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Investigation of geodiversity in Lar basin, northern Iran

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A B S T R A C T

The diversity of natural processes including geological diversity (bedrock), geomorphic diversity (landform), sediment characteristics, geo-ecosystem in the Lar basin of Iran indicates the existence of geodiversity. Lar basin is located in the folded Alborz section of northern Iran and is limited on the east by Damavand volcanic and high peaks with 5594 m height. This research is conducted based on 1: 25000 topographic maps, digital elevation model, visible bands Landsat image version 8 on 26 August 2017 and field studies. The research method includes elevation zoning for landform energy mapping and landform fragmentation based on spectral homogeneity criterion, supervised classification and visual identification of the landfill has been performed to map the land surface and to calculate geodiversity indicators, the study area is divided into 46 zones. The findings of the study showed the existence of high and low geodiversity in the mountainous area and lowlands such as the bottom of river valley. This indicates a direct relationship between height and energy of the landforms. Also, most of the landform fragmentation in Lar basin and geological formation is located in areas with andesite, shale and green tuff. In general, the elevations of the center of the basin are around of Damavand Mountains and the northwest of the Lar basin has high geodiversity zones. These areas correspond to the high mountains, the glacial erosion range, the water distribution lines, and the first-order basins and rocky and bare lands. There are also mountainous areas with medium and low altitude or hillside with more slope and numerous valleys in the high geodiversity range. These two areas comprise more than half of the Lar Basin. In general, the geodiversity of the Lar Basin is dependent on elevation changes, diversity of geological formations, lithology, and vegetation.

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1. Introduction

The landscape is a complex concept that is influenced not only by natural and biological factors but also by perceptual perception. Natural factors such as petrology, structure, landforms, and process form the basis of a landscape and are key to explaining geodiversity (Benito-Calvo et al., 2009). Due to the wide diversity of physical resources, geodiversity can play a significant role in the study of relatively pristine areas and their conservation. In developing countries due to economic-cultural problems, study and conservation of natural areas are of particular importance.

Lar basin is one of the areas that have been least affected by human interpolations in Iran. The presence of geological diversity (bedrock), geomorphic diversity (landforms), sediment characteristics, geo-ecosystems and natural activities or processes in the Lar Basin has made this basin an important location for geodiversity. On the other hand, the lack of serious attention to environmental protection in developing countries indicates the need to pay more attention to the study of relatively pristine basins. Therefore, this study investigates the geodiversity of the Lar Basin. The concept of geodiversity was first introduced in 1990 and has been rapidly investigated by earth science researchers (Zwolinski et al., 2018).

