, the landscape structure in this watershed was quantified by utilizing the Fragstats 4.2 Software. The survey results illustrated an increment in the number of patches (NP), decrementing the mean area of the patches (AREA-MN), and increasing the Interspersion & Juxtaposition Index (IJI) signifies amplified fragmentation at the landscape level in this watershed. Similarly, the NP has also incremented at the class level, and thus, the fragmentation of patches and fragmentation in the entire three classes of land use, namely, build-up areas, bare lands, and vegetated areas has occurred. The amount of patchiness for the build-up class, with due attention to the increment in the mean area of patches (AREA-MIN), which demonstrates the fact that, this class is inclined and has a tendency towards a coarse-grained structure and a metric decrement in the AREA-MIN in the vegetated areas, illustrates that this class is prone to the fine-grained structure.

Keywords: land use change, landscape metrics, sustainable regional planning, Latian Dam Watershed.

Introduction

Population growth and the expansion of human activities in nature have caused severe changes in land use and landscape pattern (Dadashpoor et al., 2019; Mohamadijoo et al., 2018), irregular land configuration, and the creation of a fragile environment (Merlotto et al., 2012; Zhou & Zhao, 2013). Numerous studies have shown that these vast changes can not only lead to various environmental issues, including changes in the ecological processes of terrestrial ecosystems (Hasan et al., 2020; Mendoza-Ponce et al., 2021), impact on the global carbon cycle (Zhu et al., 2021a), climate (Thapa, 2021; Pongratz et al.,

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2021), biodiversity (Davison et al., 2021), landscape ecology (Tang et al., 2020; Qu et al., 2021) and etc.; It also affects the structure, function, and health of the ecosystem (Edge et al., 2017; Tang et al., 2020). Therefore, mapping and quantifying the spatial and temporal changes in land use/land cover (LULC) and drivers of change to identify vulnerable areas is essential to achieve various goals such as land management, resource management, and biodiversity conservation (Abebe et al., 2022). This enables managers and planners to understand what is happening and make comprehensive plans for their future intervention, and design effective land management policies and decisions (Lambin et al., 2004). Therefore, timely information about LULC changes and its dynamics is very important to understand the relationships and interactions between human and natural phenomena for better management of natural resource bases that are the main sources of livelihood for local communities (Chen et al., 2021; Birhanu et al., 2019; Abebe et al., 2022).

Previous studies have illustrated that the analysis of land use changes is usually regarded as the basis for studying the landscape patterns change (Křováková et al., 2015) because the landscape pattern change can be interpreted as a change in patch shape, area, quality, and spatial composition (Li et al., 2010; Zhou & Zhao, 2013), which are classified by different land use types (Li et al., 2010). Recently, GIS and remote sensing systems have been widely used for LULC mapping and change detection worldwide (Mohamed et al., 2020; Chamling & Bera, 2020; Rafq et al., 2018). This technology allows the analysis of LULC by using the capability of multispectral remote sensing data and the development of digital image processing (He et al., 2021; Weng, 2002). As a result of the development of remote sensing in recent years, various approaches and algorithms such as FRAGSTATS and APACK have been developed to analyze the spatial structure of the landscape and quantify it using landscape metrics (Peng et al., 2010). These metrics are used to quantitatively describe the landscape structure over time (Frohn & Hao, 2006), as landscape indicators (Turner, 2005; Uuemaa et al., 2013), to implement watershed management strategies (Boongaling et al., 2018) and the study of the relationship between landscape patterns and ecological processes (Wickham et al., 2000). Landscape metrics can also be used to determine the extent of the decline in the overall state of the environment (Istanbuly et al., 2021). These can be measured in various studies at three elements: patch, corridor, and matrix that the extent and configuration of these elements define the pattern of the landscape (McGarigal, 2015).

In many studies around the world, to detect changes in the landscape, a combination of assessing the trend of land use change using RS and GIS and examining the measurements of the landscape has been used. For example, Tang et al. (2008) compared the temporal and spatial landscape changes of Houston, Texas in the United States, and Docking, Heilongjiang province in China. In this study, they analyzed the effect of urban development on the landscape pattern of two cities and concluded that the landscape of natural lands such as wetlands and forests have been destroyed in the last twenty years and in contrast to the landscape of urban lands has expanded. Fiener et al. (2011) evaluated the role of spatial-temporal changes in land use due to management actions on surface runoff response in agricultural lands and the relationship between land metrics and hydrological processes. The results emphasized the role of continuity and separation of patches in agricultural lands. Su et al. (2014) evaluated changes in the pattern of agricultural land over a thirty-year period in the Qantang watershed in China using landscape metrics. They concluded that the agricultural lands lost their stability and were divided into separate patches with irregular shapes in this time period. del Castillo et al. (2015) analyzed forest cover in the natural park of Monaco in Spain using remote sensing technology, GIS, and landscape metrics. The finding obtained from the analysis of land use metrics shows an increase in fragmentation and consequently an increase in spatial diversity at the land level. Mu et al. (2016) investigated the effects of programming policies on the pattern of landscape changes in the Zhengzhou region of China from 1992 to 2013. For this study, they used metrics such as PD, LPI, IJI, DIVISION, and SPLIT, and concluded that from 2004 onwards, a shift in land use from agricultural to urban expansion had an increasing tendency, leading to consistency in urban land use and fragmentation in rural lands. Kabba and Li (2011) used the NP, PD, LPI, SIEI, and SIDI metrics to analyze land use changes and their ecological impacts. Results illustrated landscape fragmentation and patchiness as forest cover. In general, changes in the structure of the landscape in different areas have occurred in different degrees according to studies, and quantifying these changes using landscape metrics can help identify the main drivers of change and develop management strategies for effective land use planning. In this regard, the purpose of this study is to quantify the changes in the spatial pattern of land use in a 30-year period in the watershed of Latian Dam using landscape metrics. In other words, in addition to evaluating land use change in this study, aspects such as dispersion, heterogeneity, and driving forces that have caused these changes have been considered so that it can be used for regional planning purposes.

