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Effects of geological formations and topography on the evolution and diversity of soils

Efectos de las formaciones geológicas y la topografía sobre la evolución y diversidad de los suelos

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ABSTRACT

Different soils with various properties and sometimes with different types of limitations can be formed which is necessary to investigate the conditions of soil formation and evolution for their optimal use. In this study, we studied the relationship between soil, topography in terms of slope and elevation, and parent material with the land morphology and physical and chemical properties of soil, how the soil formed and evolved. From 19 control soil profiles, 57 soil samples were obtained from three layers and some soil characteristics including Acidity, Salinity, Gypsum, Lime, Texture and Organic matter were measured. Using NEWHALL software, the soil temperature and moisture regime was determined. To study the conditions of topography, the digital elevation map and slope was prepared, the characteristics of geological formations were determined and based on the Gower index and Jacquard index, the relationship between soil evolution factors with topography and parent materials were studied. The diversity of soils classification was studied using richness, uniformity of Shannon and Simpson indices. Based on the results obtained from Gower and jacquard similarity indices, the effect of topography and parent materials on soil diversity was proved. Soil diversity indices showed an increasing trend from the soil order level to the soil family. The increase in the Richness index was higher at the soil family level, so that the highest soil diversity observed at the soil family level. Also, soil diversity is mainly affected by intrinsic factors and to some extent by environmental factors. Soil profile development is mostly influenced by slope, parent materials and in some areas by groundwater level.
Keywords: Soil evolution, Diversity, Topography, Landscape

RESUMEN

Se pueden formar diferentes suelos con varias propiedades y en ocasiones con diferentes tipos de limitaciones lo que es necesario para investigar las condiciones de formación y evolución del suelo para su

óptimo aprovechamiento. En este estudio, estudiamos la relación entre el suelo, la topografía en términos de pendiente y elevación y el material parental con la morfología de la tierra y las propiedades físicas y químicas del suelo, cómo se formó y evolucionó el suelo. A partir de 19 perfiles de suelo de control, se obtuvieron 57 muestras de suelo de tres capas y se midieron algunas características del suelo que incluyen acidez, salinidad, yeso, cal, textura y materia orgánica. Usando el software NEWHALL, se determinó el régimen de temperatura y humedad del suelo. Para estudiar las condiciones de topografía se elaboró el mapa digital de elevación y pendiente, se determinaron las características de las formaciones geológicas y con base en el índice de Gower y el índice de Jacquard se estudió la relación entre los factores de evolución del suelo con la topografía y los materiales parentales. La clasificación de la diversidad de suelos se estudió utilizando la riqueza, uniformidad de los índices de Shannon y Simpson. Con base en los resultados obtenidos de los índices de similitud de Gower y Jacquard, se demostró el efecto de la topografía y los materiales parentales sobre la diversidad del suelo. Los índices de diversidad de suelos mostraron una tendencia creciente desde el nivel del orden del suelo hasta la familia del suelo. El aumento en el índice de riqueza fue mayor a nivel de familia de suelos, por lo que la mayor diversidad de suelos se observó a nivel de familia de suelos. Además, la diversidad del suelo se ve afectada principalmente por factores intrínsecos y, en cierta medida, por factores ambientales. El desarrollo del perfil del suelo está influenciado principalmente por la pendiente, los materiales parentales y en algunas áreas por el nivel del agua subterránea.
Palabras clave: Evolución del suelo, Diversidad, Topografía, Paisaje.

