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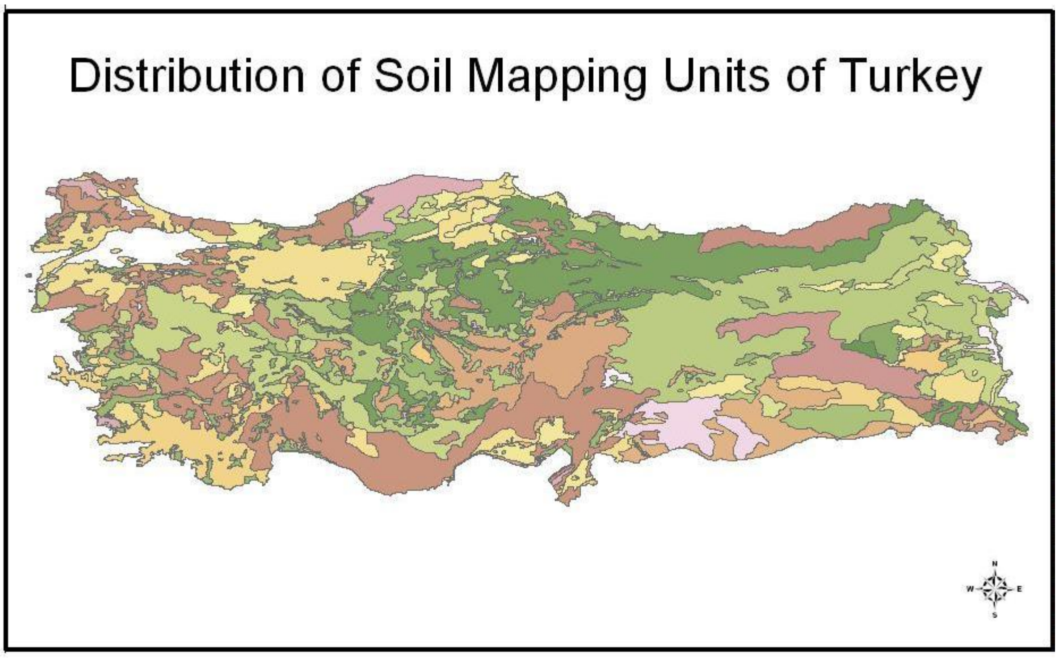
Integration of the Soil Database of Turkey into European Soil Database 1:1.000.000

Research Report

Ece Aksoy, Panos Panagos, Luca Montanarella, Arwyn Jones



Distribution of Soil Mapping Units of Turkey

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European Commission
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Contact information
Address: Joint Research Centre, TP 280, Via E. Fermi 2749, 21027 Ispra (VA) Italy
E-mail: panos.panagos@jrc.ec.europa.eu
Tel.: +39-0332-785574
Fax: +39-0332-786394

http://ies.jrc.ec.europa.eu/
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1. INTRODUCTION

The first soil map of Europe was published at 1970 (Dudal et al., 1970). In 1985, the Commission of the European Communities (EC) published the soil map of the EC at 1:1,000,000 scales (CEC, 1985). In 1986, this map was digitised (Platou, Nørr and Madsen, 1989) in order to build a soil database and furthermore to be included in the CORINE project (Co-ordination of Information on the Environment). This database was called the Soil Geographical Database of the European Community (SGDB), version 1.0.

In response to the needs of the MARS Project – Monitoring Agriculture by Remote Sensing (Vossen and Meyer-Roux,1995) – of DG VI (Directorate General for Agriculture), the database was enriched in the period 1990-1991 from the archive documents of the original EC Soil Map and as a result the version 2 has been published. The MARS project formed the Soil and GIS Support Group of experts in order to give advice on the use of the Soil Database and to continue the further improvement. The Group recommended that new information should be provided by each of the contributors. As a result of this recommendation, the version 3 of the database was developed, covering the EU–15 and Candidate Countries. (Lambert et. al., 2002). The summary of the geographical soil database history can be seen in Figure 1.

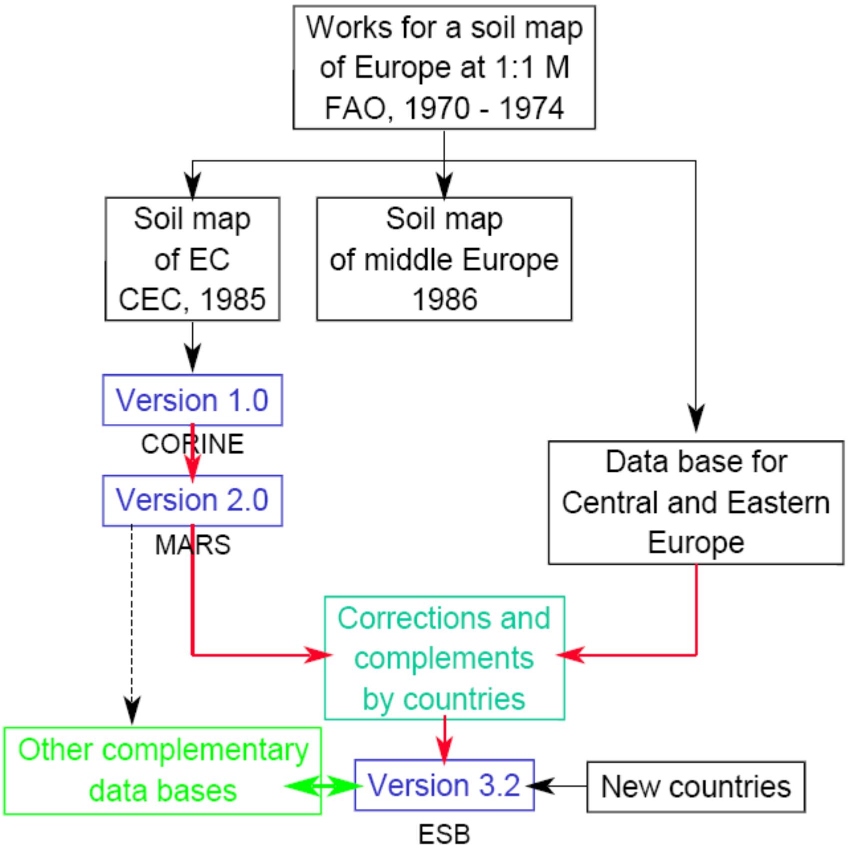


Figure 1. Diagram showing the geographical soil database history (Jamagne et al., 2001)

In later phase, the Soil Geographical Database (SGBD) Version 4.0 was compiled at the scope of MARS Project in the structure of the European Community Soil Data and Information Systems and Soil and GIS EC Support Group of experts.

Developing the Version 4 of the Soil Geographical Database at scale 1:1,000,000 aimed to provide a harmonised set of soil parameters covering Eurasia and Mediterranean countries. This Database can be used as input in agro-meteorological and environmental modelling at regional, national, and continental levels.

In order to differentiate this new version from previous ones, the title has been changed to ***"Soil Geographical Database for Eurasia and The Mediterranean: Instructions Guide*** **for elaboration** ***at scale 1:1,000,000".*** Therefore the current guide is the foundation for Version 4.0 of the Soil Geographical Database of Europe and will form the main component of Version 2.0 of the European Soil Database (Lambert et al., 2002). Besides changing title, the database has also experienced important changes during its lifetime.

The latest version includes improvements over the previous versions and contains several new components that affect both the form and content of the geographical database. Regarding the *form,* the variables are listed in their order of appearance in the Soil Typological Units table. Each attribute is given a code, its meaning and its possible values are described in a small paragraph and a table. Regarding the changes on the *contents,* they mainly focus in the use of a new "International Soil Classification" – The World Reference Base for Soil Resources (WRB) – since this is proposed as a standard classification. The FAO-UNESCO revised soil legend (has previously used) will be kept as an attribute to maintain compatibility with some of the past thematic applications that are based on it. A more detailed and completely revised Parent Material list, already in use in the 1:250,000 Manual of procedures has been introduced. This list comprises 4 levels: Major Class, Group, Type and Subtype. There are important differences between the current used list and the former list of parent materials, with many necessary adjustments since a simple translation table was not sufficient. Modifications to the *Profile Database* have also been introduced. Instructions to fill up the Profile attribute tables are now integrated in the Guide. The changes made to the Soil Typological Units attribute table, such as those concerning the soil classification and the parent material, have correspondingly been made for the profile attribute tables. (Lambert et. al., 2002)

In this context, Version 4 of the Soil Geographical Database at scale 1:1,000,000 currently covers Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, FYROM (Former Yugoslav Republic of Macedonia), Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and Yugoslavia The extension to Eurasia covers the New Independent States (NIS) of Belarus, Moldova, Russia and Ukraine (Stolbovoi et al., 2001). The further expansion to the Mediterranean Basin will eventually include Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Libya, Malta, Morocco, Palestine, Syria, Tunisia and Turkey (Lambert et.al., 2002). The Figure 2 illustrates the state of the progress of the Soil Geographical Database in Eurasia and Mediterranean Countries.

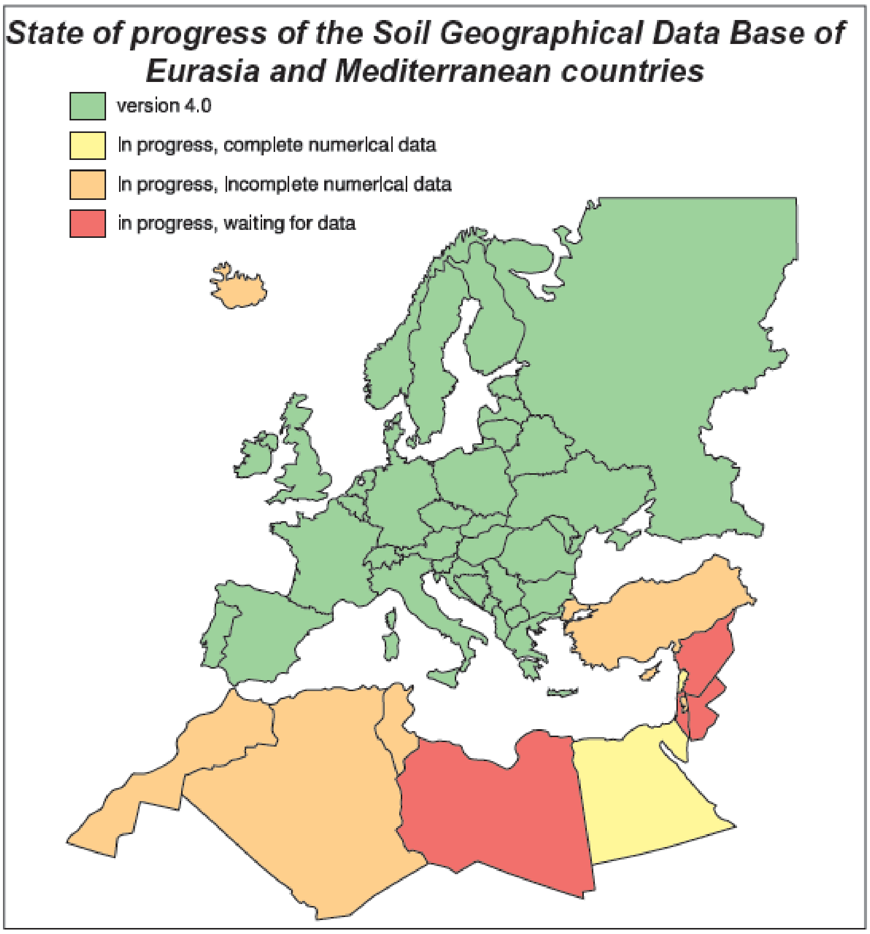
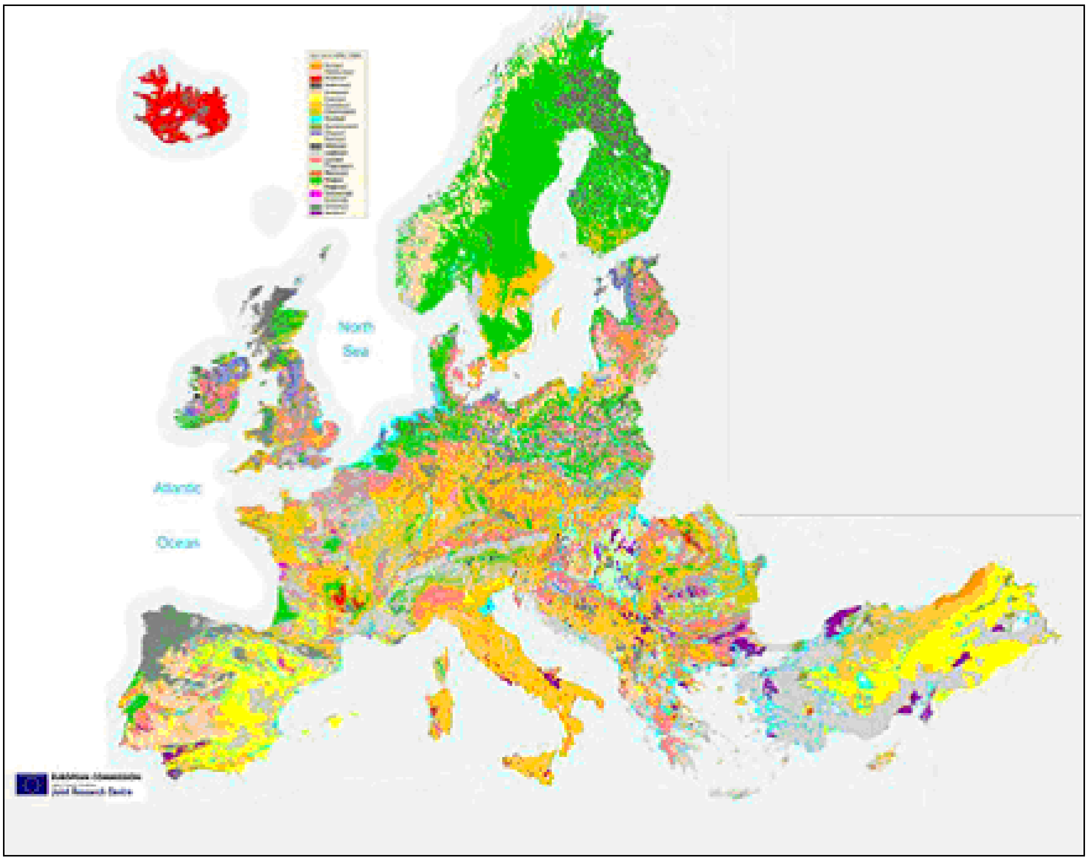


Figure 2. State of progress of the Soil Geographical Database of Eurasia and Mediterranean Countries (Jamagne et. al., 2002)

In 2001, in order to extend the European soil database to the countries of Mediterranean Basin, the preparation of soil geographical database of Turkey at 1:1 million scales had started with the collaboration of formerly “General Directorate of Rural Services National Information Center for Soil and Water Resources of Turkey” and “Cukurova University soil experts”. However, the output soil geographical database neither could be used nor could be published officially since the “General Directorate of Rural Services National Information Center for Soil and Water Resources of Turkey” had been closed its operations.

With the current study, we will describe the methodology of preparing the “soil geographical database of Turkey” according to the European database standards. The integration of the “soil geographical database of Turkey” into the version 4 of the European soil database will be achieved after building up a common understanding and nomenclature of soils in Europe and Mediterranean region.

Map 1: The Soils of Europe According to WRB Major Reference Group (Jones et.al.,2005)



2. INVENTORY OF SOIL DATA RESOURCES IN TURKEY

2.1. Land Resources of Turkey

Turkey is a mountainous and hilly country, average altitude is 1132 m, surrounded by the seas from the north (Black Sea), south (Mediterranean Sea) and the west (Aegean Sea). It is a peninsula which accounts for the great differences in climate, soil and the other ecological properties. Climate, topographical, vegetational and geological diversities of Turkey affect soil forming and also soil diversity.

Although Turkey is in the subtropical belt having a semi-arid climate with extremes in temperatures, the diverse nature of the landscape and particularly the existence of mountains results in great differences in climatic conditions from region to region. (Özden et al., 1998). Actually there are two main climatic types in Turkey (Temperate and Mediterranean); there are also 10 subdivisions of these two main climatic types due to effect of topography on climate. (Figure 3)

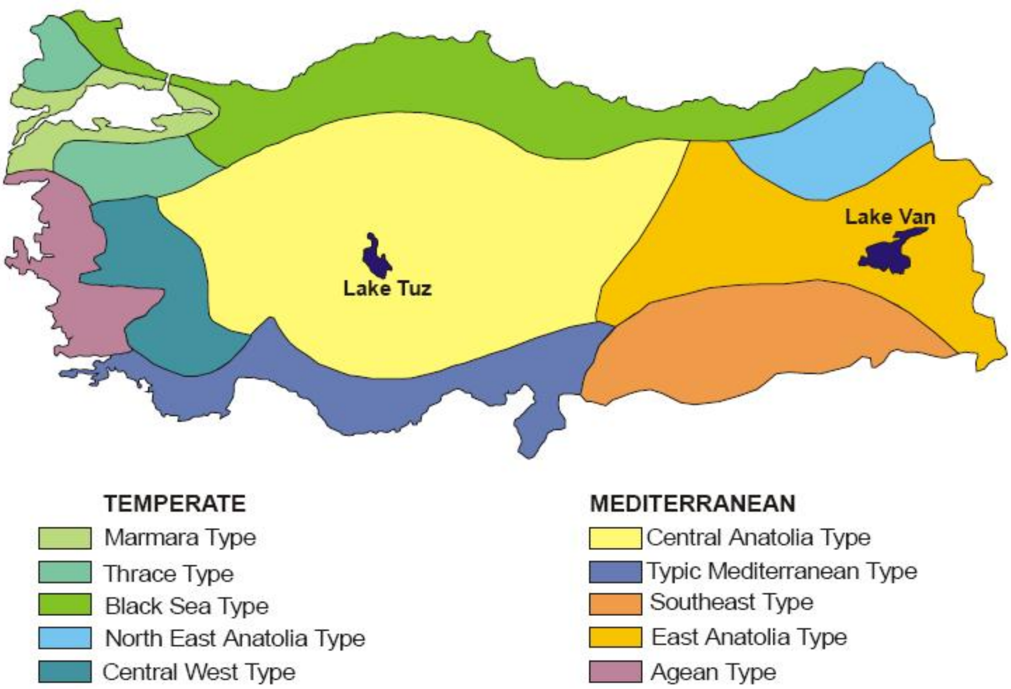


Figure 3. Climatic Regions of Turkey (Kapur et al.)

