Soil-Forming Factors

2

Soil-forming factors affect not only the course of the genesis processes but also the present and future performance of the soil systems. A brief evaluation of these factors and of their influence on the soils of Greece is presented in this section. The properties described below refer to climax undisturbed soil profiles developed under natural vegetation, which has not been disturbed to a degree that would lead to the truncation of the soil profile by erosion. It must be pointed out, however, that these conditions do not prevail in the sloping landscapes of Greece.

2.1 Climate

Greece is located in the northeastern section of the Mediterranean between the 34th and the 42nd parallels and between the 19th and 29th longitudes of the Northern Hemisphere. Therefore, in general terms, the country is dominated by the Mediterranean type of climate with mild and wet winters and warm and dry summers. However, the extremely irregular topographic configuration, characterized by from north to south significant elevation differences, which causes considerable variability of climatic types within relatively short distance. Mountain ranges dissecting the mainland from north to south and the west–east range in northern Greece affect wet climatic zones in the west and the north sections of the country, whereas the eastern coastal and low-elevation hilly provinces are generally drier. Areas at high elevations along the northern borders of the country have Central European climate.

The country has two climatic seasons: (a) the cold and rainy from the middle October to the end of February with average minimum temperatures 5–10 °C in the coastal and 0–5 °C in inland areas. In northern areas, minimum temperatures are below zero. The warmest period is from July 20 to August 10 with average maximum temperatures ranging between 29 °C and 35 °C.

Greece has been subdivided by Mariolopoulos (1938) into five climatic regions:

(a) The mountainous region
(b) The north or continental region
(c) The Ionian or marine Mediterranean region
(d) The Aegean or inland Mediterranean region
(e) The Cretean or desert-like Mediterranean region

(a) The Mountainous Region

The mountainous region consists of Mount Olympus and the long mountainous range, which runs from north to northwest and divides the mainland into two parts. It includes all the high mountains, and its lands have elevation higher than 1000 m in northern sections and 1200 m in southern. It occupies 16,446 km^2. The climatic parameters of this region are as follows:

Mean temperature is 8–10 °C, which decreases with elevation by 0.6–0.8 °C/100 m. Mean annual rainfall ranges between 1400 and 2220 mm, number of rainy days greater than 100 frost days per year more than 100.

The soil moisture regime in this region is udic. The leaching of soil bases is extensive resulting in dystric and occasionally on acid rocks ultic characteristics. The dominant diagnostic horizon of the climax soil is the cambic. The high acidity of the soil materials prevents illuviation of clay and the formation of the argillic horizon, except on limestone, where climax soils frequently develop argillic horizons.

(b) The Continental Region of northern Greece

The area of this region is 46,900 km^2 and includes large sections of the prefectures of Macedonia, Thessaly, Thrace, and Epirus. The climate is classified as transitional between that of Mediterranean and Central European. The average air temperature ranges between 11 and 15.4 °C, and the annual

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temperature variation is greater than 20 °C. The minimum winter temperatures drop in this region from −2 to −20 °C. The average rainfall ranges between 857 and 506 mm. The distribution of rainfall through the year is more even than in the other climatic regions of the country especially at high elevations. Warm and dry summers prevail in the lowlands.

The soil moisture regime is udic at higher elevations and xeric in the lowlands. The dominant climax soil horizons at elevations higher the 30 m from the sea level or the inland flood plains is the argillic, whereas in the recent alluvial plains no genetic horizon is present in the soil profile other than a weakly developed cambic horizon in wet sites.

(c) The Ionian or Marine Mediterranean Region

The mild marine Mediterranean is the characteristic climate of this region which extends along the western coastal areas from the border to Albania all the way to the southern tip of Peloponnese. It also includes the Ionian island and the Dodecanese islands in the southern eastern part of the Aegean Sea. The area of this region is 22,442 km^2.

The climate is strongly affected by the influence of the Mediterranean Sea. The winter is mild because it is protected from the northern cold winds by the mountain ranges of the mainland. The average yearly temperature variation is 15.5–17 °C, whereas the mean temperatures range from 17.1 to 18.7 °C. Winter frost days are few and occur mainly in northern coastal zone.

The dominant soil moisture regime is xeric in the hilly and low land and udic at high elevations. The dominant diagnostic horizon at elevation higher than 30 m from the sea level or the inland flood plain is the argillic. Soils in recent alluvial plains lack genetic horizons except weakly developed cambic horizons in wet soils as described above. Imperfectly and poorly drained soils form in the flood plains especially in fine-textured profiles.

(d) The Aegean or Inland Mediterranean Region

This region includes the eastern coastal lands and the islands and the northern section of Crete. The two northern Aegean islands Thasos and Samothraki belong to the northern continental region. This region occupies an area of 45,430 km^2.

The mean annual temperature ranges between 16 and 18.5 °C. The rainfall shows significant geographical variations. The Cyclades Islands and southern Attica, including Athens, have mean annual rainfall ranging between 400 and 655 mm, whereas in the northern suburbs of Athens, northwestern Attica, and the eastern Aegean islands, this range is 660–935 mm.