1. Methodology

1.1. Area of study

The Latian Dam Watershed is located to the northeast of Tehran and is one of the subordinate basins of the Jajrood River Basin, which encompasses an area of 790 sq. kilometers and is within 35°, 45′ to 36°, 5′ longitude E and 51°, 22′ to 51°, 52′ latitude N (Figure 1). The lowest and highest altitude of this region is 1,300 and 4,375 meters from sea level respectively. The annual precipitation in this watershed is approximately 500 mm, which varies

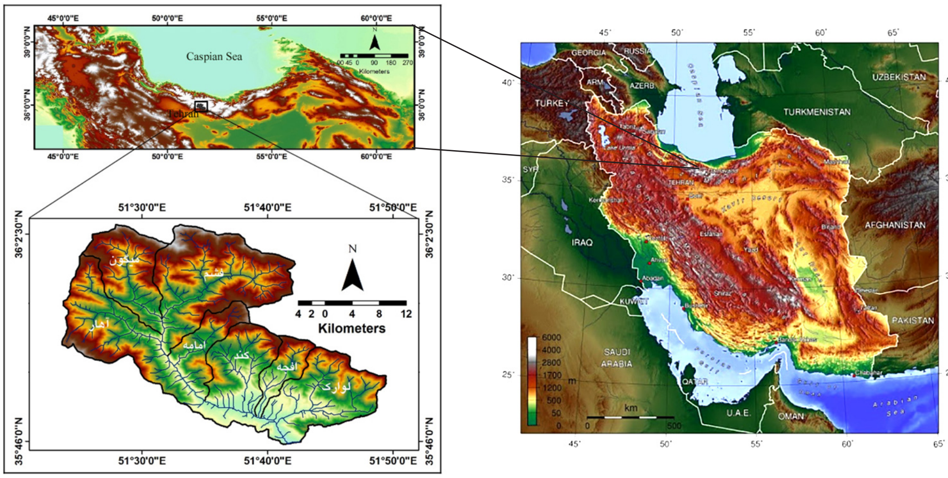

Figure 1. Location of study area

from 418 to 700 mm, depending on spatial conditions. Riparian vegetation growths are mainly Salix, Haloxylon, Tamarix and Berberis trees, and shrubs. Due to the shallow depth of soil and regional climatic conditions, which are semi-arid in most parts of the mentioned watershed, the basin is composed of endemic herbaceous and woody plant species. Likewise, this vicinity also enjoys orchards, particularly in relevance with private property and public green spaces including parks; most of the residential and commercial areas and (those offering services, etc.) are centered in Lavasan, Ooshan, Fasham, Medygoon, and Shemshak.

1.2. Land use maps extracted from satellite images

With due attention to the key objective of this research, where, its application and criterion is of an analytical-descriptive characteristic, it is essential to have an accurate and precise land use map at hand. Hence a classified and supervised procedure such as the Envi 5.3 Software was utilized. For comparing and surveying multi-period satellite images in an ideal mode, it was preferable to have images relative to one day in the year within different years, or else, take advantage of images close to each other. Due to the maximum growth of riparian vegetations and in the gardens of the region in summer, this season was chosen so as to receive satellite images. In this research, Landsat (1987/08/24; 1998/08/22), 5 TM images, Landsat 7 ETM^{+} images, (2017/08/26) and (2007/08/09) as well as Landsat 8 OLI & TIRS images were utilized; and these were received from the website (www.earthexplorer.usgs.gov).

For atmospheric rectifications, satellite images from the Envi 5.3 Software and the FLAASH algorithm were employed. This tool uses the MODTRANA 4 (radiative transfer modeling) for atmospheric rectifications, where data such as the time of the satellite transit, altitude sensor, regional geographical location, angle of the sun's rays, and the regional atmospheric model are utilized; including wavelengths, that are capable of being visualized through close and short infra-red rays and so are made distinct. Next, the amendments of the entire data were switched to the UTM system (Zone 39) of the Northern Hemisphere. In order to survey the quality of the geometric images, the tiers of roads and waterways were extracted from 1:50000 topographic maps (Iran National Cartographic Center) of the Jajrood & Karaj Watershed Comprehensive Planning and Information Organization (JAMAB Consultants, 2006) was extracted and placed on satellite images; images, from Google Earth and examples from varied levels of land use, in 40 points, having ground navigation, the data of which was registered by GPS and was utilized as a means, of interpreting the categorization of images. In the classification of satellite images, other auxiliary data comprising of 1:50000 digital topographical maps published by the Armed Forces Geographical organization of Iran were utilized for improved classification of images. The detectable satellite data bands were segregated into four tiers of land covers consisting of four land uses (Table 1).

Table 1. Classifications of Land use

Type of Land use	Descriptions
Barren Land	Rangelands, hills/hillocks, mountain skirts covered with soil, pebbles, or rocks
Constructed Land	Urban and rural bio-centers, commercial and service vicinities, and roads
Ground Cover	Natural vegetation (ground cover) and riparian vegetation, trees, gardens, and urban parks
Water	Dam lake, river

1.3. Quantification of landscape structure by utilizing metrics

In this research and with due attention to the review of sources, the opinion of experts, and similarly the objective of the research (especially with a focus on fragmentation), efforts have been made to select metrics that reveal the distribution and composition of the regional landscape competently. Thereby, according to the purpose of the study and an analysis of the structural landscape changes, this, from the viewpoint of heterogeneity, is the amount of fragmentation. Seven metrics at the landscape level and eight metrics at the class level (Table 2) have been selected and the land use map prepared. This map was transferred to the IDRISI Software (with a rasterization cell size of 30 m) and subsequently, it enters the Fragstats 4.2 Software, so as to quantify the metrics chosen at the class and landscape level. The class area (CA) and landscape percentage (PLAND) is one of the measurements of landscape, which indicates the amount of landscape, with a specific type of patch formation. A change in their amount demonstrates the structural fragmentation of the landscape. The index of the largest patch (LPI), total edge (TE), and edge density (ED) are other metrthathich are used at the class level to analyze the amount of fragmentation. McGarigal and Marks (1995) introduced the Interspersion & Juxtaposition Index (IJI) initially. This index is based on the proximity of the patch and illustrates the amount of interspersion of the patches; this signifies that varied patches are adjacent to each other (Mokhtari & Siahnia, 2017). The schematic flowchart of the methodology is shown in Figure 2.