Major causes of topographic diversity is due to the tectonic movements of the recent geologic periods (Figure 5) and the accumulation of volcanic products, which have created an elevated mass with an average altitude of 1132m. Thus, plains of 0 to 250m altitude cover only one tenth of the country, whereas places higher than 800m cover two thirds and half of the country is higher than 1000m (Özden et al, 2001) (Figure 4). Most mountain ranges extend from west to east and great ranges appear in forms of arches. The Taurus Mountains in the south can be considered a good example of this type. The highlands and basins among the mountains have formed similar geomorphologic features.

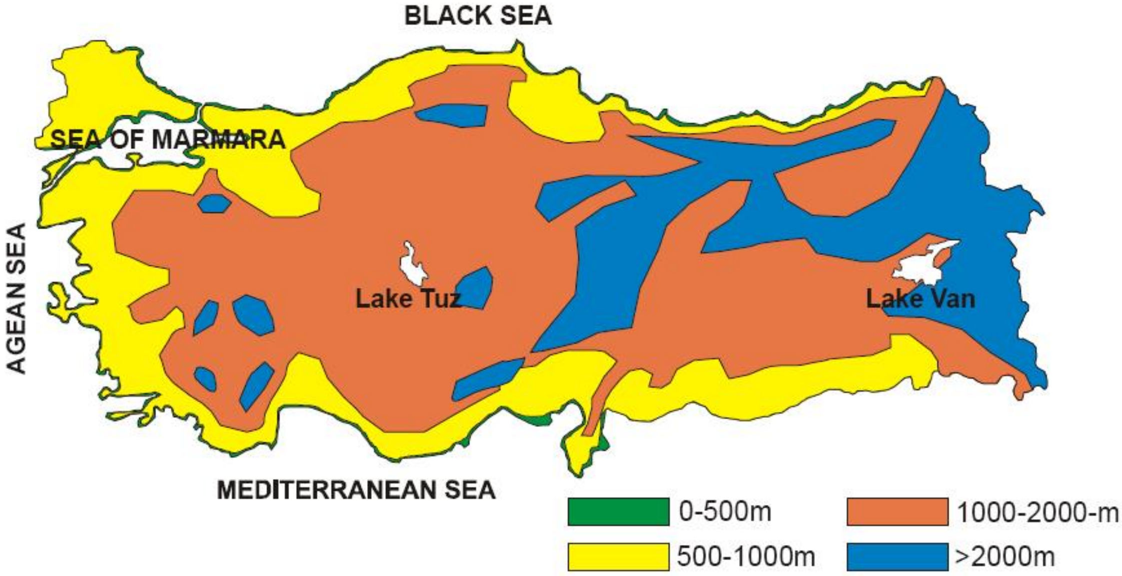


Figure 4. Average Elevation of Turkey (Kapur et al.)

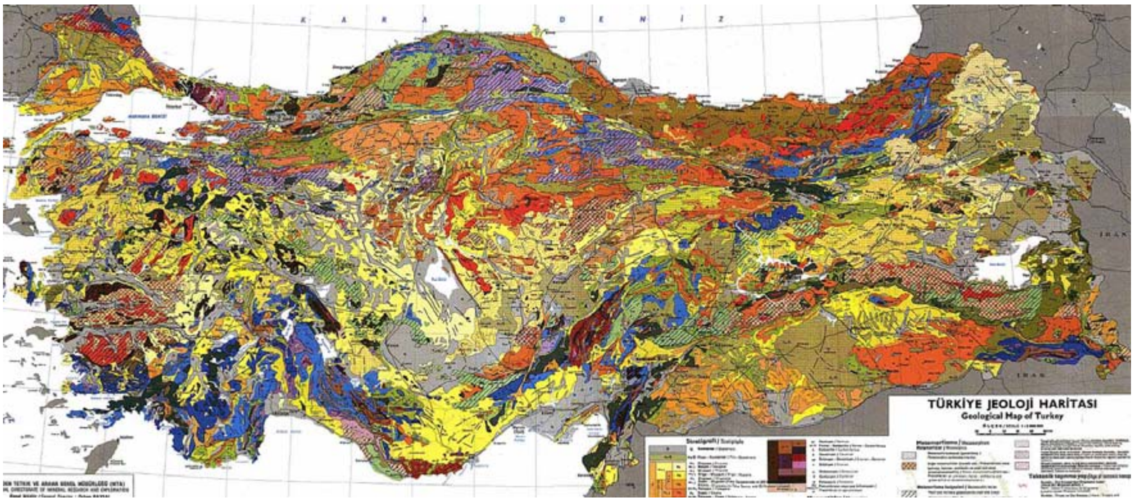


Figure 5. Geological Map of Turkey (General Directorate of Mineral Research& Exploration of Turkey, 2009)

Turkey covers totally 77.797.127 ha area. 35.6% of the total area is arable land, 26% of the total area is forest and 27.3% of the total area is pasture and grassland. A more detailed description of landuse may be found in Table 1:

Table 1. Landuse of Turkey (Kumbur et al., 1998)

Land Use	Area (Million ha)	Percentage (%)
A-ARABLE LAND	27.7	**35.6**
I. Plantation Field	22.7	82.0
1. Fallow Land	5.8	25.6
2. Every Year Crop Land	16.9	74.4

a. Cereals	12.9	76.3
b. Industrial plants	2.2	13.0
c. Edible leguminosae	1.6	9.5
d. Draw plants	0.3	1.2
II. Vineyards and Orchards Fİeld	4.0	18.0
1. Vegetable Land	1.2	30.0
2. Fruit Land	1.0	25.0
3. Vineyards	0.8	20.0
4. Olive grove	1.0	25.0
B-PASTURE and GRASSLAND	21.2	**27.3**
I. Pastures	0.7	3.3
II. Grasslands	20.5	96.7
C- FOREST LAND	20.2	**26.0**
I. Fertile Forest Lands	14.0	69.3
II. Bad Forest Lands	6.2	30.7
D-SETTLEMENT AREAS and DESERTED LANDS	8.6	**11.1**
I.Settlement Areas	0.7	8.1
II. Unused Lands	7.9	91.9
TOTAL	77.7	**100.0**

According to the Agriculture census made in 2001 by Turkish Statistic Institute (TurkStat), 4.131.099 decare (equals to 1/10 of hectare) of agricultural land have been changed land use type between the years of 1991 and 2001 (Table 2). Agricultural land use had been changed mostly to construction land and tourism land, unused potentially productive land and forest and woodland in Turkey.

Table 2. Changes in the Land Use Over the last ten years 1991-2001 (TurkStat, Agriculture Census, 2001)

	Agricultural land	Forest and woodland	Construction land and tourism land	Open wet lands (swamp)	Unused and undeveloped potentially productive land	Area covered with water	Non agricultural stony land	Non agricultural arid land	Total area transferred to other type of use
Land Use	Area gained from other type of use (Decare)								
	944 751	**1 289 298**	**1 549 049**	**44 322**	**1 289 564**	**726 501**	**254 217**	**147 072**	**6 244 774**
Agricultural land	-	686 448	1 243 592	26 441	1 212 271	643 494	193 894	124 959	**4 131 099**
Woodland and forest land	278 024	-	71 492	651	34 630	15 135	36 272	10 500	**446 704**
Construction and tourism land	34 684	12 382	-	220	9 024	2 095	5 590	813	**64 808**
Open wet lands (swamp)	49 377	2 050	4 151	-	12 580	15 700	-	-	**83 858**
Unused and uncultivated potentially productive land	247 375	221 451	132 426	100	-	13 267	12 560	3 940	**631 119**
Land covered with water	45 159	6 720	795	6 140	4 875	-	391	3 350	**67 430**
Non agricultural stony land	161 998	313 233	80 510	10 630	2 200	16 340	-	3 510	**588 421**
Non agricultural arid land	128 134	47 014	16 083	140	13 984	20 470	5 510	-	**231 335**

Even though, there are a lot of studies and articles about land cover, land use and distribution of land capability classes, there is still no common territorial land use map of Turkey. There is a need for implementing detailed and up-to-date studies of land use& land classification. This is really a major bottleneck for academic and other regional studies related to environmental field in Turkey. For this purpose, there is an urgent need for publishing official and territorial land cover and classification maps of Turkey for data harmonisation and common usage by corresponding ministries and research institutes.

2.2. Background of Soil Classification and Soil Mapping in Turkey

The terms such as soil classification and soil mapping are rather new to Turkey like many other countries in the world. In **1950**, modern soil science was established in Turkey by Prof. Dr. Kerim Ömer Çağlar. In the same year, he began distributing 'Soil Science' publications and he prepared 'Turkey's Soil Classification' schematic map which is based on American Zonal-Azonal soil classification. He took the soil colour as the main factor, mapping Turkey's soils into eleven different classes. The work contained a schematic soil colour map showing 11 soil classes, which included among others, the dry and Chestnut Dark Yellowish Soils, the Mediterranean – Aegean and South East Anatolian zone of Red Soils, the North Eastern Anatolia and Eastern Black Sea Region with Black Soils (Çağlar, 1958).

In Turkey, the real understanding of soil survey and mapping began in **1952** with the help of FAO. The Turkish team, led by the American soil consultant Harvey Oakes, undertook the first reconnaissance survey. As a result, a map of Turkey at a scale of 1:800,000 called 'Turkey General Soil Map' was prepared. The report and map of Turkey's soils were completed between **1952** and **1954**, with geological and topographical maps being used to develop an exploration level study of all the regions. Results were obtained by taking soil samples, analysing them and labelling the different soil types. The land study was finished in very short time and map units were identified according to the great groups of 1938 American Soil Classification System. Oakes used slope, stoniness, drainage and saltiness phases also. Turkey soils were placed in "Zonal, Intrazonal and Azonal soil orders" with that work. This report was considered a rather important work for Turkey, because it was the first work showing the soil resources in country scale.

Furthermore, the former General Directorate of Soil and Water prepared the Turkey Development Soil Map (TDSM), based on a topographical map, 1:25,000 scaled at the exploration level between the years **1966** and **1971**. In this study, map units were recorded based on the great groups of 1938 American Soil Classification System (soil groups include depth, slope, stoniness, erosion degree and other similar characteristics data). After evaluating the data, two maps were produced. Firstly, the 'Soil Resource Inventory Map' was published for every province at a scale of 1:100,000. Secondly, the 'Watershed Soil Map and Report' was produced showing 17 of Turkey's 26 major watersheds, or catchments, at a scale of 1:200,000. In Turkey, this was the first original land study that mapped nation-wide knowledge and at the same time brought out important problems of soils and their distribution areas. Today this study is the main resource that can be applied to the problems and uses of Turkey's soils.

The first examples of "Soil Taxonomy Classification (Soil Survey Staff)" in Turkey were applied in mapping the soils of Konya plain and the Küçük Menderes (Little Meander) valley in **1970** and **1972** years. These were done by Nederland Wageningen University Soil and Geology Department researchers and GDRS Soil and Fertilizer Research Institute.

Between the years **1982** and **1984**, “Turkey Developed Soil Map Surveys” had been updated with making “The Turkey Soils Potential Survey and Non Agriculture Aims Land Usage Planning Project” by the former General Directorate of Soil and Water. These reports identified differences in soil depth, soil stoniness, soil erosion levels and distributions in all of the provincial Great Soil Groups supported by data obtained from field trips. Moreover, differences in drainage, saltiness, alkalinity problems, land usage and land capability classes had been updated on 1:25.000 scales soil maps for all country at the scale of 1:25,000 from field studies.

From **1987** onwards, maps were prepared as a result of the Turkey Development Soil Maps Surveys at a scale of 1:100,000. With the consultation of the GDRS and the surveys, a map called the Turkey Soil Zones Map was also prepared at the scale of 1:2,000,000. This was published as the Turkey General Soil Management Plan. However, it is emphasized that in the future, generic classes should be scrutinized and an adaptation in new classifying systems and standards is required.

Turkey doesn’t own its soil classification system. In order to formulate a system for country, more detailed information of soil is needed. On the other hand, a lot of countries are thinking about establishing systems of classifying by using a single international system, instead of their own systems. Clear examples of these reference classification systems are FAO-UNESCO Word Soil Map Legend (1974) and Soil Taxonomy (Soil Survey Staff, 1975).

In fact, the 1938 American Soil Classifying System, which is used by both Harvey Oakes and the General Directorate of Soil and Water, doesn’t used commonly in many other countries because of being pedogenic system and not including new defined soils in the Earth by its categories. Instead, FAO-UNESCO (1974, 1990) and Soil Taxonomy (1975, 1996, 1998-1999) systems, which are morphometric systems, are preferred. GDRS and Wageningen University Soil and Geology Department used this new classifying system for the first time in the Konya and Ege Watershed. In addition, this new system was used completely for the GAP Fırat watershed producing detailed soil maps and reports with a scale of 1:25000. Studies were done by the country’s University researchers, master students and doctoral students by using the new soil classifying system, which created detailed soil surveys and maps. (Özden et al., 2001)

In recent years, a soil mapping work was made in 2001 by the formerly Turkish Soil and Water Resources National Information Centre (NIC). They collaborated with soil experts of Cukurova University and the “Turkish Soil Data (Dinc, Kapur et Al.,2001)” had been prepared (Section 2.3) according to WRB soil classification. Unfortunately, it was not published as an official and territorial map after the closure of Turkish Soil and Water Resources National Information Centre.

2.3 Soil Resources of Turkey

In the current section, an analysis of soils in Turkey will be demonstrated. Around 35.6% of the total area (nearly 27,700,000 hectare) is arable land in Turkey (Table 1). Majority of these arable lands are productive lands but have some limitations according to Land Capability Classification (American Soil Survey Handbook, Part 622.02) (Table 3.). First four classes (I-IV) belong to the first category and these classes have few limitation since they requires special conservations practices except class IV which requires very carefully management. These are suitable for agriculture (also suitable for cultivation and animal husbandry) covering nearly 26.5 million hectares of Turkey soils (Table 3).

Table 3. Percentage Proportion and Areal Distribution of Land Capability Classes (Kumbur et al., 1998)

Land Capability	Area (ha)	Percentage (%)	Total Area (Million ha)	Percentage (%)
I II III IV	5.012.537 6.738.702 7.574.330 7.201.016	6.5 8.8 9.9 9.4	26.4	34.6
V VI VII VIII	165.547 10.238.533 36.288.553 3.455.513	0.2 13.4 47.3 4.5	49.8	65.4
TOTAL	**76.694.523**	**100.0**	**76.2**	**100.0**

V-VI-VII classes belong to the second category and these are unsuitable for cultivation but only perennial plants with intensive conservation and development practices. It is suitable for under controlled grazing (pasture, grasslands) and forestry. This category has very severe limitations that make the land unsuitable for economic and sustainable agricultural usage. These soils classes cover nearly 46 million hectares of Turkey soils. Third category includes class VIII which is suitable only for urban or industry. This land is not covered with soil for commercial crop productions. These areal distributions of land can also be seen in Table 3.

Regarding elevation the average is around 1131 metres in Turkey. This slope condition is complicating for agricultural activities and also stimulating erosion. Lands that have lower than 12% slope covers 35.7% of total area while lands having over 12% slope cover 64.3% of total areas. Distribution of lands according to slope and their availability can be seen in Table 4.

Table 4. Distribution of Lands according to Slope and Their Availability for Agriculture in Turkey (1987, Turkey Environment Atlas)

SLOPE	AREA (hectare)	AGRICULTURAL AVAILABILITY
Flat 0-2 %	4,882,040	Suitable for Agriculture
Slight 2-6 %	8,476,067	Suitable for Agriculture
Medium 6-12%	10,514,253	Partially suitable for Agriculture, by taking precaution
Steep 12-20 %	10,747,597	Partially suitable for Agriculture, by taking precaution
Very Steep 20-30%	13,368,866	Suitable for Pasture and Forest
Very Steep 30+%	23,015,669	Suitable for Pasture and Forest

Distribution of lands according to soil depth can be seen in Table 5. According to that table, deep and median deep soils, which are suitable for agriculture, cover 26.2% of Turkey. Shallow soils (20-50cm) that can be used for producing some kinds of plants cover 30.5% of total area.

Table 5. Distribution of Lands according to Depth of Soils in Turkey (1987, Turkey Environment Atlas)

DEPTH	AREA (hectare)	%
Deep 90cm+	11,308,114	14.3
Median Deep 50-90cm	9,299,614	11.9
Shallow 20-50cm	23,696,973	30.5
Very Shallow 20cm-	28,908,455	34.2

According to the Agriculture census made in 2001 by Turkish Statistic Institute (TurkStat), nearly 24% of arable lands are irrigated, 76% of arable lands are not irrigated in Turkey (Table 6). Because of the water deficiency and land limitation 20 % of irrigable land can be hardly irrigated (Ozden et al., 1998).

Table 6. Distribution of Irrigated and Unirrigated Arable Lands in Turkey (TurkStat, Agriculture Census, 2001)

ARABLE LAND	Total Area	Irrigated Area		Unirrigated Area	
	Decare	Decare	%	Decare	%
Sown area	152 376 357	36 171 198	23.74	116 205 159	76.26
Vegetables and flower gardens*	5 867 005	4 782 143	81.51	1 084 862	18.49
Fruit orchards and other permanent crops*	23 891 026	5 704 244	23.88	18 186 782	76.12
Poplar and willow land	1 973 562	1 189 326	60.26	784 236	39.74
Unused and undeveloped potentially productive land	19 443 399	990 663	5.10	18 452 736	94.90
Permanent meadow	14 493 128	3 313 870	22.87	11 179 258	77.13
Total	218 044 477	52 151 444	**23.92**	165 893 033	**76.08**

**Land under protective cover is included*

As mentioned before, the last mapping work done in 2001 is a compilation of the previous maps and studies undertaken in the past by Cukurova University professors (Profs. U. Dinç, S. Kapur and S. Şenol, Drs. O. Dinç and E. Akça). Some input data requested the digitisation of detailed maps at 1:25,000 scale (Figure 6). The principal sources of this key national dataset are pencil tracings and annotations on transparent material. The soil map legend represents a wide range of environmental parameters. Each unit was labelled with a compound alphanumeric symbol giving information on various soils and site attributes. There are over 5,564 soil maps at 1:25,000 scale covering the whole of Turkey and the development of a national database from these data is a task requiring significant resources (Hallett et al., 2003)

1:25.000 Paper-based Soil Map | Digitized Maps | Thematic Maps

Figure 6: Using Paper-based National Soil Maps (Özden, 2002)

Soil experts have used all the listed auxiliary data; they digitized the base maps and the soil map was finalized based on WRB soil classification. For preparing Soil Map of Turkey, the following materials were used:
a. 1:1.000.000 Geology Maps
b. 1:800.000 Soil Map of Oakes (1958)
c. 1:1.000.000 Erosion Map of Turkey
d. 1: 4.000.000 Slope Map of Turkey
e. 1:100.000 County Soil Maps
f. 1:200.000 Basin Soil Maps
g. 1:25.000 South-eastern Anatolia Irrigation Project Area Soil Maps
h. University projects (Özden et al., 2001)

As an outcome of this final map produced in 2001, it is seen that soils of Turkey comprise 32 soil associations. The Leptosols are the dominant soils due to the steep sloped topographical structure of Turkey. Leptosols are followed by the Calcisols, Fluvisols, Cambisols, Vertisols, Kastonozems, Regosols, Arenosols and Acrisols (Table 7).