The soil moisture regime is xeric throughout the region. The dominant diagnostic horizon at elevation higher than 30 m from the sea level or the inland flood plain is the argillic. In several cases, it has rhodic characteristics. The ochric surface epipedon dominates in this region. However, the original climax Epipedon on marly tertiary and quaternary deposits was the mollic. This Epipedon has been removed from the soil profile by erosion and extensive cultivation. Soils in recent plains lack genetic horizons.

(e) The Cretean or Desert-like Mediterranean Region

This region according to Mariolopoulos (1936, 1960) has a climate transitional between that of Mediterranean and desert. This classification was based on mean annual rainfall of 202.1 mm, recorded during the period of 1894–1929 (Settas 1975). However, Karapiperis (1955) disputes the existence of this region on the basis of mean annual rainfall that ranges between 504.9 and 517.2 mm. Anyway, this region is considered as the driest in the country. It should also include the southeastern section of Attica and the islands of the Saronikos Bay.

2.1.1 The Bioclimate of Greece

The bioclimate is a compound climatic index, which is related to the performance and the composition of the flora and the fauna on particular landscape. Therefore, it is a parameter which prescribes the effects both of the climate and of the organisms on a particular soil landscape.

Mavromatis (1980) applied two indices to map the bioclimate of Greece

(i) The pluviothermic quotient of Emberger (1955):

$$Q_2 = \frac{1000P}{\frac{M+m}{2}(M-m)}$$

where P is the mean annual precipitation in mm, M the mean maximum temperature of the hottest month in absolute degrees, and m the mean minimum temperature of the coldest month in absolute degrees. The bioclimatic levels were drawn on a diagram m that was plotted versus Q_2, proposed by Emberger–Sauvage (Sauvage 1963).

On the basis of this diagram, Greece is subdivided into three bioclimatic levels: semiarid, subhumid, and humid. Each level was subdivided into three sections on the basis of the minimum winter temperature m as follows: warm $m > 7$ °C, mild 3 °C $< m <$ 7 °C, and cold 0 °C $< m <$ 3 °C.

(ii) The distinction of the characters of the Mediterranean climate:
   (a) The precipitation–temperature diagrams of Bagnouls–Gaussen (1953) for the determination of the duration and the intensity of the dry period, which begins and ends when $P = 2T$ where: P is the mean monthly precipitation in mm and T the mean monthly temperature 0 °C. Dry months are considered those with $P \leq 2T$.
   (b) The xerothermic index X of UNESCO-FAO (1963), calculated for every month, is as follows:

$$X_m = \left\{ J_m - \left(J_p + \left(\frac{J_{r,b}}{2} \right) \right) \right\} f_h$$

where X_m is the monthly xerothermic index; J_m the days of the month; J_p the rainy days of the month; $J_{r,b}$ the days of dew or fog of the month; and f_h the relative humidity coefficient of the month. For relative humidity $H\%$:

$$\begin{aligned} 40\% < H < 60\%, f_h &= 0.9;\ 60\% < H < 80\%, f_h \\ &= 0.8;\ 80\% < H < 90\%, f_h + 0.7; H > 90\% f_h \\ &= 0.6 \end{aligned}$$

Mavromatis (1980) prepared the bioclimatic map of Greece at a scale 1:1,000,000 by combining the estimates of the two methods in defining the following mapping units:

The Emberger–Sauvage method estimates the vertical succession of the bioclimate considering the effect of elevation on the temperature and the rainfall, which affect the vertical distribution of the plant societies. The Bagnouls–Gaussen method estimates the duration and the intensity of the drought, which affect the biological performance of the plants.

2.1.2 Climate and Vegetation Affected Soil Properties

The genetic trends of the soils are affected by the characteristics of the respective bioclimatic zone.

Soils in the xero-thermo-Mediterranean zone have been developed under mostly a xerophytic pine and shrub natural vegetation. They have a xeric moisture regime, and they become highly vulnerable to soil erosion and desertification upon losing their difficult-to-recover plant cover. Residual soils, upon long periods of undisturbed conditions, develop chromic and rhodochromic argillic horizons, except on marly deposits, where they develop cambic horizons and mollic epipedons. Due to the extensive erosion and cultivation, the present dominant soil typological units are those of Xerorthents on severely eroded landscapes and Xerochrepts on the less eroded ones. Organic matter content is generally low. On alluvial plains, the dominant soil is the Xerofluvents. Development of soil salinity takes place in some coastal or inland depression landscapes.

Xero-thermo-Mediterranean	$150 < X < 200$
Thermo-Mediterranean	$100 < X < 150$
(a) Intense	$125 < X < 150$
(b) Weak	$100 < X < 125$
Meso-Mediterranean	$40 < X < 100$
(a) Intense	$75 < X < 100$
(b) Weak	$40 < X < 75$
Sub-Mediterranean	$0 < X < 40$
Axeric	$X = 0$
(a) Subaxeric with a period when	$3t > P > 2T$
(b) Temperate axeric	

Genetic trends in the thermo-Mediterranean zone are similar to those of the above zone. However, the effects of removal of the protective plant cover on the soil profile in terms of erosion and desertification are not as acute as in the previous zone. The presence of argillic is still rare, but the cambic horizon is more frequently found. Calcic and petrocalcic horizons are developed on calcareous materials.