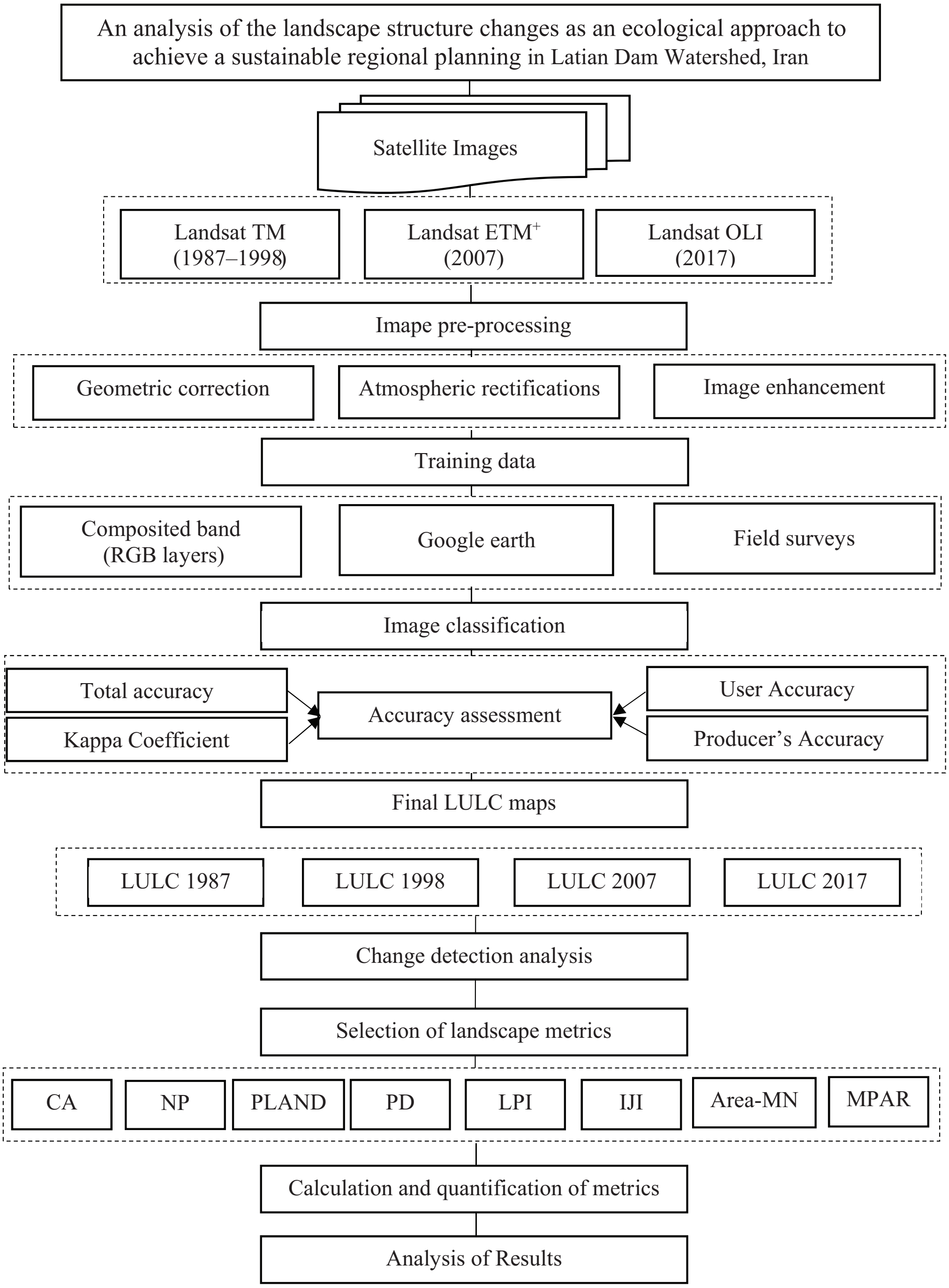

Figure 2. Methodology flowchart

Table 2. Metrics utilized at the class and landscape levels

Symbols & Domain	Class Metrics	Landscape Metrics
CA/TA CA > 0	Total (class) Area	Total Area
NP NP ≥ 1	Number of Patch	Number of Patch
PLAND 0 < PLAND ≤ 100	Percentage of Landscape	
PD PD > 0	Patch Density	Patch Density
LPI 0 < LPI ≤ 100	Largest Patch Index	Largest Patch Index
Area-MN	Patch area distribution	Patch Area Distribution
IJI 0 < IJI ≤ 100	Interspersion & Juxtaposition Index	Interspersion & Juxtaposition Index
MPAR PARA_MN > 0	Mean Perimeter to Area Rate	Mean Perimeter to Area Rate

2. Research results

2.1. A descriptive analysis and study of the macro-structural aspect of the landscape throughout the years 1987, 1998, 2007, and 2017

The satellite images were processed in the ENVI environment and then classified using the maximum feasible algorithm. For the extraction of LUCL, four classes were identified: build-up areas, vegetated areas, bare lands, and water bodies (Table 3). It is essential to assess the accuracy of land use maps obtained by remote sensing techniques (Jensen, 1996). In cases where the resolution of satellite images is in limitation for accuracy assessment (Thapa, 2009), the accuracy assessment of the LULC maps was achieved using a random sampling method (Rimal et al., 2017). The assessment for accuracy categorization for the four land use classes was performed by selecting 50 sample points at random throughout the area in order to compute the overall, user's, and the producer's accuracies. Supplementary data for accuracy assessment were collected from the topographical maps of the Armed Forces Geographical Organization (1:50000, 2010 & 2011), Google Earth images, and field surveys. The Kappa coefficient result, of more than 0.8 demonstrates the validity of modeling and simulation (Keshtkar & Voigt, 2016; Araya & Cabral, 2010). The overall, user and producer's accuracies, including the Kappa coefficient is computed for maps extracted from satellite images on the basis of remote sensing and the results show good accuracy (Table 3).