This concept is considered important in conservation, planning and environmental mapping, which has recently allowed us to identify geodiversity (Ozsahin, 2017). For this purpose, many methods have been developed with the aim of developing land conservation programs. Also, a general classification of the methods used to calculate geodiversity can be particularly useful in raising awareness of the importance of geodiversity for ecological studies, landscape studies and their recognition for human development. Indexing and geodiversity mapping techniques can play an important role in upgrading a comprehensive and integrated geosystem services ecosystem to support the sustainable management of natural services (Zwolinski et al., 2018). Poland has developed a geodiversity atlas that contains a large number of 1: 750000 maps of Poland geology, land surface, soil, surface water, groundwater, mineral waters and landscape structure where geodiversity is classified into very high, high, medium, low and very low classes (Kozlowski, 2004). Cañadas has used geological, geomorphological, hydrological and pedology elements in Spain, and has based its geomorphological map and geomorphological units on geodiversity assessment (Serrano Cañadas and Ruiz Flaño, 2007). Calvo studied geodiversity in the geodynamic zones of the Iberian Peninsula in 2009 and accordingly, it classified morphometric maps, morphological climatic maps, and geological maps and by overlaying these maps, different geodiversity indices in the region can be calculated (Benito-Calvo et al., 2009). Zwolinski uses the landform energy map derived from the SRTM-3 digital elevation model, the landform map derived from geomorphological maps and the landform conservation map to extract geodiversity maps of Poland and has evaluated the patterns and changes of perspectives and developments of the perspectives of human construction (Zwolinski, 2009). In the region of Suriya, Spain, geodiversity indices have been calculated by providing geomorphological maps and morphological units. Thus, the physical elements are extracted from geomorphological, geological, soil and terrain maps. The stiffness of the slope map is calculated and the geodiversity of the Suriya region is classified into 5 classes (Serrano et al., 2009). To understand geodiversity patterns in different perspectives against global changes, geodiversity and topographic parameters have been investigated in the Finnish Arctic. In this study, the relationship between geodiversity and topography is analyzed using the landscape-scale spatial network system (Hjort and Luoto, 2010). To study the spatial distribution of geodiversity in the Danube-Tiza region in the Hungarian plain, the Hjort (2010) study method was used. Geological features, landforms and hydrological elements of the land surface have been used. The landforms are then categorized according to the processes they have created and finally, the geodiversity index is calculated from the Serrano-Canadas (2007) method (Osri, 2011). Comanescu and Nedelea have also used the same method to evaluate and provide the geodiversity map in Buzaului Geopark in Romania (Comanescu and Nedelea, 2012). The fundamental role of geodiversity in environmental protection and biodiversity has been studied in five areas of economic development, climate change adaptation, biodiversity, science and education and recreation, health and cultural inspiration in Scotland. Given the value and impact of geodiversity, each of these issues has been studied separately (Gordon et al., 2012). Paulo Silva and Rodriguez used parameters associated with river channel patterns in a cellular network to identify geodiversity indices in the Amazon environment (De Paula Silva et al., 2014). In the province of Salamanca, Spain, geodiversity studies have been carried out using techniques of cartography switching from 2D to 3D using image overlay. For this purpose, indices with different geological parameters have been calculated in this area. Finally, the map is obtained to show areas with a high concentration of geological diversity and to define areas with a need for environmental protection when human activities are involved in natural areas (Martines-Grana et al., 2014). Also in Hong Kong due to their great biodiversity, especially in coastal areas, to study geodiversity and environmental protection, landscape features are classified into different coastal types, coastal erosion landforms, sea caves and canyons based on their appearance and the process of their creation (Wang et al., 2015). Ilic et al. quantified geodiversity based on the number of living elements and the severity of rugged terrain in space units. For this purpose, the region is divided into pixels with a size of 200 * 200 and 1000 * 1000. The size of pixels is determined based on the size of the territory and the scale of the input data, and the geodiversity map is prepared according to geological (stratigraphy, petrology), geomorphological (morphogenic), pedological (pedology) and hydrological (rivers and springs) criteria (Ilic et al., 2016). Geodiversity in Crete, Greece, has been investigated based on geomorphometric, geological classification and climatic factors. A number of geomorphometric variables have been extracted from the digital elevation model; in relation to geological and climatic information have been evaluated in GIS software. The analysis derived from this information has been used to provide geodiversity map (Argyriou et al., 2016). Serrano's (2007) techniques have been used to classify and distribute geodiversity in the mountain of Gönüs in northwestern Turkey, and as a result, mathematical analysis is derived from geodiversity grading (Ozsahin, 2017).

1.2. Study Area

The Lar River basin is located between latitude 33° 57´ to 36° 03´ and longitude 52° 06´ to 51° 33´ and is located in a folded Alborz unit. It is limited on the north by the Se Sang and Divasiab Mountains, on the west by the Kharsang, Kholeno and Sudar Mountains, on the south by the Hazar Dare and Lavasan Mountains, and on the east by Damavand Peak and Pleur area. The altitude range in Lar basin varies from 2409 to 5600 m. Most of the height is allocated to Damavand peak with the height of 5594 m. Most of the land in this basin has the height of 3,000 m and has 49 peaks with the height of more 3000 m. In fact, more than 85 percent of the Lar River basin is covered by mountains, 80% of the high hills and peaks in the Lar are caused by the mechanism of thrust faults and 90% of the lands and rocks in the Lar are created between faults. Stratigraphic studies indicate the existence of many geological formations in the Lar basin which included Shemshak, Delichai, Lar formation (dominant formation in the Lar basin) and Tiz Kooh, that each of these formations appears as extrusion in different parts of the basin. As shown in Figure 2 and Table 1, the lithological diversity in the Lar Basin is considerable. Intrusive, volcanic, metamorphic and sedimentary rocks are observed in Lar basin. In terms of climatic divisions, this basin has a semi-humid climate with cold winters in the middle part and a cold and semi-mountainous climate in the highlands where most of its rainfall is in the form of snow and at height of more 2800-3000 m, this climate can be observed. According to the statistics of 2001-2013 years, the average annual rainfall is 540.32 mm and the average annual temperature is 10.2. In terms of surface cover, most of the basin is devoted to rock cover and vegetation is only found in parts of the basin. This basin is very poorly exploited by humans and is the only place where nomads move. Due to the low impact of human structures, the Lar Basin has been selected for geodiversity assessment. Fig. 1 shows the geographic location map of the Lar Basin.

2. Material and Methods

This research is based on 1:25000 digital maps of Iranian Mapping Organization. Also the digital elevation model with a resolution of 30 m related to 17 October 2011 is taken from Earth Explorer.
(https://earthexplorer.usgs.gov/metadata/4220/ASTGDEMV2_0N35E051/) and Landsat 8 image, visible bands include blue bands (0.450-0.515 wavelength), green bands (0.525-0.6 wavelength) and red bands (0.630-0.680 wavelength) and panchromatic (band 8 or broadband with wavelength of 0.500-0.680) as of 26 August 2017 from Earth Explorer.

