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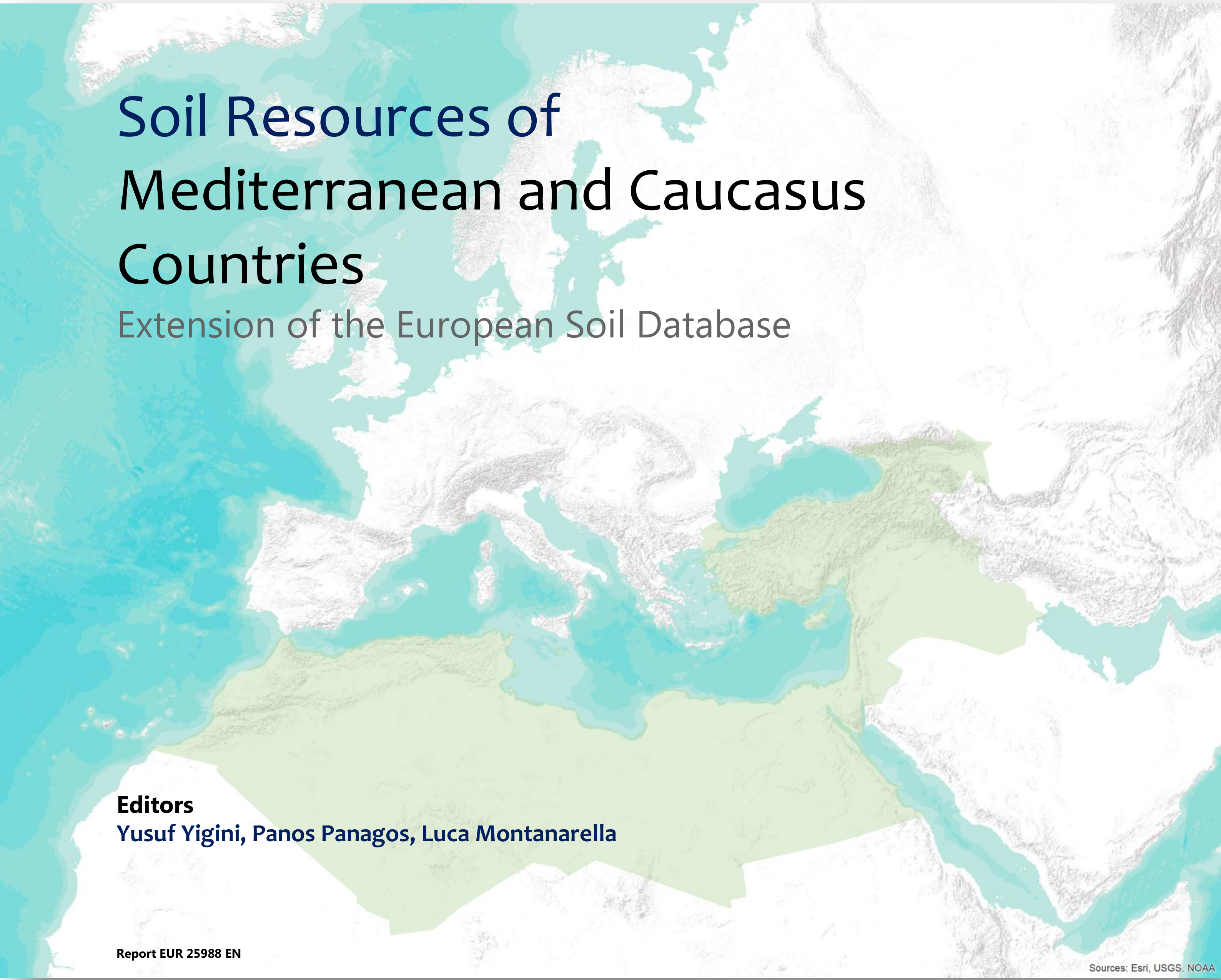

Soil Resources of Mediterranean and Caucasus Countries

Extension of the European Soil Database

Editors
Yusuf Yigini, Panos Panagos, Luca Montanarella

Report EUR 25988 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for Environment and Sustainability

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This publication is a Reference Report by the Joint Research Centre of the European Commission.