Most of the residual soil profiles in both zones are erosional descendants of original Xeralfs and on highly calcareous tertiary and quaternary deposits of original Xerolls.

The meso-Mediterranean zone, under natural conditions, has been dominated by the broad-leaved forests, mainly various species of oak. The dominant soil moisture regime in the intense subzone is the xeric, and the dominant soil horizon is the well-developed argillic. It seems that under oaks and erica, clay illuviation is a favored soil genesis process (Yassoglou 1973; Dafis 1966). According to the second author, clay illuviation is more pronounced under Quercus conferta, an oak tree growing in Greece at middle elevations. At these elevations, rainfall may contribute to clay illuviation and not to extensive leaching and extreme acidification of the profile that could inhibit clay translocation. It is worthwhile the relationships among climatic parameters and the effects of the soil organic matter produced by the litter under oaks and erica be further investigated. The main colors of this horizon are the chromic on almost all parent materials except on limestone or on schists with limestone intrusions, where the argillic horizon develops a rhodochromic hue. Thus, dominant original profile soil typological units are the Haploxeralf and the Rhodoxeralf. A special case is the upper Pleistocene terraces where the

soil profiles develop profiles with ultic morphology and base saturation.

In the weak meso-Mediterranean zone prevail the oak forests and both the xeric and the udic soil moisture regimes The kind of these regimes depends on the topography, the elevation, and the aspect of the particular soil landscape. Xeric regimes dominate on lower elevations and southern aspects, where udic is more common on the higher elevation northern slopes. The argillic horizons are well developed and characterize Haploxeralf profiles with the exception of those on limestone which classify the respective profiles as Rhodoxeralfs.

The terrain in both of the bioclimatic subzones, especially in the weak, is sloping, subjecting the soils to significant erosion risk upon removal of the protecting vegetative cover. Large sections of these zones have soil profiles, which have lost parts or all of their genetic horizons. Thus, many of the soils of this zone have been degraded to erosional descendants of the original Alfisols and are classified as Orthents (Regosols) or Orthepts.

The sub-Mediterranean zone includes the mountainous lands at elevations higher than the previous zone. It is a transitional zone between the Mediterranean and the Central European. Dominant species are the broad-leaved oaks, the Cephalonian fir, black pine, and beech. The soil moisture regime is udic, the dominant soil horizon is the argillic, and the typological unit is the Udalf. In the higher elevation sections of the zone, excessive leaching of soil bases and acidification of the profiles, on non-limestone parent materials, block clay illuviation. The dominant genetic diagnostic horizon in these areas is the cambic, and the respective typological unit is the Dystrochrept.

The axeric zone occupies the summits of the high mountains of northern Greece. The climatic conditions are more like Central European than Mediterranean. It is dominated by fir trees, Scotch pine, beech, and spruce. The dominant genetic soil the cambic is the dominant soil horizon and the Dystrochrept the respective typological unit On limestone, however, the argillic diagnostic horizon and the Udalf typological unit develop under forest vegetation, whereas the Argiudoll unit predominates in meadows. On the southern limestone slopes, the argillic horizon has a rhodic color.

The subaxeric bioclimatic zone extends in the summits of the high mountains of the central and southern mainland and Crete. The fir and pine species are a little more xerophytic to adjust a drier month during the summer. The soil profiles are similar to these of the previous zone. However, in the southern mainland and Crete, their argillic horizons and Udalfs are also present.

Soil organic matter content in the mountainous regions increases by a factor of 2 with a decrease of 100 °C in the mean annual temperature along with increasing elevation (Nakos 1984). The same author has found that exchangeable Ca and Mg show a decreasing trend from the Mediterranean to the sub-Mediterranean bioclimatic zone, whereas the total N and extractable P, K, Fe, Mn, and Zn increase.

2.2 Parent Material

The parent materials of the soils of Greece have a profound influence on their morphological, chemical, physical, and mineralogical properties. The age of the profile and the climatic conditions have not been able to wipe out this influence. The soil profile properties, which are strongly dependent on the parent materials, are as follows: the genetic diagnostic horizon, the textural and structural configuration, the pH, the mineralogy, the color, and micromorphology. This is the reason that the distinction of soils of Greece based on soil parent material was preferred to any other way (Fig. 2.1).

Greece belongs to the active Alpine orogenic territory (251 million years ago till today), which is the cause of its complex geological landscape. Its geological formations can be grouped into three major categories (Moudrakis 1985):

(i) Pre-alpine formations. They include the bulk of the metamorphic rocks: gneisses, mica and chlorite schists, marbles, and metamorphosed basic and ultrabasic rocks. Granitic and volcanic intrusions occur in faults formed during the alpine orogenesis.
(ii) Alpine formations. They include limestone of various ages, flysch, and chert. Flysch is extensive in western Greece.
(iii) Post- alpine formations. They are mainly sedimentary formations, which consist of river and coastal conglomerates, alluvial deposits sand stones siltstones, marls of lacustrine or marine origin. These formations are younger than those of the Miocene age, mostly unconsolidated and of low degree of diagenesis. They usually are parent materials of relatively high-quality soils.

The main parent rock formations are (Fig. 2.2):
Acid igneous rocks: Granites, Granodiorites (Pareo-Mesozoic and Tertiary, before 245 million years ago, 245–65 million years ago, and 65 million years ago to date).
Basic and ultrabasic igneous rocks: Gabbros, Diabase, Peridotites, Serpentines, Pyroxenites, Ophiolites.