The research steps are as follows: DEM is used to prepare the energy layer of the landforms for height zones. As such, first, to minimize local height fluctuations, filters with a minimum and maximum of 3*3 have been applied to differentiate low and high height zones and calculate the relative height of the basin by overlapping the layers of the minimum and maximum height filters. By classifying the relative height to 5 classes, the geodiversity layer is prepared based on the energy of the Lar Basin Landforms. In this layer, there were 15 zones, 5 areas were very high height, 4 areas were high height, 3 areas were medium height, and the other 3 areas were classified as low or very low, which are similar geodiversity (Table 2) (Zwolinski, 2009).

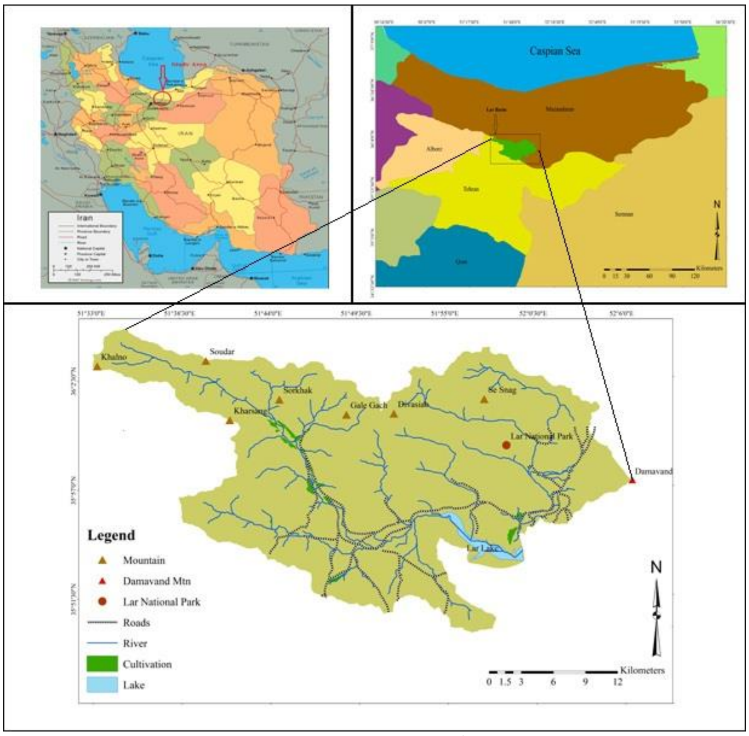

Fig. 1. Geographic location map of the Lar Basin

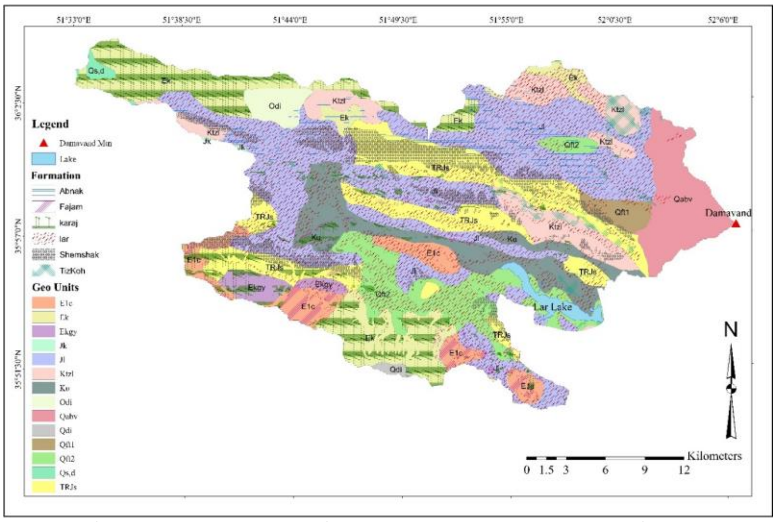

Fig. 2. Geological and lithological formations map (extracted from geological map with the scale of 1:25000, Geological Survey & Mineral Exploration of Iran)