JRC80174

EUR 25988EN

ISBN 978-92-79-30346-3

ISSN 1831-9424

doi: 10.2788/91322

Luxembourg: Publications Office of the European Union, 2013

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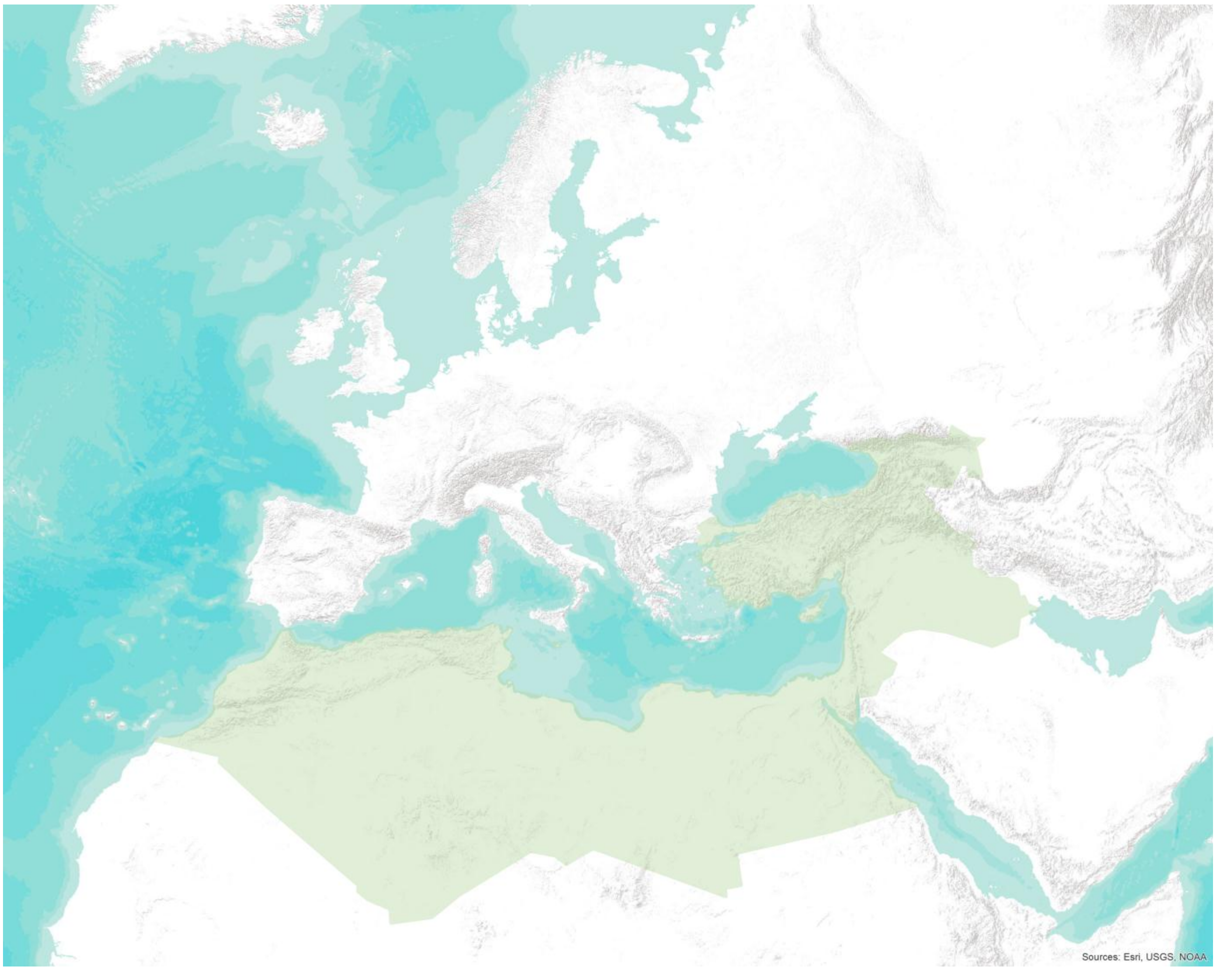

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2013

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Cover Map
U.S. Geological Survey, Tele Atlas, AND, and ESRI

Papers in this report should be cited, with Author(s), date, title and pages numbers, as:
In: "Soil Resources of Mediterranean and Caucasus Countries", Y. Yigini, P. Panagos, and L. Montanarella, (eds). (2013), . Office for Official
Publications of the European Communities, Luxembourg.

