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The relationship of soils developed on different parent materials in Niğde province with lithological units and determination of their suitability for usage agricultural purposes

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Research Article

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Lithological units, Soil, Multi criteria decision making method.

ABSTRACT

In this study, general characteristics of soils formed on different parent materials in three different regions of Niğde province, their relationship with lithological units and the extent to which they are suitable for agricultural purposes were determined. Physical and chemical analysis values of rock and soil samples were used to reveal the relationship between lithological units and soils formed in the study area and correlation analysis was applied among the parameters. Multi Criteria Decision Making method was used to determine the suitability of these soils which are formed depending on the parent materials for agricultural use. In order to determine the effect rates among the main criteria of soil, topography, climate and geology and their sub criteria, Analytical Hierarchy Process of Multi Criteria Decision Making method was applied. According to this; Depending on the influence of the lithological units, the soils developed around Bor district are of basic character and the soils developed in Çiftlik and Gölcük districts and their vicinity are more acidic reaction. In addition, it has been determined that the soils of the Çiftlik district and its vicinity are developed by accumulation and in situ, while the soils around Gölcük and Bor districts are developed in situ. In determining the suitability of soils for agricultural use, it was calculated that the main criteria of geology was 5.5% and the criteria of lithological units, which is the sub-criterion of this, was 2.7% effective.

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1. Introduction

The surface topography which is composed up the rocks are changed by various factors, and as a result of the change, soils that are an indispensable living environment and natural space for all biological entities are formed (Tarım ve Köyişleri Bakanlığı, 2008). The chemistry of the formed soils generally reflects the chemistry of the rocks of their origin. Kapur et al. (1996) concluded that basalt, as the main material, decomposes, the minerals it contains altered to clay and iron oxides, and due to the absence of quartz, the soils are brown or red-brown colored and enriched by iron-oxides. Yüksel (2003) studied the determination of the physical, chemical and mineralogical compositions of the soils formed on the rock materials (magmatic rocks and alluvial) under different environmental conditions of the Ağrı Mountain near Iğdır province and reveal the relationship between the soil, rocks, climate and mineralogical properties. It was determined that the dominant minerals for all soil samples are plagioclase, quartz, opal-CT and chlorite, while smectite is present in different amounts in all samples, and the smectite ratios in samples taken from the bottom lands are higher than other samples.

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Niğde and its territory is one of most important geological parts of Turkey (Göncüoğlu, 1981). In the study area, lithological units originating from Hasandağ, Keçiboyduran, Melendiz and Erciyes volcanics play an important role in gaining characteristic features of the developed and still developing soils. Determination of the suitability of these soils, which are sourced by regional lithology and have certain features for agricultural purposes, will play an important role both in establishing the relationship between lithological units and soils and in determining the intended use of soils developed on similar lithological units in different areas. In order to use a land for agricultural purposes, it must fulfil the conditions that the land is used for agricultural purpose. To obtain these suitable conditions, besides the soil, topography and climate factors, the geology of the region has also a great effect. Multiple Criteria Decision Making Method (MCDM), in which more than one of these factors are taken into consideration and can be applied in the easy solution of such complex problems, is effectively used (Malczewski, 2006).

By using Multi Criteria Decision Making Method, Feizizadeh and Blaschke (2012) evaluated soil, topography, climatic conditions and water adequacy factors for Tabriz region of Iran. They produced land use maps mainly consists of four classes for irrigated and dry agriculture (high, medium, marginal and unsuitable) and seven classes for land suitability (settlements, irrigated agriculture, dry agriculture, potential areas suitable for irrigated agriculture, potential areas suitable for dry agriculture, riverbed and areas unsuitable for agriculture) of the area. As a result of the land suitability analysis for agriculture, they determined that 100,028 hectares and 117.395 hectares of irrigated and dry farming areas, respectively, and they are the widest marginal suitability class area.

Torunlar and Nazlıcan (2018) applied land suitability analysis for determining the suitable areas where can be potential for producing soybean crops in Turkey by using Analytic Hierarchy Process of Multiple Criteria Decision Making Method. Based on soil, topography and climate data sets, they determined suitable areas where soybean plants can grow as land suitability classification consisting of four classes (Highly suitable, Moderate suitable, Marginally suitable and unsuitable). According to their study, the total area of 17.435.102,53 hectares, 22.34% of the study area, is highly and moderate suitable for the cultivation of the main product soybean, 15.56% (12.149.689,64 ha) of the area is marginally suitable, 62.10% (48.473.207,83 ha) of the area is not suitable for soybean cultivation.

In this study, three different areas in Niğde province are chosen and the characteristics of the soils developing on different rock materials, their relations with lithology and the classification of soils for agricultural use in three different areas of Niğde province were investigated.

2. Material and Method

2.1. Study Area

The study area has been selected as three different areas, each of which is 1/25,000 scaled size and represent the lithological units of the region within the borders of Niğde province (Figure 1). These areas are;

Çiftlik and its vicinity (L32c2); the study area is located northern side of the city, in the Çiftlik township and it is developed in the Turkey's recent geomorphological structure. The study area is in the Neogene-Quaternary, Melendiz-Quaternary volcano-sedimentary series (Beekman, 1966; Pasquare, 1968; Aydın et al., 2005). It is located on aglomerate, alluvium, andesite, basalt, ignimbrite, pyroclastics and slope debris cone units of Hasandağ-Melendiz mountains' foothills (Figure 2). The study area covers 14957.61 hectares (149.57 km^2) and covered by maquis or pastures, agricultural areas, settlements and non-agricultural areas.

Gölcük and its vicinity (L33c1); This area is located within the borders of the Central district in the north of the province and on the Neogene-Quaternary, Melendiz-Quaternary volcano-sedimentary series (Beekman 1966, Pasquare 1968, Aydın et al., 2005) and the Paleozoic-Mesozoic aged high temperature, medium pressure metamorphic rocks and cut by intrusive rocks. The study area covered by Niğde metamorphic units (Göncüoğlu, 1981) consisting of clastic and carbonate-based rocks is located on basalt, basalt-andesite, conglomerate-sandstone-mudstone, gabbro and ignimbrite (Figure 2). It is also covered by maquis or pastures, agricultural areas, settlement areas and located 15191.84 hectares (151.92 km^2) area.

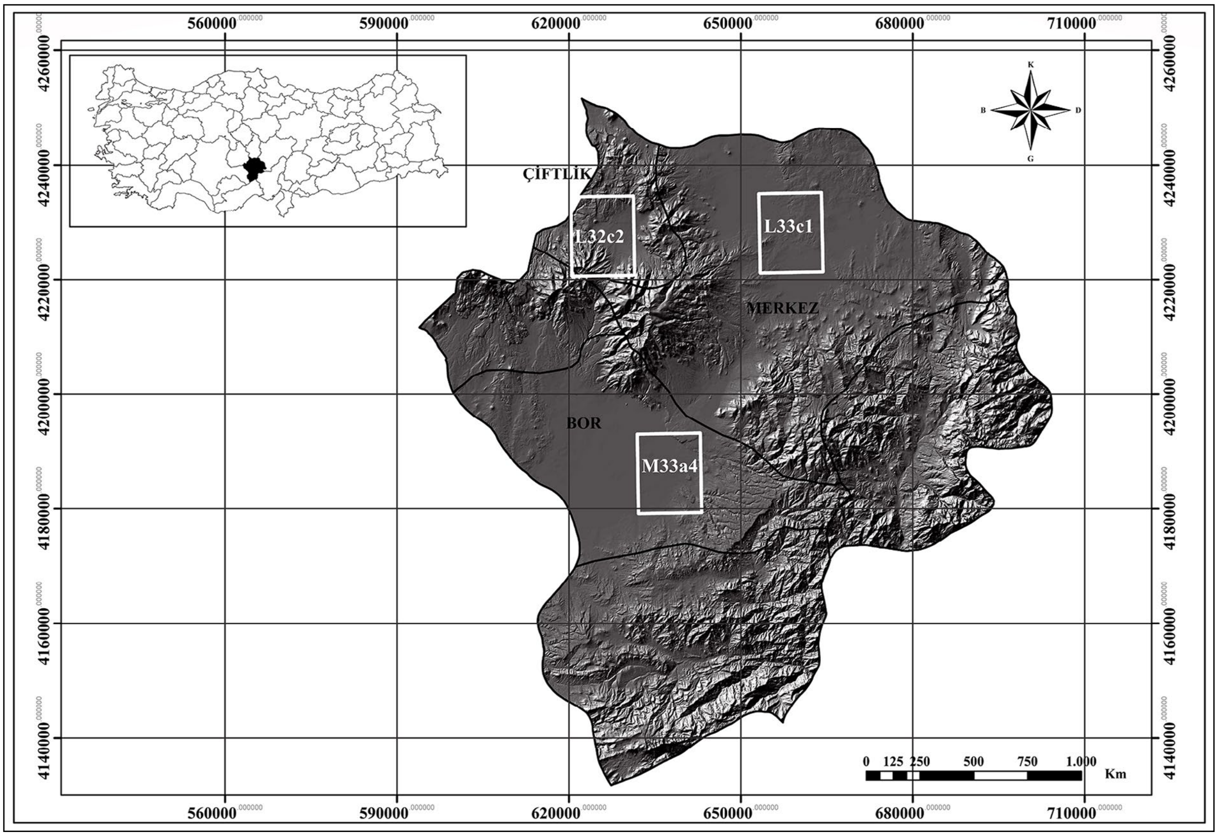

Figure 1- Study area.

Bor and its vicinity (M33a4); This area, on the other hand, is located in the Bor plain, and especially includes alluvium, ignimbrite, limestone, marble and pyroclastic rock-trachyandesite units (Figure 2). The study area is affected by Paleozoic-Mesozoic aged Niğde metamorphic units (Göncüoğlu, 1981). It covers 15266.06 hectares (152.66 km^2) in Niğde province and covered by macquis, pasture, agricultural, settlements and non-agricultural areas.

Different data sets were used in the study. These data sets;

2.2. Soil Data Set

Soil data set contains the physical and chemical analysis parameters of the sampled soils obtained from the study area. These parameters are water saturation, electrical conductivity, total salt, pH, lime, organic matter, total nitrogen, organic carbon, hydraulic conductivity (permeability), geochemical data of main and trace elements.

2.3. Topography Data Set

The maps are 1/25.000 scaled topographic maps with 10 meters accuracy in topographic contours, obtained from the General Directorate of Mapping. By using these maps, slope and land form of the area were obtained.

2.4. Climate Data Set

In this data set; The precipitation data obtained from meteorology stations in Niğde province and vicinity are used (Figure 3). For this purpose, long-year average monthly rainfall data obtained from the daily precipitation values recorded by the General Directorate of State Meteorology Affairs in the last 30 years were used (Table 1).

2.5. Geology Data Set

This data set consists of 1/25.000 scaled geology maps obtained from the General Directorate of Mineral Research and Exploration and geochemical analysis of rock samples from the study area (Figure 4).