Table 7: Distribution of Soil Associations of Turkey according to WRB Soil Classification (%)(Özden et al., 2001)

Soil Association	**Area (%)**
Mollic Leptosol/Lithic Leptosol	17,736
Luvic Calcisol/Haplic Calcisol	16,405
Calcaric Cambisol/Eutric Leptosol	9,468
Rendzic Leptosol/Haplic Cambisol/Luvic Kastanozem	7,588
Lithic Leptosol	7,094
Calcaric Fluvisol/Vertic Cambisol/Calcic Vertisol	7,019
Haplic Calcisol/Vertic Cambisol	6,027
Eutric Leptosol/Hapic Cambisol/Eutric Vertisol	3,78
Haplic Kastanozem/Haplic Cambisol	3,376
Luvic Calcisol/Petric Calcisol/Calcic Vertisol	3,102
Mollic Leptosol/Petric Calcisol/Calcic Vertisol	2,475

Umbric Leptosol/Dystric Cambisol	2,286
Haplic Acrisol/Eutric Cambisol	2,224
Lithic Leptosol/Chromic Luvisol	1,424
Haplic Calcisol/Mollic Leptosol	1,363
Water Bodies	1,337
Calcic Vertisol/Petric Calcisol/Luvic Calcisol	1,286
Eutric Vertisol/Vertic Cambisol	1,119
Luvic Calcisol/Eutric Leptosol	0,959
Vertic Cambisol	0,63
Luvic Calcisol/Petric Calcisol	0,629
Mollic Leptosol/Haplic Cambisol/Haplic Andosol	0,625
Luvic Calcisol/Calcic Vertisol	0,615
Mollic Fluvisol/Eutric Vertisol	0,224
Calcic Vertisol/Calcaric Fluvisol	0,203
Mollic Leptosol/Vertic Cambisol	0,201
Eutric Fluvisol	0,191
Haplic Arenosol	0,18
Haplic Andosol	0,173
Salic Fluvisol/Eutric Vertisol	0,138
Calcaric Regosol/Calcaric Cambisol	0,066
Dystric Leptosol/Haplic Kastanozem	0,036
Marsh	0,012
Eutric Cambisol	0,01

General explanations and distributions about soil associations of Turkey can be seen in following part of this section. These parts of report are summarised from Özden et al., 2001.

Leptosols

The abundance of Leptosols is the outcome of the vigorous Anatolian tectonic activities since the Miocene (Neotectonics) resulting to the development of steep slopes and their inevitable consequence causing mass transportation of soils and continuous destruction of the landscape (Erol, 1981).

The Dystric Leptosols associated with the Haplic Kastanozems overlying calcareous, sedimentary and igneous rocks occupy the northeastern parts of the country, which is temperate to cold with 8°C to 15°C annual temperature and rainfall varying from 350 to 1400mm annually. Other Leptosols are associated with Cambisols and Andosols and Vertisols in the eastern part of Turkey overlying volcanic rocks as well as metamorphic along strips of grabens with basins occupied by large areas of Vertisols and Fluvisols.

Lithic Leptosols of the west associate with Chromic Luvisols which are the carbonate leached Red Mediterranean Soils with high contents of kaolinite, thus being at an advanced stage of weathering i.e the typical Terra Rossa of Manchini (1966) described for the Mediterranean which are dominantly developed at relatively higher altitudes (500-1000m) with annual rainfall of 500-1000mm and on hard crystalline limestones throughout the country especially on the slopes of the Taurus Mountains located at the south. The Lithic and Mollic Leptosols may also be included into the Terra Rossa theme or the Mediterranean Red Soils developed on

Oligo-Miocene limestones -karstic land- with annual rainfall varying from 400-1500mm and annual temperature from 14° to 18°C. Rendzic Leptosols (Rendzinas) together with the Haplic Cambisols and Luvic Kastanozems overlie various ages of soft and crystalline limestones interlayered with numerous sediments on the west and northwestern parts of the country (Dinç et al. 1997).

The Mollic Leptosol, Petric Calcisol and their geomorphologically lower most versions the Calcic Vertisol association is the Red to Reddish Brown Mediterranean Soils developed on colluvial materials overlying the abundant grabens of southeastern Anatolia. This area is under the development of the huge southeastern Anatolian irrigation project seeking to irrigate 1.7 million ha of land.

Calcisols

Calcisols are the next dominant soils of Turkey taking place in the drier parts of the country, particularly developed on ancient lake basins and mudflow deposits developing to tectonically induced terraces of the Quaternary (Dinç et al. 1997).

Fluvisols

The Fluvisol association is the widely distributed SMU's throughout Turkey along river valleys and lake basins are not determined in southeastern Turkey –the northern part of the Arabian Shield which is covered by the materials transported following Neotectonic activities. Thus, the widespread Calcaric Fluvisols associating with Vertic Cambisols and Calcaric Vertisols are good examples for catenary sequential continuum encountered in countries with vigorous and frequent tectonic movements causing formation of prominent topographic/geomorphologic features/soils that are subjected to a long history of exploitation since the Neolithic.

Cambisols

Cambisol associations, the soils of the slightly more temperate areas than the typical Mediterranean, associating with Leptosols and Kastanozems, are frequently located at the northern fringes of the Calcisols, which embrace the coastal areas of the north and south Mediterranean Basin.

Vertisols

The Calcic Vertisols with less prominent cracking features and gilgai due to the coarse calcite and palygorskite contents have developed from the transported Petric Calcisols ie the Quaternary mudflow surfaces designated as the "glacis" ie the colluvials (Dinç et al. 1997; Kapur et al. 1990).

Acrisols

One of the minor soil groups of Turkey are the Acrisols (Haplic) (Table 7) associating to Eutric Cambisols overlying volcanic and metamorphic parent materials with the highest annual rainfall in the area (1500-2000mm) and annual average temperatures of 12°C to 15°C, (northeast Black Sea coastal) needs detailed filed trials and description of new profiles for the ultimate differentiation from Podzols to Acrisols (Dinç et al. 1997).

Regosols

The Calcaric Regosol and Calcaric Cambisol association covers a small part of the country (Table 7) and is located at a similar climate as the Lithic Leptosol/Chromic Luvisol association of the Mediterranean Region (Dinç et al. 1997).

Arenosols
The Haplic Arenosol association represents the coastal sand dunes being on the ancient and/or present courses of the large rivers of Anatolia intergrading to the coastal beach sands of the Mediterranean covering a relatively small part of the country (Dinç et al. 1978; Dinç et al. 1997, Akça, 2001).

Andosols
The Haplic Andosol association has been recently defined in eastern Turkey and previously at the northeast, south and western parts of the country (Kapur et al. 1980; Dinç et al. 1997). The use of especially the major class levels of the parent materials 3000 and 3300 has provided more inside in the development of a more geologically oriented concept for the designation of Andosols that have developed on or in pyroclastic rocks (tephra).

2.4. Soil Threats in Turkey

Soil sealing (especially urbanization on the productive agricultural lands), desertification and soil erosion are the most important land problems and soil threats of Turkey. Because of the mismanagement of the land, some of the main degradation types in Turkey are erosion by water or wind, soil salinization and alkalization, soil structure destruction and compaction, biological degradation and soil pollution. Some of the land problems of Turkey are shown as in the Table 8. (Özden, 1998)

Table 8: Some of the land problems and their affected area of Turkey (Özden et al., 1998)

Types of Problems	Area (ha)
Water erosion	66.576.042
Wind erosion	330.000
Alkalinization / Salinization	1.518.749
Hydromorphic soil	2.775.115
Stony or rocky problem	28.484.331
Non agriculture use	894.153

Due to climatic and topographic condition soil erosion is the biggest problem in Turkey (Table 9). Approximately 86 % of land is suffering from some degree of erosion.

Table 9: Categories of Soil Erosion Distribution (Özden et al., 1998)

Degree of erosion	Area (ha)	Ratio (%)	Criterion of degree
Slightly	5.611.892	7.22	25 % of top soil eroded
Moderate	15.592.750	20.04	25-75 % of top soil eroded
Severe	28.334.938	36.42	Top soil and 25 % of sub soil eroded
Very severe *	17.366.462	85.98	Top soil and 25-75 % of sub soil eroded

** Wind erosion is effective on 330.000 ha of very severe erosion.*

Another important land problem for Turkey is the splintery structure of land ownership. Areal size of lands is very small and the ownership of the land is split due to heritage laws. According to outcomes of Common Agriculture Census in 1980, average company size is determined as 65.8 decares (decare is equal to 1/10 of hectare) in 1980, 59.1 decares in 1991, 61.01 decares in 2001. As you can see below in table 8, the land owners, who have more than 500da land, represent 0.74% of the total companies but 11.26% of the Turkey's soil. On the other hand, land owners, who have less than 50da land, own 65% of the total companies but only 21% of the Turkey's soil. (Table 10)

Table 10: Land-Ownership Relation of Turkey (Günaydın, 2004)

A: Number of companies B: Land size (da)

		1991		2001	
		Numerical	**%**	**Numerical**	**%**
Company Size (da)	A	3 966 822	100	3 021 190	100
	B	234 510 993	100	184 329 487	100
50<	A	2 659 738	67	1 958 266	65
	B	51 889 612	22	39 331 133	21
50-99	A	713 149	18	559 999	19
	B	46 750 693	20	38 123 216	21
100-499	A	557 097	14	481 018	16
	B	95 704 065	40	85 957 939	47
500-999	A	24 201	0.6	17 431	0.6
	B	14 982 493	6	11 218 554	6
1000>	A	12 637	0.32	4 476	0.14
	B	25 184 130	10.73	9 698 645	5.26

3. MAPS – DATA

Polygon data of Turkey soil map have been prepared but never published officially. The data have been produced by the collaboration of formerly “General Directorate of Rural Services National Information Center for Soil and Water Resources of Turkey” and “Cukurova University soil experts” and they have been taken as a base soil data in this study.

Those polygon data include database information that have been reclassified using ancillary data (ex: geology and climate data) of soil groups, which are separated different clusters according to WRB classification. However, the database structure couldn’t be used as input in this study, since there were not enough data for integration and there were not coherent with European Soil Database’s data structure. In the current study, Turkish soil data were converted to European soil database by implementing some transformations and the missing ones were completed using data acquisitions from different sources and elaborating GIS and Remote Sensing techniques and technologies.

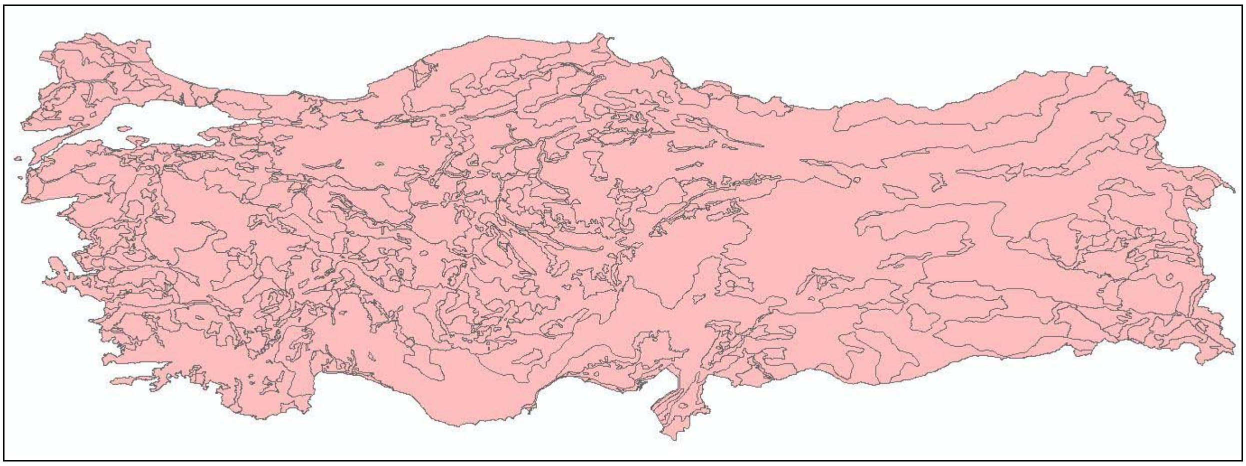
Vector and attribute data that we have at the beginning of this study can be seen in Section 3.1 and 3.2.

3.1. Map

There was only one map in ‘shapefile’ format (Map 2) and its corresponding attribute table (Table 11) were taken into account as input information in this study. There was also one additional attribute table (Table 8) that was prepared according to “Georeferenced Soil Database for Europe, Manual of procedures Version 1.1 (Finke et al., 2001)” study by Kapur et al (Dinc et Al., 2005).

The input dataset is the “Turkish Soil Data (Dinc, Kapur et Al., 2001)”, in shapefile format composed by 544 polygons (Map 2). (Attribute table of this map is given below, Table 11). The database structure of it was corrected and completed by using GIS and Remote sensing technologies. Moreover, the values of “Georeferenced Soil Database for Europe, Manual of procedures Version 1.1 (Finke et al., 2001)” study were also used for the better structure of “Turkish Soil Data (Dinc, Kapur et Al., 2001)” polygons.

Map 2: Turkish Soil Data (Dinc, Kapur et Al., 2001)



3.2. Attribute Data

Instructions of integration of soil database structures are explained detailed in “Soil Geographical Database for Eurasia &The Mediterranean: Instructions Guide for Elaboration at scale 1:1.000.000 version 4.0”. According to the guide, the attribute table of Soil map of Turkey contains some of values which are usable and significant for polygons but there are some problems related with data structure of values.

According to the guide, “each row and column of attribute table must host only one single value”; however there are list attributes such as SOIL_REGIO, SMU_ID, SMU_NAME that each row in “Turkish Soil Data (Dinc, Kapur et Al., 2001)” (Table 12) hosts multiple values. This situation was not acceptable for the integration into the European Soil Database and we have proceeded in the necessary changes.

Similar case was a major obstacle with the second dataset which has been prepared according to the “Georeferenced Soil Database for Europe, Manual of procedures Version 1.1 (Finke et al., 2001)” (Table 13 and 14). The values included in those tables were also significant but these values were not coherent with current European Soil Database structure. Further processes needed in order to get them usable and acceptable according to the desired format.

Detail descriptions of mentioned attribute tables can be seen in Table 11 and Table 13.

Table 11: Soil Data Structure According To Georeferenced Soil Database of Europe Manual Version 1.1

SOIL DATA ACCORDING TO GEOREFERENCED SOIL DATABASE OF EUROPE MANUAL VERSION 1.1 [1]	
AREA	Area of the polygon (Its automatically computed by the ArcInfo)
PERIMETER	Perimeter of the polygon (Its automatically computed by the ArcInfo)
SOILMAP_ID	Identifier of the polygon.
PARMAT	Codes for parent materials (dominant and secondary ones together)
PARENT_MAT	Description for the parent materials
SOIL_REG_N	Soil region number (According to Appendix 9)
SOIL_REGIO	Names of the soil region
SMU_ID	FAO90 codes for all Soil Names in the polygon
SMU_NAME	Soil names for all soil types in the polygon
SMU_CODE	Soil mapping unit identifier (random numbers)
WRB	WRB_GRP codes
FAO	FAO codes

Table 12: Example of Values of Table 11

AREA	PERIMETER	SOILMAP_ID	PARMAT	PARENT_MAT	SOIL_REG_N	SOIL_REGIO	SMU_ID	SMU_NAME	SMU_CODE	WRB	FAO
1692806400	297519.313	2	4240/4230	Metamorphic rocks	67.3	Leptosol-Cambisol-Luvisol Regions	LPm/LPq	Mollic Leptosol/Lithic Leptosol	67	LP	lm
227439808	98957.648	24	4000	Metamorphic rocks	67.4	Leptosol-Cambisol-Luvisol Regions	LPk/CMh/KSl	Rendzic Leptosol/Haplic Cambisol/Luvic Kastan	36-67	LP	Eh
1608700416	322981.5	22	4230	Metamorphic rocks	67.2	Leptosol-Cambisol-Luvisol Regions	LPu/CMd	Umbric Leptosol/Dystric Cambisol	36-67	LP	lu

Table 13: Soil Data Structure According to Georeferenced Soil Database for Europe, Manual of procedures Version 1.1 Study (Finke et al., 2001)

SOIL DATA ACCORDING TO GEOREFERENCED SOIL DATABASE FOR EUROPE, MANUAL OF PROCEDURES VERSION 1.1 STUDY	
ORG_MAT	Organic material, %
SAL_ID	Salinity, 1=Saline 2=Low 3=None
POP_ID	Projected urban population increase btw 1990-2025 (http://eusoils.jrc.it/library/themes/Sealing/) 1=0-10 2=10-15 3=15-20 4=>20
COMPACTION	Land compaction, 1=Low 2=Moderate 3=High 4=Very High
SEALING	Covered/Concreted land, , 1=Low 2=Moderate 3=High 4=Very High
E_RISK	Erosion risk, , 1=Low Risk 2=Medium Risk 3=High 4=Very High
TOP_S_C	Top Soil Clay, %
TOP_S_S	Top Soil Silt, %
TOP_S_SA	Top Soil Sand, %
SUB_S_C	Sub Soil Clay, %
SUB_S_S	Sub Soil Silt, %
SUB_S_SA	Sub Soil Sand, %

Table 14: Example of Values of Table 13

ORG_MAT	SAL_ID	POP_ID	COMPACTION	SEALING	E_RISK	TOP_S_C	TOP_S_S	TOP_S_SA	SUB_S_C	SUB_S_S	SUB_S_SA
2	3	2	2	2	2	45	35	20	50	30	20
3.1	3	2	1	3	3	30	45	25	30	45	25
2	3	3	1	3	3	40	35	25	50	30	20

4. IMPLEMENTATION METHODOLOGY

As mentioned above, the original data and the database structure of Turkey soil map were not used directly in this study because of inconsistency with the European Geographical Soil Database in the scale of 1:1.000.000. In this study, we will describe how the different data of soil map of Turkey were converted and how the missing data were completed using GIS and Remote Sensing techniques and technologies.