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Editor's Note

The editors thank all of the authors who contributed their time, insights, and energy to completing the chapters that form this book.

The Soil Geographical Database of Eurasia at scale 1:1,000,000 is part of the European Soil Information System (EUSIS). It is the resulting product of a collaborative project involving all the European Union and neighbouring countries. It is a simplified representation of the diversity and spatial variability of the soil coverage. The aim of the database is to provide a harmonised set of soil parameters, covering Europe and neighbouring countries, to be used in agro-meteorological and environmental modeling at regional, national, and/or continental levels. The database has been recently extended to cover countries in the Mediterranean basin, the Russian Federation, Ukraine, Belarus and Moldova, formerly part of the Soviet Union. A further objective is to extend the coverage to the Caucasus, Mediterranean and Middle East Countries. In this context, the European Commission, Joint Research Centre, SOIL action invited experts from those countries to extend the coverage of the European Soil Database.

This book is result of the workshop on "Extension of the European Soil Database" held in Izmir/Turkey on 14-15 May 2012. The country reports on the status of soil mapping and the development of national soil information systems were presented briefly and discussed in relation to the objective on extension of the European soil database and information system.

The most recent extension studies cover Algeria, Armenia, Azerbaijan Cyprus, Egypt, Georgia, Iraq, Israel, Jordan, Lebanon, Libya, Malta, Morocco, Palestine, Syria, Tunisia, and Turkey this book features country chapters, with contributions from 13 of the above-mentioned countries.

The exchange of views and the fuller understanding of the needs and potential contributions of each of the countries that resulted from this meeting will facilitate enhanced cooperation in the future. The conclusions and recommendations set some priorities for immediate and longer term action.

Yusuf Yigini, Panos Panagos, Luca Montanarella

Chapter I.
Soil Resources of Armenia

SOILS OF ARMENIA

H. Ghazaryan[1]

ABSTRACT

The present article is dedicated to the generalization of data obtained in the framework of the preparation of Armenian portion of European Soil Database. Briefly described geography of Armenia. Great variability of soil variants represented in Armenia is recorded. It is shown that nearly all zonal soil types those are developed not only in the region of Little Caucasus and the Armenian Volcanic Plateau but also in the mountain system of the Big Caucasus, are available in Armenia's territory. In general the soils in the country are classified to 14 types and 27 subtypes which include a lot of families, varieties and species of soils; total number of soil kinds is 228. Brief description is presented of main soil types including area coverage in the country, altitudinal range, distribution, natural conditions (climate, forming rocks, etc.), structure and composition, current and prospective usage. Distributional map of zonal soils in the country is given.

Keywords: Armenia, classification, natural-soil zones, types of soil, soil use.

Armenia has an area of 30 thousand km^2. Mountains make about 70% of the country's territory. The average altitude is 1,800 meters above sea level (a.s.l.). About 90% of the territory is located above 1,000 meters.

The great diversity of bioclimatic and lithological-geometric conditions as well as the long and diverse land use has led to formation of different soil types. The most common types are mountainous-meadow (Umbrisols), mountainous meadow-prairie (Phaeozems), mountainous brown forest, mountainous cinnamonic forest (the last two types, together with the forest humus-calcareous types are joined in the Reference soil group of Acrisols), mountainous black soils (Chernozems), mountainous chestnut (Кastanozems), and mountainous brown semidesert (Calcisols) soils. In addition to the zonal soil types, the following intra-zonal soil types are developed in the territory: bottomland-marshy, bottomland-meadow, meadow-brown irrigated (crop – irrigable), meadow-black soil, sod-carbonate, alkaline paleohydromorphic, saline-alkaline hydromorphic, etc. In general Armenia has 14 types, 27 subtypes, and a lot of families, varieties and species of soils. The total number of soils is 228.