Table 1. Geological and lithological formations

Geology Units	Descriptions	Formation
E1c	polygenic conglomerate and sandstone	Shemshak/Lar
Ek	Well bedded green tuff and tuffaceous shale	Karaj/ Abnak
Ekgy	Gypsum	Lar/Karaj
Jk	Conglomerate, sandstone and shale with plant remains and coal seams	Lar
Jl	Light grey, thin - bedded to massive limestone	Tizkouh/ Lar
Ktzl	Thick bedded to massive, white to pinkish Orbitolina bearing limestone	Tizkouh/ Shemshak/Abnak
Ku	Upper cretaceous, undifferentiated rocks	Lar/ Karaj
Odi	Diorite	Abnak
Qabv	Andesite to basaltic volcanics	(Damavand Domain)
Qdi	Diorite	Karaj
Qft1	High level piedmont fan and valley terrace deposits	Lar
Qft2	Low level piedmont fan and valley terrace deposits	Lar
Qs,d	Unconsolidated wind-blown sand deposits including sand dunes	Karaj
TRJs	Dark grey shale and sandstone	Shemshak/ Abnak

Table 2. Geodiversity classification in landform energy

Category of Geodiversity	Amount of point region	Local elevation	Examples in Lar Basin
Very High Geodiversity	5	495-167	Mainly in Damavand Mtn. And the heights of Northwest and Center of basin
High Geodiversity	4	167-130	Low or medium high mountains, a range of ridges.
Medium Geodiversity	3	130-97	Domains of low high mountains, foothills.
Low Geodiversity	2	97-56	mainly slopes of inbasins and hollows
Very Low Geodiversity	1	56-0	vast bottoms of inbasins and hollows as well as bottoms of river valleys

Landsat 8 satellite bands, altitude data, and multiple fragmentation algorithms were used to segment the Lar basin landforms in e-Cognition software. This algorithm locally minimizes the average heterogeneity of image elements with respect to resolution. For this purpose, the spectral and height homogeneity criterion was used to determine the best neighbor (e-Cognition reference book, 2011) (Table 3).

Table 3. Geodiversity classification in landform fragmentation

Category of Geodiversity	Amount of region	Types of relief fragmentation/segmentation	Examples in Lar basin
Very High Geodiversity	5	high-mountain relief transformed by glacial and periglacial processes, with arêtes and gullies	Damavand Mtn.
High Geodiversity	4	medium and low mountains and high foothills, a dense network of both valleys and ridges, linear tectonic and denudation thresholds with steep slopes as well as high and precipitous (often also densely incised) scarps of gorge	Ranges of Kholeno, Kharsang and sudar Mts.
Medium Geodiversity	3	low foothills, low tectonic and denudation thresholds as well as deeper river gorges	Lar National Park, Residential area in the height of 2800.
Low Geodiversity	2	Intramontane basins, stretches of low uplands, scarps of varying genesis	Upstream of Lar valley
Very Low Geodiversity	1	valley floors (margins of river terraces were omitted)	Lar valley

Surface protection is based on the land surface map. For this purpose, the user map of Landsat 8 was prepared using supervised classification and visual identification. The final classification of land surface protection illustrates the distribution of natural to human factors in the development of landforms, their evolution, and changes (Table 4).

Table 4. Geodiversity classification in terrain preservation

Category of Geodiversity	Amount of point	Types of relief fragmentation/segmentation [extracted from Starkel (1998) for mountain areas only]	Examples in Lar basin
Very High Geodiversity	5	very high level of relief preservation: the morphological surface is the least transformed by morphogenetic processes and almost untouched by man-made processes, i.e. primeval mountain forests, peat bogs, swamps	The western slopes of Damavand Mtn. and Kholeno and Kharsang Mts.
High Geodiversity	4	high level of relief preservation; areas sporadically affected by morphogenetic processes with a slight contribution of man-made processes, i.e. slopes with landslides	The foothills, elevation about 3500 meters, Lar National Park
Medium Geodiversity	3	medium level of relief preservation as a result of both morphogenetic and man-made processes, i.e. arable grounds inbasins, Carpathian Foothill zone (partially	Agricultural land, height of 3100 meters and upstream of Lar valley.

Low Geodiversity	2	poor level of relief preservation indicating substantial changes in the relief as a result of human activity, i.e. urban areas	Scattered residential areas in the lower reaches of the basin, 2700 meters high.
Very Low Geodiversity	1	very poor level of relief preservation, i.e. a complete transformation of the relief by man, the transformation being usually irreversible, i.e. mine-industrial areas, quarries, dam reservoirs	Lar lake dam in the south of the Lar basin.

Finally, the geodiversity map of the Lar Basin was prepared by overlapping the three layers of landform energy, landform fragmentation and land conservation layer. Each of the above layers has 5 levels of geodiversity that range from very high to very low. By dividing these layers into 5 classes and assigning the number of points that represent the extent of geodiversity in each class, a general classification is provided for the geodiversity map. To study geodiversity more precisely, the study area was divided into 46 zones with dimensions of 110 m, and the indices of Table 5 were calculated for each cell by Fragstats software and Z Score was used to match the values of the indices and to compare the indices in the cells. Fig. 3 shows the network of zones. Fig. 4 is a diagram of the steps of preparing a geodiversity map.