Table 3. Mapping accuracy obtained by maximum likelihood classifier to the Landsat images

Accuracy	1987	1998	2007	2017
Total Accuracy (%)	80.66	83.21	84.32	85.12
User's Accuracy (%)	85.33	83.75	86.68	91.14
Producer's Accuracy (%)	88.47	88.89	88.76	89.21
Kappa Coefficient	0.80	0.82	0.84	0.86

The above users are prepared to be converted after classification from digital to a rasterization mode and by utilizing an Arc GIS 10.3 Software tool with a cell size of 30 m. After disclosures and the preparation of appropriate colored images of several land uses, their specifications and limits were drawn up in the environment. So as to ensure the precise drawing of polygons, in the topology environment of Arc GIS Software, regulations such as the overlapping of polygons or the presence of gaps between them are defined and then the existing errors are amended. Finally, a valid land use map of the area was prepared (Figure 3).

In addition, major changes in the land use of the study area occurred between 1987 and 2017, as shown in Figure 4 and Table 4.

A variety of natural and human causes can induce changes in land use and the transfer rate over time. Land use changes for the area were grouped into three time periods as described below.

2.1.1. Land use changes between 1987 and 1997

One of the most land use changes between these years is the reduction of vegetated areas by 1.5% and their conversion into built-up areas. The results show that 71 hectares of areas with natural vegetation have been destroyed and converted to built-up areas, which indicates a 4.8% growth in construction. Most of these changes occur at the common border between riparian vegetation, gardens, and urban areas. The rising value of the property, the prosperity of villa construction, the desire of Tehran citizens to have a house in the countryside around Tehran, and the

Table 4. Area and percentage of different land use classes from 1987 to 2017

LULC	1987		1998		2007		2017	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Built-up areas	14.81	1.86	15.52	1.95	20.16	2.54	26.90	3.39
Vegetated areas	47.13	5.93	46.42	5.84	43.26	5.44	42.58	5.35
Bare land	728.86	91.70	728.86	91.70	727.38	91.51	721.32	90.75
Water bodies	4.03	0.51	4.03	0.51	4.03	0.51	4.03	0.51
Total	794.83	100	794.83	100	794.83	100	794.83	100

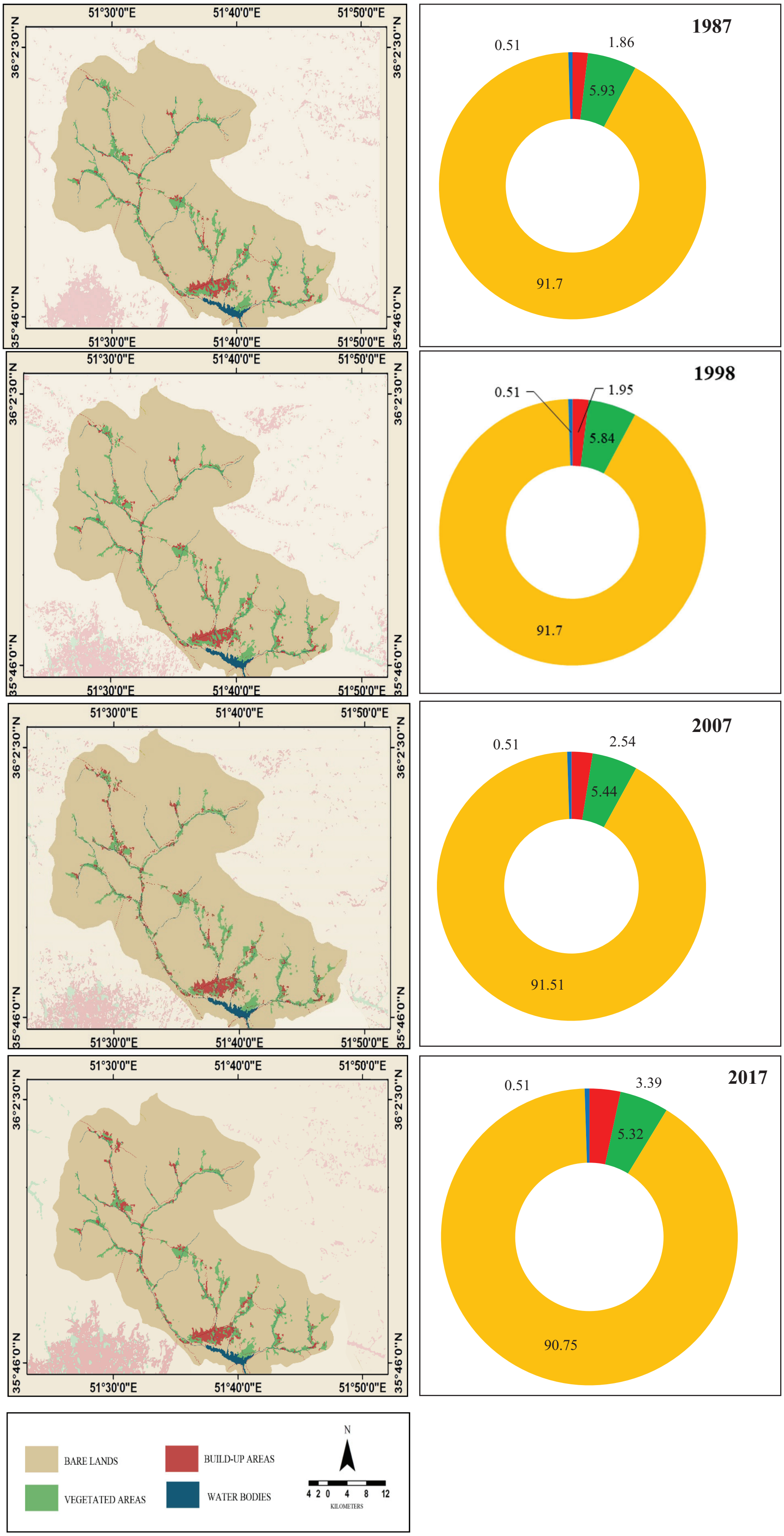

Figure 3. The tendency of spatio-temporal changes in the watershed area of the Latian Dam for the years 1987 to 2017