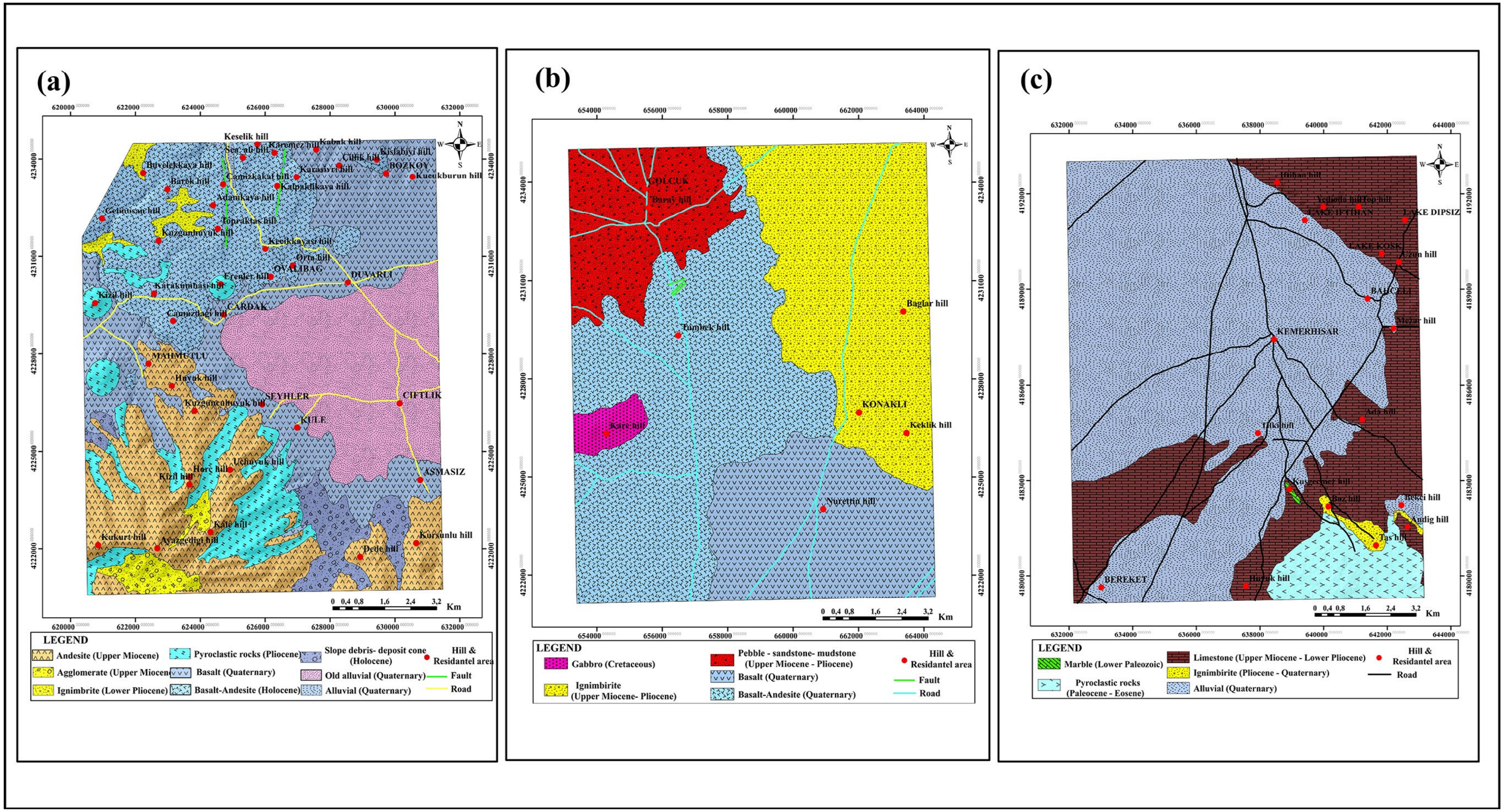

Figure 2- General geological map of (a) Çiftlik and its vicinity (L32c2, MTA 2010*a*), (b) Gölcük and its vicinity (L33c1, MTA2010*b*) and (c) Bor and its vicinity (M33a4, MTA2010*c*).

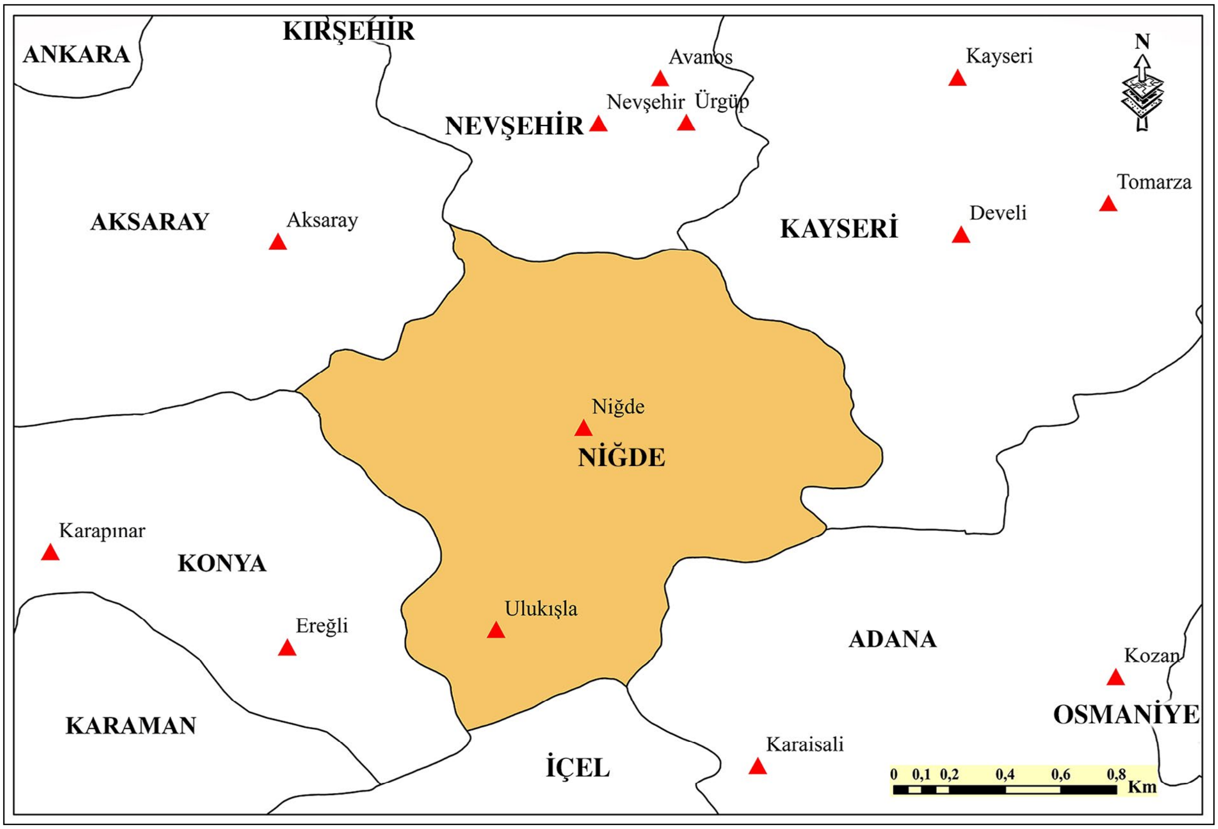

Figure 3- Meteorological stations in Niğde province and its vicinity.

Table 1- Monthly average precipitation datas for long term measured from Niğde province and surrounding meteorological stations.

CITY NAME	Station Name	Latitute	Longitude	Elevation	Station No	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total Precipitation
ADANA	Karaisalı	35.0576	37.2499	235	17936	147.6	100.9	90.9	91.9	84.8	46.3	12.3	15.1	22.4	48.8	95.4	157.3	**913.8**
ADANA	Kozan	35.8210	37.4394	123	17908	107.6	80.1	90.9	96.1	87.8	59.3	22.6	21.4	33.6	57.5	83.1	109.5	**849.5**
AKSARAY	Aksaray	34.0341	38.3680	971	17192	37.2	31.1	36.3	52.5	43.8	22.7	7.0	3.7	7.5	26.8	33.0	41.6	**343.2**
KAYSERİ	Develi	35.4911	38.3831	1.233	17836	39.6	39.3	44.4	55.5	50.0	21.0	4.4	2.8	7.3	28.5	33.3	43.7	**369.8**
KAYSERİ	Kayseri	35.4835	38.7177	1.058	17196	31.9	32.3	39.8	56.3	59.1	35.8	12.3	5.8	10.3	32.5	37.9	40.6	**394.7**
KAYSERİ	Tomarza	35.8051	38.4493	1.394	17837	35.5	34.8	38.4	54.4	58.1	36.4	9.1	5.0	13.4	35.5	36.5	40.8	**397.9**
KONYA	Ereğli	34.0542	37.5029	1.054	17248	30.1	25.8	30.3	44.0	38.2	23.9	5.3	3.9	6.6	22.6	28.7	35.2	**294.6**
NEVŞEHİR	Avanos	34.8495	38.7157	928	17833	29.9	34.4	28.3	40.1	44.7	25.2	8.1	3.7	8.2	26.5	32.8	38.1	**320**
NEVŞEHİR	Nevşehir	34.7177	38.6196	1.199	17193	41.9	40.9	44.0	53.3	60.9	27.8	9.9	4.3	11.8	34.4	38.6	49.7	**417.5**
NEVŞEHİR	Ürgüp	34.9050	38.6215	1.092	17835	36.9	33.1	36.6	55.0	57.7	31.6	10.9	3.9	11.8	32.2	34.8	40.0	**384.5**
NİĞDE	Niğde	34.6860	37.9706	1.223	17250	30.6	31.0	33.8	47.8	47.4	25.2	5.3	3.4	7.1	27.2	33.2	39.7	**331.7**
NİĞDE	Ulukışla	34.4996	37.5399	1.409	17906	24.4	22.5	35.1	49.4	54.1	29.3	6.8	4.6	7.6	27.8	26.7	33.3	**321.6**

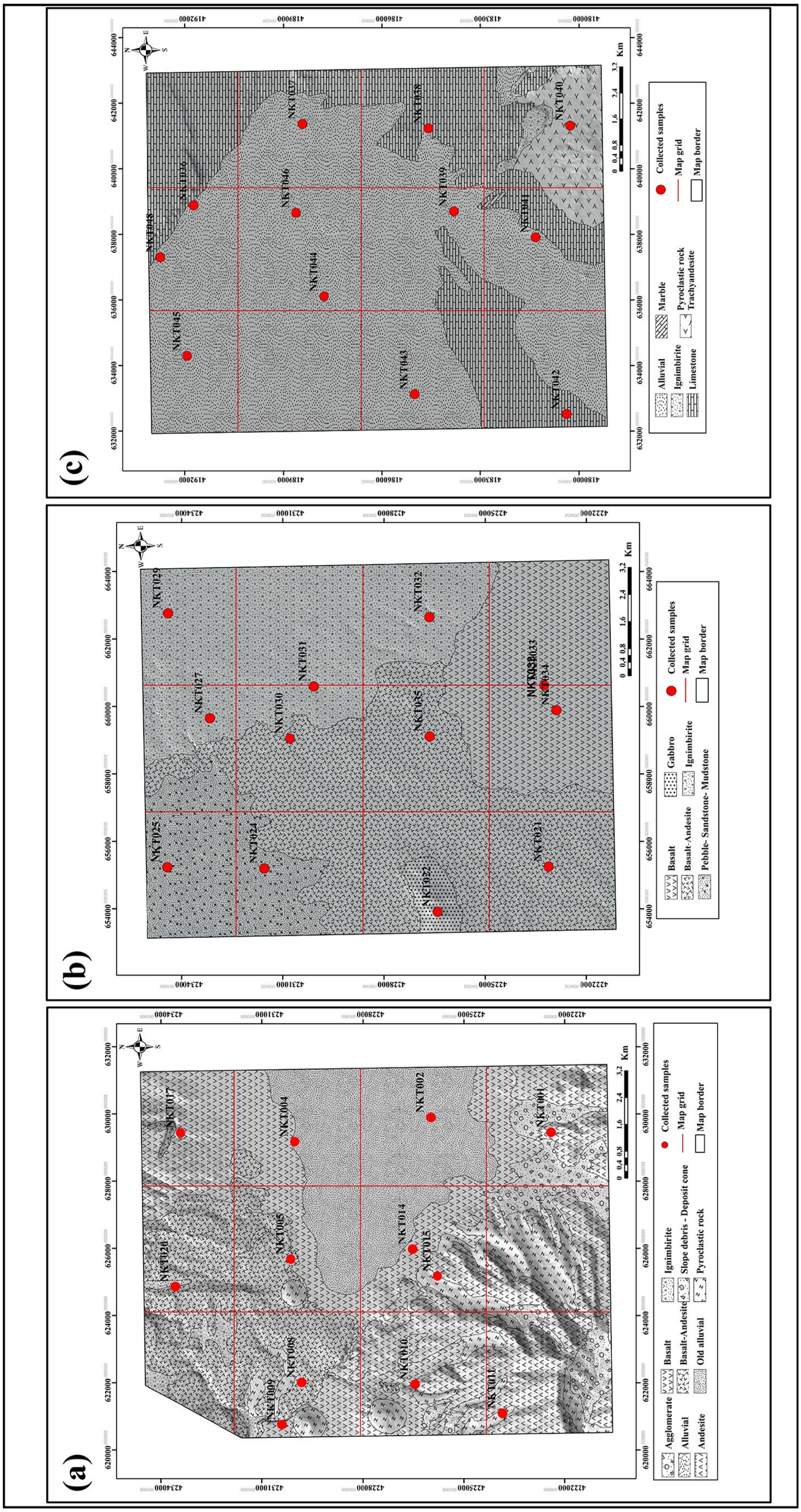

Figure 4- Soil and rock samples locations in (a) Çiftlik and its vicinity (L32c2), (b) Gölcük and its vicinity (L33c1), (c) Bor and its vicinity (M33a4)

2.6. Field Studies

In order to reveal the relationship between soils and the lithological units made up of different main materials, 12 soil and rock samples were taken from each study area and 36 samples in total. Within the reachable topographic conditions, dominant lithological units within each grid area was sampled. Rock samples were taken from points representing each different lithological unit, and soil samples were taken from 0-20 cm depth from the points where rock samples were taken (Figure 4).