1. INTRODUCION

Primary, scientific and appropriate use of soil as a source of food production is essential and it is necessary to know more accurately the physicochemical, morphological and soil classification characteristics in relation to geological and topographic formations for further use and productivity. The main goal in assessing land sustainability is to identify management that, firstly promotes quantitative and qualitative improvement of production in the long term and, secondly maintains soil quality and does not lead to land degradation (Horel et al., 2015). Therefore, it seems necessary to know how soil characteristics change to achieve greater production, better and more sustainable management (Sokouti Oskoei, 2004). Soil evolution is a type of soil forming process (Phillips, 2001). Soil diversity resulting from soil evolution may also be considered in one classification level or in any other context. In order to study soil diversity, different indices can be used. Indicators of the landscapes and soils diversity consist of Shannon-Wiener entropy, richness and uniformity. Ibanez et al. (1998) determined the soil diversity based on soil maps, individual characteristics, richness and uniformity of the main soil groups (Alba Alonso, Ibáñez Martí, Lobo Aleu, & Zucarello, 1998). Toomanian et al. (2006) studied soil diversity and origin using a variety of soil characterization and landforms and concluded that soil diversity increases when the soil and geomorphic classification levels decrease (Toomanian, Jalalian, Khademi, Eghbal, & Papritz, 2006). Esfandiarpour et al. (2009) concluded that soil diversity, Shannon Index differs from the soil order to the soil family level, and only at the family level there is a significant difference among the average soil diversity (Esfandiarpour, Toumanian, Salehi, & Mohammadi, 2010). Jafari et al. (2013) examined the characteristics of diversity at the soil series level and concluded that from the soil order to the soil family level, the variety of soil increases (Jafari, Ayoubi, Khademi, Finke, & Toomanian, 2013). The highest purity and lowest entropy are observed in the soil order level, and the lowest purity and the highest entropy is observed in the soil subgroup level. Soil diversity in arid and semi-arid regions is mainly affected by slope and parent materials. Topographic factor also can affect soil characteristics such as slope and elevation (Minasny & McBratney, 2006). The slope affects the characteristics of the soils by affecting the erosion and the slope aspect on the distribution of microclimate on the terrain (White, 2013). Topography, as one of the soil formation factors, has a significant effect on the spatial distribution of moisture, temperature and, consequently, the organic matter of the soil (Yoo, Amundson, Heimsath, & Dietrich, 2006). In addition, topographic features affect runoff, drainage, soil temperature and soil erosion (Brady & Weil, 2004). According to Tsui, Chen, and Hsieh (2004) the position and direction of the slope can control the movement of water and eroded materials along the slope and play a role in spatial differences and soil characteristics. The different properties of the parent material do not change at the same rate (Rabenhonst and Wilding, 1986). Along the time and the evolution of soil formation, the changes that occur in the soil are less controlled by the parent material and more determined by climate and topography (Caspari and et al. 2006). Under these conditions, the morphology of neighboring soils that are formed on different parent materials usually leads to similarity. However, the color, soil profile development, and acidity of the parent material can change speedily under the influence of soil forming processes (Buol, Southard, Graham, & McDaniel, 2011). In contrast, some other properties of parent material are very stable and affect the soil over longtime (Costantini and Damiani, 2004). Parent materials are one of the factors that have the greatest impact on soil formation and development, and are mainly responsible for the nature, composition and behavior of the soil. Santos et al. (2017) showed the differentiation of soil profiles in geological formations and in different locations. The distinction between soils derived from different materials in similar locations is related to the formation of homogeneous groups of soil profiles. In general, physical and chemical properties of soil are related to parent materials, because its composition affects pedogenic processes and nutrient values. The results of Cardelli et al (2017) showed all studied soils was rarely fertile due to low available phosphorus concentration, exchangeable calcium and potassium, and organic carbon. Despite the researches, considering the geographical distribution of soils is different based on soil forming factors and as a result, different soils with various properties and sometimes with different limitations are created, so it is necessary to study of the soil forming and development conditions of their optimal use. In the present study, the relationship of soil with elevation, slope and parent material in terms of soil physical and chemical characteristics, how the soil formed in different land conditions and the impact of these factors on soil diversity were studied.

2. MATERIALS AND METHODS

Study Area

The study area includes the southern part of Urmia plain with an area of 22400 (ha) in West Azerbaijan province, Iran, between the coordinates of 37ˋ and 10ˋ to 37ˋ and 35ˋ of north latitude and 45ˋ 21ˋ to 45ˋ 41ˋ east longitudes (Figure 1). The average elevation of Urmia plain is 1350 meters above sea level and the physiography of the lands in the study area are Piedmont plain, river alluvial plain and low land (Karei. 2015). Geologically, the watershed of the study area is mostly composed of Oligomiocen formations equivalent to Qom formation and Permian limestone (Soltani Sisi, 2005). The climate of Urmia with an average temperature of 9.8 degrees Celsius is almost hot in summer and cold in winter (Asheri, Safar Alizadeh, & Hosseinzadeh, 2016). The rainy season starts in late October and early November and continues until June. The average long-term rainfall data in Urmia (1976-2016) is 339 mm and a total of 120 days of frost.

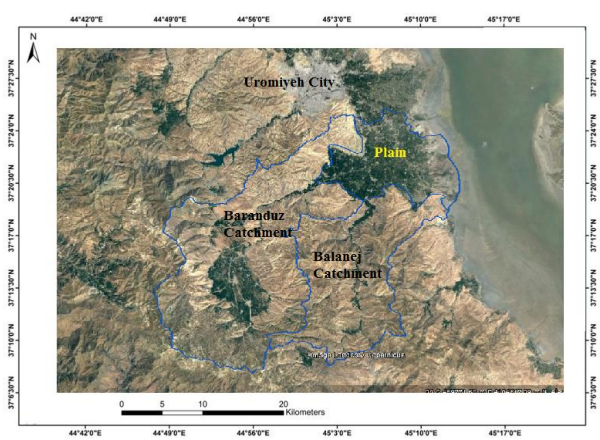


Figure 1: Location of the study area.