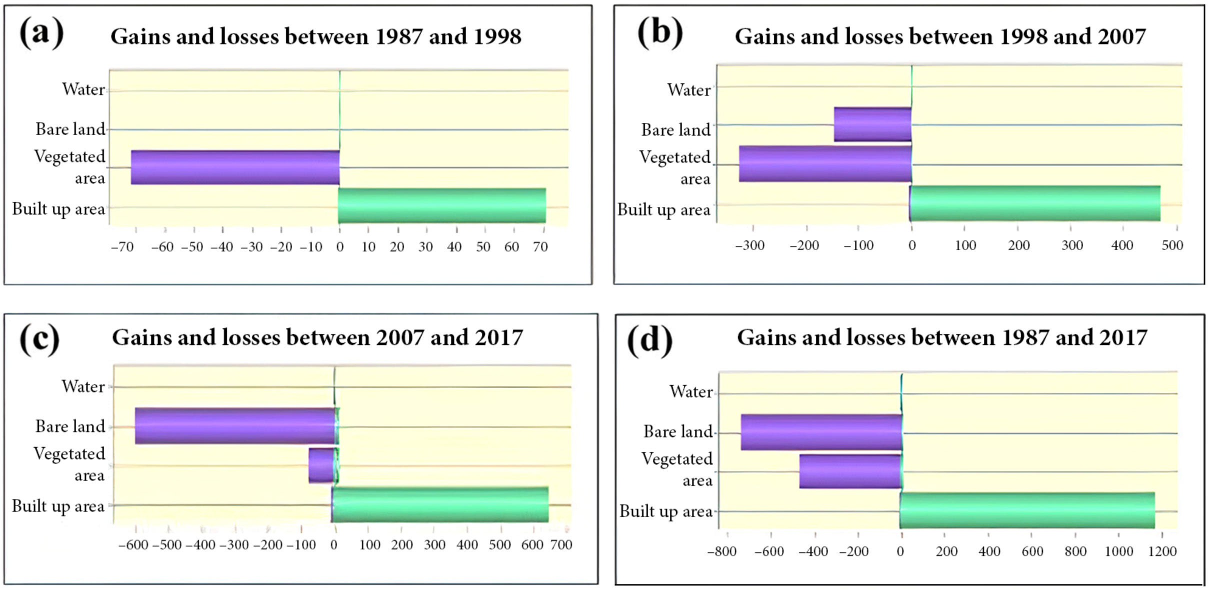

Figure 4. The amount of land use changes in hectares: a) 1998–1987; b) 1998–1998; c) 20017–2007; d) 2017–1987

acquisition of lands along the river are the most factors contributing to this change. There has been no change in the extent of barren land and water over the years (the lake behind the dam and the river).

2.1.2. Land use changes between 1987 and 2007

Between 1998 and 2007, 316 hectares (6.8%) of vegetated areas were destroyed, with the majority of them being converted into built-up areas. The vegetated areas have been increased by 5 hectares, whereas the built-up areas have been reduced by the same amount, i.e. 5 hectares. In addition, 122 hectares of barren land (17% of the overall study area) have been destroyed and added to built-up areas during these years. Generally, the built-up area increased by 464 hectares, which is about 30% growth. The lake behind the dam remained unchanged throughout this time.

2.1.3. Land use changes between 2007 and 2017

Between 2007 and 2017, 68 hectares (1.6%) of vegetated areas were destroyed and converted to build-up areas. Approximately 600 hectares of barren lands (8%) have been destroyed at the same time, owing to the increasing trend of development of cities in the study area. It appears that this decrease was mostly due to the conversion of this class from land use to built-up class. At the same time, 20 hectares of vegetated areas (mostly parks) and 16 hectares of barren lands have been added over the last ten years. This is despite the fact that the built-up area has grown by 33.4 percent, to 674 hectares.

2.2. Quantitative analysis of landscape structure on the basis of landscape surface metrics in 1987 to 2017

The total area (TA) of the limits under study amounts to 79,462 hectares. The mean perimeter to area rate (MPAR) indicates the amount of patchiness in the landscape structure. During the years 1987 and 1998, MPAR was stable. But this amount declined outstandingly in 2007 and showed a drop of approximately 1.1 percent in comparison to the prior decade time period. It also revealed an increase in patchiness across the landscape. A survey on the number of patches (NP) indicated an increment of about 13.8 percent within a 30-year duration. An increment, in the largest patch index (LPI), which is relative to the bare lands, shows patchiness and a tendency towards heterogeneity, at the landscape level. A comparison of the average or mean area of patches (AREA-MIN), during the study period exemplifies that, with a decrement of 17.8 hectares from the average area of patches, which equates to a decrease of 8.7 percent of this metric in 2007, the fragmentation of patches that have occurred in the landscape, in the last decade, is more than double.

The Interspersion & Juxtaposition Index (IJI) indicates the proximity of each patch with other patches that are not similar to each other and in other words demonstrates the amount of interspersion or intermingling of the patches. An 8.2 percent increase in this metric over a 30-year period indicates heterogeneity in landscape and patch fragmentation. The degradation and reduction of vegetated areas, as well as build-up areas in their stead, are examples of this issue. The patch density metric (PD) illustrates an increase in the density of patches; the annihilation of patches of vegetated areas and bare lands and their conversion into build-up areas has led to an increase in PD within the interval of 1987 to 2017. Figure 5 indicates the changes in the 7 metrics under study at the landscape level within the study area. In general, an increase in NP, a decrease in AREA-MN, and an augmentation in IJI exhibit increment in the heterogeneity of landscape-level.