One of the most important phases of the data integration process was achieved by developing the "Soil Mapping Unit (SMU)" and "Soil Topological Unit (STU)" structure and their relationship which are the basic components of European soil database. In order to prepare SMU/STU structure, soil group codes are corrected according to the rules, and then we have proceeded performing some calculations with the soil clusters. After developing the SMU/STU structure, there are two important steps for the integration of data into the new structure:

- if the actual data exists and they're in the old format then convert the data (data transformation from original data)

- if there is no data; obtain the data from different sources and analysis with the help of GIS and Remote Sensing techniques and technologies. (data acquisition from different sources)

In general, explanation of the method can be summarized as above, however detailed descriptions about the methods and deliverables can be seen in next sections.

4.1 SMU/STU Structure

One of the most important phases of data integration for Turkey is achieved with this study by developing "Soil Mapping Unit (SMU)" and "Soil Topological Unit (STU)" structure that are providing the basis of European soil database. Detailed explanation about those terms and general structure of database can be found in "Soil Geographical Database for Eurasia &The Mediterranean: Instructions Guide for Elaboration at scale 1:1.000.000 version 4.0" (Lambert et al., 2002).

4.1.1 Description of SMU/STU Structure

The database contains a list of Soil Typological Units (STU). Besides the soil names they represent, these units are described by variables (attributes) specifying the nature and properties of the soils: for example the texture, the water regime, the stoniness, etc. The geographical representation was chosen at a scale corresponding to the 1:1,000,000. At this scale, it is not feasible to delineate the STUs. Therefore they are grouped into Soil Mapping Units (SMU) to form soil associations and illustrate the functioning of pedological systems within the landscapes. Each SMU corresponds to a part of the mapped territory and as such is represented by one or more polygons in a geometrical dataset. (See Figure 7)

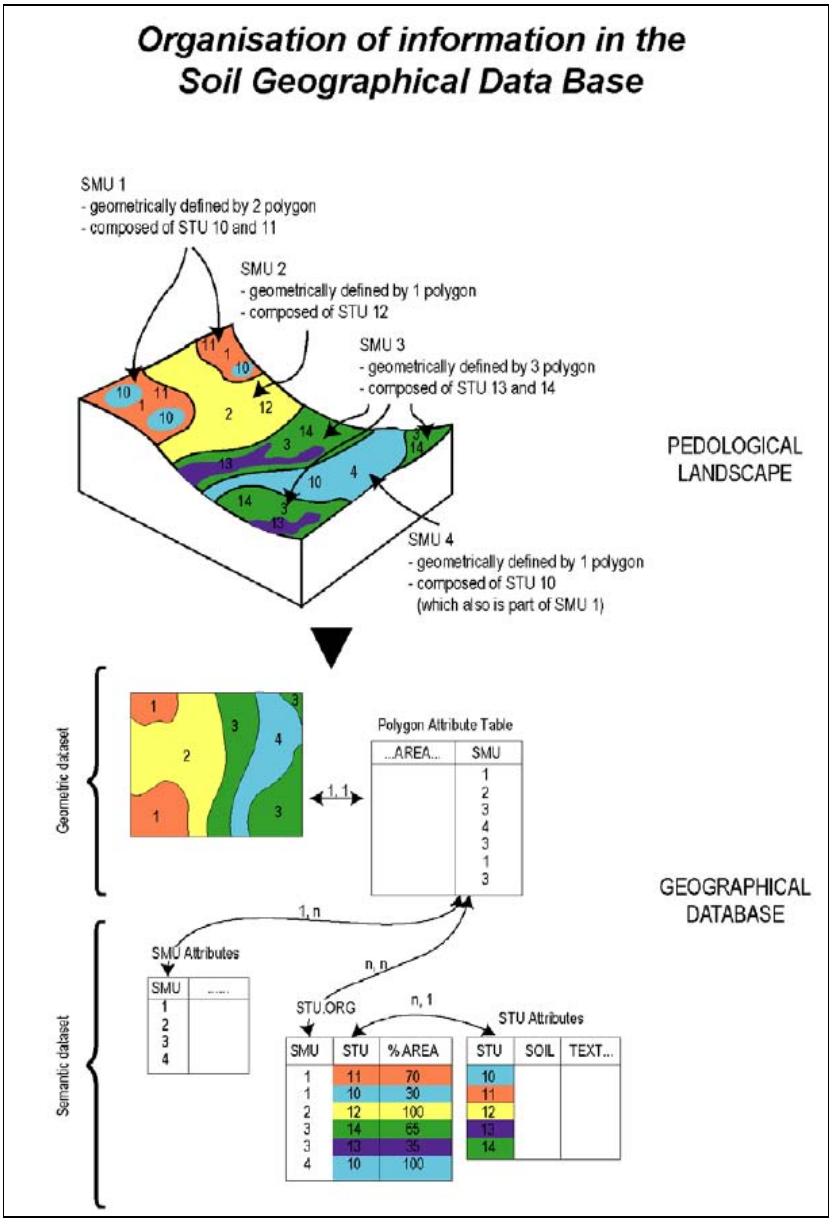


Figure 7. Information Organization in the Soil Geographical Database of Europe (Lambert et.al, 2002)

The Soil Geographical Database of Eurasia (SGDBE) has been used as the original source of information for current value added products and assessments in Europe. The SGDBE at scale 1:1,000,000 is part of the European Soil Information System (Van Liedekerke et al. 2004, Panagos 2006) and is the resulting product of a collaborative project involving soil survey institutions and soil specialists in Europe and neighbouring countries.

The SGDBE consists of both a geometrical dataset and a semantic dataset (set of attribute files) which links attribute values to the polygons of the geometrical dataset. The way that map polygons, SMU's and STU's are linked together is illustrated in the Figure 7.

In view of general expansion and next version of the European Geographical Soil Database, harmonization of the soil data from the Mediterranean/ neighbouring countries is required. The World Reference Base(WRB) is the most important reference for harmonization. Therefore, in current work, an approximate correlation between the WRB 1998 and 2006 soil nomenclatures for soils of the Europe derived from the SGDBE should be provided.

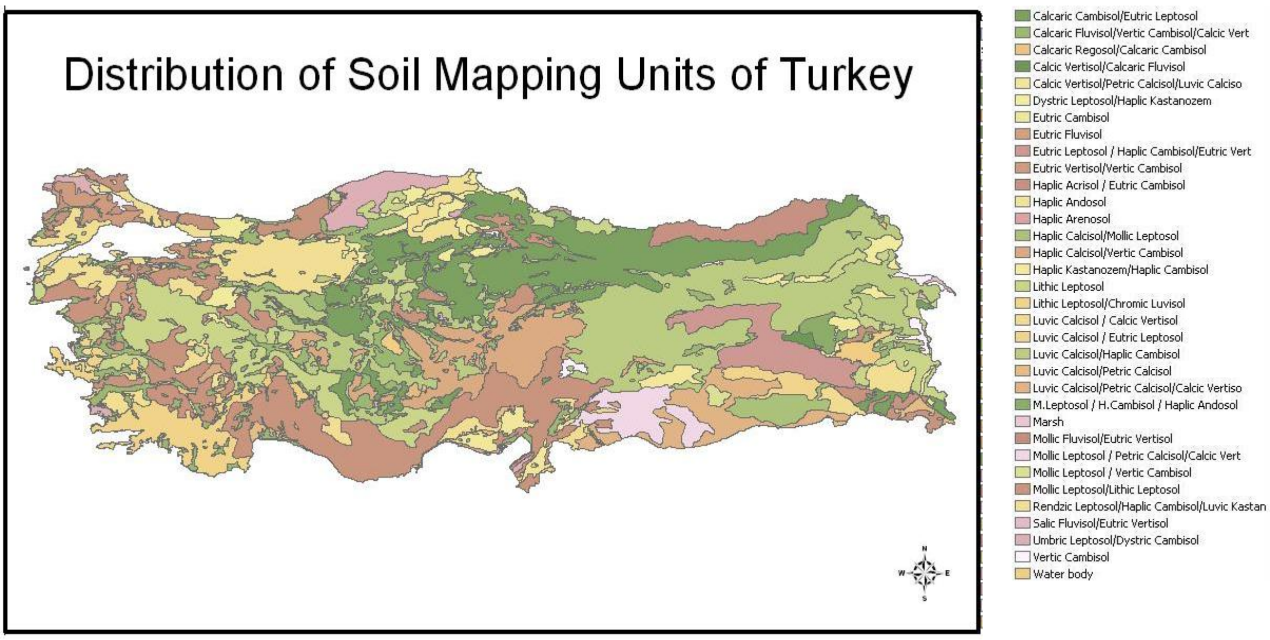
Main objective of this work is to convert the Turkish Soil Database values which are based on older WRB values, into European Soil Database values and integrating Soil Geographical Database Version 4 at scale 1:1,000,000. In order to achieve this objective, a whole appraisal of the current data could help and furthermore the re-use of some. Moreover, auxiliary information obtained from different sources will help to implement the soil database. Prior to this steps, SMU/STU structure for Turkish soil data, which will be explained in 4.1.2, had to be established.

4.1.2 Developing SMU/STU Structure for Turkish Soil Database

As mentioned before, 32 soil associations have been identified in Turkey according to WRB soil classification. Each soil associations contain least 2, but sometimes 3 Soil Topological Unit (STU). Major obstacle was the lack of SMU/STU structure according to the Soil Geographical Database requirements. In order to prepare SMU/STU structure for Turkey, the soil group codes were corrected according to the rules, and then further calculations executed with the soil clusters.

There were only 16 SMU_CODE (Table 11) for each SOIL REGION and as a consequent step the major soil types should have been prepared according to WRB soil classification structure. These soil regions and major soil types were not coded as a single value but they were proposed as a list of values. Due to this fact, only one single value, which is the most covering area and major type for each polygon, was assigned to the polygon. These assigned values are known as dominant soil types, which are the most representative for each polygon.

Map 3: Distribution of Soil Mapping Units of Turkey



As a next step, each major soil type for each soil region was classified according to WRB_FU (Table 11) and their areal percentage was calculated (Table 15). In this point, some espousals were taken into account. According to the “Soil Geographical Database for Eurasia &The Mediterranean: Instructions Guide for Elaboration at scale 1:1.000.000 version 4.0”, each STU must cover at least 5% of the total area of the SMU. Any STU under this threshold value should be ignored.” This assumption was not fully respected in the Turkish

Soil Database since there were so much extreme values which are under 5% coverage. We didn't want to lose those extreme values, consequently data. As a result, STU codes for those extreme values were also assigned with the objective of not losing data some minor information.

Another recommendation given imn the above mentioned guide is to round up values to multiples of 5% (e.g. 5, 10, 15…90, 95 and 100 %), but we have preferred not to follow this in the Turkey case. Instead, real values (e.g. 2%, 34%) were assigned with the aim of not altering the statistics and not losing any information.

Table 15: Calculation of percentage of each STU in each SMU

MAJOR SOIL TYPE (WRB)	COUNT	AREA (he)	%
LPli	26	63049718840	34.07
CLha	2	34303371040	18.54
LPmo	14	32865333720	17.76
LPrz	12	16665861964	9.01
ACha	1	13056249856	7.06
KSha	16	12411735248	6.71
FLca	3	5129153056	2.77
VReu	1	3220125952	1.74
CMca	2	3083955008	1.67
CLlv	1	1206505600	0.65
CMeu	1	61979804	0.03
	79	1.85054E+11	

Furthermore, the major soil types were classified according to WRB_FU and sorted according to their coverage percentages. At the end, 17 Soil Mapping Units and 78 Soil Topological Units are determined in SMU-STU structure (Table 17) for Turkey and their codes were assigned according to the Instructions guide.

SMU codes are assigned numbers starting with 90xxx which is corresponding country prefix call identifier of Turkey. The numbers of polygons and STUs which are corresponding to each SMU can also be seen in the database as NPOL and NSTU columns (Table 17). The Percentage of the SMU covered by the corresponding STU is also visible in the database as PCSMU attribute. (Table 17)

Table 16: Attribute Table of STU-SMU Organization

NAME	**DESCRIPTION**
SMU	"Soil Mapping Unit" identifier
NPOL	Number of the polygons that are in corresponding SMU
NSTU	Number of STUs that are in corresponding SMU
STU	"Soil Typological Unit" identifier
PCSMU	Percentage of area of the SMU
WRB-GRP	Soil Group code of the STU from the World Reference Base (WRB) for Soil Resources.
WRB-ADJ	Soil Adjective code of the STU from the WRB for Soil Resources

Table 17: Summary of STU-SMU organization

SMU	NPOL	NSTU	STU	PCSMU	WRB-GRP	WRB-ADJ
90001	79	11	90001	34	LP	LPli
			90002	18	CL	CLha
			90003	17	LP	LPmo
			90004	9	LP	LPrz
			90005	7	AC	ACha
			90006	7	KS	KSha
			90007	3	FL	FLca
			90008	2	VR	VReu
			90009	2	CM	CMca
			90010	1	CL	CLlv
			90011	0	CM	CMeu
90002	85	9	90012	34	CM	CMca
			90013	27	LP	LPmo
			90014	18	LP	LPrz
			90015	11	LP	LPli
			90016	6	LP	LPum
			90017	4	KS	KSha
			90018	0	FL	FLca
			90019	0	CL	CLlv
			90020	0	KS	KSrz
90003	3	1	90021	100	VR	VReu
90004	74	6	90022	72	CL	CLlv
			90023	20	CL	CLha
			90024	7	FL	FLca
			90025	1	CM	CMvr
			90026	0	LP	LPli
			90027	0	LP	LPrz
90005	7	3	90028	90	AN	ANha
			90029	6	CL	CLha
			90030	4	LP	LPli
90006	9	4	90031	39	CM	CMvr
			90032	33	CL	CLlv
			90033	25	CL	CLha
			90034	3	LP	LPrz
90007	3	2	90035	70	CM	CMca
			90036	30	AR	ARha
90008	35	6	90037	50	CM	CMca
			90038	22	LP	LPmo
			90039	18	CL	CLha
			90040	8	CL	CLlv
			90041	1	FL	FLca
			90042	1	LP	LPli
90009	3	1	90043	100	CL	CLlv
90010	4	1	90044	100	RG	RGca
90011	4	1	90045	100	VR	VRcc
90012	19	4	90046	77	CL	CLlv
			90047	10	FL	FLca
			90048	10	CM	CMvr
			90049	3	FL	FLsz
90013	136	11	90050	90	FL	FLca
			90051	3	FL	FLmo

			90052	3	FL	FLeu
			90053	2	KS	KSha
			90054	1	AR	ARha
			90055	1	VR	VReu
			90056	0	CM	CMca
			90057	0	LP	LPli
			90058	0	CL	CLlv
			90059	0	CM	CMvr
			90060	0	LP	LPrz
90014	14	3	90061	79	FL	FLca
			90062	14	LP	LPrz
			90063	7	FL	FLeu
90015	3	3	90064	55	CL	CLlv
			90065	35	LP	LPli
			90066	10	KS	KSha
90016	10	4	90067	60	CL	CLlv
			90068	31	LP	LPmo
			90069	6	LP	LPli
			90070	3	LP	LPdy
90017	21	8	90071	63	CL	CLlv
			90072	22	LP	LPmo
			90073	15	LP	LPeu
			90074	0	CM	CMca
			90075	0	KS	KSha
			90076	0	LP	LPli
			90077	0	CM	CMvr
			90078	0	FL	FLca

4.2 Soil Database for Turkey According to the ESDB's SMU/STU Structure

SOIL.PAT, STU.ORG and STU tables were also prepared according to the format required in the Instruction Guide for developing the European Soil Database's SMU/STU structure.

The SOIL.PAT table (Table 18) is the polygon attribute table for coverage SOIL. It holds one record (line) for the description of each polygon in the coverage (plus one record for the "universe" polygon).

Table 18: Attribute Table of SOIL.PAT

NAME	**DESCRIPTION**
AREA	Area of the polygon (Its automatically computed by the ArcInfo)
PERIMETER	Perimeter of the polygon (Its automatically computed by the ArcInfo)
SOIL#	ArcInfo internal identifier of the polygon(Its automatically computed by the ArcInfo)
SOIL-ID	User's identifier of the polygon(Its automatically computed by the ArcInfo)
SMU	Identifier of the Soil Mapping Unit (SMU) to which the polygon belongs.

The STU.ORG table (Table 19) describes the organization of STU within each SMU. Each record stores information about the relationship between an SMU and its components STUs. Each set of records with the same SMU number provides the list of STUs that compose the associated SMU. Descriptions of STU.ORG attribute table can be seen in Table 19 and the output file for Turkey can be seen in Table 20.

Table 19: Attribute Table of STU.ORG

NAME	**DESCRIPTION**
SMU	“Soil Mapping Unit” identifier
STU	“Soil Typological Unit” identifier
PCAREA	Percentage of area of the SMU covered by the STU

Table 20: STU.ORG File

SMU	STU	PCAREA	SMU	STU	PCAREA
90001	90001	34.07	90008	90040	7.91
90001	90002	18.54	90008	90041	1.49
90001	90003	17.76	90008	90042	1.04
90001	90004	9.01	90009	90043	100.00
90001	90005	7.06	90010	90044	100.00
90001	90006	6.71	90011	90045	100.00
90001	90007	2.77	90012	90046	76.69
90001	90008	1.74	90012	90047	10.29
90001	90009	1.67	90012	90048	9.53
90001	90010	0.65	90012	90049	3.49
90001	90011	0.03	90013	90050	90.01
90002	90012	34.38	90013	90051	3.03
90002	90013	26.77	90013	90052	2.20
90002	90014	17.80	90013	90053	1.51
90002	90015	10.93	90013	90054	1.13
90002	90016	5.50	90013	90055	0.84
90002	90017	3.52	90013	90056	0.40
90002	90018	0.51	90013	90057	0.30
90002	90019	0.40	90013	90058	0.26
90002	90020	0.19	90013	90059	0.17
90003	90021	100.00	90013	90060	0.14
90004	90022	72.07	90014	90061	78.51
90004	90023	19.58	90014	90062	14.11
90004	90024	6.68	90014	90063	7.38
90004	90025	1.21	90015	90064	54.90
90004	90026	0.37	90015	90065	35.34
90004	90027	0.09	90015	90066	9.76
90005	90028	89.73	90016	90067	59.61
90005	90029	6.55	90016	90068	31.11
90005	90030	3.72	90016	90069	5.87
90006	90031	38.62	90016	90070	3.41
90006	90032	32.56	90017	90071	62.35
90006	90033	25.32	90017	90072	21.84
90006	90034	3.50	90017	90073	14.94
90007	90035	69.95	90017	90074	0.25
90007	90036	30.05	90017	90075	0.23
90008	90037	49.98	90017	90076	0.21
90008	90038	21.96	90017	90077	0.12
90008	90039	17.62	90017	90078	0.07

The STU table (Table 21) contains Soil Typological Units (STU) descriptions. It holds one record (line) for the description of each STU.