In the study, both the lithological units and the soils formed on these lithological units, as well as determining the general characteristics of these soils and at the same time, the substrate data used as base data in determining the suitability of the soils for agricultural use were produced by applying different methods. Surface distribution maps of climate and soil parameters were created based on interpolation method. This method relies on the parameter values at the current measurement points in the calculation of values belonging to another unknown location (Esri, 2004). The Inverse Distance Weighting-IDW interpolation method, which is one of the local interpolation methods that uses the measured data at peripheral points, is one of the most used methods (Willmott and Matsuura, 1995; Dodson and Marks, 1997). This IDW interpolation method was used to create distribution maps of 9 different physical and chemical parameters and precipitation parameters obtained from soil samples taken from the study area.

X-Ray Fluorescence (XRF) analysis method was used for geochemical analysis of rock and soil samples. From the physical and chemical analysis of soil samples; Çağlar (1949) is used for the determination of lime ($CaCO_3$) ratio, Richards (1954) for soil reaction (pH), electrical conductivity (EC) and total salt ratio, Kaçar (1972) in determining the total nitrogen ratio, Ülgen and Ateşalp (1972) in determining the organic matter (OM) ratio, Kaçar (1994) in determining the organic carbon ratio, Klute (1965) in determining the hydraulic conductivity (permeability), and TS 8333 (1990) in determining the saturation ratio with water. Correlation Analysis, one of the statistical methods, was used to determine the relationships between rock and soil samples.

Topographic maps are used to create the slope and land forms data of the study area. The slope data was created using the Surface Analysis / slope menu in the Spatial Analyst module of the ArcGIS program (Mc Coy and Johnston, 2001), and the landform data was generated by using the Topograph Tools / Landform Classification module, which is an extension of the ArcGIS program (Jenness, 2005). Agricultural usage of an area is related to its ability to meet the requirements. The required many main criterias (soil, topography, climate and geology) and their sub-criterias (water saturation, electrical conductivity, total salt, pH, lime, organic matter, total nitrogen, organic carbon, hydraulic conductivity (permeability), precipitation, slope, land forms and lithological units) were evaluated together in the study area, The Multi Criteria Decision Making Method was used to determine the suitability classes for agricultural use. This method is combination of many complex spatial data and reveals how the data will be combined within different alternatives in the same evaluation dimension (Yu et al., 2011). Although it contains more than one different techniques in itself, the Weighted Linear Combination Method was used in this study (Patrono, 1998).In the Weighted Linear Combination method; For the criteria that affect the determination of the suitability for agricultural use, weight points were given by considering the relative importance. These criteria are divided into subcriteria, and the standardized subcriteria scores have been calculated with a separate numerical evaluation (Table 2).

Multiplying the subcriteria score and the weight values of each criteria provide that the criteria have been added to the same scale. The numerical equality provided by the method in determining the suitability classes for agricultural use is given below.

$$S = \sum_{i=1}^{n} W_i X_i \tag{1}$$

According to the equation, S: total score; Wi: weight value of the criterion; Xi: subcriteria score, n: total number of criteria. Using this numerical equation of the Weighted Linear Combination method, numerical values for each suitability class were calculated and reclassified according to the land suitability class ranges specified in (FAO, 1985), and the agricultural use classes of the soils formed on different main materials were determined. The weight points of the main and sub criteria used are effective on the distribution of the suitability classes within the field. Weighting scores of each criterion

Table 2- Classes and weight scores of Criteria and subcriteria (FAO, 1976, Dorronsoro, 2002, Chuong and Boehme, 2005, Jenness, 2005, Turoğlu 2005, Cengiz and Çelem, 2006).

CRITERIA	Suitability Classes			
	Highly suitable (S1)	Moderate suitable (S2)	Marginally suitable (S3)	Unsuitable (N)
	Weighted scores for subcriteria			
	4	3	2	1
SOIL MAIN CRITERIA				
pH	7.3-6.7	6.7-5.5 or 7.3-8.0	5.5-4.5 or 8.0-9.0	<4.5 or >9.0
Lime ($CaCO_3$) (%)	<7	7-15	15-25	>25
Total nitrogen (%)	> 0.2	0.1 – 0.2	< 0.1	----
Total salt (%)	<2	2-6	6-12	>12
Electrical conductivity (EC) (dS/m)	< 4	4 - 8	8 - 16	> 16
Organic matter (%)	>5	5-2	2-1	<1
Organic carbon (%)	> 2.5	1.0 – 2.5	< 1.0	-----
Permeabilite (cm/hour)	>2	2-0.5	0.5-0.1	<0.1
Saturation (%)	>75	75-50	50-25	<25
TOPOGRAPHY MAIN CRITERIA				
Slope (%)	0 - 2	2 - 6	6 - 12	> 12
Landforms	Plains - Open slope areas	Hollow valleys	Canyons, deeply incised streams, Midslope drainages, shallow valleys, Upland drainages, headwaters	Upper slope areas, local ridges, hills in valley, midslope ridges, mountain tops, high ridges
CLIMATE MAIN CRITERIA				
Precipitation (mm)	>1000	1000-600	600-300	<300
GEOLOGY MAIN CRITERIA				
Lithological units	Alluvial, Old alluvial	----	Slope debris, deposit cone, pebble-sandstone-mudstone	Ignimbrite, pyroclastic rocks, basalt-andesite, agglomerate, gabbro, limestone, trachyandesite, marble

were calculated according to the Analytical Hierarchy Process (AHS) technique of the Weighted Linear Combination Method (Satty, 1980).

The Analytical Hierarchy Process (AHP) technique allows the criteria to be compared with each other in pairs based on priority level. Pairwise comparisons of criteria with each other were made using the binary comparison scale developed by Satty (1980) (Table 3).

In order to measure whether the paired comparison matrix made between the criteria is consistent or not, the Consistency Ratio (CR) is calculated in the AHS technique. The consistency ratio, which is accepted as the 10% threshold value, must be equal to or less than the threshold value. If it is greater than 0.10 (10%), paired comparisons between criteria are inconsistent and in this case, the paired comparison matrix has to be reconstructed (Armacost et al., 1994). The consistency ratio is obtained using the equation below.

Table 3- The AHS scales for paired comparisons (Satty, 1980).

Numerical values	Description
1	Items are equally important
3	1st criterion is slightly more important than 2nd
5	1st criterion is more important than 2nd
7	1st criterion is much more important than 2nd
9	1st criterion has the strongest significance than 2nd
2,4,6,8	It is the intermediate value between two close criterions. Used when compromise needed

$$CR = \frac{CI}{RI} \tag{2}$$

CI = Consistency index, RI = Random index,

Consistency index (CI) is calculated using the formula below.

$$CI = \frac{(\lambda\, max - n)}{(n-1)} \tag{3}$$

CI: Consistency index

n: the number of compared elements

λmax: Maximum eigenvalue;

Maximum eigenvalue is the arithmetic mean of the values obtained by dividing each element of the weighted total vector obtained by multiplying the normalized weight values with the matrix of paired comparisons belonging to the criteria, by the corresponding normalized weight values. Random index (RI) refers to the average consistency index of randomly generated matrices of binary comparisons. RI values take the following values depending on the number of compared elements (n) (Table 4).

3. Findings and Discussion

There is a close relationship between soil and geological units. In soil formation process, firstly the rocks turn into the soil parent material and then the soil is formed from the soil parent material (Brady, 1990). Main soil material is only one of the factors that affect the formation of soils. However, its effect should be considered together with climate, topography, organism and time factors (Akalan, 1983). One or few of these factors, especially in local areas, main material and topography, climate and vegetation have dominant effect in large geographical areas. For this reason, the same soils do not always occur from the same parent material. Very different soils from similar parent materials occur in different parts of the world. In this study, the relationship between the soils of the region and lithological units developed on the main materials composed of different lithological units is revealed. For this purpose, the characterization of soils and their relationship with lithology is determined by using parameters obtained from physical, chemical and geochemical analysis of soil and rock samples collected from the field (Table 5, 6, 7, 8, 9, 10, 11, 12, 13).

Accordingly it was observed that the soils around Çiftlik and Bor districts were medium fine soils in the clay soils group, while Gölcük and vicinity soils were medium-very coarse soils in the loamy-sandy soils group. It has been determined that the soils observed in all three areas are salt-free soils, the soils in Çiftlik and its vicinity are generally very slightly acidic - medium alkaline soils, and the soils around Bor and Gölcük are light alkali - strongly alkaline soils.

At the same time, it has been determined that the soils around Çiftlik and Gölcük are generally lime-free-very little calcareous soils, while the soils around Bor are very calcareous - marly soils due to the fact that the soils around the region are developed on the upper Miocene-lower Pliocene limestones. Although some of the Çiftlik and its vicinity soils are slightly higher in terms of organic matter content compared to the soils observed in the other two areas, it has been determined that the soils of the region in general terms contain low and medium levels of organic matter. Due to the fact that Gölcük and its vicinity soils are medium-very coarse soils in the loamy-sandy soils group, Çiftlik and Bor soils are with higher permeability compared to other soils. Accordingly it was determined that the soils around Gölcük and its vicinity are generally fast, while the soils around Çiftlik and Bor districts are medium permeable soils.

The geochemical analysis of the main rock and the sampled soils in all three regions of the study area were done and the relations of the soils with lithology were revealed by using the obtained main and trace element contents and some element ratios calculated in soils. As an example of geochemical analysis for soil and rock samples belong to Çiftlik and its vicinity is given in table 6 and table 8. According to these tables, major oxide contents of soil samples from Çiftlik and its vicinity area: SiO_2 content is 52.78 -

Table 4- Random index values that vary according to matrix sizes (Satty, 1980).

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Table 5- Physical and chemical analysis of the soils samples from study areas.