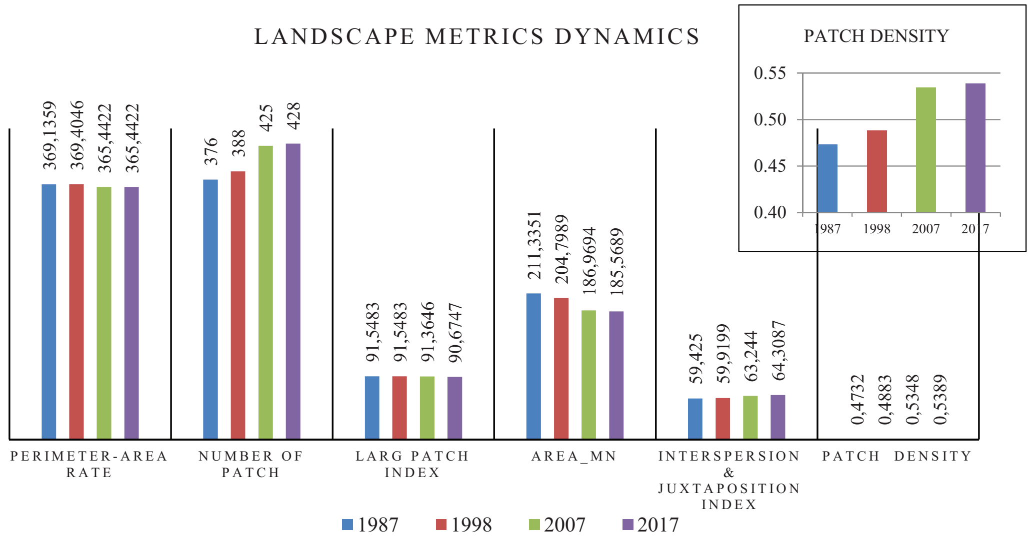

Figure 5. Quantification of composition and distribution metrics at a landscape level from 1987 to 2017

2.3. Quantitative analysis of landscape structure on the fundaments of class-level metrics in 1987–2017

In CA metric, the vegetated areas, amounting to 4,715 hectares in 1987, declined to 4,643 in 1998, showing a decrease of 1.5 percent. This amount displayed a reduction of 7.9 and 1.4 percent in 2007 and 2017 respectively. In total, this classification of land use in this watershed illustrates deterioration of 9.6 percent over the last 30 years. The area in the build-up areas showed an augment of 4.8 percent, that is, from 148, 275 hectares in 1987, it incremented to 155, 421 hectares in 1998; and subsequently, with an increase of 30 percent within a decade, it totaled to 202, 158 hectares in 2007. In 2017, the build-up areas displayed an augmentation of 264, 762 hectares, which in relative to the preceding decade revealed a growth of 31 percent. On an overall basis, this category of use has increased by 78.5 percent in the past 30 years. The area of bare lands has not altered from the years 1987 to 1998, and during the second and third decades has demonstrated a decrease of 0.17 and 0.8 percent respectively. In a span of 30 years, the area of the water bodies in a comparison survey was 403 hectares (Table 5).

The MPAR in bare lands and vegetated areas showed a mode of increment, which itself depicts the patchiness of landscape in these two land uses. On the contrary, in the built-up areas, this metric had a decrementing process, which indicated that the patches had become larger. The numbers of patches (NP) illustrate an augmentation in all the classifications, (except for the water bodies). An increment in NP’s during the years 1987 to 2017 is approximately 15.5 percent for the vegetated areas, for the build-up areas, is about 11.9 percent, whereas, in the case of bare lands it is 15 percent. The largest patch index (LPI) which relates to bare lands showed no modification from the years 1987 to 1998. A reduction of bare lands by 0.2 percent and 0.75 percent in 2007 and 2017 equally indicates a decrease of 11.3 percent of the vegetated areas over a period of 30 years. This displays a fragmenting of patches and an increase in landscape fragmentation in vegetated areas and bare lands. On the reverse, the size of the largest patch in the build-up areas showed an increment and has a growth of 23.7 percent, which specifies that a conjoining or continuity of build-up patches is due to an impact of urban expansion.

A comparison of the mean area of patches (AREA-MIN) over a period of 30 years also shows a decreasing trend in bare lands and vegetated areas. This reduction is 19.2 and 13.9 percent for vegetated areas and bare lands respectively; whereas, on the contrary, the build-up areas had a 54.6 percent growth which designates an increase in the continuity of patches in the stated use. In comparison to other LPI, NP, and MPAR metrics, increased heterogeneity at the landscape level and an augment in fragmentation at the class level are determined. The Interspersion & Juxtaposition Index (IJI) metric exemplifies an increment of 9.1 and 14.3 in percentage for vegetated areas and bare lands over a 30-year period. Similarly, a drop in these metrics has occurred in build-up areas and displays a tendency, of this class, being toward homogeneity and continuity. An eradication of vegetated patches and their conversion into build-up ones has given rise to an increase in PD in bare lands and vegetated areas. The PLAND percentage metric shows that in 2017, bare lands accounted for 90.79 percent, 5.36 percent for vegetated areas, and 3.33 percent for the build-up areas of the landscape (Table 5).

3. Conclusions and discussion

Sustainable planning is a multi-angled activity, with objectives to ensure the feasibility and an acceptance of ecological and socio-economic systems; and having access to sound conclusions for planning, cannot be attained without ecological considerations. Ecology is relevant to the efficiency of the system and resources and planning

Table 5. Comparison of class and landscape-level metrics during the years 1987 to 2017

Year	Land Use	CA	NP	LPI	AREA_MN	PAR_MN	IJI	PD	PLAND
1987	Bare lands	7286.21	20	91.5483	3643.605	488.5624	61.6691	0.0252	91.6932
	Build up areas	1482.75	194	0.6628	7.643	411.7592	63.1672	0.2441	1.866
	Vegetated areas	4715.01	160	0.5098	29.4688	299.7488	53.7735	0.2014	5.9337
	Water bodies	403.02	2	0.5068	201.55	591.3842	38.6711	0.0025	0.5072
1998	Bare lands	72861.21	20	91.5483	3643.0605	488.5624	62.4212	0.0252	91.6932
	Build up areas	1554.21	200	0.707	7.771	408.6043	63.1831	0.2517	1.9559
	Vegetated areas	4643.55	166	0.5098	27.9732	305.1452	54.3353	0.2089	5.8437
	Water bodies	403.02	2	0.5068	201.51	591.3842	38.6711	0.0025	0.5072
2007	Bare lands	72715.23	20	91.3646	3635.7615	488.5671	68.5793	0.0252	91.5094
	Build up areas	2021.58	230	0.8027	8.7895	399.3196	63.0235	0.2894	2.5441
	Vegetated areas	4322.16	173	0.5098	24.9836	303.5567	57.3141	0.2177	5.4393
	Water bodies	403.02	2	0.5068	201.51	591.3842	38.6711	0.0025	0.5072
2017	Bare lands	72109.98	23	90.6747	3135.2165	593.588	70.4709	0.029	90.7918
	Build up areas	2647.62	224	0.8197	11.8197	378.3412	62.7448	0.282	3.3335
	Vegetated areas	4262.58	179	0.4521	23.8133	305.7127	58.6677	0.2254	5.3669
	Water bodies	403.29	2	0.5074	201.645	591.5835	40.0508	0.0025	0.5078