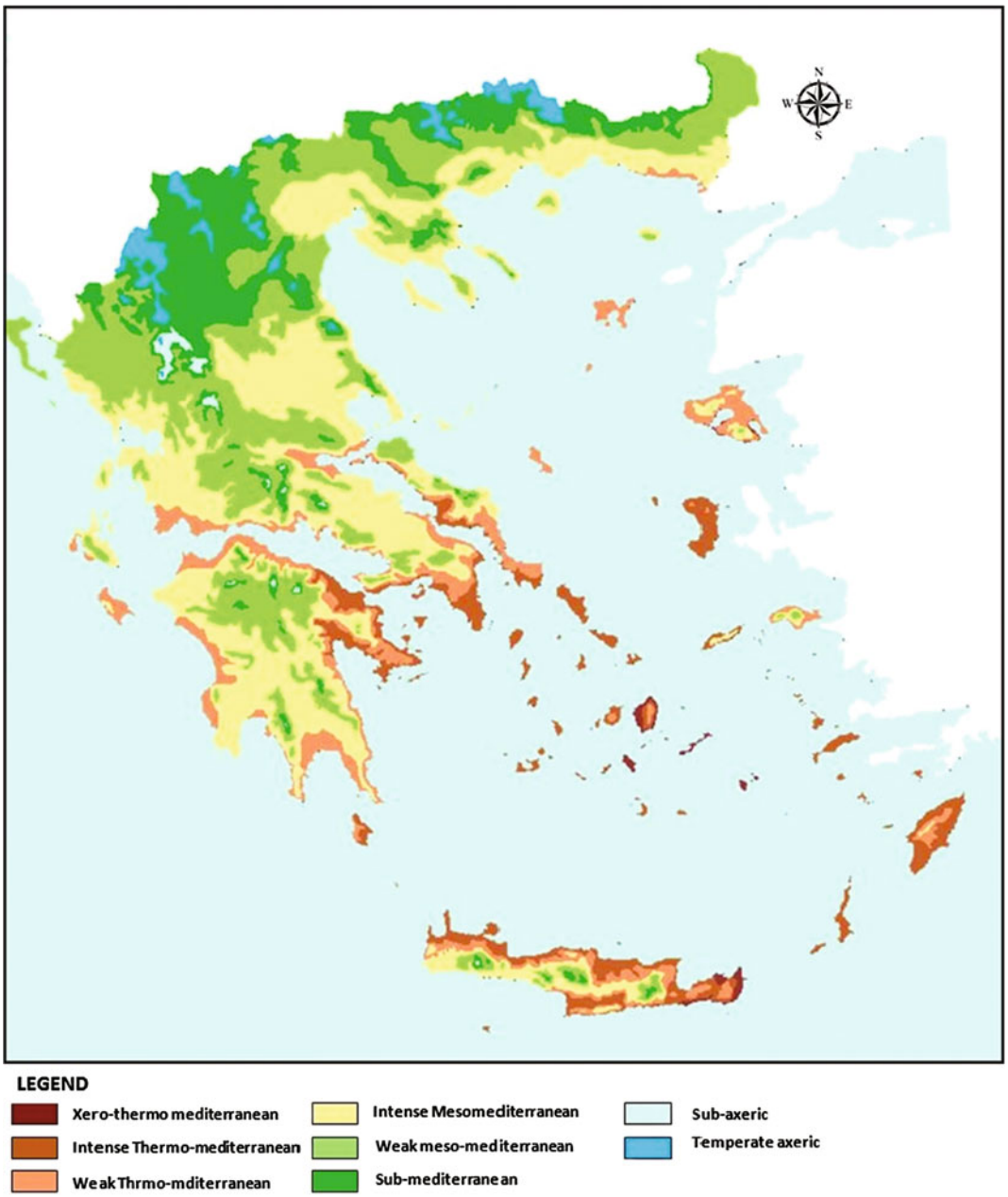


Fig. 2.1 Bioclimatic map of Greece (Mavromatis 1980)

Metamorphic rocks: Gneiss, Mica, Chlorite and Quartz Schists often with layers of Marble, Phyllites (Paleozoic and Triassic, 600 and 208–146 million years ago, respectively).
Flysch: Interbedded sandstones and shales (Jurassic and Cretaceous, 208–146 and 146–65 million years ago, respectively).
Volcanic rocks: Rhyolite, Dakite, Andesite, Basalt
Sedimentary Rocks:

- Limestones [Mesozoic (252–66 million years ago), Triassic (251–200 million years ago), Jurassic (200–145 million years ago), Cretaceous (145–66 million years ago).
- Marine and Lacustrine deposits, Marls, Sandstones, Conglomerates, Clays (Oligocene, 38–28 million years ago).
- Marine and Continental Formations (Undivided Quaternary, 1.8 million years ago).
- Marine and Continental deposits, Clays, Loams, Sands, Conglomerates a clayey materials (Pleistocene, 5–1.8 million years ago).



Fig. 2.2 The main parent rock formations in Greece

Alluviums (Holocene, 11,000 years ago**)**

- Recent Plains
- Older Plains (more than 2000 years old).