Çiftlik (L32c2)	X (Latitute)	Y (Longitute)	Elevati. (m)	Text. Clas.	EC dS/m	T.T %	pH	Lime %	O.M %	T.A %	O.K %	Per. cm/hour	Sat. %	Lithology
NKT1	629454.81	4222400.49	1744.69	CL	0.983	0.039	6.77	0.00	1.10	0.06	0.64	16.52	62	Andesite
NKT2	629896.00	4225982.00	1551.16	CL	0.951	0.033	6.67	0.00	1.23	0.06	0.71	9.85	55	Old alluvial
NKT4	629177.00	4230026.00	1556.06	L	0.442	0.013	4.33	0.00	0.80	0.04	0.46	1.81	45	Old alluvial
NKT5	625681.00	4230145.00	1542.72	CL	0.911	0.041	7.36	0.59	3.36	0.17	1.95	4.57	70	Basalt-Andesite
NKT8	622009.00	4229815.00	1503.56	CL	1.013	0.035	7.69	12.19	3.31	0.17	1.92	2.20	54	Basalt-Andesite
NKT9	620757.00	4230410.00	1471.11	L	0.797	0.024	7.71	3.40	4.24	0.21	2.46	2.02	48	Basalt
NKT10	621956.00	4226448.00	1664.58	CL	0.819	0.029	7.28	0.37	1.16	0.06	0.67	16.89	55	Basalt
NKT11	621094.07	4223854.08	1917.36	L	0.603	0.019	7.60	0.59	1.39	0.07	0.81	1.55	48	Pyroclastic rock
NKT14	625977.00	4226518.00	1548.49	L	0.417	0.011	5.75	0.00	0.90	0.05	0.52	7.69	42	Basalt
NKT15	625179.00	4225786.00	1640.62	C	0.944	0.043	7.12	0.00	0.97	0.05	0.56	2.27	71	Pyroclastic rock
NKT17	629435.00	4233419.00	1678.06	L	0.902	0.027	7.91	1.92	0.87	0.04	0.50	2.47	46	Basalt
NKT20	624865.00	4233582.00	1713.07	CL	1.179	0.043	7.69	0.74	0.84	0.04	0.49	1.43	57	Basalt-Andesite
Gölcük (L33c1)	**X (Latitute)**	**Y (Longitute)**	**Elevati. (m)**	**Text. Clas.**	**EC dS/m**	**T.T %**	**pH**	**Lime %**	**O.M %**	**T.A %**	**O.K %**	**Per. cm/hour**	**Sat. %**	**Lithology**
NKT21	655250.00	4223122.00	1358.48	S	0.571	0.009	7.94	0.59	1.13	0.06	0.66	1.77	25	Basalt-Andesite
NKT22	653909.97	4226416.04	1455.07	L	0.843	0.022	7.87	0.59	1.01	0.05	0.59	12.25	41	Gabbro
NKT24	655197.00	4231537.00	1313.33	L	0.844	0.020	7.91	0.74	1.20	0.06	0.70	6.17	37	Pebble-sandsto-ne-mudstone
NKT25	655231.00	4234416.00	1317.17	S	0.348	0.006	8.23	1.63	1.09	0.05	0.63	2.83	26	Pebble-sandsto-ne-mudstone
NKT27	659650.00	4233159.00	1360.04	L	0.593	0.015	7.35	0.15	2.42	0.12	1.40	14.06	39	Ignimbrite
NKT29	662760.00	4234396.00	1387.30	L	1.185	0.024	7.74	0.37	2.12	0.11	1.23	10.82	32	Ignimbrite
NKT30	659048.00	4230781.00	1338.90	L	0.702	0.017	7.42	0.30	1.08	0.05	0.63	12.35	37	Basalt-Andesite
NKT31	660592.00	4230079.00	1355.06	L	0.687	0.018	7.61	0.15	1.54	0.08	0.89	9.27	42	Ignimbrite
NKT32	662645.00	4226663.00	1370.00	CL	0.632	0.022	7.89	1.26	1.14	0.06	0.66	1.97	55	Ignimbrite
NKT33	660623.00	4223256.00	1340.08	S	0.715	0.013	7.83	0.30	0.97	0.05	0.56	23.98	28	Basalt
NKT34	659888.00	4222888.00	1339.45	L	0.892	0.026	7.74	1.26	0.93	0.05	0.52	17.98	46	Basalt
NKT35	659110.00	4226652.00	1335.00	S	0.625	0.011	8.02	4.95	1.06	0.05	0.61	3.02	28	Basalt-Andesite
Bor (M33a4)	**X (Latitute)**	**Y (Longitute)**	**Elevati. (m)**	**Text. Clas.**	**EC dS/m**	**T.T %**	**pH**	**Lime %**	**O.M %**	**T.A %**	**O.K %**	**Per. cm/hour**	**Sat. %**	**Lithology**
NKT36	638883.00	4191734.00	1104.57	L	0.757	0.018	8.02	35.17	1.64	0.08	0.95	1.47	38	Alluvial
NKT37	641367.00	4188417.00	1137.89	L	0.811	0.020	8.10	33.18	2.14	0.11	1.24	12.75	39	Alluvial
NKT38	641234.00	4184589.00	1122.05	C	1.541	0.082	8.62	16.70	1.72	0.09	1.00	0.00	83	Limestone
NKT39	638703.00	4183810.00	1093.56	CL	1.749	0.071	7.72	29.56	0.58	0.03	0.34	3.54	63	Alluvial
NKT40	641315.00	4180267.00	1173.94	L	0.705	0.018	8.01	14.33	2.30	0.12	1.33	4.84	40	Pyroclastic rock Trachyandesite
NKT41	637908.00	4181325.00	1094.25	L	0.754	0.020	7.98	18.55	1.04	0.05	0.60	2.02	41	Alluvial
NKT42	632522.89	4180374.00	1060.00	C	1.427	0.065	8.60	24.75	0.87	0.04	0.50	0.91	71	Limestone
NKT43	633126.00	4185001.00	1069.55	L	0.834	0.024	8.11	29.56	1.39	0.07	0.81	0.80	45	Alluvial
NKT44	636111.00	4187762.00	1083.10	CL	0.871	0.034	8.14	39.90	2.03	0.10	1.18	2.24	61	Alluvial
NKT45	634298.00	4191933.00	1087.42	CL	1.502	0.065	7.74	32.66	2.00	0.10	1.16	3.60	68	Alluvial
NKT46	638656.00	4188620.00	1106.13	L	0.873	0.027	7.93	41.23	2.02	0.10	1.17	4.00	49	Alluvial
NKT48	637300.00	4192751.00	1100.00	L	0.657	0.019	8.00	40.49	1.68	0.08	0.97	1.11	44	Alluvial

L: Loam, CL: Clayey Loam, C: Clayey, S: Sandy, EC: Electrical conductivity, TS: Total salt, OM: Organic matter, TN: Total nitrogen, OC: Organic carbon, Per .: Permeability (Hydraulic conductivity) Sat .: Water Saturation

70.74%, TiO_2 content is 0.24 - 1.05%, Al_2O_3 content is 12.66 - 22.16%, Fe_2O_3 content is 1.74 - 7.89%, MnO content is 0.07 - 0.15%, MgO content is 0.69 - 2.79%, CaO content varies between 1.73 - 15.58%, Na_2O content is 0.93 - 2.45%, K_2O content is 1.86 - 4.76%, P_2O_5 content is between 0.09 - 1.07%. Similarly, SiO_2 content of the main oxides of rock samples is 53.82 - 68.83%, TiO_2 content is 0.13 - 1.22%, Al_2O_3 content is 9.23 - 24.7%, Fe_2O_3 content is 1.11 - 7.77%, MnO content is 0.07 - 0.14%, MgO content is 2.81 - 0.42%,

Table 6- Geochemical analysis of soil samples taken from Çiftlik and its surrounding area.

	ÇT-1	ÇT-2	ÇT-3	ÇT-4	ÇT-5	ÇT-6	ÇT-7	ÇT-8	ÇT-9	ÇT-10	ÇT-12_1	ÇT-12_2
X1	621094	625179	629455	621956	625977	629896	622009	625681	629177	620757	629435	629435
Y1	4223854	4225786	4222400	4226448	4226518	4225982	4229815	4230145	4230026	4230410	4233419	4233419
Elevation	1917	1641	1745	1665	1548	1551	1504	1543	1556	1471	1678	1678
%												
SiO_2	67.12	66.28	65.05	61.58	65.58	66.22	52.78	60.46	70.74	60.8	63.03	68.43
TiO_2	0.65	0.7	0.87	0.84	0.80	0.80	1.04	1.05	0.45	0.89	0.81	0.24
Al_2O_3	18.57	16.3	18.91	22.16	16.98	17.68	16.66	19.97	16.61	16.66	19.7	12.66
Fe_2O_3	4.27	5.19	5.72	6.17	5.07	5.32	7.43	7.89	3.06	6.39	5.57	1.74
MnO	0.1	0.1	0.13	0.13	0.13	0.13	0.15	0.15	0.07	0.14	0.14	0.08
MgO	1.28	2.11	1.37	1.41	1.4	1.23	2.79	2.31	0.80	2.57	1.21	0.69
CaO	2.82	4.6	3.24	3.24	4.32	3.56	15.58	4.32	1.73	7.42	4.39	8.75
Na_2O	1.83	1.1	1.68	1.67	2.45	2.02	1.28	1.21	1.96	0.93	1.27	2.34
K_2O	3.05	3.22	2.59	2.43	2.68	2.6	1.86	2.27	4.26	2.89	3.55	4.76
P_2O_5	0.11	0.23	0.23	0.13	0.36	0.2	0.16	0.12	0.17	1.07	0.09	0.09
Total	99.80	99.83	99.79	99.76	99.77	99.76	99.73	99.75	99.85	99.76	99.76	99.78
ppm												
Nb	17	8	14	18	11	10	16	17	24	16	25	15
Rb	91	91	91	91	82	91	71	91	183	91	183	183
Ba	1000	700	700	1000	800	800	700	700	600	800	900.00	1500.00
Sr	400	300	500	500	600	500	700	400	200	500.00	400	300
Zr	200	200	300	300	200	200	400	300	200	200	400	100
Fe	29900	36300	40000	43200	35500	37200	52000	55200	21400	44700	39000	12200
Mn	800	800	1000	1000	1000	1000	1200	1200	500	1100	1100	600
Cr	65	137	68	68	137	137	274	205	68	205	137	50
Cu	34	58	63	55	51	57	64	57	40	68	70	30
Ni	68	73	79	76	62	64	157	157	35	79	79	37
Zn	66	77	80	80	80	76	80	80	59	80	80	47
As	19	27	3	23	14	26		19	2	14	26	23
Y		16	20		17	18		23	17		27	9
Ca/Mg	2.20	2.18	2.36	2.30	3.09	2.89	5.58	1.87	2.16	2.89	3.63	12.68
Ba/Sr	2.50	2.33	1.40	2.00	1.33	1.60	1.00	1.75	3.00	1.60	2.25	5.00

CaO content varies between 3.41 - 23.88%, Na_2O content is 2.16 - 4.03%, K_2O content is 1.64 - 4.96%, P_2O_5 content is 0.14 - 0.52%.

The Ca/Mg ratios of the soils from the Çiftlik and its vicinity vary between 1.87 and 12.68 and the lime ratios measured from the same soils between 0 - 12.19% (Table 5, 6), the study area under the influence of magmatic origin region lithology which is an indicator of the low lime content of the soils. In the correlation analysis applied to the parameters of Çiftlik and its vicinity soils (Table 7), it was determined that the main elements showed low positive and negative values among themselves and especially with Si. This indicates that magmatic and sedimentary lithology are observed predominantly in soils of the study area, especially alkali (such as Ca, Na, K) elements in the soil are washed due to alteration (Price and Velbel, 2003) and it indicates that they are formed by developing locally (Gürel, 2006).

Normalized value means that each geochemical parameter obtained from a soil profile relative to the fresh bedrock on which the profile is developed (Soil/Rock; S/R). These values provide very useful data to better interpretation of the elemental distribution-enrichment in the soil profile formed in the region (Tijani et al., 2006). The normalized values of the

Table 7- Correlation matrix of parameters obtained from the soils of the Çiftlik and its nearby area ($p<0.01$).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Rb	Ba	Sr	Zr	Cr	Cu	Ni	Zn	As	EC	T.Salt	pH	$CaCO_3$	O.M.	T.N	O.C.	Perm.	Sat.
SiO_2	1.00																											
TiO_2	-0.79	1.00																										
Al_2O_3	-0.29	0.62	1.00																									
Fe_2O_3	-0.82	0.98	0.61	1.00																								
MnO	-0.81	0.93	0.53	0.91	1.00																							
MgO	-0.81	0.76	0.12	0.81	0.65	1.00																						
CaO	-0.71	0.20	-0.43	0.24	0.31	0.56	1.00																					
Na_2O	0.58	-0.59	-0.31	-0.67	-0.48	-0.76	-0.24	1.00																				
K_2O	0.73	-0.93	-0.58	-0.90	-0.83	-0.69	-0.22	0.37	1.00																			
P_2O_5	-0.17	0.22	-0.17	0.21	0.24	0.46	0.13	-0.36	-0.13	1.00																		
Rb	0.51	-0.71	-0.32	-0.68	-0.57	-0.66	-0.17	0.25	0.88	-0.27	1.00																	
Ba	0.24	-0.60	-0.35	-0.57	-0.33	-0.47	0.15	0.43	0.51	-0.19	0.39	1.00																
Sr	-0.74	0.71	0.23	0.63	0.78	0.52	0.51	-0.07	-0.80	0.23	-0.69	-0.18	1.00															
Zr	-0.72	0.72	0.62	0.71	0.69	0.42	0.27	-0.52	-0.57	-0.22	-0.16	-0.42	0.47	1.00														
Cr	-0.82	0.72	0.00	0.75	0.70	0.88	0.65	-0.60	-0.60	0.35	-0.45	-0.46	0.57	0.48	1.00													
Cu	-0.64	0.79	0.43	0.78	0.81	0.61	0.20	-0.69	-0.59	0.38	-0.35	-0.54	0.51	0.70	0.63	1.00												
Ni	-0.86	0.81	0.35	0.86	0.75	0.80	0.51	-0.59	-0.74	-0.05	-0.52	-0.38	0.53	0.68	0.79	0.51	1.00											
Zn	-0.63	0.93	0.65	0.89	0.86	0.63	0.02	-0.55	-0.84	0.28	-0.66	-0.62	0.64	0.66	0.57	0.87	0.58	1.00										
As	-0.28	0.05	0.06	0.11	0.20	0.13	0.32	-0.17	-0.06	-0.22	-0.06	0.43	0.06	0.04	0.21	0.09	0.16	0.09	1.00									
EC.	-0.03	-0.27	-0.34	-0.25	-0.06	-0.01	0.31	0.15	0.19	0.12	-0.01	0.71	0.13	-0.33	-0.01	-0.21	-0.20	-0.19	0.70	1.00								
T.Salt	-0.13	-0.18	-0.20	-0.14	-0.01	0.12	0.29	0.02	0.07	0.32	-0.15	0.65	0.18	-0.33	-0.01	-0.18	-0.16	-0.11	0.55	0.92	1.00							
pH	-0.27	0.07	-0.05	0.11	0.28	0.12	0.29	0.03	-0.03	-0.02	0.04	0.39	0.19	0.00	0.36	0.01	0.17	0.03	0.77	0.68	0.55	1.00						
$CaCO_3$	0.11	0.07	-0.06	-0.04	0.18	-0.17	-0.11	0.56	-0.14	0.06	-0.17	-0.03	0.39	-0.14	0.05	-0.01	-0.17	0.21	0.02	0.27	0.11	0.35	1.00					
O.M.	0.02	0.20	0.30	0.14	0.25	-0.14	-0.24	0.41	-0.39	-0.06	-0.40	-0.02	0.39	-0.11	-0.03	0.05	-0.11	0.29	0.33	0.16	0.14	0.39	0.58	1.00				
T.N	0.02	0.20	0.30	0.14	0.24	-0.14	-0.24	0.42	-0.39	-0.05	-0.41	-0.04	0.40	-0.12	-0.03	0.03	-0.11	0.29	0.31	0.16	0.14	0.38	0.59	1.00	1.00			
O.C.	0.02	0.20	0.30	0.14	0.25	-0.14	-0.24	0.41	-0.39	-0.06	-0.40	-0.02	0.39	-0.11	-0.03	0.04	-0.11	0.29	0.34	0.17	0.14	0.40	0.58	1.00	1.00	1.00		
Perm.	-0.25	0.05	-0.05	0.05	-0.16	0.29	0.35	-0.18	-0.19	-0.22	-0.26	-0.17	0.12	0.19	0.18	-0.20	0.25	-0.07	0.03	0.06	0.10	-0.11	-0.30	-0.25	-0.23	-0.25	1.00	
Sat.	-0.28	0.07	0.06	0.12	0.12	0.32	0.23	-0.19	-0.18	0.49	-0.37	0.38	0.27	-0.20	0.06	-0.03	-0.01	0.09	0.31	0.63	0.87	0.30	-0.10	0.13	0.14	0.13	0.16	1.00

T.N: Total Nitrogen. **OC:** Organic Carbon. **OM:** Organic Matter. **T.SALT:** Total Salt . **PERM.:** Permeability. **SAT:** Saturation.