Research method

In this study, satellite images, aerial photographs, Google Earth, topographic and geological maps were used to identify and differentiate the forms of land units. Geological formations in watersheds have been identified, and soil series have been separated based on geomorphologic and soil forming processes. The coordinates of the soil profiles were determined by GPS. Digital elevation map was conducted using contour line at a map scale of 1: 20000 in the ARC GIS environment.

Out of 19 control profiles, 57 soil samples were obtained from three layers. Samples were air-dried, pounded, and passed through a standard 2 mm sieve. After separating particles larger than 2 mm (pebbles) from particles smaller than 2 mm (soil), the percentage of pebbles in the samples was calculated. soil texture was determined using Hydrometric method, acidity of saturated extraction using pH meter, electrical conductivity (EC) of saturated extraction using electrical conductivity meter (Nelson, 1982), neutralizing lime with hydrochloric acid and titration with profit (Van Reeuwijk, 2006) and organic matter were measured by Walkley and Black (1934). The soil temperature and moisture regime was determined using NEWHALL software. Soils were classified based on the American Classification System key up to the family level (Shahid, Abdelfattah, Wilson, Kelley, & Chiaretti, 2014).

Statistical analysis and analysis of soil evolutionary diversity

In order to determine the evolutionary paths, the soil of the plain and the watersheds were compared and examined in terms of the similarity of topographic factors and parent materials. To determine the topographic status of the study area, a digital elevation model and its derivatives including height and slope were used. Topographic similarity was determined using Gower index (Gower, 1971). The Gower index is a variable between zero and one. The closer it is to one, the greater the similarity of the variables that obtained from the equation (1):

$$Sij = (\frac{1}{p}) \sum_{k=1}^{p} (1 - \frac{|Xik - Xjk|}{rangeK}) \quad (1)$$

Where: Sij, Gower Index, p Number of variables

| Xik-Xjk | the absolute difference between the variables I j and k is the domain of the variable.

The similarity of parent materials between regions was investigated using the Jacquard Index (Jaccard, 1912). The jacquard is an index in terms of presence and absence a feature according to the relation (2):

$$J = \frac{A}{A+B+C} \quad (2)$$

To analyze soil diversity, richness and uniformity indices were used (Alba Alonso, et al., 1998; Shannon, 1948; Simpson, 1949). It was considered to be an area, the diversity indices are calculated based on the relative frequency N of the soil class relative to the total sampled points (Minasny, McBratney, & Hartemink, 2010). The Shannon Entropy Index is calculated according to the equation (3):

$$H' = -\sum_{i=1}^{n} p_i \,.\, ln\, p_i \quad (3)$$

Where H´ is the same as entropy or community diversity, and pi is expressed in terms of ni / N ratio.

The Richness index is used to calculate the Evenness Index when all the components in the unit have an equal probability (equation 4).

$$H' = H_{max} = \ln s$$

(4)

Then we can calculate the uniformity index (E) as relation 5:

$$E = {H'}/{\ln s}$$

(5)

Where H´ is entropy Hmax is the maximum entropy and S is richness. The presence of higher enrichment and homogeneity indicators is a reason for the greater fragmentation. Enrichment index calculated using Margalf's relationship (6).

$$R = \frac{S-1}{LnN}$$

(6)

The dominance index was also obtained by Simpson's relationship (7):

$$D = \frac{\sum ni(ni-1)}{N(N-1)} = \sum_{i=1}^{N} Pi^2$$

(7)

3. RESULTS

According to the results, the watershed of Baranduz River, with an area of 1203 square kilometers, consists of two main branches named Baranduz and Qasemlu, and originates from the Dalampar mountains, including Nahar-Helaneh and the border mountains of Iran and Turkey. Its main river with a length of 75 km in a west-to-east direction leads to Lake Urmia after irrigating the Urmia plain. The maximum height in this watershed is 3500 meters and the minimum height at the outlet is 1250 meters above sea level (Figure 2).