2.2.1 Parent Material Affected Soil Properties

Soil properties and morphologies described below refer to undisturbed by human actions or other natural condition profiles. The effects of human action have caused significant deviations in the properties and morphologies of many soils. These deviations will be discussed in the section of the anthropic role on soil genesis.

Soils on acid igneous rocks are usually coarse-textured (loamy sands and sandy loams) and relatively shallow. Their reaction is acid. Their pH on high elevations, where the annual rainfall exceeds 1000 mm, may drop as low as 3.8. Consequently, the base saturation corresponds in most cases to the dystric character of the profile and occasionally to the ultic. At lower elevations, they develop weakly formed argillic horizons.

Acid metamorphic rocks produce soils with a little finer textured (sandy loams and loams) and deeper soils than the acid igneous rocks. Acidity follows the same patterns, except

in the case the rocks are interbedded with marble. In the last case, the soil profiles have finer textures, an eutric acidity regime and redder color hues, indicating the formation of hematite.

On basic igneous rocks soils have eutric acidity regime with high base saturation and a mostly neutral pH and fine textures (clay loams to clay). Their profiles form a well-developed chromic argillic horizon, which has frequently vertic characteristics.

Flysch is quite extensive in the mountainous and hilly terrains of Greece. It consists of sandstone, shale, and interbedded layers of both. Genetically related to the soil are the uppermost layers. Sandy layers produce usually sandy loam, loam, and sandy clay loam textures, whereas shale produces finer textures. In cases where the thickness of the layers is smaller than that of the profile, texturally stratified soils are formed. Acidity varies according to the composition of the parent material. In most cases, the pH ranges between 5 and 6 (Nakos 1984). However, in the meso-Mediterranean and axeric zone soils may become strongly acid. Clay illuviation is common in soils with moderate acidity, whereas in the strongly acid soils, no clay illuviation is observed and dystric and ultic cambic horizon is usually formed (Yassoglou 1969, 1973).

Limestone formations have a profound effect not only on the genetic course and properties of the soils but also on the distribution of the vegetation zones disrupting the regular succession with the elevation from the more xerophytic to the less xerophytic. The general characteristics of the residual soils on limestone are as follows:

- A well-structured surface mineral horizon, rich in well-decomposed mull-type organic matter and high biological activity.
- A well-developed argillic horizon, with a clay loam to clay texture and reddish (rhodochromic to chromic) color hues, is formed. In the axeric zone, it may have a brownish hue.
- Soil depth is generally shallow due to the fact that the amounts of soil materials remaining in situ after the dissolution of the carbonates are small.

Marine and lacustrine deposits are calcareous or siliceous. Calcareous sandstones, clays, and conglomerates form soils with pH usually ranging between 7.0 and 8.0. Their textures vary according to the composition of the parent material. Carbonate leaching and formation of calcic and petrocalcic horizons form in their profiles, along with calcaric and eutric cambic horizons. Argillic horizon may form on parent materials not very rich in carbonates such as conglomerates.

Soils developed on marine and lacustrine deposits are usually deep varying in textures according to that of the parent material. In most cases, they range from clay loams to silty clays and clays. They are considered among the productive soils of the country.

Marls, as parent materials, exert a profound influence on the soils, because of the high number of carbonates they contain. Under the Mediterranean climatic conditions, they are difficult to be leached out of the profile. Soils usually maintain residual quantities of carbonates and base over saturation. These conditions prevent clay illuviation and favor strong structural aggregation and formation of mollic epipedons and cambic and calcic horizons.

Sands and conglomerates also contain carbonates in several cases but not so abundant as to prevent clay illuviation.

Pleistocene terraces form chrono-toposequences at elevations usually ranging from 50 to 300 m from the sea level in coastal lands or from the flood plain of the inland areas.

The degree of development increases from the lower terrace to the uppermost in the topo-chronosequence. Their characteristic is the absence of carbonates from the profile, argillic horizon, the increasing acidity, and decreasing base saturation from the lower to the upper terrace. The upper member of the topo-chronosequence develops ultic and paleosolic characteristics. Soils on level terrain in the subhumid areas of the country acquire hydromorphic characteristics and contain abundant Fe–Mn concretion character (Antonakopoulos 1978; Antonakopoulos and Yassoglou 1986). Soils in the drier areas of eastern Greece lack hydromorphic properties. Bisequal profiles have been developed in some of the upper members of the topo-chronosequence.

Soils on Holocene alluviums are the most productive of the country. They can be divided into two groups: (a) those of age older than 2000 years and (b) the recent alluvium of younger than 2000 years.

The first group is geomorphologically located on the Upper Holocene terraces, usually at elevations greater than 20–30 m from the sea level in coastal areas or from inland present flood plains. Soils on these terrains have in many cases formed argillic horizons at variable stage of development. Studies on archaeological sites by Yassoglou and Nobeli (1972) and Haidouti and Yassoglou (1982) have shown that the formation of these horizons in meso-Mediterranean bioclimatic zone takes 2000–3000 years. They could be considered as the youngest argillic horizons found in soils of Greece. The profiles taxonomically belong to the Typic Haploxeralfs (Soil Survey Staff 1975, 1992) or Typic Luvisols (FAO 1998).