Table 21: STU Table.

NAME	DESCRIPTION
STU	Soil Typological Unit (STU) identifying number
WRB-GRP	Soil Group code of the STU from the World Reference Base (WRB) for Soil Resources.
WRB-ADJ	Soil Adjective code of the STU from the WRB for Soil Resources.
WRB-SPE	Complementary code of the STU from the WRB for Soil Resources.
FAO90-MG	Soil Major Group code of the STU from the 1990 FAO-UNESCO Soil Revised Legend.
FAO90-UNI	Soil Unit code of the STU from the 1990 FAO-UNESCO Soil Revised Legend.
FAO90-SUB	Soil Sub-unit code of the STU from the 1990 FAO-UNESCO Soil Revised Legend.
SLOPE-DOM	Dominant slope class of the STU.
SLOPE-SEC	Secondary slope class of the STU.
ZMIN	Minimum elevation above sea level of the STU (in metres).
ZMAX	Maximum elevation above sea level of the STU (in metres).
PAR-MAT-DOM	Code for dominant parent material of the STU.
PAR-MAT-SEC	Code for secondary parent material of the STU.
USE-DOM	Code for dominant land use of the STU.
USE-SEC	Code for secondary land use of the STU.
AGLIM1	Code for dominant limitation to agricultural use of the STU.
AGLIM2	Code for secondary limitation to agricultural use of the STU.
TEXT-SRF-DOM	Dominant surface textural class of the STU.
TEXT-SRF-SEC	Secondary surface textural class of the STU.
TEXT-SUB-DOM	Dominant sub-surface textural class of the STU.
TEXT-SUB-SEC	Secondary sub-surface textural class of the STU.
TEXT-DEP-CHG	Depth class to a textural change of the dominant and/or secondary surface texture of the STU.
ROO	Depth class of an obstacle to roots within the soil profile of the STU.
IL	Depth class of a presence of an impermeable layer within the soil profile of the STU.
WR	Dominant annual average soil water regime class of the soil profile of the STU.
WM1	Code for normal presence and purpose of an existing water management system in agricultural land on more than 50 % of the STU.
WM2	Code for the type of an existing water management system.
CFL	Code for a global confidence level of the STU description.

Detailed descriptions for each group of attributes can be seen in “Soil Geographical Database for Eurasia &The Mediterranean: Instructions Guide for Elaboration at scale 1:1.000.000 version 4.0”, EUR 20422 EN.

There was no information for the attributes AGLIM1, AGLIM2, TEXT-DEP-CHG, ROO, IL, WR, WM1, WM2 and CFL (Table 21) for soils of Turkey.

4.3 Methodology for Explaining Data Transformation and Acquisition of new data

In the next section, we will describe the transformations from original data to the requested one. Furthermore, we will describe the data acquisitions from different sources and the use of GIS and remote sensing techniques and technologies.

4.3.1 Data Transformation

To be complete the variables of soil database for Turkey, some data transformed into compatible structure of European soil database. Those data are;

- WRB and FAO data (Table 11) transferred into WRB-GRP, WRB-ADJ,WRB-SPE, FAO90-MG, FAO90-UNI and FAO90-SUB (Table 21) data
- PARMAT and PARENT-MAT data (Table 11) transferred into PAR-MAT-DOM and PAR-MAT-SEC (Table 21) data
- TOP_S_C, TOP_S_S, TOP_S_SA, SUB_S_C, SUB_S_S, SUB_S_SA data (Table 11) transferred into TEXT-SRF-DOM, TEXT-SRF-SEC, TEXT-SUB-DOM and TEXT-SUB-SEC (Table 21) data

Polygon and attribute data of Original Turkish Soil Data (Dinc, Kapur et Al.,2001) have been reclassified with the use of ancillary data (ex: geology and climate data). In this context, first of all, WRB and FAO90 transformations were performed from the original data using the instructions guide of the European soil database.

Afterwards, the parent material codes have been also transformed from the original data into the desired PAR-MAT-DOM and PAR-MAT-SEC of European soil database codes by using the instruction guide.

Percentages of clay, silt and sand proportions of soils were transformed into desired texture codes of Soil Geographical Database Version 4.0 by using the texture class's triangle. Since there was no information about secondary texture of surface, the value of TEXT-SRF-DOM has been also used for TEXT-SRF-SEC. Same method was implemented for TEXT-SUB-DOM and since there was no information about secondary texture of surface, the value of TEXT-SUB-DOM has also be used for TEXT-SUB-SEC.

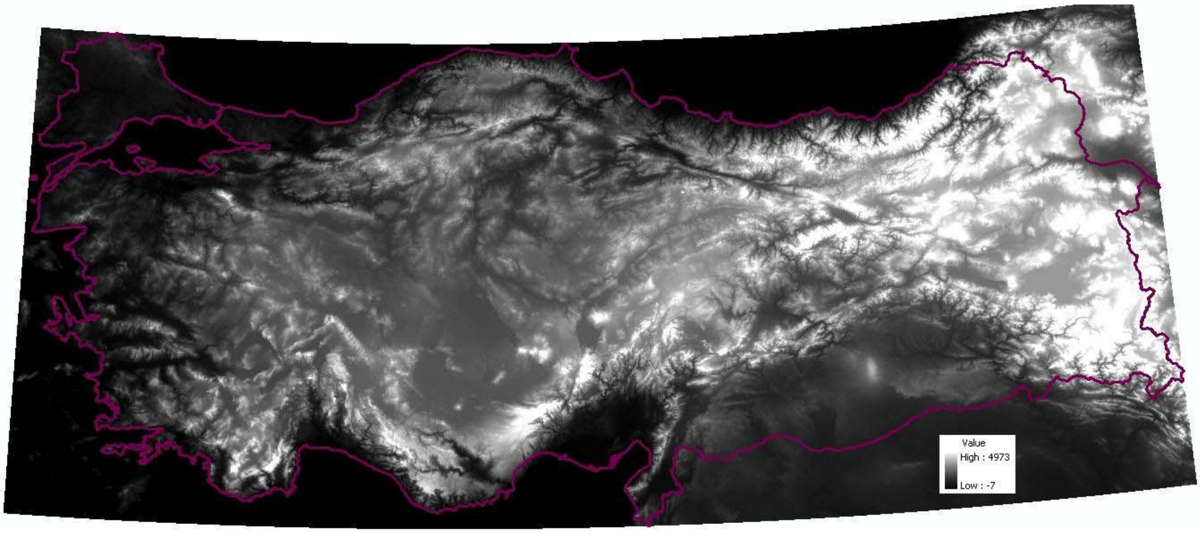
4.3.2 New Data Acquisition

There were no available data for SLOPE-DOM, SLOPE-SEC, ZMIN, ZMAX, USE-DOM and USE-SEC (Table 21) values in Turkey soil database. So far, all those values have been acquired by using different ways with the help of GIS and remote sensing. ESRI ArcGIS 9.3 software was used in GIS analysis and application of techniques. Moreover, the Global Land Cover Map and SRTM were used as an input in this study. Some detailed descriptions about data acquisition can be found next sections.

4.3.2.1 *Slope Data*

Dominant and secondary SLOPE classes were acquired from DEM by using SRTM image.

Map 4: DEM of Turkey

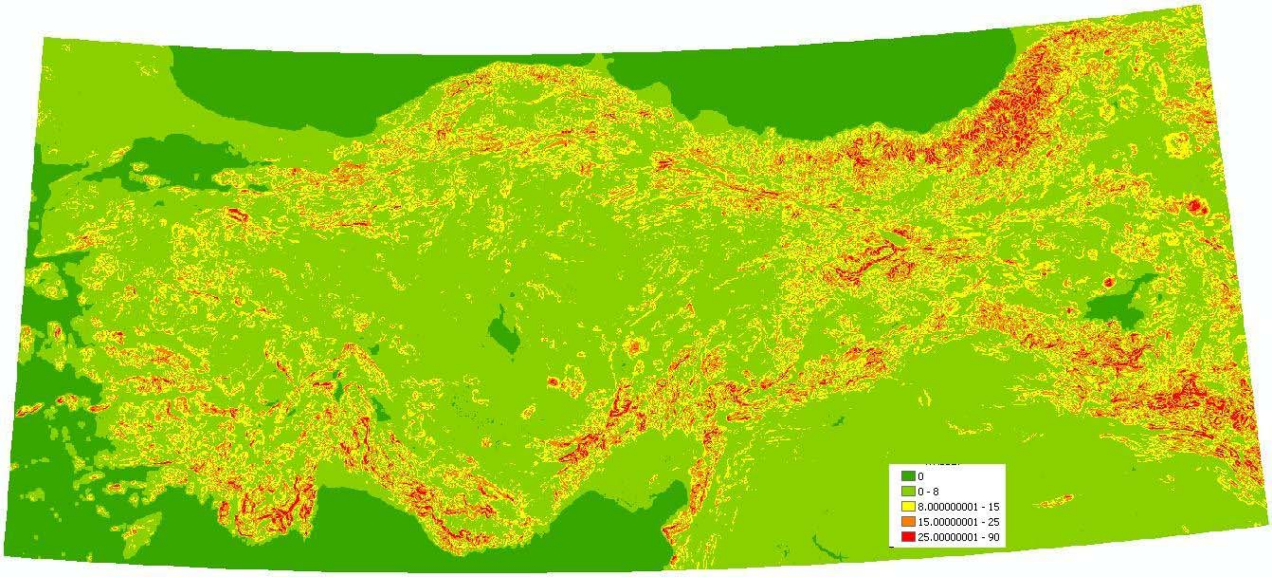


Map 5: Elevation Analysis on DEM Map of Turkey

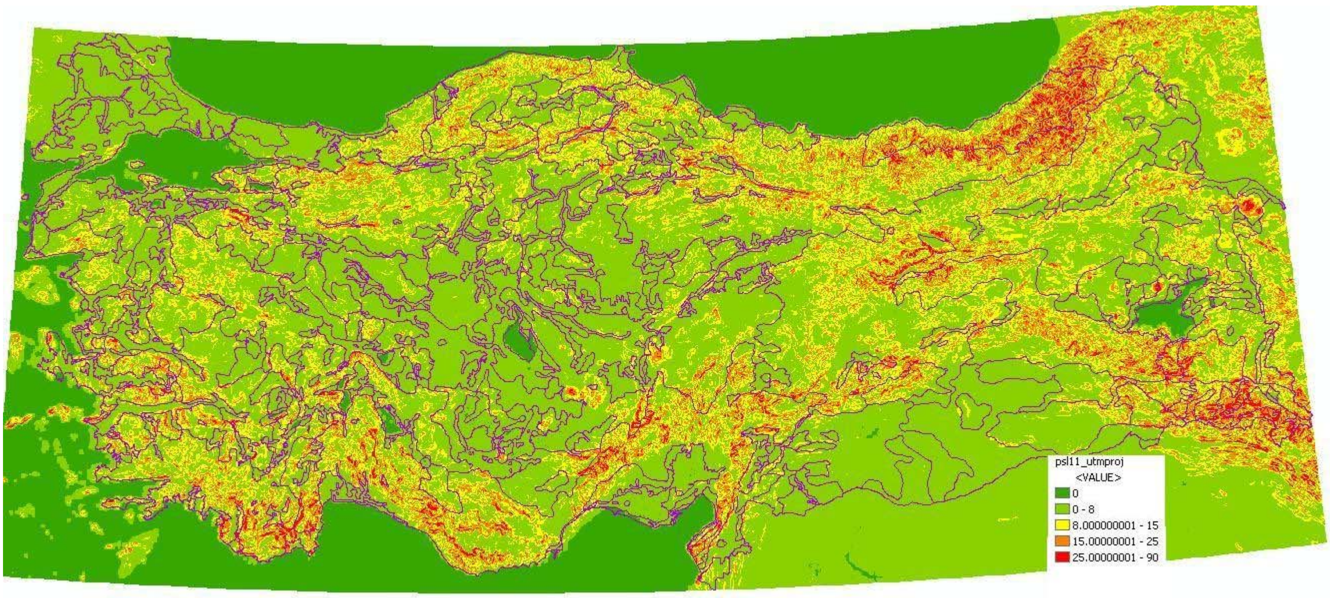
The output map of slope analysis was reclassified according to desired ranges (0-8%, 8-15%, 15-25%, 25> %) (Map 6). The statistical values which coincide with each polygon were received from the reclassified map. Mean slope values for each polygon were assigned to SLOPE-DOM in the new Turkey soil database.

The values were checked again if they were suitable for each polygon (Map 7). Since some of the polygons mean values' could mislead, SLOPE_SEC values for each polygon were also given by checking the map and using the expert knowledge. We have noticed that there were significant gaps between min and max values. For those cases, an expert knowledge was requested. (Figure 8)

Map 6: Reclassified slope map of Turkey



Map 7: Coincidence of reclassified slope map and soil polygons.



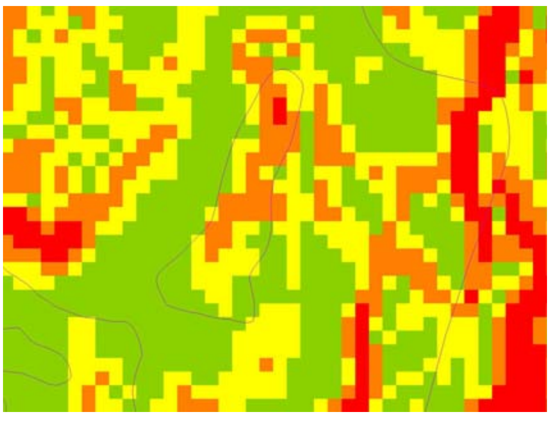
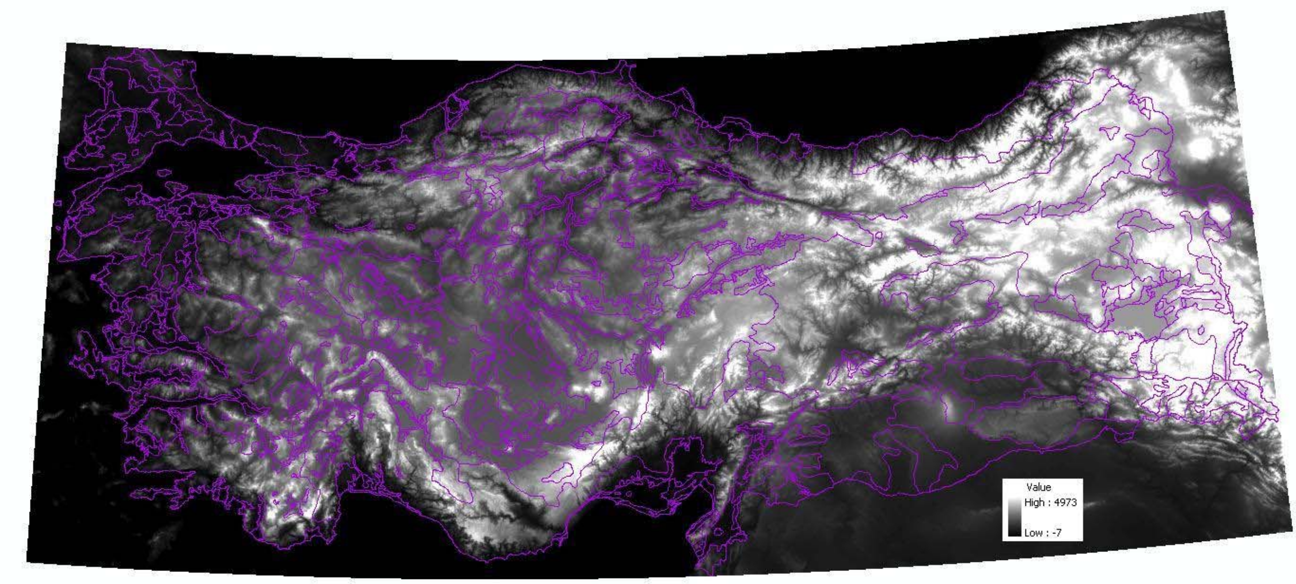


Figure 8: Detailed research for checking suitability of slope class.

4.3.2.2 *ZMIN and ZMAX Data*

ArcGIS Spatial Analyst module was used for getting min and max Z values. ZMIN and ZMAX values were acquired from DEM data source by using GIS analysis and remote sensing images (Map 8).

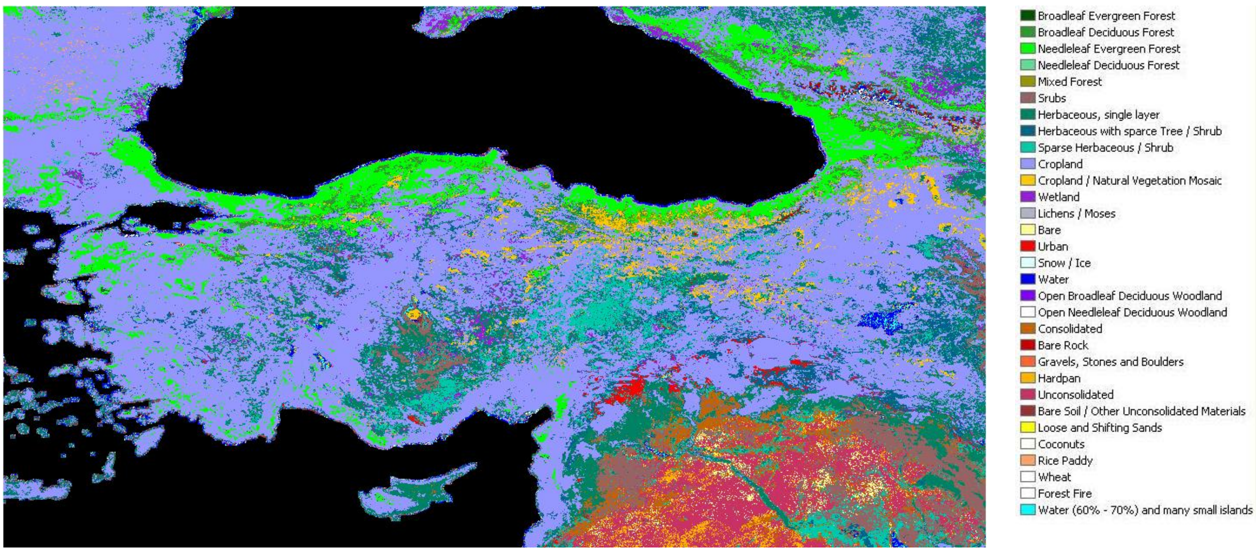
Map 8: DEM of Turkey with soil polygons.