Table 8- Geochemical analysis of bedrock samples taken from Çiftlik and its surrounding area.

	ÇK-1	**ÇK-2**	**ÇK-3**	**ÇK-4_1**	**ÇK-4_2**	**ÇK-5**	**ÇK-7**	**ÇK-8**	**ÇK-10**	**ÇK-11**	**ÇK-12_1**	**ÇK-12_2**
X_1	621094	625179	629455	621956	621956	625977	622009	625681	620757	624865	629435	629435
Y_1	4223854	4225786	4222400	4226448	4226448	4226518	4229815	4230145	4230410	4233582	4233419	4233419
Elevation	1917	1641	1745	1665	1665	1548	1504	1543	1471	1713	1678	1678
%	**Pyroclastic**	**Pyroclastic**	**Andesite**	**Basalt**	**Basalt**	**Basalt**	**Basalt Andesite**	**Basalt Andesite**	**Basalt**	**Basalt Andesite**	**Basalt**	**Basalt**
SiO_2	62.66	58.19	64.45	63.25	57.26	61.54	57.6	57.58	53.82	59.2	68.83	58.38
TiO_2	0.66	0.84	0.54	0.69	0.84	0.71	0.71	0.99	1.22	0.85	0.43	0.13
Al2O3	17.08	20.3	16.57	18.17	24.7	20.1	18.14	19.43	18.02	16.01	15.64	9.23
Fe_2O_3	4.53	5.7	4.06	5.06	5.32	4.71	5.17	6.17	7.77	5.87	2.64	1.11
MnO	0.09	0.11	0.07	0.1	0.09	0.11	0.11	0.14	0.13	0.12	0.09	0.07
MgO	1.81	1.78	2.06	1.44	1.01	1.45	1.66	1.87	2.81	2.81	0.42	0.6
CaO	6.44	7.07	6.29	4.95	5.56	5.18	10.34	7.2	9.44	8.22	3.41	23.88
Na_2O	3.82	3.88	3.59	3.23	2.78	3.07	3.82	3.87	4.03	3.98	3.21	2.16
K_2O	2.51	1.64	2.05	2.67	1.84	2.37	1.82	2.22	1.95	2.61	4.96	4.03
P_2O_5	0.24	0.27	0.19	0.23	0.3	0.52	0.38	0.26	0.52	0.14	0.16	0.18
Total	**99.84**	**99.78**	**99.87**	**99.79**	**99.7**	**99.76**	**99.75**	**99.73**	**99.71**	**99.81**	**99.79**	**99.77**
ppm												
Nb	10	11	7	8	12	10	10	9	10	10	16	12
Rb	65	33	56	75	46	59	13	32	34	70	183	183
Ba	600	800	400	900	1200	800	1000	1200	700	600	1000	1200
Sr	600	700	500	500	700	600	800	400	900	300	300	500
Zr	200	400	100	200	400	300	400	200	400	200	300	0,03
Fe	31700	39900	28400	35400	37200	32900	36200	43200	54300	41100	18500	7800
Mn	700	900	500	800	700	900	900	1100	1000	900	700	500
Cr		60	30	68		38	53	68	65	137		
Cu	36	56	36	69	37	72	47	37	73	60	32	26
Ni	45	79	41	61	157	79	63	79	52	71	19	28
Zn	59	66	63	63	80	72	68	72	80	67	58	60
As				11	11	11						20
Y	13			19	15		22	24	26	20	17	9

main and trace elements observed in Çiftlik and its vicinity soils with the bedrock are given in Table 9. Accordingly, among the trace elements proportional to the bedrock of the soil of the region; Nb is 0.75 - 2.36, Rb is 1 - 5.57, Ba is 0.58 - 1.75, Sr is 0.22 - 1.67, Zr is 0.50 - 3, Fe is 0.39 - 1.56, Mn is 0.50 - 2, Cr is 1 - 5.19, Cu is 0.54 - 2.20, Ni is 0.39 - 4.17, Zn is 0.73 - 1.39, As 0.00 - 3.31 and Y is 0.64 - 1.55 times higher (Table 9).

The abundance of these elements in the soil is result of the decomposition of the volcanic rocks predominant basalt andesite magmatism in the study area.

Major oxides of soil samples from Gölcük and its vicinity; SiO_2 content is 39.6 - 69%, TiO_2 content is 0.45 - 1.08%, Al_2O_3 content is 11.53 - 18.18%, Fe_2O_3 content is 3.27 - 9.6%, MnO content is 0.08 - 0.18%, MgO content is 1.06 - 4.76% from the soil samples of Gölcük and its vicinity. The CaO content varies between 3.02 - 37.01%, Na_2O content is 0.35 - 2.39%, K_2O content is 1.67 - 4.26%, P_2O_5 content is 0.09 - 0.26%. SiO_2 content is 19.4 - 93.9%, TiO_2 content is 0.16 - 1.14%, Al_2O_3 content is 0.38 - 19.93%, Fe_2O_3 content is 0.11 - 14.4%, MnO content is 0.04 - 0.14%, MgO content is 0.08 - 14.01% in rock samples

Table 9- Normalized values of major and trace elements with bedrock in Çiftlik and its nearby area soils (Soil/Rock).

	ÇT-1	ÇT-2	ÇT-3	ÇT-4	ÇT-5	ÇT-6	ÇT-7	ÇT-8	ÇT-9	ÇT-10	ÇT-11	ÇT-12
	Pyroclastic	Pyroclastic	Andesite	Basalt	Basalt	Basalt	Basalt Andesite	Basalt Andesite	Basalt	Basalt Andesite	Basalt	Basalt
SiO_2	1.07	1.14	1.01	0.97	1.15	1.08	0.92	1.05	1.31	1.03	0.92	1.47
TiO_2	0.98	0.83	1.61	1.22	0.95	1.13	1.46	1.06	0.37	1.05	1.88	1.85
Al_2O_3	1.09	0.80	1.14	1.22	0.69	0.88	0.92	1.03	0.92	1.04	1.26	1.37
Fe_2O_3	0.94	0.91	1.41	1.22	0.95	1.13	1.44	1.28	0.39	1.09	2.11	1.57
MnO	1.11	0.91	1.86	1.30	1.44	1.18	1.36	1.07	0.54	147	1.56	1.14
MgO	0.71	1.19	0.67	0.98	1.39	0.85	1.68	1.24	0.28	0.91	2.88	1.15
CaO	0.44	0.65	0.52	0.65	0.78	0.69	1.51	0.60	0.18	0.90	1.29	0.37
Na_2O	0.48	0.28	0.47	0.52	0.88	0.66	0.34	0.31	0.49	0.23	0.40	1.08
K_2O	1.22	1.96	1.26	0.91	1.46	1.10	1.02	1.02	2.18	141	0.72	1.18
P_2O_5	0.46	0.85	1.21	0.57	1.20	0.38	0.42	0.46	0.33	7.64	0.56	0.50
Nb	1.79	0.75	2.00	2.36	0.94	0.93	1.53	1.94	2.27	1.53	1.57	1.29
Rb	1.41	2.78	1.64	1.22	1.80	1.55	5.57	2.86	5.41	1.30	1.00	1.00
Ba	1.67	0.88	1.75	1.11	0.67	1.00	0.70	0.58	0.86	1.33	0.90	1.25
Sr	0.67	0.43	1.00	1.00	0.86	0.83	0.88	1.00	0.22	1.67	1.33	0.60
Zr	1.00	0.50	3.00	1.50	0.50	0.67	1.00	1.50	0.50	1.00	1.33	0.33
Fe	0.94	0.91	1.41	1.22	0.95	1.13	1.44	1.28	0.39	1.09	2.11	1.56
Mn	1.14	0.89	2.00	1.25	1.43	1.11	1.33	1.09	0.50	1.22	1.57	1.20
Cr		2.27	2.27	1.00		3.64	5.19	3.00	1.05	1.50		
Cu	0.96	1.03	1.76	0.80	1.39	0.79	1.36	1.54	0.54	1.13	2.20	1.19
Ni	1.53	0.93	1.92	1.26	0.39	0.81	2.50	2.00	0.67	1.11	4.17	1.34
Zn	1.12	1.17	1.27	1.28	1.01	1.06	1.18	1.11	0.73	1.19	1.39	0.77
As	1.58	3.31	0.61	2.07	1.27	2.43	0.00	1.89	0.25	2.06	1.72	1.15
Y					1.11			0.97	0.64		1.55	1.00

corresponding to soil samples. The CaO content varies between 1.65 - 74.9%, Na_2O content is 0.03 - 3.66%, K_2O content is 0.04 - 4.56%, P_2O_5 content is 0.05 - 0.83% in the same samples.

The Ca/Mg ratios of the soils taken from Gölcük and its vicinity vary between 1.50 and 14.51 and the lime ratios measured from the same soils vary between 0.15 and 8.17% (Table 5). The low lime contents observed in the study area indicates that they developed in situ from the dominant magmatic lithology in the region. In the correlation analysis applied to soil parameters (Table 10), the main elements shows low but positive values among themselves which the developed soils in this study area are less washed, less transported and in situ developed (Gürel, 2006).

In normalized values with the bedrocks of Gölcük and vicinity soils; the main and trace element values have variable values at low rates and according to the bedrock Nb is 0 - 1.50, Rb is 0.50 - 4.54, Ba is 0.43 - 1.20, Sr is 0.23 - 2.50, Zr is 0.01 - 1.54, Fe is 0.27 - 4.73, Mn is 0.83 - 3, Cr is 1.67 - 9.12, Cu is 0.49 - 1.63, Ni is 0.69 - 4.25, Zn is 1 - 2.62, As is 0.25 - 2.26 times higher. Cr, with values between 1.67 and 9.12, is the most observed element in the soils of the study area, indicates the predominance of the basic lithology observed in the region (Table 11).