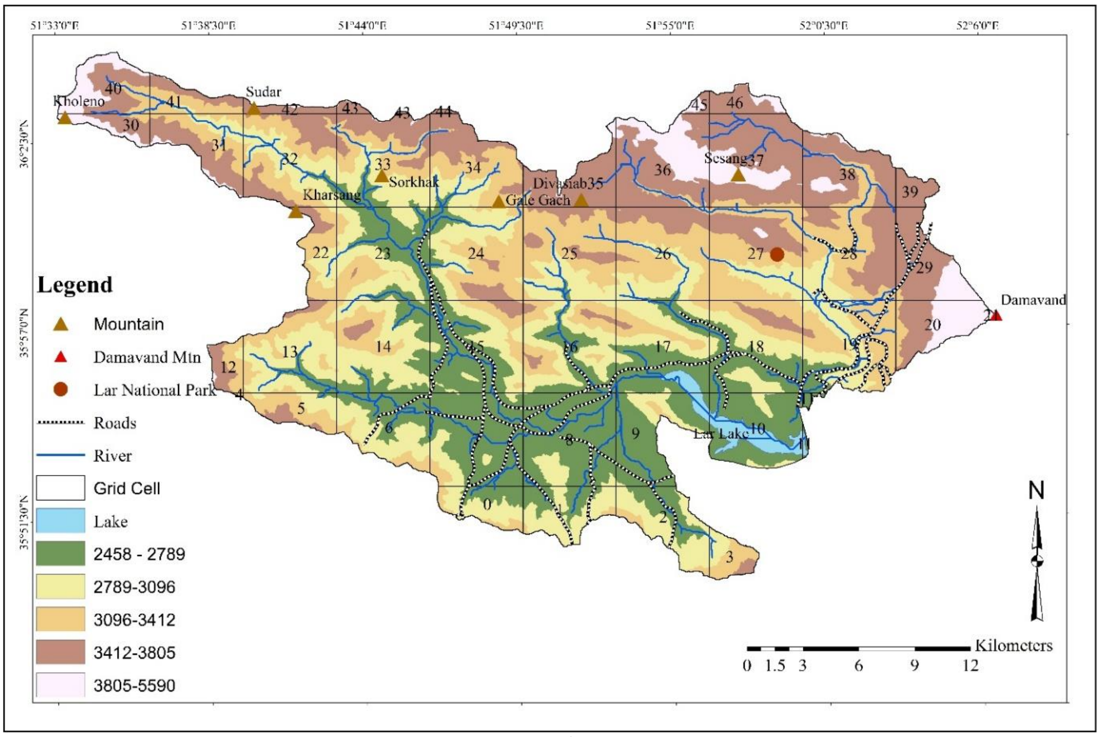

Fig. 3. Zonation of the Lar basin

Table 5. The indexes of geodiversity calculation (FRAGSTATS reference 2015)

Indices	Formula	Description
PRD	$\frac{m}{A}(10^4)(10^2)$	m = numbers of patch types (classes) present in the landscape, excluding the landscape border if present. A = total landscape
RPR	$\frac{m}{m_{max}}(100)$	m = numbers of patch types (classes) present in the landscape, excluding the landscape border if present.

SHDI	$-\sum_{i=1}^{m}(p_i \ ln \ p_i)$	Pi = proportion of the landscape occupied by patch type (class) i.
SIDI	$1-\sum_{i=1}^{m} p_i^2$	Pi = proportion of the landscape occupied by patch type (class) i.
MSIDI	$-ln\sum_{i=1}^{m} p_i^2$	Pi = proportion of the landscape occupied by patch type (class) i.
SHEI	$-\sum_{i=1}^{m}(p_i^2 \ lnp_i^2)/\ln m$	Pi = proportion of the landscape occupied by patch type (class) i. m = numbers of patch types (classes) present in the landscape, excluding the landscape border if present.
SIEI	$1-\sum_{i=1}^{m} p_i^2 \ /1-(\frac{1}{m})$	Pi = proportion of the landscape occupied by patch type (class) i. m = numbers of patch types (classes) present in the landscape, excluding the landscape border if present.
MSIEI	$\frac{-ln\sum_{i=1}^{m} p_i^2}{\ln m}$	Pi = proportion of the landscape occupied by patch type (class) i. m = numbers of patch types (classes) present in the landscape, excluding the landscape border if present.
GDL	$\frac{LE_0+LF_0+SP_0}{T_0}$	LE = Local elevation or relative elevation LF = Landform Fragmentation(segmentation) SP= State of contemporary relief preservation (natural vs man-made processes) T = evolution of the relief over time