The second group consists of recent alluvial deposits at elevations usually less than 20 m from the sea level or inland flood plains. The soils show no or minimum genetic profile differentiation other than the formation of an A1 surface horizon and weak color or texture-differentiated cambic horizons. Weak calcic horizons occasionally form in the imperfectly or poorly drained lower members of the catena.

The soils are in most cases calcareous throughout the profile, stratified and their composition reflects that of the sources of the alluvial sediments. Their textures vary vertically and spatially, according to successively deposited alluvial layers. In many cases, textural and hydromorphic differentiation is observed in relation to the geomorphologic location in the alluvial plain. Soil textures coarser along and close to the river levees, becoming gradually finer away from them. They are also finer and more hydromorphic in the depressions of the flood plain.

An investigation contacted by Kollias et al. (1999) in a holocene alluvial plain of western Peloponnese showed a considerable spatial variation of textural and drainage configuration of the profiles of respective mapping units. The purity of five such units was evaluated using kriging, inverse-squared distance (ISD) interpolation, and conventionally. Soil parameters examined were soil clay content at three depths and the level of the profile drainage Respective fuzzy maps were prepared. The results showed that the overall purity of the five mapping units estimated by kriging, ISD, and conventionally 62.8, 55.7, and 60%, respectively.

Sediments on quaternary terraces and alluvial plains, derived from the erosion of residual soils formed on basic and ultrabasic rocks, develop, on well-drained sites, Vertisols or vertic soil subgroups. These soils usually have fine textures with predominantly expanding clay minerals.

Volcanic rocks are widespread in the Aegean islands and in rather small patches along the northern borders of Greece. Studies conducted by Moustakas and Georgoulias (2005) in the Aegean islands have shown the absence of andic and vitric properties in the soil materials, which are dominated by crystalline aluminosilicates. The only amorphous materials found were the non-crystalline silica. Therefore, the soils even though they have been formed on acid volcanic parent materials (Rhyolites, Dacites, Andesites) cannot be classified as Andisols. They are coarse-textured xeric Entisols and Inceptisols.

In northern Greece, the volcanic rocks are acid Eocene and OligoceneTrahytes and Tuffites which produce fine-textured soils characterized as Vertisols or as Vertic subgroups. Their moisture regimes are udic on high elevations and xeric on low.

2.3 Relief

Relief is also expressed as physiography and topography. A great part of the country consists of rugged mountainous and hilly terrains. Elevation rises within a few kilometers to dozens of kilometers from the sea level to several hundred meters high. Slope gradients, in about 55% of the country, are high enough to cause extensive erosion and significant retrogressive evolution of soil profiles on these lands when they are not adequately protected by vegetation (Table 2.1).

Besides the slope gradient, aspect plays an important role in the erosion risk the moisture regime, the organic matter content and the resilience of the disturbed soils and vegetation, by modifying the local microclimate. Thus, northern, northeastern, and northwestern slopes have a significant wetter microclimate as compared to the southern, southwestern, and southeastern slopes. The erosion risk on the former aspects is significantly smaller on the former than on the latter. Consequently, the depth, the moisture regime, the productivity, and the rate of pedogenetic processes are generally greater on the northern and northeastern slopes and to a lesser degree on the northwestern slopes, as compared to south-oriented slopes.

Topography plays an important role in the hydromorphic characteristics of the soils. Its effect is most pronounced in the more humid western section than in the drier eastern section of the country. Fine-textured soils in the lower parts of the flood plains in the west of the country are usually imperfectly and poorly drained. In most cases, however, the shallow water table is present only during the wet season of the year. In the drier eastern part of the country, poorly drained soils occur only in locations of the alluvial plains where there are permanent shallow water tables supplied by the underground water. Fine-textured soils in these sections of the country are well drained unless when they are supplied by shallow permanent underground water table.

Soil textures in alluvial plains show a significant stratification and usually become finer with distance from the present or past river banks.

Table 2.1 Physiographic distribution of the Greek land (Center of Programming and Economical Studies 1976)

Physiography	Elevation (m)	Area (km^2)	%
Mountainous	>700	56,192	42.6
Semi-mountainous	100–700	35,814	27.1
Level	0–100	39,983	30.3
Total		131,990	100

Slope classes shown in the above map are as follows:

Class	Description	Gradient (%)	Area covered (%)
1	Level	<6	45
2	Slightly sloping	6–18	11.1
3	Steep	18–35	17.8
4	Very steep	>35	26.3
	Other		0.7

2.4 The Biotic Factor

The biotic soil-forming factor can be distinguished into (a) the natural biosystems and (b) anthropogenic influences.

(a) The Natural Systems

The most influential biotic factor is the natural vegetation which along with the soil organisms affects the course and the rate of soil genesis processes. Of course, the vegetation is not entirely independent of the climate and the geology. Thus, its role could be evaluated in situations where the other soil-forming factors are constant. That is in sets of biosequence. Natural vegetation systems are not constant but vary within the time frames of soil genetic changes. Therefore, the present biotic system should be regarded as the present member of a biotic continuum (Fig. 2.3).