Major oxides values belong to soil samples from Bor and its vicinity: SiO_2 content is 28.2 - 51.92%, TiO_2 content is 0.48 - 1.01%, Al_2O_3 content is 7.03 - 15.31%, Fe_2O_3 content is 3.67 - 8.78%, MnO content is 0.08 - 0.18%, MgO content is 1.53 - 11.4%, CaO content varies between 16.86 - 55.19%, Na_2O content is 0.35 - 1.46%, K_2O content is 1.37 - 3.21%, P_2O_5 content is between 0.09 - 0.64%. Major oxides of the rock samples from this region: SiO_2 content is 0.38 - 70.03%, TiO_2 content is 0.06 - 1.06%, Al_2O_3 content is 0.12 - 13.89%, Fe_2O_3 content is 0.06 - 7.58%, MnO

Table 10- Correlation matrix of parameters obtained from the soils taken from Gölcük and its nearby area (p<0.01).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Rb	Ba	Sr	Zr	Cr	Cu	Ni	Zn	As	EC	T.Salt	pH	$CaCO_3$	O.M.	T.N	O.C.	Perm.	Sat.
SiO_2	1.00																											
TiO_2	-0.41	1.00																										
Al_2O_3	0.51	0.43	1.00																									
Fe_2O_3	-0.47	0.92	0.43	1.00																								
MnO	-0.59	0.84	0.27	0.96	1.00																							
MgO	-0.53	0.71	0.26	0.91	0.92	1.00																						
CaO	-0.93	0.10	-0.77	0.13	0.27	0.23	1.00																					
Na_2O	0.81	-0.61	0.18	-0.65	-0.68	-0.71	-0.66	1.00																				
K_2O	0.77	-0.82	-0.10	-0.91	-0.90	-0.87	-0.50	0.85	1.00																			
P_2O_5	-0.42	0.23	-0.45	-0.02	0.01	-0.15	0.51	-0.39	-0.13	1.00																		
Rb	0.88	-0.60	0.30	-0.69	-0.77	-0.74	-0.72	0.88	0.86	-0.43	1.00																	
Ba	0.30	-0.45	-0.07	-0.58	-0.66	-0.54	-0.12	0.25	0.51	0.34	0.38	1.00																
Sr	0.02	0.56	0.35	0.35	0.25	0.03	-0.17	0.13	-0.20	0.15	0.07	-0.16	1.00															
Zr	-0.07	0.34	0.10	0.09	-0.03	-0.27	0.06	-0.02	-0.14	0.40	0.02	0.04	0.65	1.00														
Cr	-0.27	0.37	0.09	0.49	0.52	0.64	0.11	-0.43	-0.46	-0.36	-0.28	-0.59	-0.05	-0.43	1.00													
Cu	-0.68	0.76	0.10	0.71	0.74	0.55	0.47	-0.71	-0.80	0.34	-0.66	-0.42	0.37	0.43	0.19	1.00												
Ni	-0.95	0.36	-0.52	0.40	0.52	0.47	0.91	-0.84	-0.71	0.43	-0.84	-0.30	-0.18	0.02	0.27	0.69	1.00											
Zn	-0.66	0.85	0.05	0.79	0.83	0.70	0.43	-0.78	-0.84	0.38	-0.74	-0.51	0.35	0.25	0.52	0.83	0.62	1.00										
As	-0.81	0.14	-0.49	0.32	0.42	0.54	0.78	-0.77	-0.60	0.25	-0.81	-0.12	-0.51	-0.35	0.22	0.37	0.86	0.34	1.00									
EC.	0.19	-0.60	-0.48	-0.65	0.61	-0.65	0.07	0.41	0.56	0.14	0.28	0.16	-0.27	0.03	-0.56	-0.32	-0.04	-0.58	-0.02	1.00								
T.Salt	0.11	-0.54	-0.33	-0.61	-0.61	-0.63	0.11	0.25	0.47	0.22	0.27	0.48	-0.24	0.16	-0.70	-0.16	0.01	-0.58	0.04	0.80	1.00							
pH	-0.04	-0.11	-0.04	0.12	0.18	0.34	-0.01	-0.01	-0.07	-0.39	-0.14	-0.12	-0.40	-0.72	0.40	-0.44	-0.03	-0.17	0.29	-0.28	-0.38	1.00						
$CaCO_3$	0.29	-0.44	0.04	-0.32	-0.23	-0.22	-0.22	0.45	0.37	-0.47	0.44	0.02	-0.23	-0.32	0.15	-0.49	-0.36	-0.35	-0.28	-0.25	-0.30	0.52	1.00					
O.M.	0.06	-0.02	-0.01	-0.07	-0.18	-0.18	-0.02	0.16	-0.03	-0.05	0.10	-0.04	0.32	0.64	-0.36	0.08	-0.10	-0.07	-0.20	0.24	0.13	-0.55	-0.33	1.00				
T.N	0.09	-0.03	-0.02	-0.10	-0.23	-0.24	-0.04	0.20	0.02	-0.01	0.14	0.01	0.36	0.65	-0.41	0.04	-0.13	-0.12	-0.23	0.30	0.19	-0.55	-0.37	0.99	1.00			
O.C.	0.05	-0.01	-0.01	-0.06	-0.18	-0.18	-0.02	0.15	-0.04	-0.04	0.09	-0.04	0.32	0.63	-0.35	0.08	-0.09	-0.07	-0.19	0.24	0.12	-0.55	-0.33	1.00	0.99	1.00		
Perm.	-0.11	-0.07	-0.43	-0.18	-0.09	-0.21	0.23	-0.03	0.16	0.42	-0.10	-0.13	0.18	0.22	-0.15	0.18	0.10	0.15	-0.09	0.39	0.33	-0.50	-0.43	0.07	0.09	0.06	1.00	
Sat.	0.03	-0.23	0.00	-0.32	-0.39	-0.39	0.07	0.01	0.21	0.29	0.18	0.72	-0.04	0.31	-0.63	0.06	-0.01	-0.34	0.02	0.22	0.75	-0.36	-0.22	0.03	0.07	0.03	0.07	1.00

T.N.: Total Nitrogen. **OC:** Organic Carbon. **OM:** Organic Matter. **T.Salt:** Total Salt . **Perm.:** Permeability. **Sat:** Saturation.

Table 11- Normalized values of major and trace elements with bedrock in Gölcük and its nearby area soils (Soil/Rock).

	GT-1	GT-2	GT-3	GT-4	GT-5	GT-6	GT-7	GT-8	GT-9	GT-10	GT-11	GT-12
	Andesite	Sandy Limestone	Basalt Andesite	Andesite	Basalt Andesite	Andesite	Sandy Limestone	Basalt	Andesite	Sandy Limestone	Andesite	Andesite
SiO_2	1.29	0.67	1.31	1.17	0.89	0.94	3.28	1.02	1.08	2.80	0.94	0.92
TiO_2	2.38	0.86	0.92	2.26	0.96	1.61	5.06	1.43	1.93	3.39	1.81	2.04
Al_2O_3	1.08	0.65	1.14	1.14	1.12	1.13	8.01	1.06	1.24	4.98	1.17	1.20
Fe_2O_3	0.91	0.93	0.95	1.21	1.28	1.35	4.73	1.38	0.27	2.66	1.86	2.22
MnO	0.93	1.08	0.99	1.28	0.81	1.14	2.60	1.30	1.60	3.00	1.80	1.29
MgO	0.33	1.23	0.95	0.57	1.39	1.22	2.37	0.94	0.71	1.75	1.87	1.41
CaO	0.35	5.08	0.16	0.47	1.64	2.15	0.06	0.75	1.24	0.13	1.49	1.97
Na_2O	1.04	0.10	0.44	0.70	0.45	0.77	7.93	0.61	1.58	4.39	0.62	0.74
K_2O	2.53	0.71	1.16	1.60	0.99	0.94	7.80	0.70	1.41	5.15	0.91	0.94
P_2O_5	1.22	0.58	0.44	0.61	0.63	2.14	1.05	0.40	2.10	2.00	2.17	2.80
Nb	1.14	1.50	0.00	0.00	1.10	0.00	1.40	0.00	0.00	1.50	1.07	0.00
Ba	0.75	0.44	0.75	0.54	0.64	0.89	0.74	0.43	1.00	1.20	1.13	0.90
Rb	1.04	1.28	1.19	0.59	1.02	1.00	4.54	0.85	1.00	2.27	1.00	0.50
Sr	1.70	0.43	0.23	1.13	0.51	2.00	0.40	0.82	1.33	0.45	2.50	2.00
Zr	0.02	0.67	0.64	0.01	1.54	1.00	1.00	1.00	1.00	0.67	1.00	1.00
Fe	0.91	0.93	0.95	1.21	1.28	1.36	4.73	1.38	0.27	2.66	1.86	2.20
Mn	0.91	1.11	0.99	1.27	0.83	1.20	2.50	1.33	1.50	3.00	1.75	1.40
Cr	2.42	2.00	2.34	2.42	4.00	3.42	6.84	6.67	1.67	9.12	4.28	5.07
Cu	0.73	0.89	0.63	0.81	1.10	0.92	1.08	0.64	0.49	0.77	1.63	1.24
Ni	1.08	4.25	1.14	1.16	2.16	1.98	1.32	1.36	0.69	1.03	2.32	1.19
Zn	1.38	1.06	1.00	1.38	1.18	1.50	1.79	1.20	1.14	1.42	1.88	2.62
As	1.26	1.52	1.70	2.26	0.25	0.97	1.39	0.76	1.01	0.87	2.14	0.50

content is 0.05 - 1.59%, MgO content is 0.12 - 4.56%, CaO content varies between 4.31 - 96.1%, Na_2O content is 0.05 - 3.85%, K_2O content is 0.03 - 5.27%, P_2O_5 content is between 0.05 - 0.25%.

It has been determined that the Ca / Mg ratios of the soils of this region vary between 2 and 25, and the lime ratios measured from the same soils vary between 9 - 41% (Table 5) and these soils have calcite content. It is understood that the soils are derived from the carbonate-rich rocks that crop out in the region rather than being transported. In the correlation analysis applied to soil parameters (Table 12), the main elements show high positive (Ca high negative correlation) among themselves, and this indicates that soils were formed by similar processes and from similar lithogenic origin. Likewise, it was determined that there is very weak positive or negative correlation between trace elements and pH which plays an important role on the mobility of metals. Pb has poor mobility in neutral and alkaline soils, but Cu, As and Zn complexes are more common in such soils. It is seen that it coincides with the results of the researches that show that it has high mobility (Lee et al., 2001; Fernandez-Turiel et al., 2001).

Normalized values of Bor and its vicinity soils lithology, Rb is 0.41 - 3.57, Ba is 0 - 2, Sr is 0.03 - 3.67, Zr is 0.01 - 1.67, Fe is 0.44 -84.20, Mn is 0.10 - 2.40, Cu is 0.95 - 2.86, Ni is 0.19 - 10.48, Zn is 0.97 - 3.14, As is 1.91 - 6.67 times higher than the bedrock. It is quite enriched by Fe, Ni and As elements than lithology (bedrock) (Table 13). This shows that it was lithologically originated from the basaltic andesites in the region. The phosphate source of these soils, which are also rich in phosphate, increases the possibility of being pesticides and other fertilizers used in agricultural activities rather than lithology.

In addition, the relationships between the rock materials developed due to the effect of the volcanism

Table 12- Correlation matrix of parameters obtained from the soils taken from Bor and its nearby area (p<0.01).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Rb	Ba	Sr	Zr	Cu	Ni	Zn	As	EC	T.Salt	pH	$CaCO_3$	O.M.	T.N	O.C.	Perm.	Sat.
SiO_2	1.00																										
TiO_2	-0.08	1.00																									
Al_2O_3	0.73	0.49	1.00																								
Fe_2O_3	0.69	0.61	0.85	1.00																							
MnO	0.40	0.59	0.73	0.81	1.00																						
MgO	0.34	-0.32	-0.17	0.22	0.00	1.00																					
CaO	-0.95	-0.12	-0.76	-0.85	-0.56	-0.45	1.00																				
Na_2O	0.71	0.33	0.87	0.79	0.67	0.02	-0.77	1.00																			
K_2O	0.71	0.33	0.54	0.79	0.48	0.40	-0.80	0.61	1.00																		
P_2O_5	-0.23	0.24	-0.29	0.03	-0.11	0.09	0.14	-0.32	0.27	1.00																	
Rb	0.73	0.05	0.65	0.61	0.49	0.16	-0.72	0.50	0.53	-0.28	1.00																
Ba	0.71	0.42	0.63	0.88	0.64	0.38	-0.84	0.59	0.94	0.22	0.66	1.00															
Sr	0.14	-0.27	-0.32	0.11	-0.05	0.94	-0.27	-0.10	0.31	0.17	0.09	0.30	1.00														
Zr	0.11	0.36	0.02	0.39	0.00	0.41	-0.27	0.15	0.67	0.55	-0.05	0.55	0.40	1.00													
Cu	0.03	0.55	0.31	0.47	0.32	0.03	-0.19	0.04	0.17	0.27	0.30	0.43	0.09	0.32	1.00												
Ni	0.42	0.42	0.44	0.77	0.68	0.46	-0.63	0.57	0.80	0.15	0.45	0.84	0.44	0.62	0.35	1.00											
Zn	-0.02	0.58	0.47	0.40	0.31	-0.26	-0.11	0.40	0.05	-0.16	0.31	0.10	-0.19	0.09	0.43	0.19	1.00										
As	-0.01	-0.42	-0.15	-0.27	-0.39	0.03	0.10	-0.38	-0.32	0.07	0.21	-0.23	-0.06	-0.20	0.21	-0.36	0.08	1.00									
EC.	-0.24	0.11	-0.34	-0.25	-0.48	-0.17	0.29	-0.38	0.04	0.63	-0.43	-0.06	-0.04	0.35	0.08	-0.30	-0.30	-0.19	1.00								
T.Salt	-0.22	0.19	-0.30	-0.16	-0.34	-0.16	0.25	-0.35	0.12	0.73	-0.41	0.02	-0.04	0.33	0.07	-0.22	-0.33	-0.23	0.97	1.00							
pH	0.36	-0.03	0.06	0.31	0.33	0.38	-0.38	-0.01	0.49	0.51	0.15	0.52	0.26	0.16	-0.02	0.33	-0.58	-0.05	0.11	0.30	1.00						
$CaCO_3$	-0.44	0.12	-0.25	-0.30	-0.11	-0.15	0.42	-0.50	-0.53	-0.40	-0.05	-0.35	-0.06	-0.38	0.23	-0.33	0.14	0.09	-0.12	-0.19	-0.36	1.00					
O.M.	-0.39	0.55	0.10	0.22	0.56	-0.20	0.19	0.08	-0.01	0.04	0.00	0.09	-0.14	0.09	0.26	0.45	0.43	-0.13	-0.48	-0.39	-0.07	0.20	1.00				
T.N	-0.36	0.57	0.13	0.25	0.56	-0.20	0.17	0.11	0.03	0.08	0.03	0.14	-0.15	0.15	0.29	0.49	0.46	-0.12	-0.46	-0.37	-0.06	0.15	1.00	1.00			
O.C.	-0.39	0.56	0.10	0.22	0.56	-0.20	0.20	0.08	-0.01	0.04	0.00	0.09	-0.14	0.09	0.27	0.45	0.44	-0.12	-0.48	-0.39	-0.07	0.20	1.00	1.00	1.00		
Perm.	0.02	0.36	0.31	0.23	0.19	-0.21	-0.08	0.21	0.12	-0.29	0.09	0.20	-0.31	0.30	0.35	0.32	0.23	-0.02	-0.26	-0.35	-0.31	0.21	0.42	0.44	0.42	1.00	
Sat.	-0.27	0.24	-0.29	-0.15	-0.19	-0.22	0.29	-0.39	0.07	0.74	-0.40	0.00	-0.12	0.18	0.00	-0.24	-0.36	-0.24	0.85	0.95	0.45	-0.13	-0.24	-0.23	-0.23	-0.44	1.00