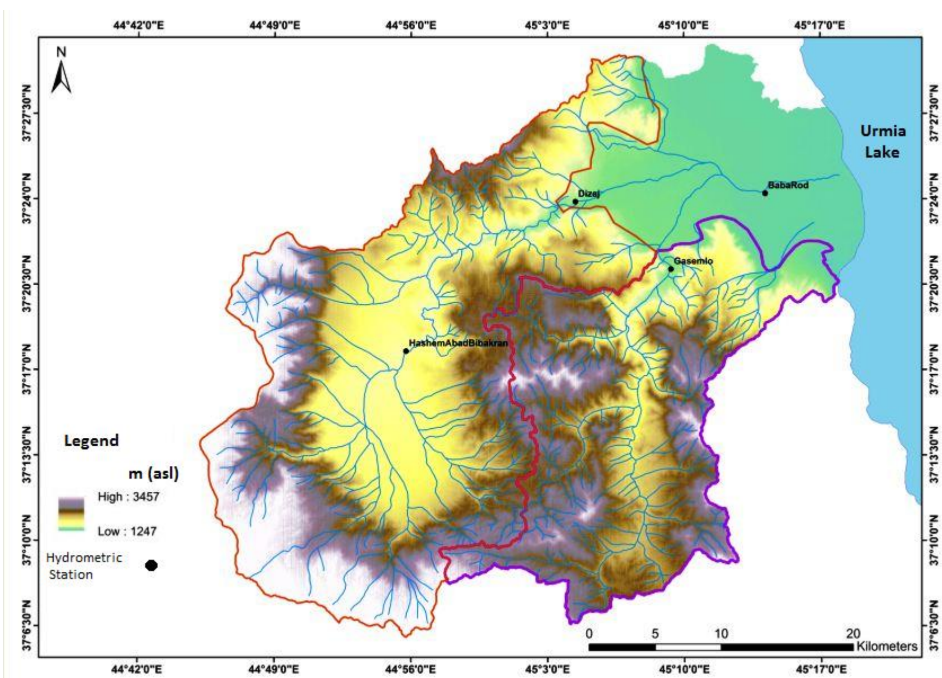


Figure 2: Rivers and Hydrometric Stations with Altitude Classes in the Study Area

The average elevation of Baranduz, Balanej and Plain watershed were 1900, 1853 and 1293 m, respectively. Table 1 presents the statistical distribution of elevation classes of these three watersheds.

Table 1: Statistical Distribution of Altitude Classes of the Study Areas

	watershed	Statistical statement	Mean Elevation (m)
1		Minimum	1250
2	Barandoz	Maximum	3457
3		Average	1900
4		Minimum	1258
5	Balanj	Maximum	2643
6		Average	1853
7		Minimum	1247
8	Plain	Maximum	1480
9		Average	1293

The mean slope of Baranduz, Balanej and plain watersheds were 11.3%, 11.5% and 1.1%, respectively (Figure 3). Table 2 presents the statistical distribution of the slope classes of these three watersheds.

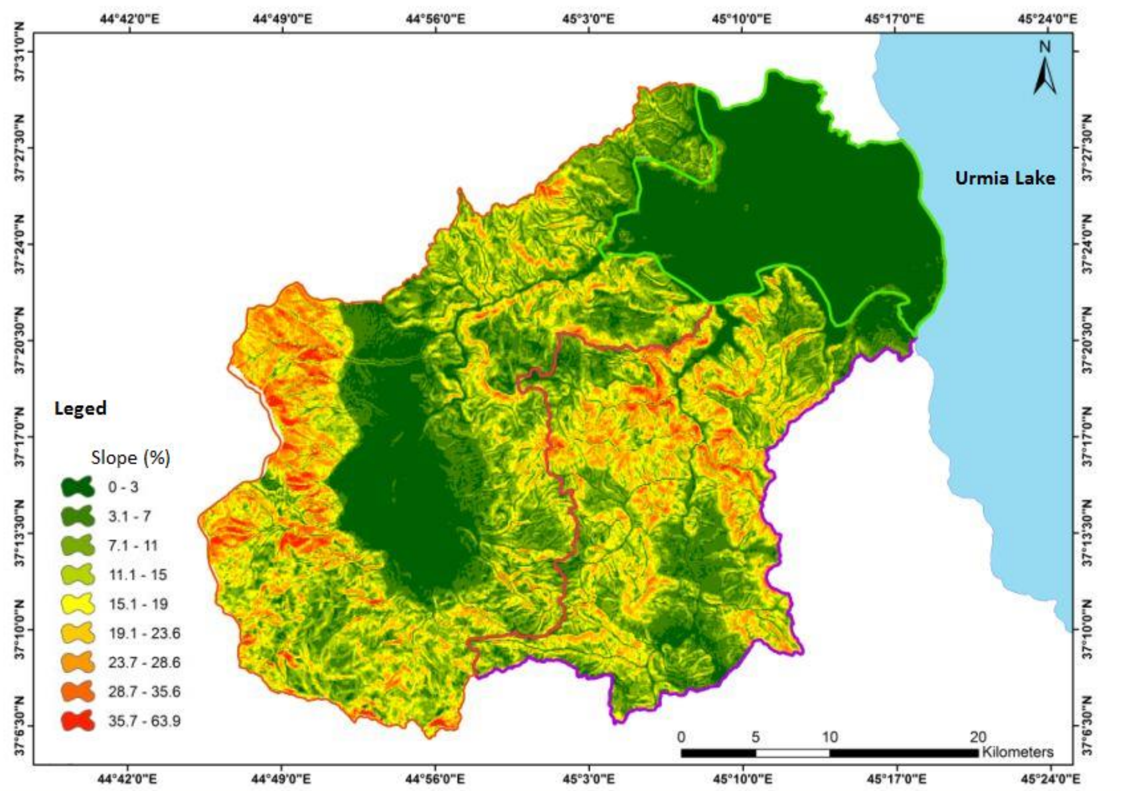


Figure 3: Distribution of slope classes in the study area

Table 2. Statistical Distribution of Slope Classes in the Study Areas

	Watershed	Statistical statement	Slope (%)
1		Minimum	0.0
2	Barandoz	Maximum	64.0
3		Average	11.3
4		Minimum	0.0
5	Balanj	Maximum	52.3
6		Average	11.5
7		Minimum	0.0
8	Plain	Maximum	31.5
9		Average	1.1

Based on the mean long-term precipitation data of Urmia station (1976-2016), the soil moisture regime is xeric and the temperature regime is mesic determined by NEWHAL software (Table 3).