The effects of vegetation on soil genesis and properties were discussed above in combination with those of climate. Here is given additional information on the natural vegetation distribution of natural vegetation within the bioclimatic zones of Greece and on its role as soil genesis factor.

Dominant species of forest trees and shrubs with significant effects on soils are distributed as follows (Nakos (1984) and Mavromatis (1980)):

Thermo-Mediterranean Zone:
Pinus halepensis, *Quercus coccifera*, *Pistacia* sp., and *Erica* sp.

Meso- and Sub-Mediterranean Zone:
Quercus conferta, *Quercus pubescens*, *Quercus Cerris*, and *Abies cephalonica*.

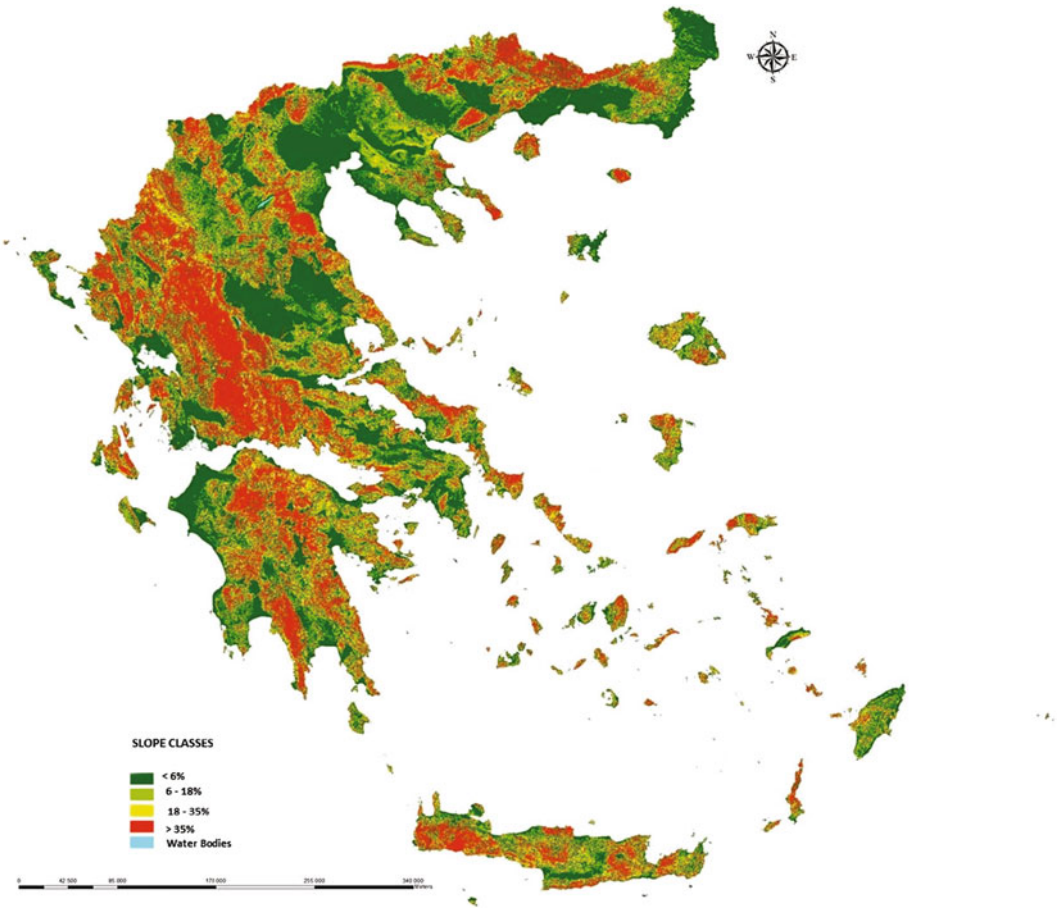


Fig. 2.3 Slope map of Greece (Karamesouti 2011 and Kosmas personal data)