T.N.: Total Nitrogen. **OC:** Organic Carbon. **OM:** Organic Matter. **T.Salt:** Total Salt . **Perm.:** Permeability. **Sat:** Saturation.

Table 13- Normalized values of major and trace elements with bedrock in Bor and its nearby area soils (Soil / Rock).

	BT-1	BT-2	BT-3	BT-4	BT-5	BT-6	BT-7	BT-8	BT-9	BT-11	BT-12
	Calcite	Sandy Limestone	Ignimbrite	Ignimbrite	Calcite	Calcite	Ignimbrite	Ignimbrite	Ignimbrite	Sandy Limestone	Ignimbrite
SiO_2	5.35	1.13	0.69	0.66	115.24	25.08	0.63	0.62	0.59	0.67	0.56
TiO_2	2.13	0.83	3.37	2.81	14.20	11.83	1.96	1.90	3.31	0.81	2.67
AI_2O_3	4.51	1.60	1.00	0.86	96.17	18.45	0.57	0.67	0.33	0.79	0.86
Fe_2O_3	4.60	1.04	4.08	2.76	100.33	17.07	2.10	2.22	2.95	0.48	2.54
MnO	0.09	0.28	2.25	1.14	3.00	2.50	1.43	1.13	2.14	0.16	2.00
MgO	12.26	142	13.09	7.47	35.50	11.44	16.93	16.70	4.88	0.63	3.48
CaO	0.25	0.61	4.00	6.26	0.30	0.18	7.08	7.38	7.37	1.75	8.95
Na_2O	1.96	0.75	0.28	0.21	2.17	29.20	0.10	0.10	0.18	0.26	0.18
K_2O	3.27	1.65	0.61	0.46	87.00	36.00	0.41	0.35	0.41	0.82	0.27
P_2O_5	1.13	1.15	2.56	5.40	ae	1.80	7.40	1.48	3.80	2.15	0.72
Rb	3.57	1.10	0.50	0.50	0.83	1.13	0.41	0.50	0.49	0.65	0.50
Ba	0.53	2.00	1.20	0.75	1.03	0.91	0.63	0.40	0.63	0.00	0.40
Sr	2.11	1.17	3.33	2.33	0.03	5.00	3.67	3.67	1.33	1.17	1.67
Zr	1.33	1.67	1.67	1.33	ae	0.01	1.00	1.00	0.67	1.33	0.33
Fe	4.13	0.94	3.68	2.48	84.20	15.31	1.89	2.00	2.66	0.44	2.29
Mn	0.10	0.27	2.33	1.20	ae	2.40	1.60	1.17	2.40	0.16	2.00
Cu	0.95	1.30	2.86	2.73	1.21	1.36	2.33	2.60	2.36	1.13	2.86
Ni		0.50	5.72	4.24	10.48	4.91	4.76	2.46	4.76	0.19	2.86
Zn	3.14	0.97	1.28	1.61	2.13	1.46	1.58	1.28	1.61	0.97	1.28
As	2.04	3.96	2.03	2.55	2.73	2.51	2.24	6.67	1.91	2.78	3.33

of the region and the soils developed on them were revealed using the diagram obtained with SiO_2 (%) - $Na_2O + K_2O$ (%) parameters used in the classification of volcanic rocks developed by Cox et al. (1979) (Figure 5). Based the diagrams; Subalkaline tholeiitic magma series, which are poor in total alkali ($Na_2O + K_2O$) and rich in Fe content, are defined as basaltic andesite, andesite, trachy-andesite, dacite and rhyolite with medium and acid content. It was observed that most of the soils formed on these rocks developed in situ due to the effect of magmatism of the region and overlapped with the main rock materials. The main rock materials outcropping in Bor and its vicinity are defined as basic-ultrabasic rocks under the effect of regional metamorphism as alkaline magma series that are richer in total alkali content but poorer in SiO_2 composition. The similarity of the sample distributions in the diagram revealed that the soils observed in this area were also developed in situ by deriving from the rocks of calcic composition rich in Ca content.

There are many studies conducted to support the relationship between lithology and soil. One of them is Özdemir et al. (2008) which was conducted in Erzurum region. Four different main materials (andesite, alluvial, gypsum and basalt) and soil samples are taken from areas under three different land use types and based on the Mn, Fe, Cu and Zn element contents They determined that the distribution of these elements was significantly affected by the type of the rock material and the land use. Accordingly, they determined that the distributions of total microelement contents and fractions were generally higher in soils composed of andesite rocks than others.

The lithology of an area is an important parameter for agricultural use, not directly but indirectly. Lithological units constitute the main material of the soil, which is one of the most important parameters for agricultural use. The fact that the soils that can be cultivated are soils that develop on certain lithological units or developed on some lithological units do not have any importance for agricultural use, reveal the importance of lithological unit types for agricultural use. In this study, besides the soil, topography and climate factors, effects of geological factors of the selected areas on the determination of the suitability classes for agricultural use are determined. The effect level was determined by the normalized weight scores of the main parameters and their sub-parameters among themselves. Normalized weight scores for

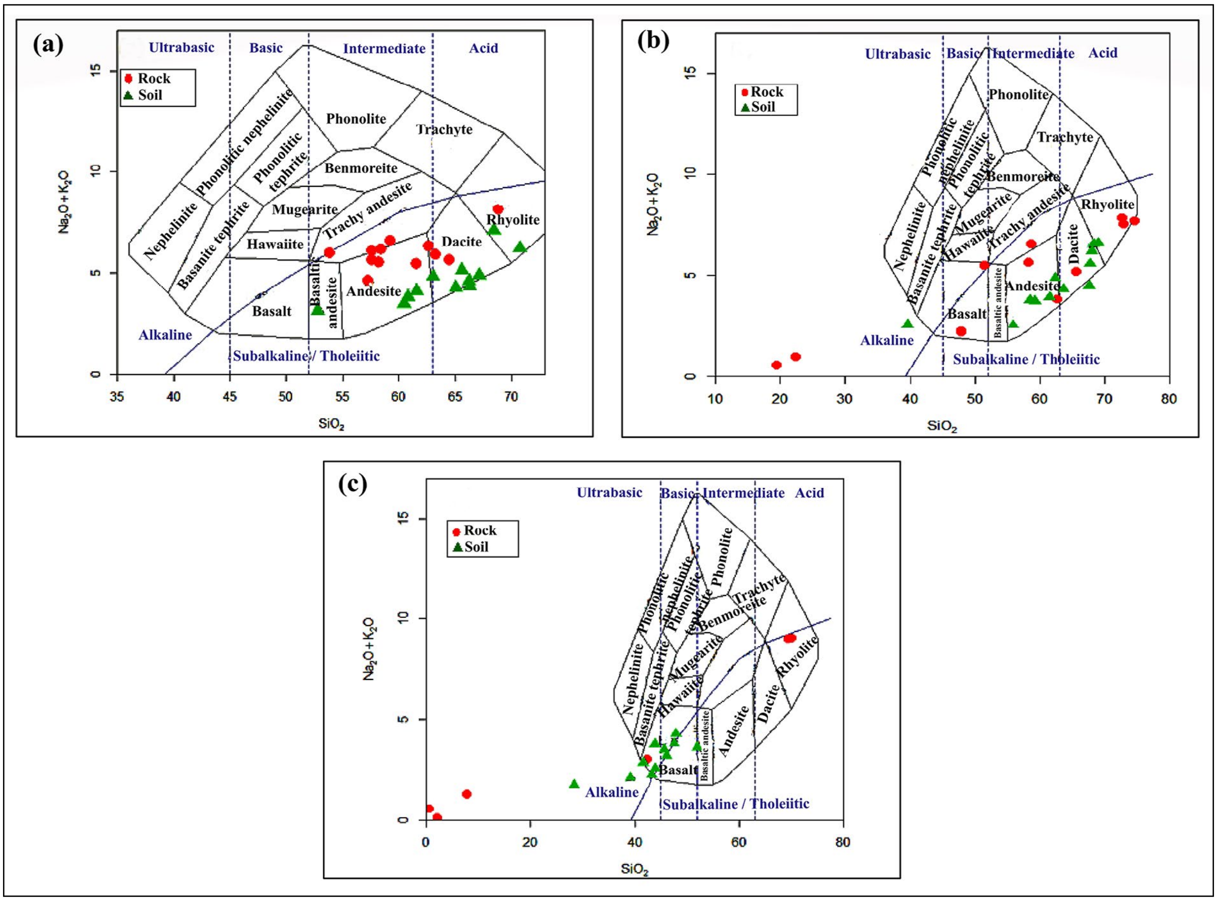

Figure 5- SiO_2-$Na_2O + K_2O$ diagrams of a) Çiftlik, b) Gölcük, c) Bor and its vicinity rock and soil samples (Cox et al., 1979).

main and sub-parameters were calculated using the AHP technique (Table 14).

A consistent matrix of 0.028 consistency rate was created for the main parameters. In the matrix, it was determined that the soil main parameter has the highest weight (53.4%) on the determination of the agricultural suitability classes of the study area. This was followed by the main parameters of topography (30.3%), climate (10.8%) and geology (5.5%). Maddahi et al. (2014) made the agricultural land suitability classification of the rice product of economic importance in the Amol region of Iran. In this study, which they conducted by using the main parameters of soil, topography, climate and irrigation water and their sub-parameters, Analytical Hierarchy Process technique was used in the calculation of the weight values of the parameters. While they calculated the consistency ratio of the paired comparisons of the main parameters as 0.06, they determined that the soil, which is one of the most important parameters in terms of agriculture, was the factor with the greatest impact with 60.2% weight ratio. In this study, in which the topography is 11.3%, the climate is 4.7% and the irrigation water is 23.8% by weight, they have made land suitability classification consisting of 4 (four) classes in terms of agriculture as high suitable, suitable, moderate suitable and not suitable.

For the sub-parameters, consistent comparison was made with consistency ratio of 0.08 in the paired comparison matrix. When the normalized weight scores of the sub-parameters were evaluated, the slope was determined as the sub-parameter with the highest weight with value of 21.2%. Effective parameters in determining the suitability classes for agricultural use based on the weight values, after the slope are landforms (19.5%), pH (13.8%), organic matter (10.5%), lime (8.5%), precipitation (6.1%), total salt (4.6%) , hydraulic conductivity (permeability) (3.4%), electrical conductivity (EC) (3.2%), water saturation (2.8%), lithological units (2.7%), total nitrogen (2.4%) and organic matter (1.3%) parameters, respectively.

Table 14- Paired comparison matrix and normalized weight values of the main and subcriteria.