Table 3: Estimates of soil moisture and temperature regime estimates in the Newhall program

Urmia Station

Longitute: 37° 40´ N
Latitute : 45° 30 ´ E
Elevatio (asl) : 1328 m

NEWHALL

Annual Raifal : 339 mm
Average

Month	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
Temp (s)	-1.8	0.1	5.3	11	715.7	20.3	23.9	23.5	19.3	13.4	6.8	1.3
Rain (mm)	29.3	23.2	51.5	61.3	44.2	14.1	5.5	2.4	4.7	24.3	39.6	28.6
ETP (mm)	0.0	0.1	16.3	46.1	82.2	116.5	147.3	134.8	91.3	52.9	18.8	2.0

:Xeric : Mesic

Along the Baranduz River from the watershed to the Urmia Lake, the specifications of some soils series are as follows (Figure 4).

Soil Series 1: It is a very deep dark brownish- yellowish brown soil (10YR 4/4) with medium texture and clumpy building on dark brownish- yellowish brown soil (10YR 4/4) with heavy texture and angular cubic structure. It is relatively strong.

Soil classification up to the family level is Fine loamy, mixed, mesic - Typic Calcixerepts.

Soil Series 2: It is a very deep, dark brownish- yellowish brown soil (10YR 4/4) with medium texture and clumpy and granular structure on a layer of dark yellowish brown (10YR 4/4) with medium texture and relatively strong cube structure.

The classification of this soil is determined by Fine Loamy, mixed, mesic-Fluventic Haploxeropts.

Soil Series 3: It is a very deep brown soil with a medium texture (10YR 4/3) and a clumpy building that is located on a brown layer with a relatively strong angular cubic structure. The above layers are located on layer of dark brownish brown (10YR 4/2) with a very heavy texture, and in the lower layer there is a very dark grayish brown (10YR 3/4) soil with a very heavy texture. It has a very strong angular cubic structure. The classification of this soil is Fine mixed, mesic, Fluventic Haploxerepts.

Soil Series 4: It is a relatively deep, dark brownish-brown soil (10YR 4.4) with a medium texture and a clumpy building on a dark brownish-brown (10YR 4/4) class with a medium texture and a cubic structure with a weak corner. These layers are also located on the layer with more than 75% pebbles and sandy texture.

The soil classification is Loamy over sandy skeletal, mixed, mesic-Fluventic Haploxerepts.

Soil Series 5: It is a very deep dark brownish brown (10YR 4/2) soil with a very heavy texture and a clumpy building on a layer of very dark grayish brown (10YR 3/2) with a very heavy texture and structure. It is a relatively strong column. These layers are covered with a very dark brownish brown layer (2/3YYR 10) with medium texture and a weakly angular cubic building, which is generally on a very dark brown layer (10/2 YR 2) and light texture and cubic structure. They are weak in a corner.The classification of this soil is Fine mixed, mesic - Typic Haplaquepts.