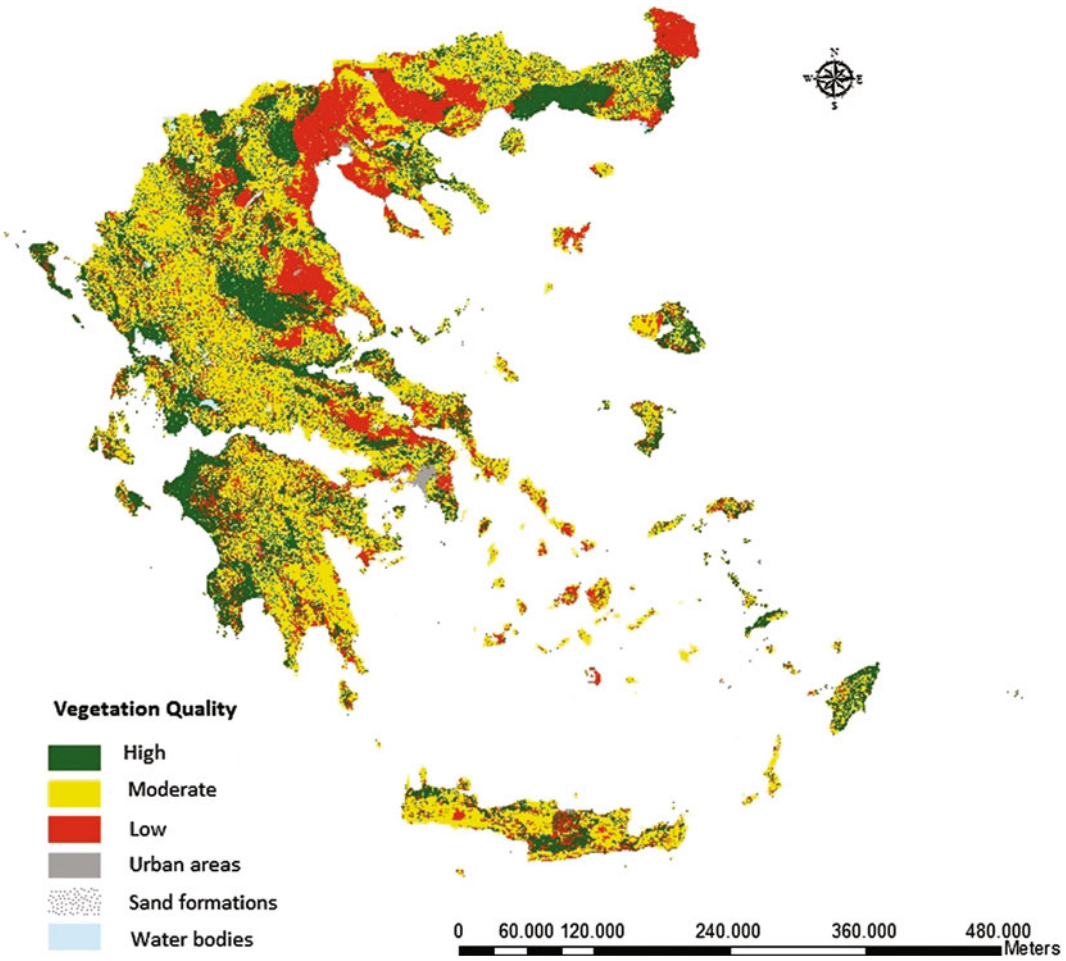


Fig. 2.4 Map of vegetation quality (Kosmas unpublished data; Karamesouti 2011)

Subaxeric and Pseudo-Alpine Zone:
Fagus sp., *Pinus nigra*, *Pinus silvestris*, *Picea excelsa*, and various shrubs and grasses.

The magnitude of the impact of the natural vegetation on soil genesis processes and soil properties depends on the quantity, the composition, and the turnover of its biomass of each particular biosystem.

Kosmas (unpublished data) and Karamesouti (2011) have qualitatively evaluated the role of the vegetation on the Greek terrestrial ecosystems on the basis of its density, resilience, and the degree of protection it offers to the soil against erosion. They have determined vegetation quality, using qualitative indices, and prepared a respective map shown in Fig. 2.4.

The relative areas that the vegetation quality classes in Greece are:

High	Moderate	Low	Other land uses
29.4%	46%	21%	3.6%

The above map and estimates of vegetation quality reflect the present situation. However, the intensity and the effects of human activities on the vegetation and the soil properties varied significantly during the not so remote past.

(b) The Anthropic Factor

Man has effected soil development and properties since about 11,000–13,000 years ago (Arnon 1972). By lumbering, clear-cutting, grazing, and cultivating, land has altered significantly the natural biotic–soil ecosystem. The main effects on soils of Greece were the reduction of organic matter. The deterioration of structure, the decline in surface water infiltration, the truncation of soil profiles through accelerated erosion in sloping terrains, the deposition of fertile sediments in the bottomlands and changes in the chemical and physical properties through cultivation, fertilization, and irrigation. Greeks had employed wise land use systems since at least the Bronze Age. They avoided cultivating marginal sloping land even if it were near their settlements (Yassoglou and Nobeli 1972). Things turned for the

worst during the Roman domination. Population and cities grew demanding more food and other supplies. Irrigation and drainage expanded along with river damming. Marginal land brought into cultivation. Inexperienced peasants and slaves caused extensive degradation (Rubio 2007).

Cultivation of undulating hilly lands on tertiary calcareous materials resulted through erosion in the removal or the mollic epipedon and the retrogression of the original soil profiles from Mollisol to Ochrept or event to Orthent.

During the long period of Turkish occupation of Greece, the local Greek population was forced, in many occasions escaping suppression, to move to remote mountainous territories, where unsustainable agriculture, grazing, and forest cutting were practiced in marginal lands.

Over exploitation of forest lands, overgrazing, and unsustainable cultivation of slopping mountainous lands and hill lands on hard rocks resulted in extensive truncation of the original natural soil profile by water erosion. Diagnostic genetic horizons have been removed, and as mentioned in pervious sections, soils retrogressed in large areas from the climax Alfisols Inceptisols and Ultisols to moderately deep and shallow Orthents (Lithic in many cases) and rock outcrops. Undisturbed climax soil profiles are found today only in areas protected by undisturbed natural vegetation.

It should be mentioned, however, that the ruling Turks had in many occasions practiced soil conservation in the more productive lands they held. Agricultural practices have improved the productivity of bottomland soils through cultivation, fertilization drainage and irrigation. In some occasions, however, certain properties such as surface structure, hydromorphic status, salinity, and acidity have been adversely affected through improper practices.

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