4.3.2.3 *Land Use Data*

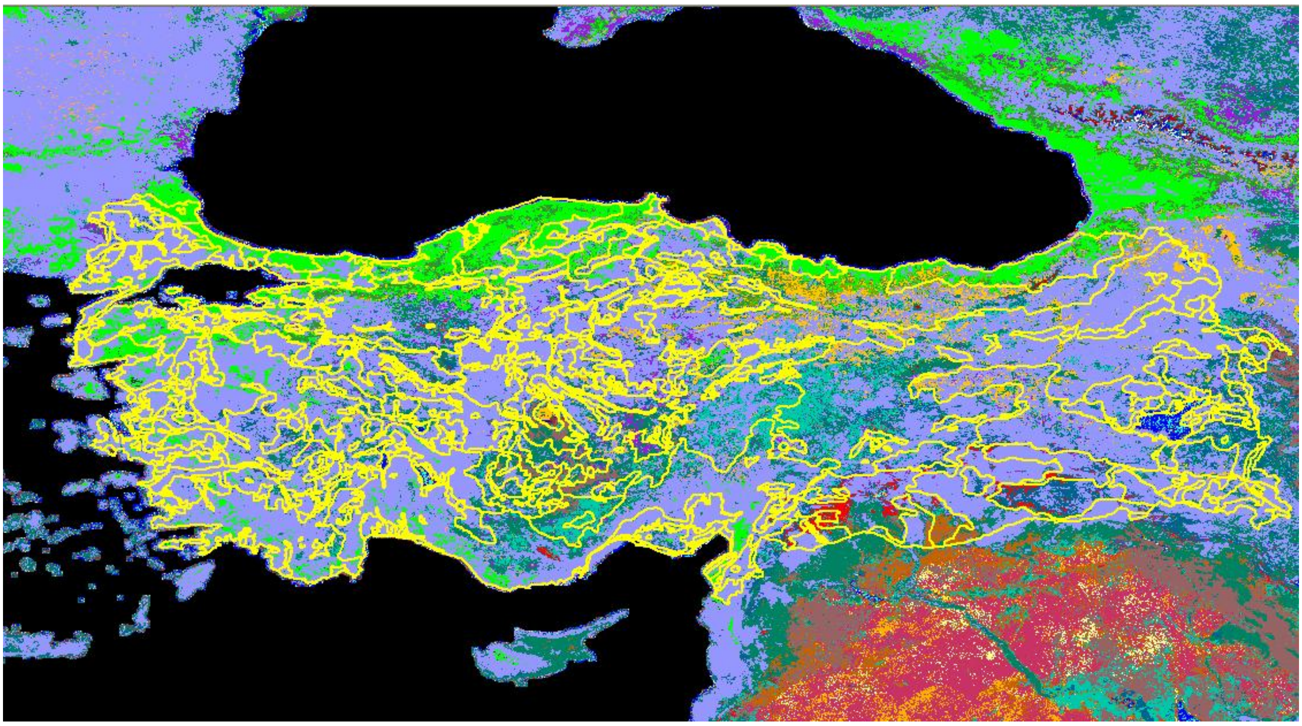
Since we couldn’t find any land cover map for the whole Turkey in the desired format, the Global Land Cover map was used in order to obtain Turkey land use data. Turkey part was cropped from Global Land Cover Map taken from SRTM Turkey images (Map 9). Due to the fact that there were big differences in legend classification between Global land cover and European soil database, some arrangements were performed and some assumptions were taken in order to develop a common legend for the soil database.

Map 9: Global Land Cover Classification of Turkey



After defining the Land Cover legend, the soil map was patched into Google Earth image (Map11). Land cover map (Map 10) and Google Earth image were simultaneously layered and their combination helped us to decide the dominant and secondary land use for each polygon by using also the expert knowledge.

Map 10: Global Land Cover Classification of Turkey with soil polygons.



Map 11: Google Earth image with soil polygons.

Due to the good knowledge of land, it's realized that some part of land cover maps were wrong or not well-identified. Same colour was assigned for bare rock and settlements in the Global Land Cover map legend and this situation could be a problem for the user who doesn't know the study area. For example; there is very big red area in South-East part of Turkey that can be seen in Figures 9. When we looked at Google Earth Image (Figure 10), we can realize that those places are not settlements. It was useful using Google Earth image in those cases.

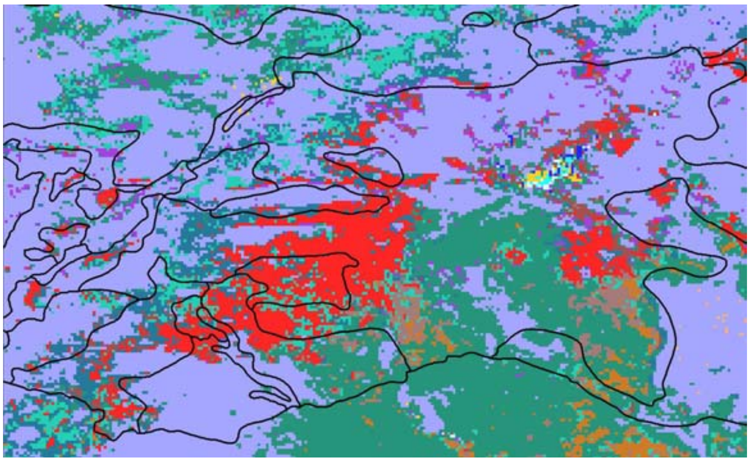


Figure 9: Detailed view of South-East part of Turkey from Global Land Cover Map

Figure 10 : Detailed view of South-East part of Turkey from Google Earth image

Moreover, some areas, where are undistinguished in first sight (Figure 11), were classified very detailed in global land cover map (Figure 12) instead Google Earth. For example; when looking detailed in Google Earth Image (Figure 12), forest types couldn't be differentiated. Instead, in Figure 11, different classes can be seen and assigned as secondary land use with the help of reclassified raster image technology of Global Land Cover.

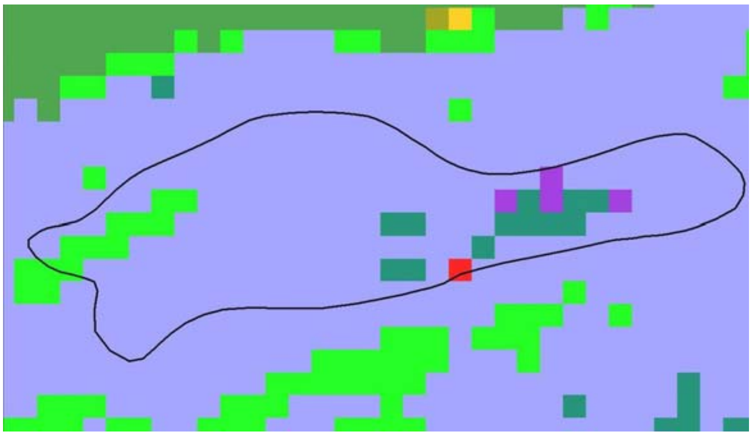


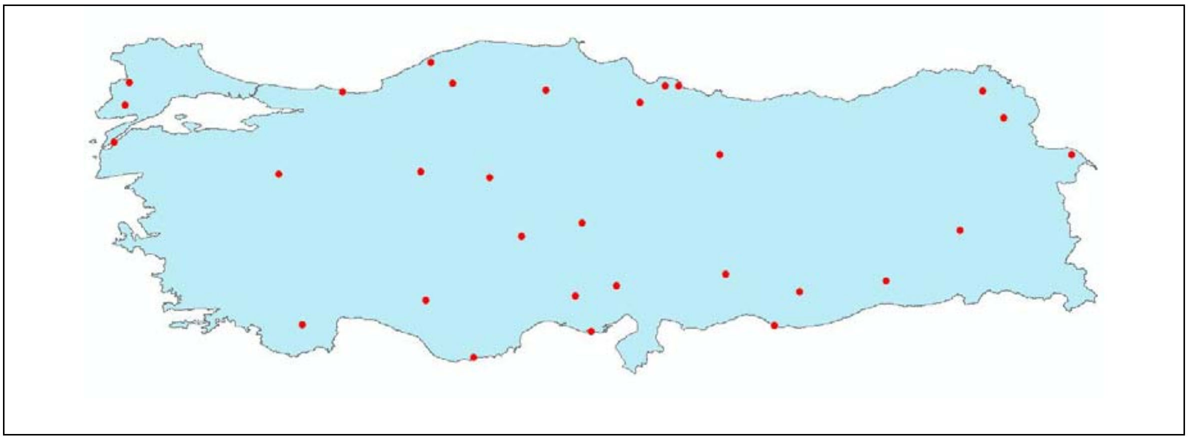
Figure 11: Detailed view of west part of Turkey from Global Land Cover Map

Figure 12: Detailed view of west part of Turkey from Google Earth image

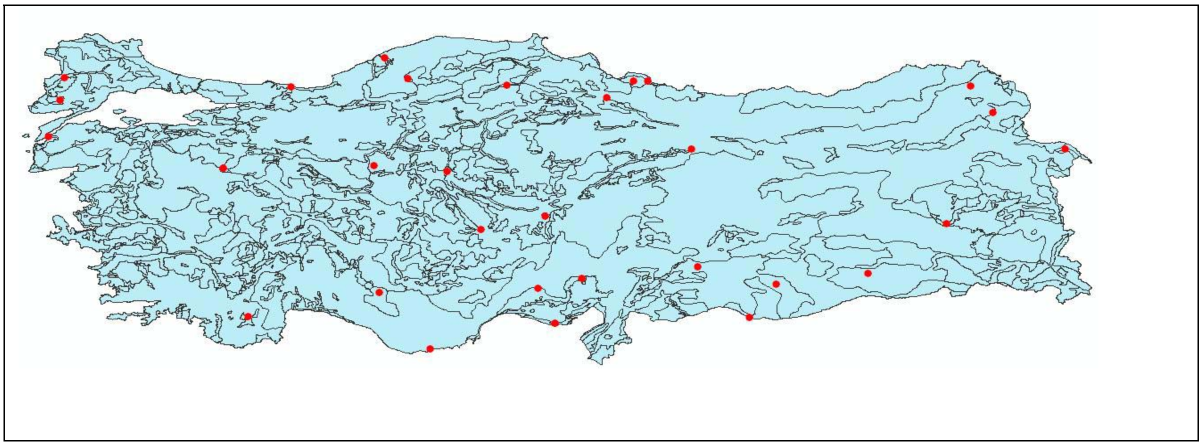
4.3.2.4 ***Measured soil profile data***

There were some information about 31 measured soil profiles but the geographic places of them were not known in map format. Those soil profiles have been assigned coordinates (Map 12) and we manage to locate their corresponding polygon (Map 13).

Map 12: Geographic locations of measured soil profiles



Map 13: Corresponded polygons of measured soil profile points



The measured data for soil profiles are recorded in "Measured profiles" table. These data represent soil profile measurements and descriptions in the field, as well as analyses of soil samples in the laboratory. These data can be used in further studies for Turkey soil database in detailed scales. Measured profiles table is also prepared for 31 soil profile according to desired format. Attribute table of measured profiles can be seen Table 22.

Table 22: Example of attribute table of measured profiles

Country CY	STU	MEAS_PRF_N	Soil Name: WRB-GRP	WRB-ADJ	WRB-CMP	FAO90-MG	FAO90-UNI	FAO90-SUB	Location: LAT	LONG	ELEV	PAR-MAT	Water Regime: TWT	HGWT	LGWT	USE-DOM	Root Depth: ROO	ROC	OBS	HRZ	DEP	STR	COL	Texture: Clay	ESD	SLT	ESD	SD1	ESD	SD2	ESD	SD3	ESD	Stones gravel	OC: VAL	COD
TR		900001	AN	ANtf		AN	ANh		42°16'	38°30'	100	3710	0	3	5	1	30	50	50	A	9	6	10YR5/4	18.4	2	31.60	50	10.2	200	25.6	500	14.2	2000	3	0.00	3
																				A2	19	6	10YR5/4	18.6	2	34.80	50	11.5	200	27.5	500	17.6	2000	3	0	
																				A3	29	9	10YR6/4	7.7	2	22.40	50	10.5	200	32.4	500	27.0	2000	4	0	
																				C	41	9	10YR2/1	5.7	2	20.20	50	9.8	200	40.5	500	24.8	2000	4	0	
		900002	LP	LPli		LP	LPq		33°27'	39°29'	1400	2111	0	3	5	5	35	50	35	A	8	9	2.5Y5/3	16.6	2	39.70	50	0	200	43.7	500	0	2000	3	0.68	
																				A2	37	4	10YR3/3	21.4	2	32.10	50	0	200	43.5	500	0	2000	3	0.98	
																				C	50	8	2.5Y5/4	15.8	2	33.20	50	0	200	51.0	500	0	2000	3	0.43	
		900003	FL	FLca		FL	FLc		33°9'	36°4'	10	5412	1	2	4	16				Ap	11	8	5YR5/3	28.6	2	53.00	50		200	18.4	500		2000	0	0.23	
																				C1	33	5	2.5Y4/2	30.2	2	55.00	50		200	14.8	500		2000	0	0.49	
																				C2	46	8	2.5Y4/2	30.6	2	53.00	50		200	16.4	500		2000	0	0.35	
																				C3	85	8	2.5Y5/3	26.4	2	59.00	50		200	14.6	500		2000	0	0.2	
																				C4	156	8	2.5Y5/4	22.6	2	65.00	50		200	12.4	500		2000	0	0.24	
		900004	CM	CMca		CM	CMc		32°09'	39°36'	1000	5520	0	3	5	3	130	150	30	Ap	15	6	7.5YR4/4	50	2	32.20	50		200	17.8	500		2000	0	1.41	
																				Ad	29	8	7.5YR3/4	52.3	2	31.60	50		200	16.1	500		2000	0	1.15	
																				Bw1	58	4	7.5YR3/4	60.9	2	24.00	50		200	15.1	500		2000	0	0.77	
																				Bw2	82	4	7.5YR4/6	55.9	2	25.00	50		200	19.1	500		2000	0	0.12	
																				BC	95	4	7.5YR4/4	51.1	2	25.60	50		200	23.3	500		2000	0	0.01	
																				C	150	8	7.5YR6/4	26.3	2	37.60	50		200	36.1	500		2000	0	0.35	
		900005	CL	CLca		CL	CLh		34°03'	38°23'	900	5410	0	3	5	3	120	150	40	Ap	16	6	7.5YR7/3	42	2	23.40	50		200	34.6	500		2000	0	0.77	
																				Ad	36	8	7.5YR7/3	45.6	2	20.10	50		200	34.3	500		2000	0	0.59	
																				Bw	77	5	7.5YR7/4	46.6	2	17.80	50		200	35.6	500		2000	0	0.16	
																				Bk	107	8	7.5YR6/4	50.7	2	18.20	50		200	31.1	500		2000	0	0.19	
																				Ck	140	8	7.5YR8/4	37.7	2	25.50	50		200	36.8	500		2000	0	0.05	
		900006	AR	ARca		AR	ARh		35°21'	36°36'	0	10	0	2	3	16	100	200	100	A	10	9	10YR6/2	1.2	2	3.50	50		200	95.3	500		2000	0	0.03	
																				C	100	9	10YR6/1	1.3	2	3.20	50		200	95.5	500		2000	0	0.01	
		900007	VR	VReu		VR	VRe		26°41'	41°16'	60	2117	1	3	4	13	140	200	80	Ap	30	6	5Y4/2	47	2	23.00	50		200	30.0	500		2000	0	1.6	
																				Ad	76	2	5Y4/1	47	2	21.00	50		200	32.0	500		2000	0	1.42	
																				A3ss	96	2	5Y4/1	74	2	15.00	50		200	11.0	500		2000	0	1.06	
																				C1	142	8	5Y5/2	77	2	14.00	50		200	9.0	500		2000	0	0.99	
																				C2	200	8	5Y5/3	70	2	15.00	50		200	15.0	500		2000	0	0.89	
		900008	KS	KSha		KS	KSh		43°05'	40°36'	1800	2113	0	2	5	19	100	150	100	A1	22	6	10YR6/4	33.28	2	44.72	50		200	22.0	500		2000	3	1.01	
																				A2	41	5	10YR6/3	25.28	2	42.72	50		200	32.0	500		2000	2	1.06	
																				BC	56	5	10YR6/3	29.28	2	35.72	50		200	35.0	500		2000	2	0.96	
																				C	100	8	10YR8/3	0	2	0.00	50		200	0.0	500		2000	5	0	
		900009	CM	CMca		CM	CMc		35°03'	37°16	2000	2110	0	3	4	5	100	150	80	Ao	2	6	10YR3/2	27.28	2	22.72	50		200	50.0	500		2000	0	4.74	
																				A1	26	6	10YR3/4	37.28	2	24.72	50		200	38.0	500		2000	0	2.1	
																				AC	44	9	10YR4/4	45.28	2	26.72	50		200	28.0	500		2000	0	1.22	
																				C1	108	8	2.5Y7/4	49.28	2	26.72	50		200	24.0	500		2000	4	0.35	
		900010	LP	LPum		LP	LPu		42°41'	41°07'	1500	3130	0	3	4	19	90	180	90	A1	9	6	10YR4/3	36.7	2	25.00	50		200	38.3	500		2000	0	1.35	
																				A12	12	6	10YR3/3	46.5	2	22.80	50		200	30.7	500		2000	0	0.87	
																				Bw	92	2	10YR3/3	48.9	2	20.10	50		200	31.0	500		2000	0	0	
																				C	150	8	10YR5/2	0	2	0.00	50		200	0.0	500		2000	0	0	
		900011	FL	FLmo		FL	FLm		29°30'	39°33'	0	1000	1	1	4	15	150	200	50	Ap	16	6	10YR3/2	63.9	2	26.30	50		200	9.8	500		2000	0	1.44	
																				C1	52	4	10YR4/2	71	2	23.10	50		200	5.9	500		2000	0	1.22	
																				C2	150	4	10YR4/2	84.7	2	7.30	50		200	8.0	500		2000	0	0.83	