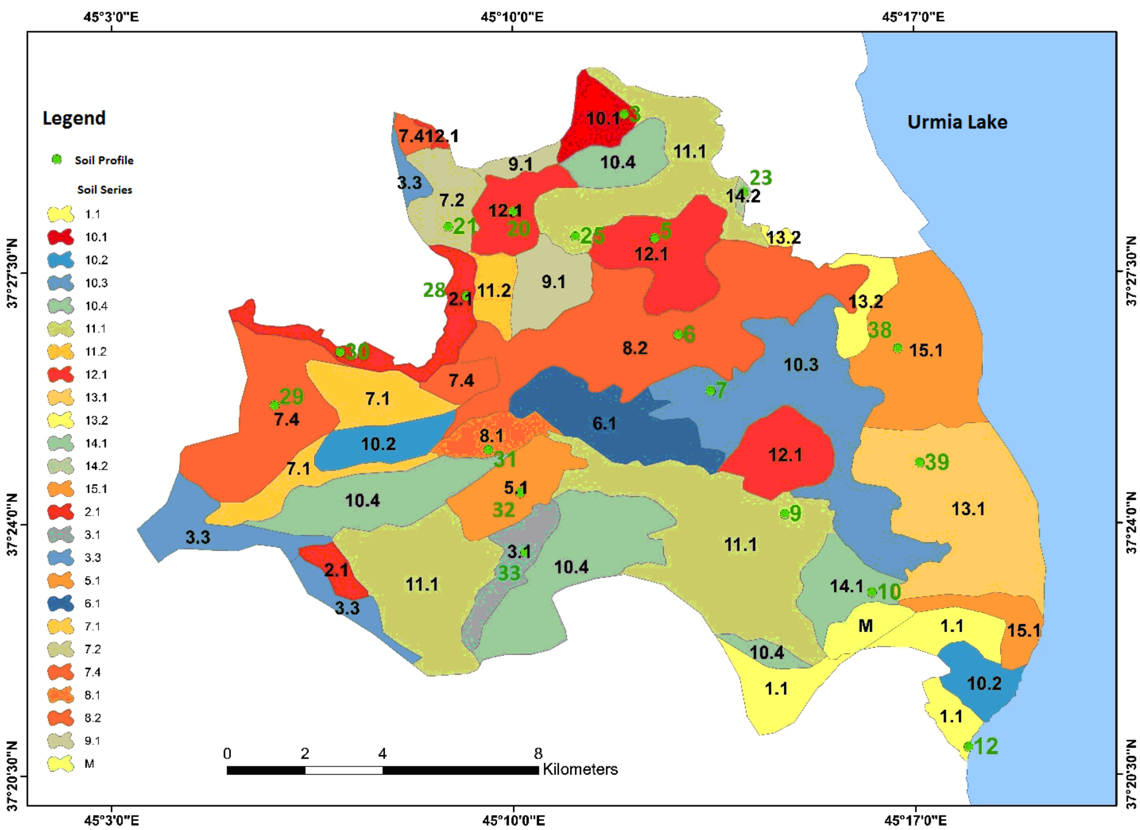


Figure 4: Soil Series map of the study area.

Soil classification results show the presence of 14 soil series with 24 states as described in Table 4:

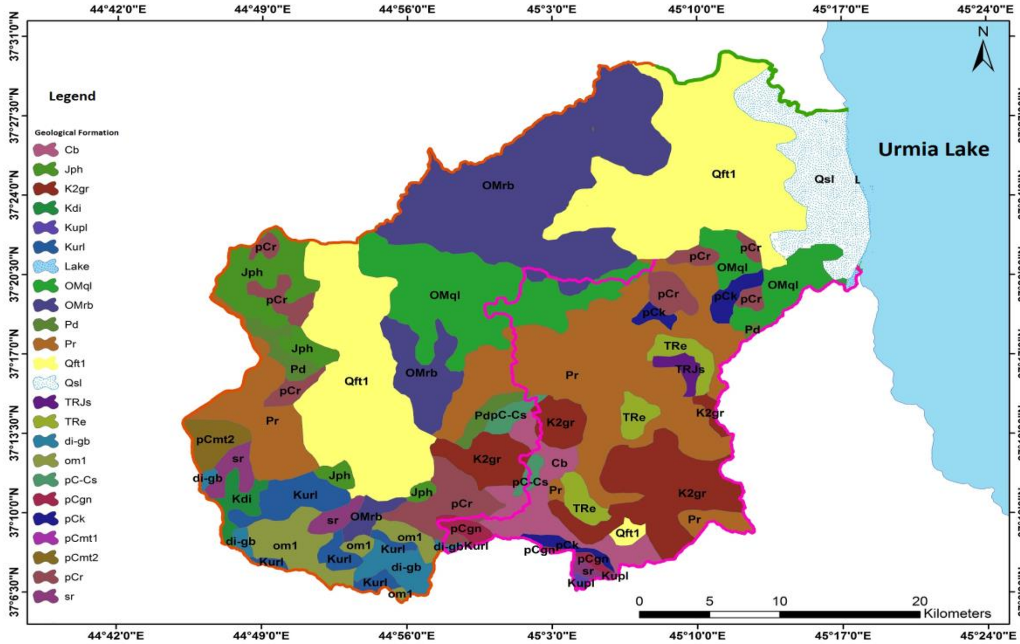
Table 4: Distribution of series and soil conditions of the region

Soil Seri	Area (Km2)	Area (%)	condition Soil	Area (Km2)	Area (%)
1	7.73	3.44	1.1	7.73	3.44
10	45.07	20.06	10.1	2.57	1.14
			10.2	5.73	2.55
			10.3	16.37	7.29
			10.4	20.4	9.08
11	40.53	18.05	11.1	38.6	17.19
			11.2	1.93	0.86
12	14.75	6.57	12.1	14.75	6.57
13	18.21	8.11	13.1	15.78	7.03
			13.2	2.43	1.08
14	3.99	1.78	14.1	3.73	1.66
			14.2	0.26	0.12
15	14.11	6.28	15.1	14.11	6.28
2	6.8	3.03	2.1	6.8	3.03
3	10.18	4.53	3.1	3.48	1.55
			3.3	6.7	2.98
5	4.69	2.09	5.1	4.69	2.09
6	7.08	3.15	6.1	7.08	3.15
7	22.39	9.97	7.1	7	3.12
			7.2	3.59	1.6
			7.4	11.8	5.25
8	22.44	9.99	8.1	2.39	1.06
			8.2	20.05	8.93
9	4.7	2.09	9.1	4.7	2.09
Marsh	1.9	0.85	Marsh	1.9	0.85
-	224.5	100	Total	224.5	100