focuses on them to be utilized for human benefit (Botequilha & Ahren, 2002). From the ecological viewpoint, sustainability can serve as planet earth's capacity in the way of guarding and supporting life and as standing, be denoted as a principle (Franklin, 1997). Many believe in the fact that, planning for the purpose of conservation, support and suitable utilization of the natural resources of landscapes is the ultimate objective of landscape planning (Forman, 1995). However, the landscape is adaptive on the scale of comprehension, decision-making, and the physical management of humans (Forman, 1995; Botequilha & Ahren, 2002). Hence, it is an optimal spatial configuration of ecosystems and land use, which leads to an increment of ecological integration, conservation of natural landscape structure and function, access to the fundamental requirements of mankind, and eventually the establishment of a sustainable living environment. Change is the evolution and replacement of ecological structure and function in the landscape mosaic over time (Forman & Gordon, 1986). Change can be portrayed and analyzed when minimum a comparison between dual-time conditions is feasible. The considered time period reflects the speed of change (intermittence and importance) of the components under study. In this regard, the purpose of this study is to investigate the change in the structure of the land landscape and the efficiency of land landscape metrics in analyzing the trend of LULC changes over a thirty-year period in the watershed of Latian Dam in Iran.

The findings of the study on the trend of land use changes between 1987 and 2017 show that the land use of the study area has changed dramatically. The linear growth of increasing constructions and destroying natural vegetation and barren lands and converting them into construction and residential structures in the watershed is quite evident. Overall, the results show that 1209 hectares (81.6%) were added to built-up areas and 455 hectares (9.65%) of natural vegetation areas have been reduced between 1987 and 2017. In addition, 754 hectares (1%) of barren land have been destroyed during the last 30 years. According to the findings, 9 hectares of built-up areas have been reduced, while 19 hectares of vegetated areas and 16 hectares of barren lands have been added during the last 30 years. Based on the findings, the size of the lake behind the dam and the river has not changed at a scale of 1: 50,000. The decrease in vegetated coverage and barren lands in the area, as well as the rising trend of built-up uses, indicate that the region's natural cover is being replaced and converted by man-made uses. Increasing human population and land expansion for human activities has been the most important factor affecting land cover in the study area, especially in areas with natural vegetation and gardens. Similar findings in the Munessa Shashemene landscape by Kindu et al. (2015); Reported in central Ethiopian highlands by Gessesse and Bewket (2014), and in the Muga watershed by Belay and Mengistu (2019).

This study showed that the spatial characteristics of each class also changed in the period 1987 to 2017. That is, the effects of destruction and conversion of LULC have also affected the shape and size of land use. In this study, these changes were quantified by land use metrics. According to studies, the CA index has the most change in the vegetated area and urban area classes, the least change in barren area class, and no change in water body class.

This index has decreased by 9.6% in the vegetated area use and has increased by 78.5% in the class of the built-up area during 30 years. In addition, this index did not change in the use of barren lands from 1987 to 1998, and it decreased by 0.17 and 0.8 percent, respectively during the second and third ten-year periods. The results of the NP index also show an increase in the number of patches during the years 1987 to 2017 in the classes of vegetation, built-up, and barren lands by 15.5, 11.9, and 15 percent, respectively. This indicates the increase in the number of patches, the fragmentation of patches and the division of the structure of the land into smaller patches, and the disintegration of the land in all three land use classes over the past 30 years. Oertli et al. (2002) stated that the high number of patches isolated from a habitat indicates a high level of fragmentation.

In addition, the results of the MPAR index indicate that the ratio of perimeter to area in the classes of barren and vegetated areas has an increasing trend, which indicates an increase in land patching in these two land use classes. On the contrary, this metric has a decreasing trend in the class of built-up areas, which indicates that the constructions will contain larger patches of land than before. This class of land use has an increasing trend in the development of the study area. In other words, the results of three metrics NP, CA, and MPAR show the phenomenon of elimination at the level of vegetated and barren lands, and the occurrence of the phenomenon or creation at the level of built-up class. In other words, the classes of vegetated and barren lands have been destroyed, while built-up areas have expanded and increased spatially. Bogaert et al. (2004), and Japolghy et al. (2017) declared an increase in NP and a decrease in CA as indicators of land degradation in their study. Japolghy et al. (2017) also stated that the phenomenon of creation has occurred in agricultural and residential classes as a result of changes in land use in natural ecosystems. Furthermore, the study of the average area of patches (AREA-MN) that the area of patches has been decreasing over the past 30 years in the land use classes of vegetation and barren lands. This trend shows a decrease of 19.2% and 13.9%, respectively for vegetated and barren land classes from 1987 to 2017. The class of built-up areas shows 54.6% growth in patch area means, although shows the continuity of patches in this class of land use but built-up land growth, natural environmental change to the artificial environment, and the increase of disintegration at the level of the landscape and class levels are confirmed compared to other LPI, NP, and MPAR metrics. This findings is consistent with the research of Griffiths and Lee (2000) and Muhammed and Elias (2021).