4.4 Deliverables

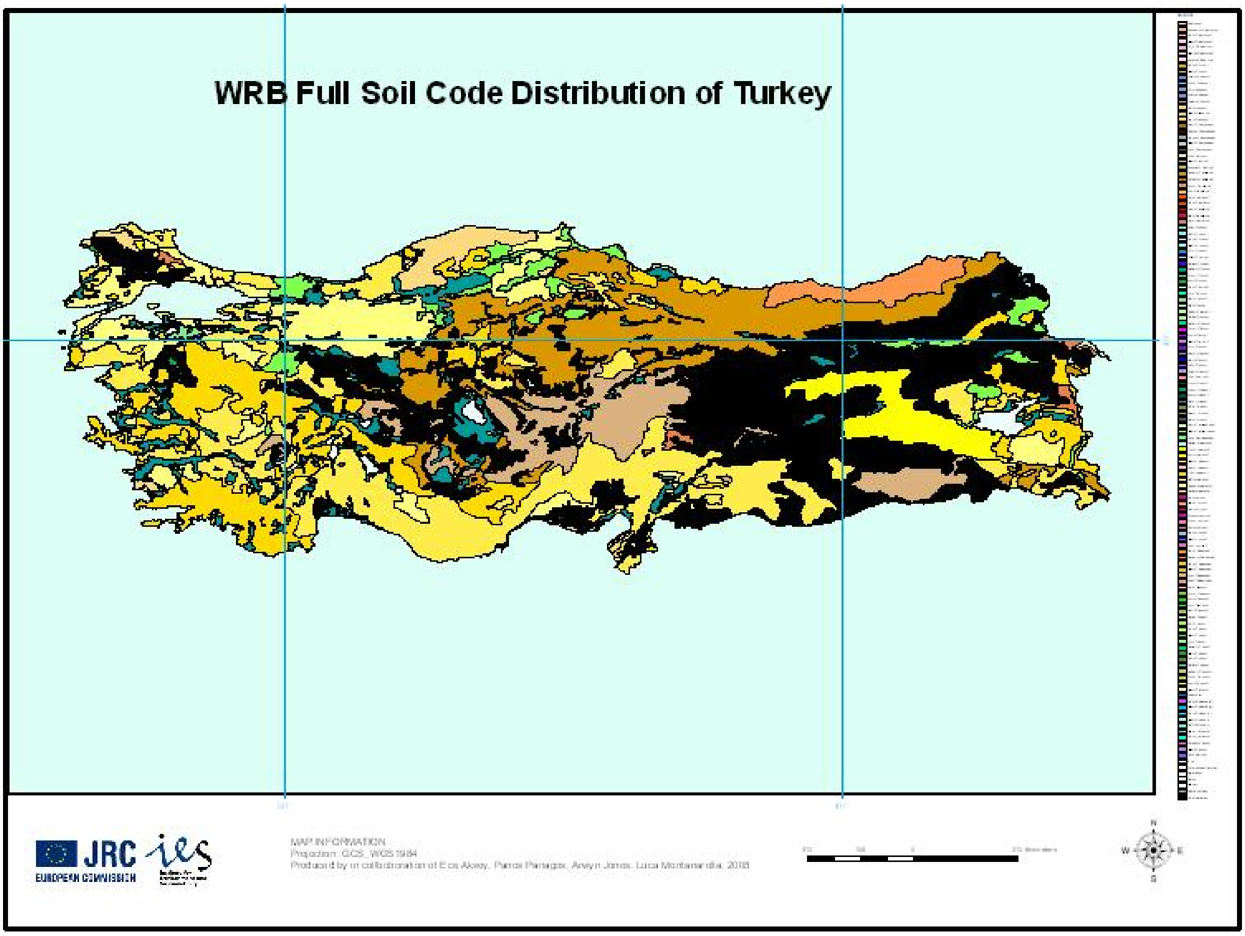
The list of deliverables of the current can be seen below:

1. The Soil database of Turkey that is compatible with European soil database structure of Version 4.0.
2. Thematic maps of variables that are in soil database;
    a. WRB Full Soil Code Distribution of Turkey
    b. 1990 FAO full soil code distribution of Turkey
    c. Dominant slope class distribution of Turkey
    d. Secondary slope class distribution of Turkey
    e. Dominant parent material distribution of Turkey
    f. Secondary parent material distribution of Turkey
    g. Dominant land use distribution of Turkey
    h. Secondary land use distribution of Turkey
    i. Dominant surface textural class distribution of Turkey
    j. Dominant sub-surface textural class distribution of Turkey

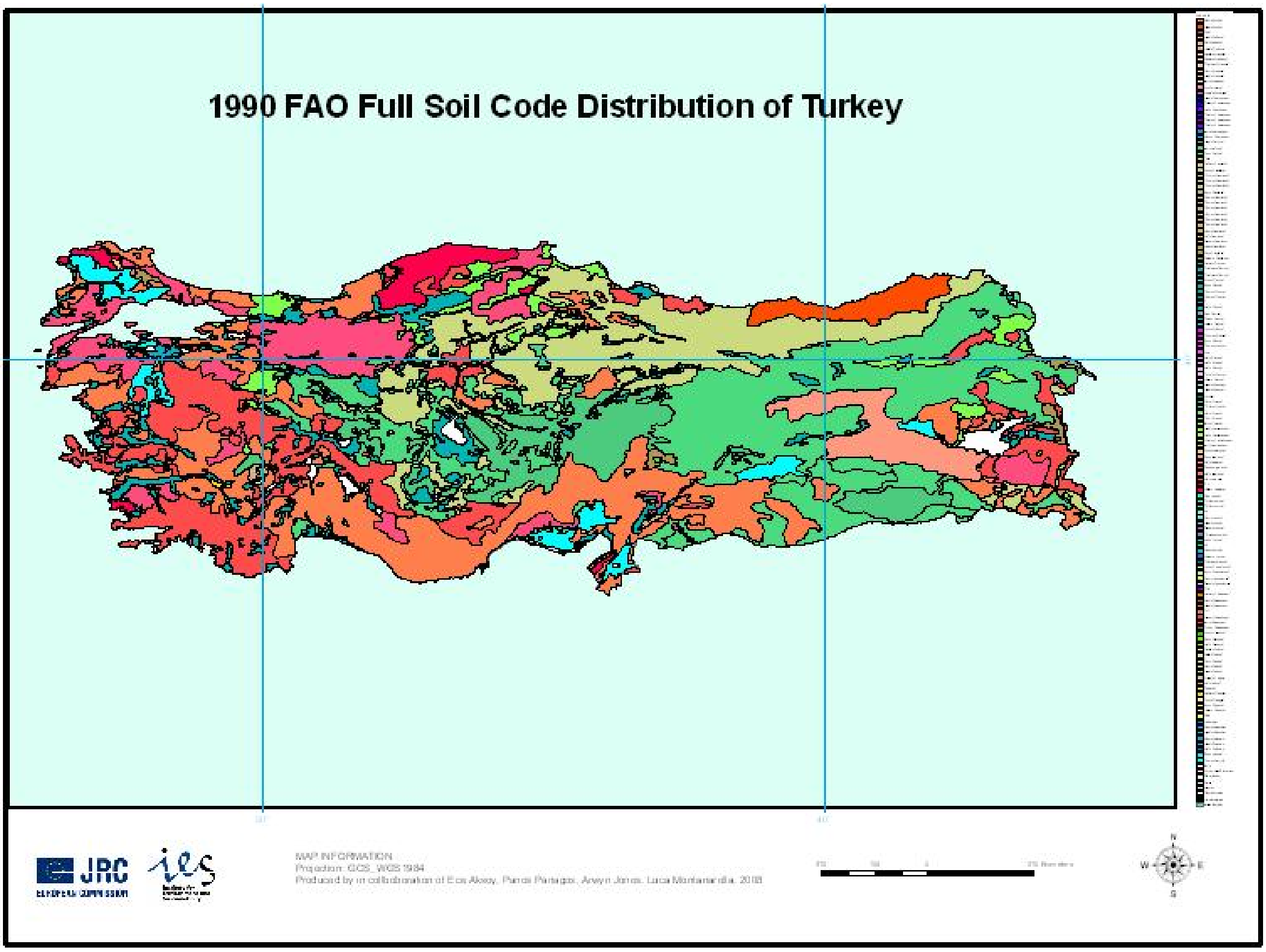
The Thematic maps were prepared by using ESRI ArcGIS software and their corresponding legends were created according to “Legends of the European Soil Database (ESDB)”.

The most important could be considered the WRB thematic map which is prepared according to the full WRB code. In case that no colours for the full codes could be found in the Turkish case (CLlv, VRcc and VReu) the black color was used for them.

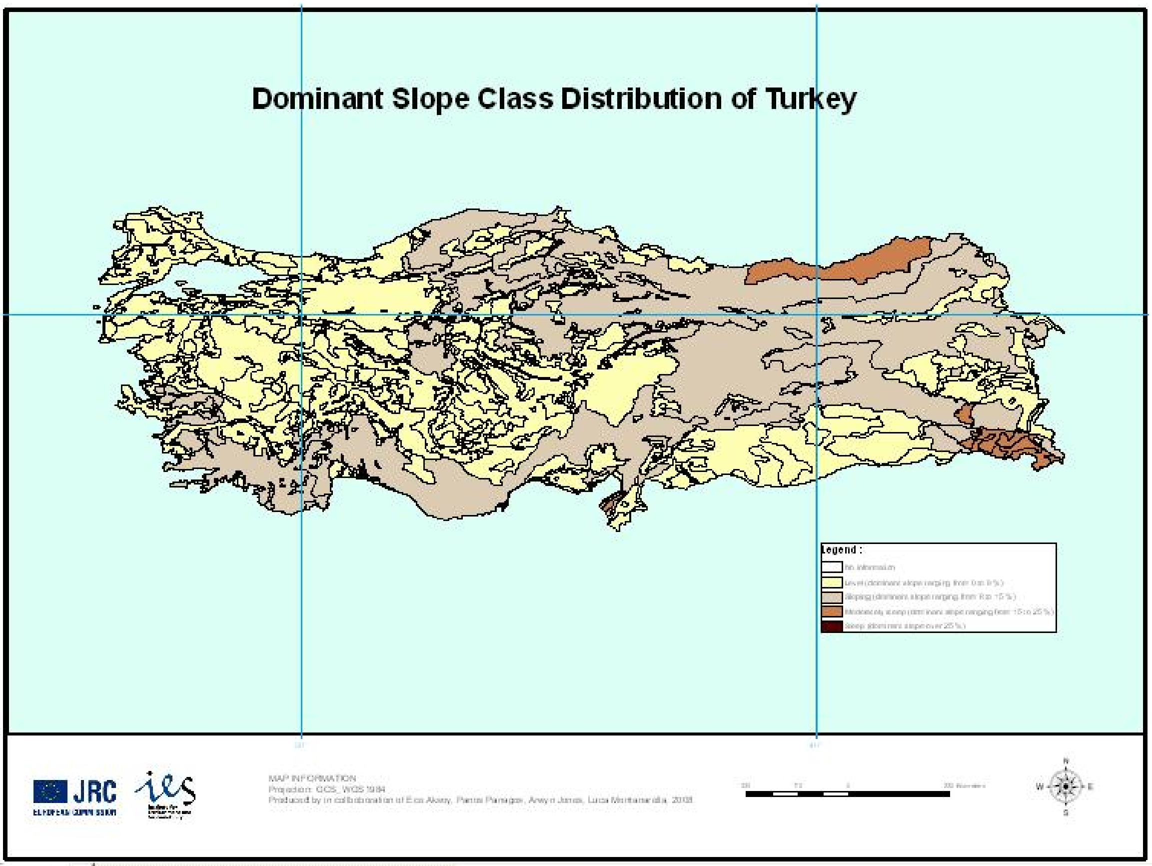
Map 14: WRB full soil code distribution of Turkey



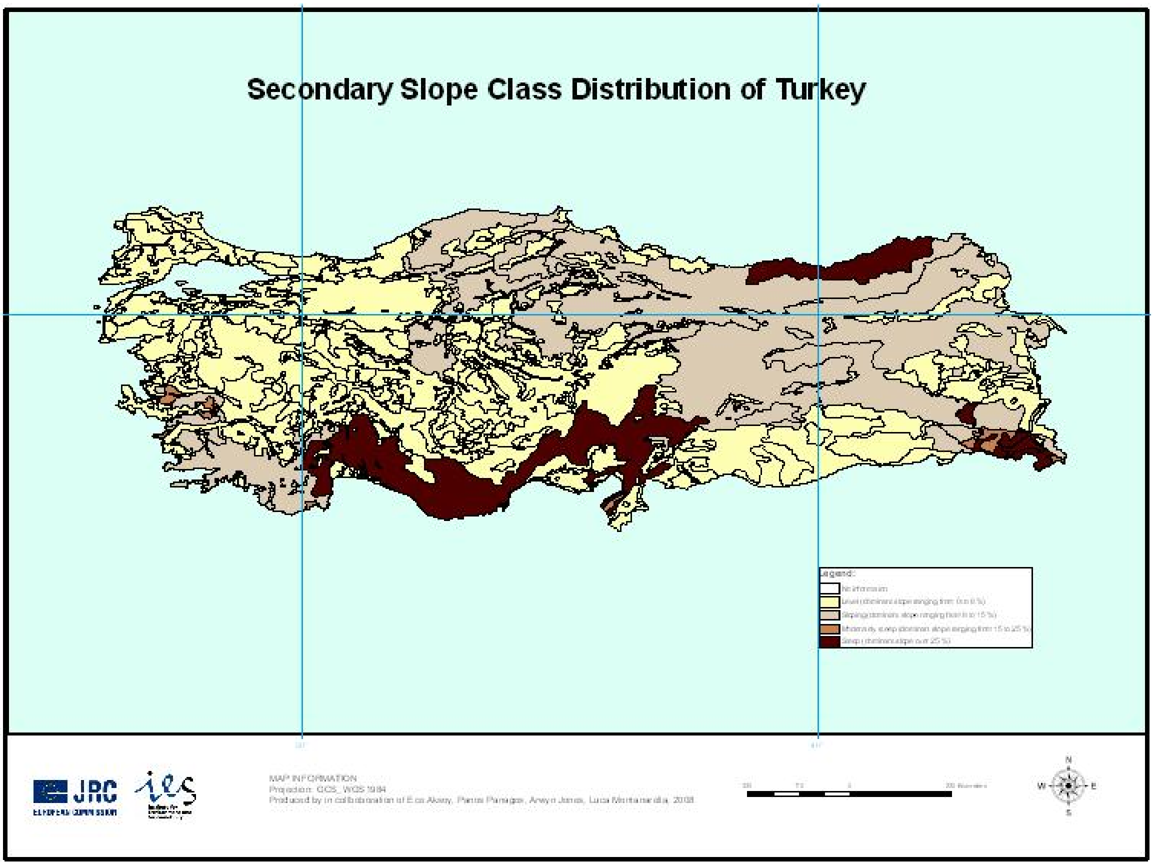
Map 15: 1990 FAO full soil code distribution of Turkey



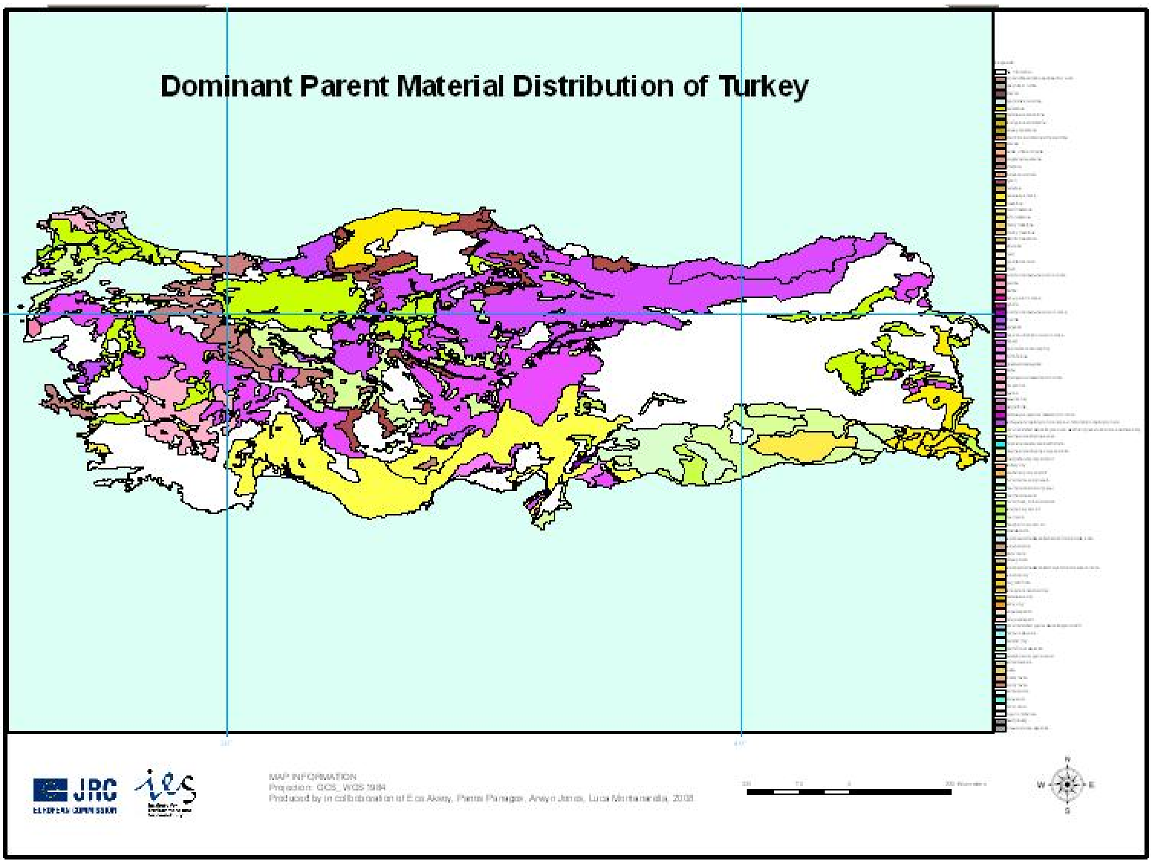
Map 16: Dominant slope class distribution of Turkey