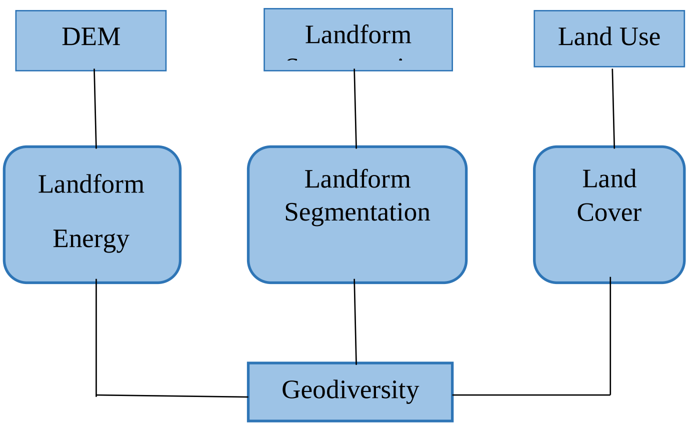

Fig. 4. Diagram for preparing geodiversity map

3. Results and discussion

As shown in Fig. 5, geodiversity dispersal in the Lar Basin for Damavand Mountain and Kholeno, Suder, Kharsang and Sorkhag mountains, show high geodiversity and appear on the map is shown in brown and dark brown. Geodiversity at altitudes of 3500 meters is less than Damavand and west of the basin, but it is still more diverse at altitudes of about 3,000 meters. Also at the bottom of the basin, the pits and bottom of the river valleys have the lowest geodiversity. This indicates a direct relationship between height and geodiversity. This is due to the fact that the energy layer of the landforms is calculated with respect to the distribution of relative height and increases from lower altitude to higher altitude areas. In other words, the western hillside of Damavand and the Kholeno Mountains and the northwest elevations of the basin with height of more 3900 m have the highest landform energy. The landforms fragmentation in the Lar basin are also related to the geological formation and most of it placed in the Damavand Mountains and the northwest and northeast mountainous basins, where there is the geological unit of the andesite, shale and green tuff. So, around

Damavand Mountain, the altitudes of the center of the basin and northwest of the Lar basin are very geodiversity. These areas with elevated mountains, glacial erosion range, water distribution lines, and first-rate basins show that they are more covered by rocky and bare land. There are also mountainous areas with medium and low altitude or with steep slopes and numerous valleys with different altitudes range of about 150 to 450 m in high geodiversity territory. These two territories included more than half of the Lar Basin, indicating a high potential for landscape conservation and environmental sustainability.