In this study, the results of the PLAND metric study show that barren lands with 90.79% coverage have the highest amount, and built-up and vegetation classes with 28.2 and 22.5% in 2017 are in the next ranks, respectively. Furthermore, the study of the PD index shows the loss of vegetation and its transformation into urban construction patches, which has led to an increase in patch density in vegetation and barren classes from 1987 to 2017. On the other hand, the mixing rate of patches was investigated using the IJI metric. An increase of 9.1% and 14.3% in this metric in the classes of vegetated and bare areas, and a 0.67% decrease in this metric in the built-up class indicate inhomogeneity in land appearance, fragmentation, and replacement of patches. They are with other types of patches in two classes of vegetated and barren lands over a period of 30 years. Furthermore, the decrease of this metric in the class of built-up areas shows that the patches in this class of land use have a trend towards homogeneity. Results of Muhammed and Elias (2021) in the Bale Mountains National Park and Tolessa et al. (2017) in Jibat forests in Ethiopia also confirmed the increase of natural land fragmentation and replacement with other lands. Moreover, the findings of the LPI index show that the largest patch is related to barren lands, which did not change from 1987 to 1998 but decreased by 0.2 and 0.75% in the second and third decades, respectively. In addition, over a 30-year period, the largest patch in the class of vegetated areas decreased by 11.3 percent over a period of 30 years, indicating the fragmentation of the patches and the structure of the landscape at the class level in these two land use. Furthermore, the size of the largest patch in the class of built-up areas increased by 23.7%, which shows that the scattered patches of construction are connected to each other due to further development and construction, and gradually form larger patches. Therefore, the study of PLAND, PD, LPI, and IJI metrics shows the destruction and reduction of vegetated areas and construction instead of these lands. These findings are consistent with the research of Megahed et al. (2015), Sertel et al. (2018), and Muhammed and Elias (2021). Landscape metrics analysis also clearly shows the effects of human activities and urbanization on the environment. The results show that the landscape of the Latian Dam Watershed has become finer, more complex, more geometrically irregular, more fragmented, and less cohesive. The results of this study are also consistent with the research of Muhammed and Elias (2021), Zhu et al. (2021b), and Nazar Neghad et al. (2020) indicating that the land uses especially vegetated areas have changed and destroyed in recent years.

Bihamta Toosi et al. (2014) stated a relocation of residential and commercial areas to rural and agricultural areas on the outskirts of urban vicinities reflects the economic growth of the region, which increasingly has adverse environmental effects and creates socio-economic impacts and infrastructure costs. Jafari et al. (2011) stated changes in land cover on the outskirts of cities are actually due to the rapid expansion of sparsely populated areas. Recognition of these studies and changes and the impacts arising from it, by the regional and local managers and policymakers, so as to gain access to planning and sustainable development is crucial. A summarization of this research, along with the results of Mu et al. (2016), Wang et al. (2020), Nasiri and Darvishsefat (2018), and Seto et al. (2012) has conformity that urban expansion is the cause for the degeneration and destruction of natural lands, vegetation, and habitats. The aspect which differentiates this research from the prior studies is the regional scale, climatic and geographical location, propinquity with the metropolis of Tehran, and the driving forces bringing about change in this watershed. The four driving forces causing land use changes and thus have modified the landscape structure in the said watershed are:

1. The availability of sufficient land for housing and urban expansion purposes.
2. Density and population growth in the macro-city of Tehran and an increase in demand for construction.
3. A scarcity of open and recreational spaces in Tehran.
4. Modifications in the lifestyle of people and an inclination towards luxury.

Open spaces and orchards and the fringes of the Jajrood River in the Latian Dam Watershed is an extremely good destination for the residents of the capital city of Tehran, as a temporary outlet for the abode and a single or multi-day recreation on weekends and holidays; or else, as a permanent residence. This issue has had a considerable impact on land use changes (especially in vegetated areas), which has led to changes in landscape structure in this watershed and is in the context of being under discussion; and survey from the two angles of nature and intensity (speed) of changes. Firstly, the nature of the changes which has emerged in terms of the degradation of vegetated areas, a decline in bare lands and an increase in build-up areas, has altered the composition and distribution of patches in the landscape pattern. Secondly, it is the intensity or a rapid pace of these changes, during the years 1998 to 2007, which has additionally increased, in relative to the initial decade of 1987 to 1998 and the third decade of 2007 to 2017 of this research. The MPAR in vegetated areas showed a mode of the increment (from 299.7488 to 305.7127 hectares), which itself depicts a patchiness of landscape. Also, the comparison of the (AREA-MN) of the patches during the period of study, shows that vegetated areas have followed a decreasing trend from 29.4688 to 23.8133 hectares, while the build-up areas had increment from 7.643 to 11.8197 hectares at the same years. An increment in NP's during the years 1987 to 2017 shows the fragmentation of vegetated areas, where the patch number increased from 160 to 179. Meanwhile, NP of build-up areas followed this trend too, 194 to 224 patches which shows the growth of construction industry during the second decade of the study (1998 to 2007).

This matter is in accord with the improvement of economic conditions of the second decade. Another vital prevailing problem, are the shortcuts for the issue of construction permits, which lead to the destruction of vegetated areas, bare lands and even the skirts of foothills. An absence of infrastructure development which is appropriate with the requirements of the indigenous population, unfavorable policies in regards land and housing, due to the manipulations of mediators and the purchase of endemic properties at low rates, have engulfed the indigenous community with financial and economic issues, such that, they are indirectly involved in the degeneration and destruction of their environment, resources and natural heritage. Darabi and Jalali (2018) demonstrate that, transaction costs are the cause for the inefficiency of official organizations, which leads to the expansion of unendorsed developments and those beyond the legal formalities. Scientific findings arising from the current research, assists the planners and decision-makers to achieve a sustainable regional development. This awareness will lead to the conservation of the environment and metropolitan lands for future generations as a natural heritage; and will lead to an apt perceptive and interpretation of nature and a participation in its conservation. Similarly, gaining information about the regional landscape structure can be effective in conservation planning and development of such plans for the natural ecosystem and cultural landscape of this watershed. Thereby, the following cases are proposed:

– Determining land value amendments strategies to reduce unplanned construction, additional control as to the conservation of the river boundary to preserve riparian vegetation, the adherence of ecological standards and the conservation of cultural and tourism ideals are proposed.
– Due to the impact of the endemic and non-endemic communities (residential or non-residential), as to environmental destruction, it is suggested that, the socio-economic and cultural studies be conducted with a public participation approach and be supplemented to the predictions and quantification results, so that, decision-making and policies are performed with certainty and enhanced accuracy.
– The enforcement of planning and management scenarios, as well as macro-decision-making policies across the Tehran Province, in the sphere of incrementing the infrastructure of tourism, with regard to appropriate regional planning, in order to maintain and expand the protected area of Jajrood and its neighboring areas are recommended.

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