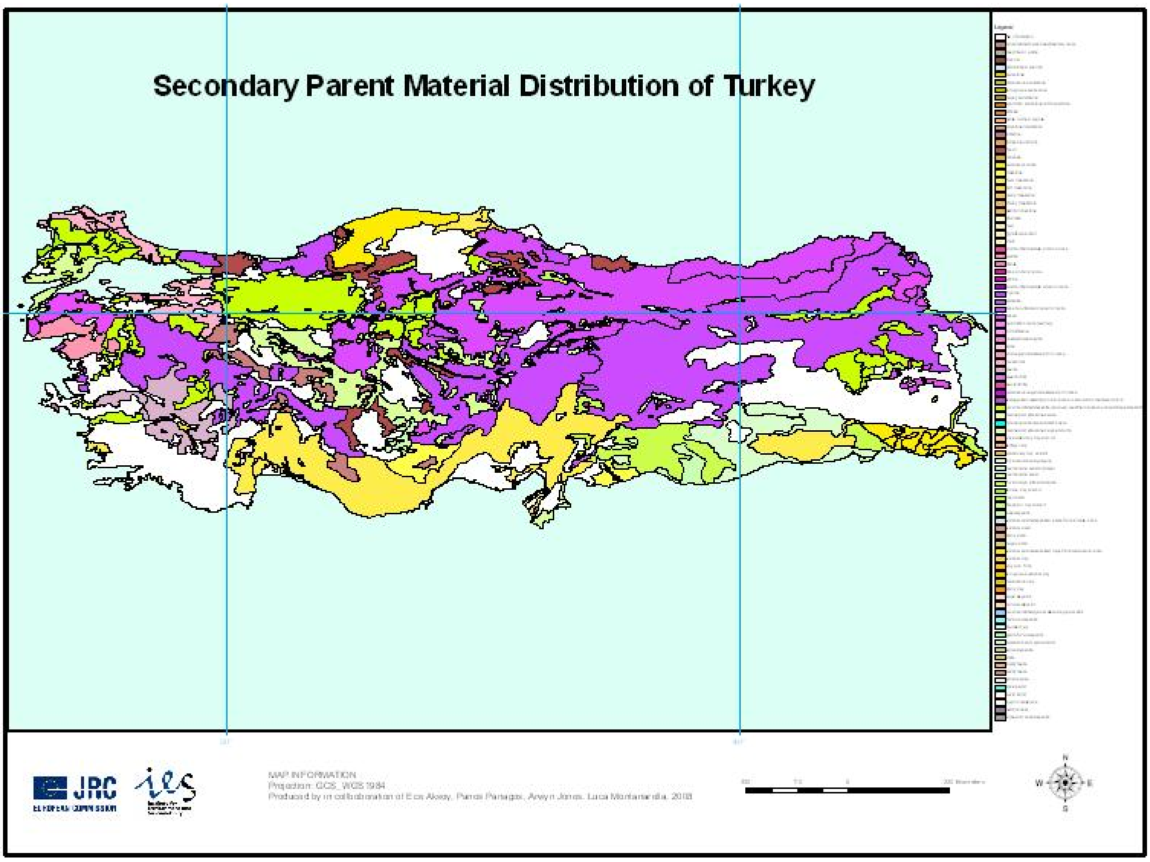
Map 17: Secondary slope class distribution of Turkey



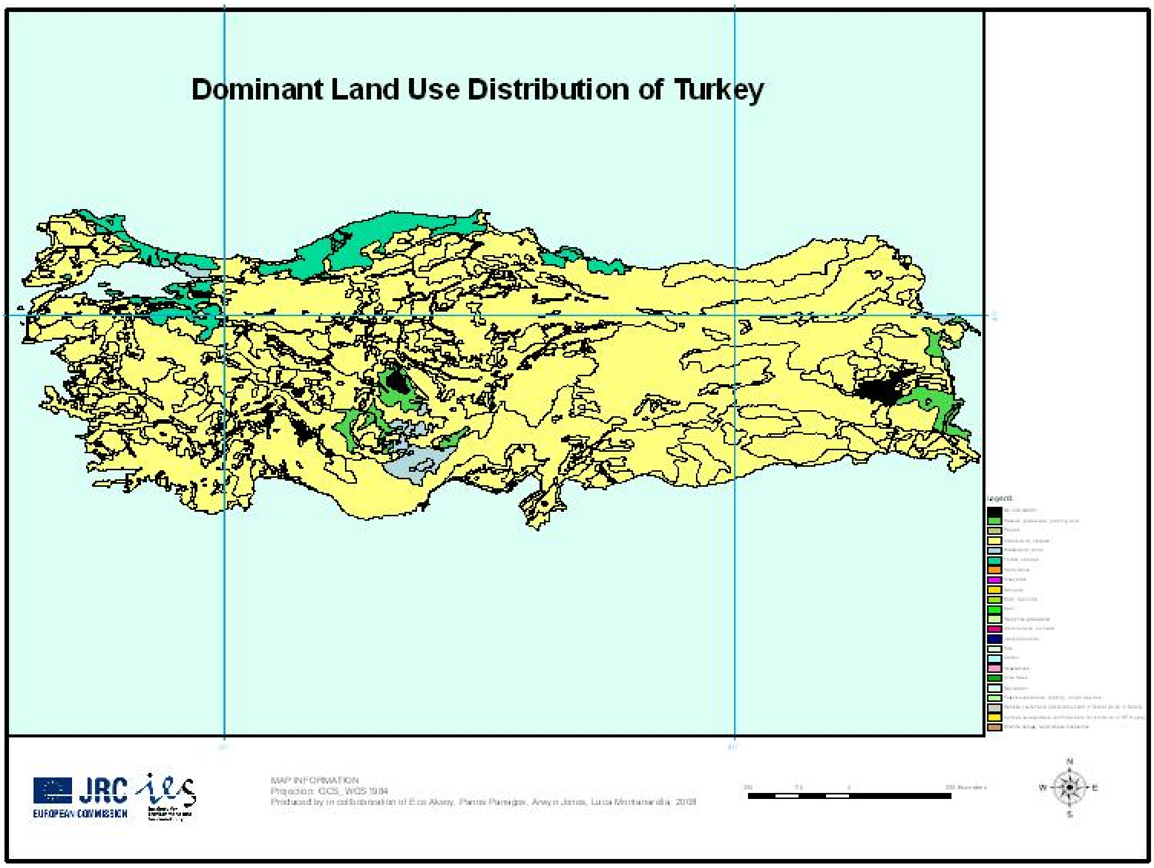
Map 18: Dominant parent material distribution of Turkey



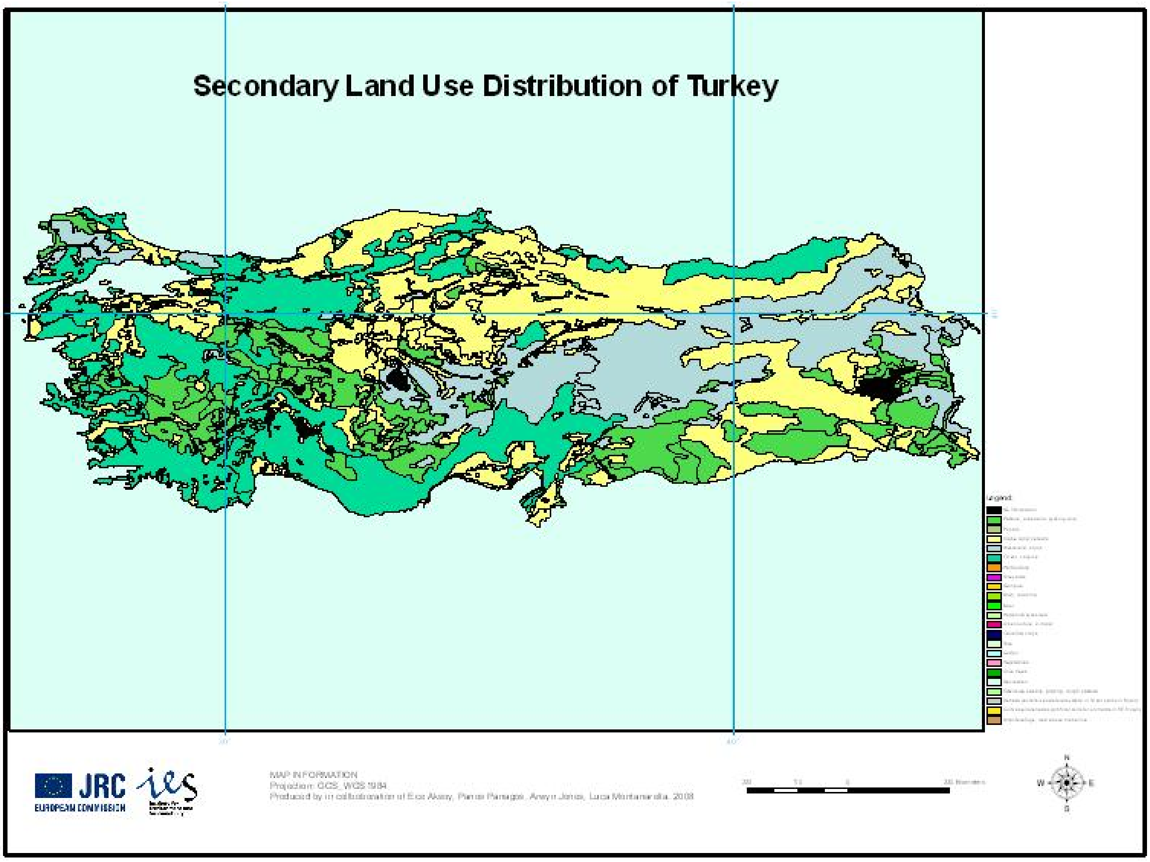
Map 19: Secondary parent material distribution of Turkey



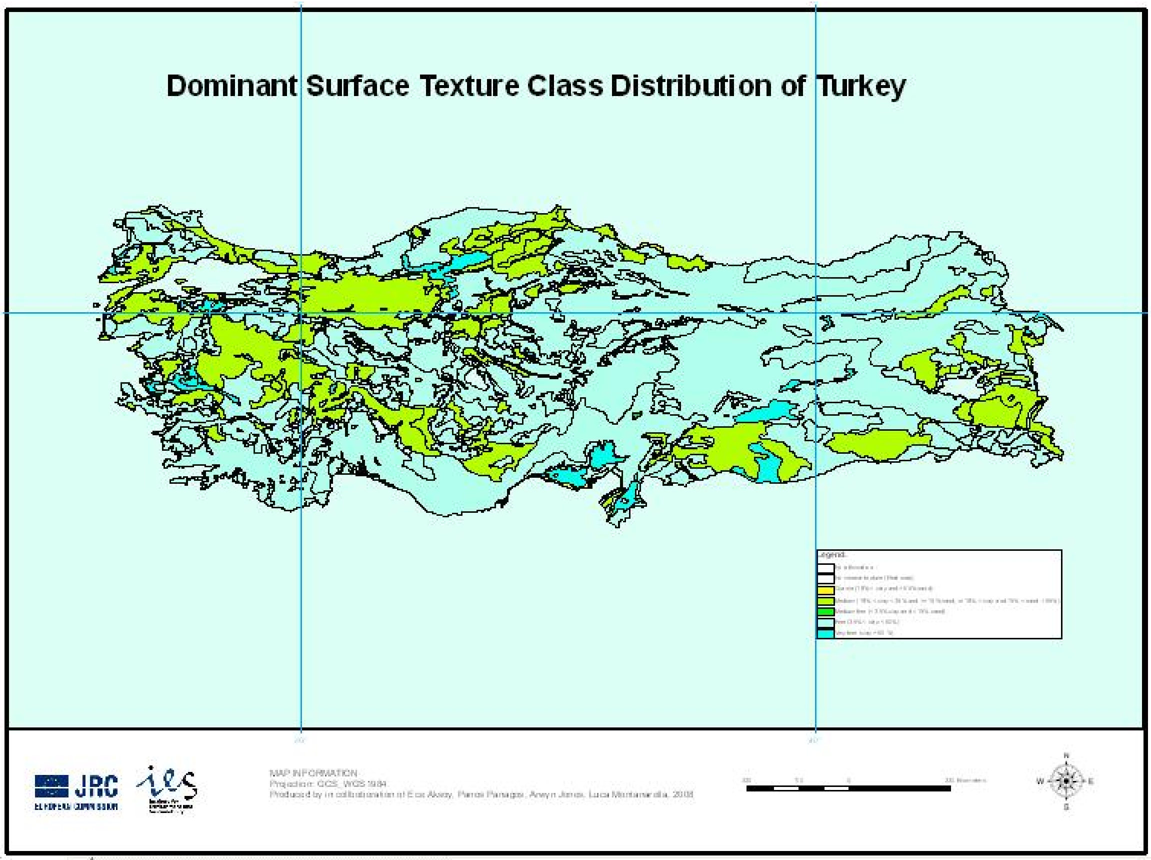
Map 20: Dominant land use distribution of Turkey



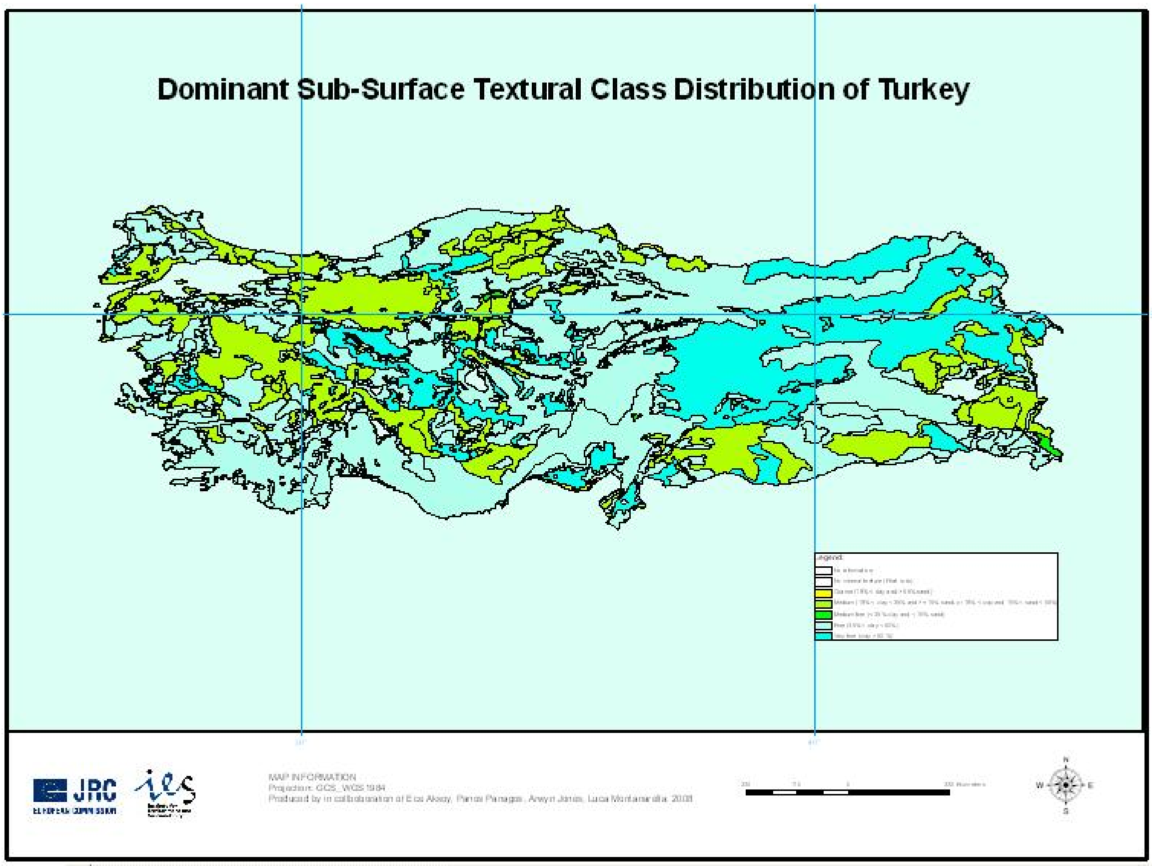
Map 21: Secondary land use distribution of Turkey



Map 22: Dominant surface textural class distribution of Turkey



Map 23: Dominant sub-surface textural class distribution of Turkey



5. FUTURE WORKS FOR TURKEY

Future works can be summarized as below:

- Obtaining lacking soil data (AGLIM1, AGLIM2, TEXT-DEP-CHG, ROO, IL, WR, WM1, WM2 and CFL)
- Preparing detailed land use map
- Enriching measured soil profiles
- Interpolation of measured soil data

Some variables of the soil database such as AGLIM1, AGLIM2, TEXT-DEP-CHG, ROO, IL, WR, WM1, WM2 and CFL (Table 21) couldn't be filled due to the lacking data. Those data should also be obtained from other sources and the soil database should be completed.

As referred before in section 2.1 and 2.4, even though, there are a lot of studies/articles about land cover, land use and distribution of land capability classes, there is no common territorial land use map of Turkey. The need for making detailed and up-to-date studies of land use& land classification is increasing. This is really a major bottleneck for academic and any other regional studies in Turkey. For this purpose, there is an urgent need for publishing official and territorial land cover and classification maps of Turkey for data harmonisation and common usage by corresponding ministries and research institutes.

Some measured soil profiles exist from different part of Turkey as explained in section 4.3.2.4. Actually there are a lot of detailed studies made at university level and Agricultural Ministry. Number of these soil profiles can be increased and more detailed soil maps can be made in different scales for Turkey by using also some geostatistics implementation. By using these statistic methods and interpolation techniques, continuous surfaces can be obtaining from those measured profiles points.

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Abstract
Developing the Version 4 of the Soil Geographical Database at scale 1:1,000,000 aims that providing a harmonised set of soil parameters covering Eurasia and Mediterranean countries for use in agro-meteorological and environmental modelling at regional, national, and continental levels. In this context, the expansion into the Mediterranean Basin will eventually include Turkey. In order to extend the Soil Geographical Database (SGDBE) to the countries of Mediterranean Basin, the preparation of soil geographical database of Turkey at 1:1 million scales was initiated at the end of 2008. In the current report, the reader will be informed about the preparation of soil geographical database of Turkey compatible with European database and how the Turkish soil data have been integrated the European Soil Database. The implementation of this work has been achieved since we have built a common understanding and nomenclature of soils in Europe and Mediterranean region. A number of attributes have been transformed from local/regional/national soil datasets while some other attributes have been obtained from auxiliary datasets using remote sensing and GIS Techniques.

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