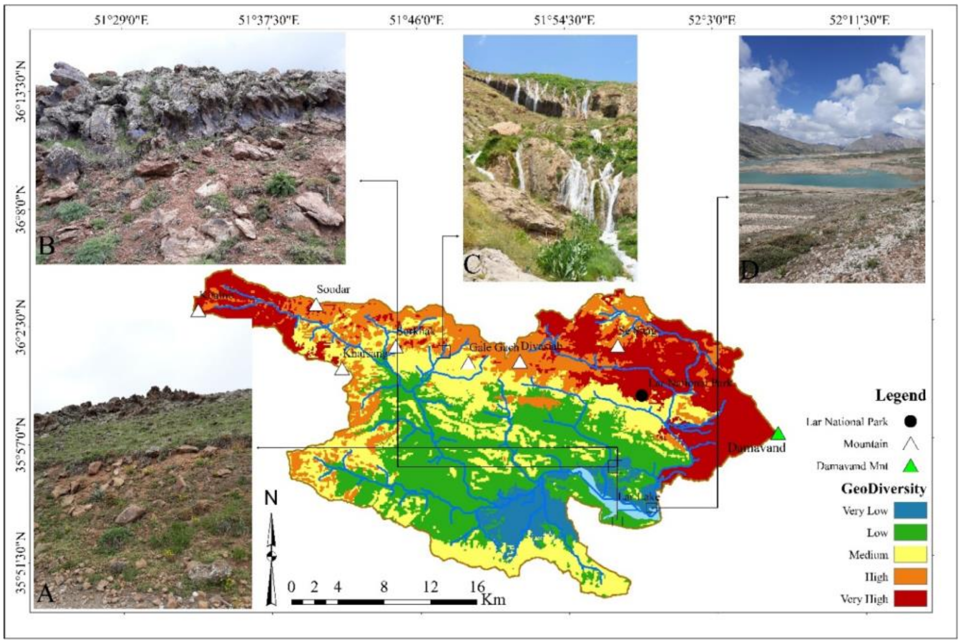

Fig. 5. Geodiversity in Lar basin

The calculations of the geodiversity indices in the cells of Lar Basin are shown in Table 5 and Fig. 6 is the diagram of Z-Score variation of the geodiversity indices. Table 6 and Fig. 6 show the maximum variation of PRD index in 35, 5, and 4 cells, with the high altitude. The latter two cells have a very small area, these cells, at an altitude of 3800 meters, coincide with the highest parts of the Damavand Mountains in the northern part of the basin. The maximum variation of RPR index is in cells 35, 25 and 1 which are geographically located in the western hillside of Damavand Mountain and in the Khelno hillside. The height of these cells is between 3900 and 5600 m. In the SHDI index, the range of changes in cells 32 to 35 is very high and the geodiversity of these cells is very high. Some of these cells are located on the western hillside of the Damavand Mountains and another in the karst canyons of Lar basin. The SIDI index indicates a large variation in the two-thirds of the basin area. The maximum geodiversity in the analytical diagram of this index is in the cell of 34. The cell is located at the western hillside of Damavand with a height of 5500 m. In the MIDI index calculations, the geodiversity distribution in the basin is balanced. As only the cells at 1, 9, 10, 25 and 34, which is the peak of diversity, there is a great deal of geodiversity. Field observations from the study area (Fig. 5) show the distribution of landform diversity in different parts of the basin. Fig. C in zone 34 shows high diversity in the basin. This figure is part of the Sefidab River located northwest of the basin near the Galehgach and Sorkhak mountains at a relatively high altitude and has high energy. The geological formation in this zone is gray shale and limestone and the Shemshak Formation is the dominant form in the area. Figures A, B and D are located in zones 10 and 18. This part of the basin is less elevated and the energy of the landforms is lower. The range of these figures lies on the southeastern slope of the basin and is adjacent to Lar basin. On a larger scale, this area has little geodiversity and is located on low altitude terraces that form the Lar Formation.

Table 6. Quantitative calculation of geodiversity indexes in cells

Cell NUM	PRD	RPR	SHDI	SIDI	MSIDI	SHEI	SIEI	MSIE
1	94.37	23.14	6.89	0.998	6.8	0.977	0.9998	0.964
2	120.23	16.1	6.53	0.998	6.43	0.976	0.9996	0.961
3	193.79	8.82	5.85	0.996	5.71	0.962	0.999	0.938
4	324.58	6.74	5.67	0.996	5.55	0.975	0.9991	0.954
5	686.99	3.98	5.16	0.993	5.04	0.975	0.9985	0.952
6	269.95	6.26	5.57	0.995	5.44	0.97	0.9989	0.948
7	106.54	9.74	5.9	0.996	5.74	0.954	0.9988	0.927
8	191.39	18.82	6.62	0.998	6.47	0.966	0.9995	0.945
9	74.47	20.32	6.82	0.998	6.77	0.986	0.9998	0.978
10	42.95	20.9	6.85	0.998	6.8	0.986	0.9998	0.978
11	46.97	23.2	6.96	0.999	6.9	0.986	0.9999	0.978
12	49.63	2.05	6.76	0.998	6.65	0.975	0.9997	0.959
13	59.04	13.48	5.99	0.996	5.76	0.92	0.9983	0.885
14	38.79	18.22	6.64	0.998	6.55	0.975	0.9997	0.961
15	33.46	16.68	6.43	0.998	6.25	0.956	0.9993	0.929
16	46.03	15.88	6.46	0.998	6.36	0.968	0.9995	0.953
17	56.98	3.86	4.94	0.992	4.82	0.94	0.9971	0.916
18	94.58	15.78	6.53	0.998	6.44	0.979	0.9997	0.965
19	33.5	16.9	6.41	0.997	6.16	0.952	0.9991	0.915
20	43.49	22.03	6.82	0.998	6.73	0.973	0.9997	0.96
21	38.61	19.48	6.66	0.998	6.55	0.968	0.9996	0.953
22	42.62	21.5	6.77	0.998	6.64	0.971	0.9996	0.951
23	36.43	18.38	6.63	0.998	6.52	0.972	0.9996	0.955
24	28.86	14.56	6.44	0.998	6.36	0.978	0.9997	0.966
25	95.51	26.14	6.49	0.997	6.06	0.904	0.9984	0.845
26	187.96	17.32	6.6	0.998	6.5	0.977	0.9997	0.961
27	47.92	19.96	6.55	0.998	6.41	0.949	0.9994	0.928
28	40.87	20.62	6.64	0.998	6.49	0.957	0.9995	0.936
29	50.11	25.42	6.52	0.997	6.05	0.912	0.9984	0.846
30	43.41	21.9	6.84	0.998	6.75	0.978	0.9998	0.965
31	40.68	20.52	6.65	0.998	6.43	0.959	0.9994	0.927
32	42.82	21.6	6.83	0.998	6.7	0.978	0.9997	0.959
33	39.09	18.8	6.63	0.998	6.53	0.969	0.9996	0.954
34	163.04	39.16	7.3	0.999	7.11	0.964	0.9997	0.938
35	842.02	2.28	4.62	0.988	4.5	0.976	0.9977	0.95
36	128.97	20	6.67	0.998	6.54	0.966	0.9996	0.946
37	46.05	15.68	6.39	0.998	6.19	0.959	0.9992	0.929