Geological Formations

The existing formations in the study area include the southern part of Urmia plain and the Baranduz watershed with a variety of sedimentary rocks including dolomite calcareous rocks and permian limestone such as Ruteh and Mila formations along with new Quaternary sediments in Urmia plain (Figure 5).

Igneous rocks, such as ageless granite, are also present in parts of the region that are highly tectonics and fragmented. The function of these granites, by penetrating most limestone rocks, has also caused proximity changes. There is also a colored-melange complex called the Ophiolitic complex in the area, which is a collection of basic and ultra-basic rocks. Colored-melange can be seen in the main tributaries of the Baranduz River and in the heights of Bezsina. Ruteh Formation consists of Permian deposits consisting of well-layered gray fossilized limestone and dolomite limestone, which is found in the eastern and western parts of the Baranduz watershed, the branches of which originate from the heights of Mai Helaneh Mountain. Mila Formation includes dolomite, limestone, shale and marl and is scattered in the upstream and western branches of Baranduz along the Iranian-Turkish border. Young alluvial deposits, which consist of a large part of the Saline lands of Lake Urmia are in the form of swamps and muddy areas.



Legend

Cb - Barut formation (shale limestone, dolomite)
PeK - Kalhor Formation (Murad and Kalhor Series)
Fm = pd – Dorud Formation
TRe – Lika Formation
J ph - Hamada fillites
Om1 – Colored Melange
OMrb - sandstone, gypsum and gypsum marinades

Pe.CS - Soltanieh Formation
Pc cr- Rizo series
pr - Rute limestone
TR js - Shemshak Formation
K2gr - Granite
OMq1 - limestone

Figure 5: Geological formations of the study area

Analysis of Topographic Relations and Geological Formations with Soil Evolution and Diversity

The relationship between soil evolution and topography

In order to investigate the differentiation of topography in relation with the slope and elevation variables, the Gower index was calculated. The numerical value of the Gower index varies from zero to one, and the closer it is to one, the similarity of the topography of the two regions is greater. The numerical value of the Gower index for slope between plain and Baranduz was 0.43 and for Balanej and plain was 0.49. Regarding the elevation, the calculated value of the Gower index for the Plain and Baranduz was 0.55 and for Balanej and Plain was 0.52. The values of the Gower index obtained for both height and slope factors indicate the differentiation of topography between the two study areas, and topography is effective in soil diversity and evolution. So that the range of elevation and slope changes in Baranduz region is more than Balanej. Mueller et al. (2004) used the Gower Index to determine the similarity of soil forming factors, including topography. Afshar et al. (2018) used elevation and slope changes to determine the topographic differences between Bam and Zarand regions.

The relationship between soil evolution and parent materials

The role of bedrock and parent material in soil formation varies depending on the influence of other soil forming factors. Based on the two indicators of Jacquard and Manley similarity, the similarity of regions in terms of parent material type was determined. The numerical value of the jacquard index was 61% and 63%, respectively, for the two regions of Baranduz and Balanej. The Manly index of these two regions was calculated to be 59 and 52 percent, respectively, indicating the presence of almost identical parent substances in the study area. Esfandiarpour, et al. (2010) used a jacquard index the similarity at the family level to less than 50%. Inouy and Freestone (2006) concluded that, by using the Jacquard Index, environmental heterogeneity affects the similarity of soils. This heterogeneity has the positive and significant relationship between individuals and soil parent materials. The differentiation of soil forming factors, in other words, different evolutionary paths, has led to the presence of different soils in the study area.

Using the Jacquard Index, concluded that environmental inequality affects the dissimilarity of soils. This dissimilarity has a positive and significant correlation with the communities and the soil material. The fragmentation of soil forming factors, in other words, different evolutionary paths, has led to the presence of different soils in the study area.

The relationship between evolution and soil diversity

Different environmental processes lead to differences and diversity of soils as the affected phase (Table 5). Therefore, soil forming factors in the study area are expected to be able to detect soil diversity. The process of soil differentiation was calculated based on the USDA soil Taxonomy from soil order to family using Shannon's (H), Richness (E), and Simpson (D) indicators. Soil diversity indices showed an increasing trend from soil order level to soil family (Table 6). The highest amount of Shannon was obtained 6, which is related to the soil family level.