Paired comparison matrix of the main criteria					
	Soil	Topography	Climate	Geology	*Normalized Weight*
Soil	**1**				0.534
Topography	0.5	**1**			0.303
Climate	0.166	0.250	**1**		0.108
Geology	0.125	0.200	0.333	**1**	0.055

λ_{max} *:* 4,080*; Rİ:* 0.90*; TO:* 0,028 < 0,10 ∑ = 1

Paired comparison matrix of the subcriteria														
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*Normalized Weight*
1	**1**													0.085
2	0.25	**1**												0.024
3	0.16	0.25	**1**											0.013
4	0.14	0.50	2	**1**										0.032
5	3	5	6	4	**1**									0.105
6	4	6	7	4	3	**1**								0.138
7	0.33	3	4	3	0.50	0.25	**1**							0.046
8	0.50	2	3	0.50	0.25	0.20	0.50	**1**						0.034
9	0.33	2	2	0.50	0.25	0.20	0.50	0.50	**1**					0.028
10	0.20	4	5	2	0.20	0.25	2	3	3	**1**				0.061
11	6	7	8	6	3	4	5	6	6	5	**1**			0.212
12	6	6	7	6	3	3	6	5	5	4	1	**1**		0.195
13	0.33	3	3	0.33	0.20	0.16	0.50	0.33	0.33	0.20	0.16	0.20	**1**	0.027

λ_{max} : 14.66 ; Rİ : 1.56 ; TO : 0.08 < 0.10 ∑ = 1

1: Lime, 2: Total nitrogen, 3: Organic carbon, 4: EC, 5: Organic matter, 6: pH, 7: Total salt, 8: Hydraulic conductivity (Permeability), 9: Water saturation, 10: Precipitation, 11: Slope, 12: Terrain shapes, 13: Lithological units

Dengiz and Sarıoğlu (2013), on the agricultural land suitability map of the lands covering Dedeli and Çetinkaya villages and their close vicinity in the Bafra district of Samsun province, is determined the lands based on the suitability classification consisting of 4 (four) classes (Highly suitable, Moderate suitable, Marginally suitable and Not suitable). While they calculated the consistency ratio of the paired comparisons of the parameters used in determining these classes as 0.07, they revealed the slope parameter as the parameter with the highest weight with a weight value of 23.3%. The slope parameters are respectively drainage (16.2%), constituent (15.7%), pH (14.1%), depth (10.3%), EC (10%), efficiency (4.4%) and lime (0.8%), respectively.

Turoğlu (2005) evaluated the suitability of Kayaköy (Fethiye) polje for ecotourism, settlement and agriculture together with the geomorphology, slope, aspect, hydrography, vegetation, soil and land use parameters in his study, in which he used the lithology factor as an important parameter. In determining areas suitable for agriculture; While no weighted multiplier was used for limestones, one of the sub-classes of lithology parameter, the weighted multiplier for alluviums was used as 10 points. As a result of the evaluation, he divided the agricultural suitability classification of the study area into 5 (five) general suitability classification (Very suitable, Suitable, Moderately suitable, Less suitable and Inappropriate).

The main and sub-parameters used in the determination soils in the study area, developing on different main materials and the agricultural use classes were combined according to the normalized weight values assigned using the AHP technique, according to the weighted linear combination method, and the suitability classes map of the study area was created (Figure 6). The general distribution rates

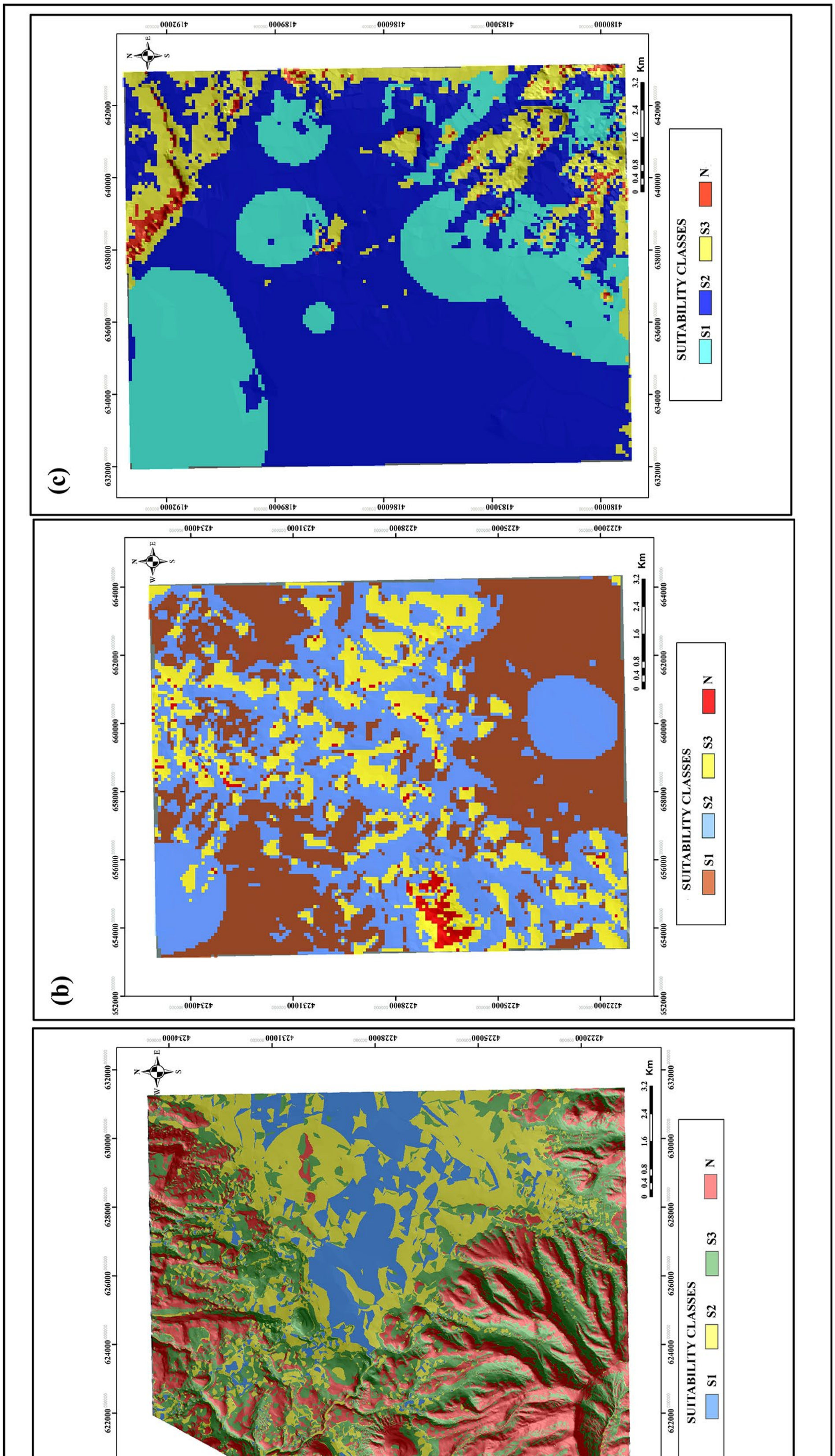

Figure 6- Suitability classes for agricultural use of a) Çiftlik and its vicinity, b) Gölcük and its vicinity, c) Bor and its vicinity.

of suitability classes in all three study areas were calculated as areal and percentage and given in table 15. It has been determined that the lands developed in Gölcük and its vicinity are much more suitable for agricultural use with a rate of 38.31% compared to the lands seen in the other two areas. Different from the other two areas of Çiftlik and its vicinity lands, due to the restrictive effects such as the excess of areas with a slope greater than 12%, the excessive observation of magmatic origin lithological units that are not agriculturally suitable and the excess of agriculturally unsuitable land forms (Table 2), the highest amount of agriculturally unsuitable soils with a rate of 27.93%. (Table 15).

Likewise, the distribution of agricultural suitability classes of developed soils on lithological units in each area was calculated as a percentage and given in Table 16. The calculated percentages express the ratio of each suitability class in its total area. While most of the arable lands around Çiftlik and Bor are alluvium units, the arable lands in Gölcük and its vicinity have formed the basalt-andesite unit. In addition, it has been determined that the soils developed on basalt-andesites in Çiftlik and its vicinity, gabbros in and around Gölcük, and limestones in and around Bor are not suitable for agriculture (Table 16).

4. Conclusions

In the research, the general characteristics of the soils that have developed and continued to develop on different rock materials, the relationships of these soils with lithological units observed in the area and also the quality of the soils derived from different various rock materials for their suitability in agricultural activity have been tried to be investigated. During the research, the geochemical analysis of the soil and rock samples collected from the study area, the physical and chemical analysis of the soils integrated with the topographic and climatic factors were evaluated. According to the results; depending on the lithological features of the units alkaline characteristics of the soils has been developed around Bor district and the soils developed around Çiftlik and Gölcük districts and their vicinity are more acidic reaction. The results of geochemical analysis from soil and rock samples indicated that the soils are developed by both in situ and accumulation around Çiftlik district and vicinity, while the soils around Gölcük and Bor districts are developed in situ. It has been calculated that the main criterion of geology is 5.5% and the criterion of lithological units, which is its' sub-criterion, is 2.7% effective in determining the agricultural suitability of the soils in the study area.

When the distribution of suitability classes for agricultural use is compared with lithological units, most of the suitable area for agricultural purposes around Çiftlik and Bor is alluvium and basalt-andesite units in and around Gölcük district. In addition, the unsuitable classes for agriculture are found to be distributed on basalt-andesites in and around Çiftlik, gabbros in and around Gölcük, and limestones in and around Bor districts.

Consequently, the soils developed around Gölcük and Bor are more suitable for agriculture than the soils developed in Çiftlik and its vicinity.

Table 15- Area and percentage rates of suitability classes for agricultural use in the study area.

Study areas	Suitability Classes for Agricultural Use			
	S1 (Highly suitable) (km^2)	**S2** (Moderate suitable) (km^2)	**S3** (Marginally suitable) (km^2)	**N** (Unsuitable) (km^2)
Çiftlik and its nearby area	18496.717 **%12.41**	37634.490 **%25.25**	51303.096 **%34.41**	41639.939 **%27.93**
Gölcük and its nearby area	57486.326 **%38.31**	62614.022 **%41.72**	27881.142 **%18.58**	2084.933 **%1.39**
Bor and its nearby area	44698.648 **%29.34**	85595.006 **%56.18**	19616.688 **%12.87**	2458.639 **%1.61**

Table 16- Distribution ratios of suitability classes for agricultural use on the lithological units in study area.

Study areas	Suitability Classes for Agricultural Use			
	S1 (Highly suitable) (%)	**S2 (Moderate suitable) (%)**	**S3 (Marginally suitable) (%)**	**N (Unsuitable) (%)**
Çiftlik and its nearby area	Alluvial %63.65	Basalt. Andesite %53.08	Basalt. Andesite %71.37	Basalt. Andesite %81.24
	Basalt. Andesite %19.61	Alluvial %36.51	Pyroclastic rock %13.92	Pyroclastic rock %11.77
	Pyroclastic rock %8.81	Slope debris. deposit cone %5.77	Alluvial %3.52	Alluvial %0.43
	Slope debris. deposit cone %4.50	Pyroclastic rock %2.70	Ignimbrite %1.68	Ignimbrite %0.42
	Agglomerate %2.10	Ignimbrite %1.71	Agglomerate %3.53	Agglomerate %3.01
	Ignimbrite %1.33	Agglomerate %0.23	Slope debris. deposit cone %5.98	Slope debris. deposit cone %3.13
Total	%100	%100	%100	%100
Gölcük and its nearby area	Basalt-Andesite %61.68	Basalt-Andesite %57.22	Basalt-Andesite %48.63	Gabbro %60.51
	Peble-sandstone-mudstoneı %18.18	Ignimbrite %29.62	Ignimbrite %43.49	Basalt-Andesite %23.96
	Ignimbrite %20.14	Peble-sandstone-mudstone %12.75	Peble-sandstone-mudstone %3.65	Ignimbrite %12.83
		Gabbro %0.41	Gabbro %4.23	Peble-sandstone-mudstone %2.70
Total	%100	%100	%100	%100
Bor and its nearby area	Alluvial % 85.88	Alluvial %68.32	Limestone %71.40	Limestone %75.70
	Limestone %10.17	Limestone %26.63	Pyroclastic rock Trachyandesite %14.90	Pyroclastic rock Trachyandesite %17.58
	Pyroclastic rock Trachyandesite %3.87	Pyroclastic rock Trachyandesite %4.65	Ignimbrite %4.13	Ignimbrite %2.77
	Ignimbrite %0.03	Ignimbrite %0.34	Alluvial %9.43	Alluvial %3.26
	Marble %0.05	Marble %0.06	Marble %0.138	Marble %0.69
Total	%100	%100	%100	%100

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