38	33.36	16.74	5.76	0.994	5.2	0.856	0.9957	0.773
39	21.96	11.08	5.51	0.993	4.99	0.872	0.995	0.791
40	43.44	15.12	6.08	0.996	5.66	0.917	0.9979	0.855
41	27.42	10.42	5.58	0.994	5.18	0.892	0.9963	0.829
42	268.62	5.1	5.2	0.998	4.93	0.939	0.9967	0.89
43	78.46	13.76	6.37	0.998	6.29	0.976	0.9996	0.963
44	55.51	13.36	6.23	0.997	6.12	0.958	0.9993	0.941
45	55.98	15.54	6.39	0.998	6.25	0.96	0.9994	0.939
46	168.22	16.92	6.53	0.998	6.37	0.969	0.9995	0.945

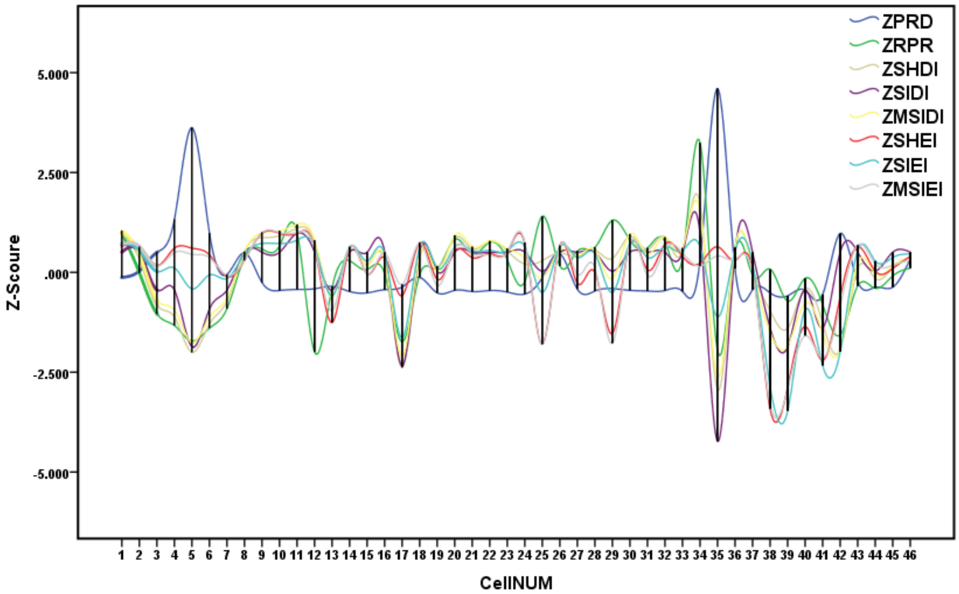

Fig. 6. Changes in geodiversity indexes in cells

4. Conclusion

The diversity of geological formations, lithological, elevation changes and tectonic changes are the basis of geodiversity in the Lar Basin. The presence of more than 7 types of geological formations, a combination of sedimentary, intrusive, volcanic and metamorphic rocks, in a basin with a height of 3200 m, has created a variety of phenomena side by side. Topographically, the altitudes of the north, south, west, and east of Damavand are 4,000, 3300, 4125 and 5594 m high, respectively and have 49 peaks more than 3000 m high. Also, high mountains along alluvial terraces, basaltic flows, and volcanic lava flow along karst forms, steep slopes along low slopes, alluvial fans and floodplains and alluvial gullies and lakeside landscapes indicate high geodiversity in the Lar Basin. The results show that the maximum geodiversity is located west, northwest, and east of the Lar Basin and decreases toward the center of the basin, this indicates that increased erosion in the interior has caused homogeneity in elevation, topographic slope, and lithology. Also, calculations of geodiversity indices in the cells of the Lar Basin indicate that geodiversity indices are high in the west, north, and northwest, with less erosion effect. Consistent with the results of the analysis with field studies, it can be concluded that the Lar Basin has a variety of landforms and natural landscapes which is a function of altitude, geological formations, lithology and vegetation of the region as shown in Fig. 7. The latter figure is zone 1 of the study area and have moderate geodiversity, but has variations in vegetation types and eroded faces.

Fig. 7. Zone 1 in the Lar basin

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