Table 5: Results of soil classification identified in the study areas

	Plane	Baranduz		Balanej	
Soil Class	Inceptisols	Inceptisols	Entisoils	Inceptisols	Entisoils
Subclass	Aquepts xerepts	xerepts		xerepts	
Soil Grate Group	Haplaquepts Endoaquepts Haploxerepts Calcixerepts	Haploxerepts		Haploxerepts	
Soil Subgroup	Typic Haplaquepts Vertic Endoaquepts Fluventic Endoaquepts Typic Endoaquepets Fluventic Haploxerepts Typic Calcixerepts	Lithic Calcixerepts	Lithic Xerortens	Lithic Calcixerepts	Lithic Xerortens
Soil Familiy	Fine, mixed, mesic Fine, mixed, mesic (Sodic phace) Coarse loamy, mixed, mesic Fine Loamy, mixed, mesic Loamy over sandy skeletal, mesic Fine, Carbonatic, Mesic	Coarse loamy, mixed, mesic	Loamy over sandy skeletal, mesic	Coarse loamy, mixed, mesic	Loamy over sandy skeletal, mesic

Table 6: Diversity Indicators Based on the 2014 American Soil taxonomy

		N	S	H	E	D
1	Soil Class	15	-	-	-	-
2	Subclass	15	2	.691	.369	1.991
3	Soil Grate Group	15	4	.691	1.108	3.947
4	Soil Subgroup	15	6	1.657	1.846	4.787
5	Soil Familiy	15	6	1.729	1.846	4.814

(Evenness index):E ، :D .(Simpson index) (number of profile):N،(Richness index):S ،(Shannon diversity index):H´ ، (maximum diversity)،

According to Table 6, the lowest richness index at level Soil suborder was obtained 2 and the highest richness at family level was 6. It was not possible to calculate soil diversity at the Soil order because there was only one category. The increase of the Shannon diffraction index is due to the increase in the subdivision of the richness and uniformity of subdivision into the family, which is consistent with the studies of Afshar et al. (2018). Ibáñez et al. (2005) also showed that Enrichment and Shannon indices increased during USDA soil classification at different scales. In some cases, the indices are fixed from sub-order to sub-group or family of soil, which is classified at lower levels due to the lack of soil in the new classes.

Soil-Landscape Evolution Relationships

In the study area, three Landscape units including Piedmont, river alluvial plain and low lands have been identified. It seems that the most important process of supply of soil parent materials in the study area is erosion and sedimentary processes and sedimentation in the plain. The results of soil diversity and differential indices in the soil taxonomy of the landscapes are presented in Table 7.

Table 7: Values of Diversity and Diffraction Characteristics of Soil Classification Landscapes in the Area

		N	S	H	E	D
1	Soil Suborder	8	4	1.213	1.443	0.744
2	Soil Grate Group	9	4	1.288	1.365	0.942
3	Soil Subgroup	15	4	1.287	1.108	2.848
4	Soil Familiy	24	4	1.041	0.994	2.072

The results of calculations of soil richness and soil diversity indices show that by increasing the study scale from the soil landscape to lower soil taxonomic classification levels, diversity and enrichment indices increase. These results are consistent with those of Toomanian, et al. (2006), Jafari et al. (2013), and Afshar et al. (2018). Also, the results of Table 6 show that there is an increase in the diversity index by the Soil-order to the family level. Saldaña and Ibáñez (2004) showed that increased soil unevenness and heterogeneity in soil taxonomic classification confirms the existence of divergent cycles in the studied soils. Similarly, the level of classification decrease from the soil order to the subgroup, which increases diversity or, in other words, observes more different classes at lower levels. Yoo et al. (2006) used the Shannon entropy index to study different levels of classification, including suborder, subgroup, Grate group, family, and series. They showed that the classification and richness of Shannon entropy indices increased from the Soil order to the soil series. Minasny et al. (2010) reported that the number of soil classes affects the Shannon index. As the number of soil classes increases, a larger number accumulates in the Shannon index, so taxonomic levels with greater richness are more diversity; this is clearly seen at the subgroup and grate group levels where there are more soil classes.

4. CONCLUSION

The results of this study showed that the evolution of soil profiles is mostly influenced by slope, parent materials and in some areas groundwater level so that in areas with high topography, the evolution is minimal and in flat areas, developed soils were observed. In other words, all the processes that are involved in the formation and evolution of landscapes in the long term, directly or indirectly, have caused the formation, evolution of soils. The soils distinguished in the map units are in some cases most similar to each other while have the maximum difference with the soils in other units of the map. The study of soil diversity indices used for the soil classification showed that these indices increase with decreasing soil class hierarchy. The results of this study can be used for identifying and differentiating between soil classes and soil mapping units, and it is expected that the purity of the prepared maps will decrease with increasing diversity during the classification.

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