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The general characteristics of natural-soil zones of Armenia are shown in Table 1.

Table 1. Natural-soil zones and soil types in Armenia

Natural-soil zone	Soil types	RSG (respective soil group)	Territory		Altitudes
			Thousand ha	%	
Semidesert	1.Semidesert brown 2.Irrigated meadow-brown 3 Paleohydromorphic 4. Saline-alkaline hydromorphic	Calcisols Antrosols Solonetz-Solonchaks Solonetz-Solonchaks	152.0 53.0 2.0 29.0	5.8 2.0 0.1 1.1	850-1250
Dry-prairie	Mountainous chestnut	Kastanozems	242	9.2	1250-1900
Prairie	1. Mountainous blacksoils 2. Meadow blacksoils 3. Bottomland – terraced 4. Soils of Lake Sevan	Chernozems Chernozems Antrosols Regosols and rocк outcrops	718.0 13.0 48.0 18.0	27.4 0.5 1.8 0.7	1300-2450
Forest	1. Mountainous-brown forest 2. Mountainous sod – carbonate forest + 3. Mountainous cinnamonic forest	Acrisols Acrisols Acrisols	133.0 15.0 564.0	5.2 0.6 21.6	500-2400
Mountainous - meadow	1. Mountainous - meadow 2. Mountainous - meadow prairie	Umbrisols Phaeozems	346 283	13.2 10.8	2200-4095
Total area			2616.0	100.0	

In addition to the area of soil types listed in Table 1, nearly 358,000 hectares of the country are covered by the rock outcrops, sands, infrastructure and residential zones.

For better and more detailed understanding of characteristics of Armenian soils see Table 2 and Map on Figure 1 (in the map are presented mainly zonal types of soils).

Table 2. Some characteristics of soils of Armenia

	TYPES OF SOIL	**Area(ha)**
1	Mountain-meadow	346000
2	Meadow- prairie	283000
3	Fulvous forest	133000
4	Pre-purulent-carbonate	15000
5	Brown forest	564000
6	Mountain black earth	718000
7	Meadow-black earth	13000
8	Mountain chestnut	242000
9	Mountain fulvous semi-desert	152000
10	Irrigated meadow-fulvous semi-desert	53000

11	floodland-terraced	48000
12	Saline-alkali hydromorph	29000
13	Poleo-hydromorph poured saline	23000
14	Soils of Lake Sevan	18000
	output of native rocks	101000
	soils under water, structures, and roads	257000

1 Mountain-meadow

Area(ha)	346000
Location	Developed in subalpine and alpine zones on bushy grass stand in conditions of cold climate. Disseminated within the range of altitudes of 2200m-4000m above sea level.
soil-forming rocks	Eluvium and eluvium-talus of andesite-basalts, andesites, pophitites, granites and grano-diorites serve as soil-forming rocks.
Climate	Mountainous, cold, annual average temperature: +1 - -2^{0}C, absolute minimum: -33 - -40^{0}C, sum of temperature over 10^{0}C; approx. 400-700, annual average precipitation: 700mm-1100mm, moistening rate: 2,5-2,5.
Climate	Brown colouring of upper horizons and fulvous colouring in deeper layers. Comparatively week capacity, week differentiation of soil profile.
Structure	Powdery-granular structure of humic horizons.
Mechanical composition	Loamy, considerably skeletal (especially in deep horizons).
Chemical composition	Considerable content of humus (17%-31%), deep leached layer (lack of carbonates), lack of indications of podzol, pH H_2O=4.5-6.2, pH KCl=3.8-5.0.
Usage	

2 Meadow- prairie

Area(ha)	283000
Location	A narrow stripe is stretched between the altitudes of 1800m and 2600m above sea level.
soil-forming rocks	Eluvium and eluvium-talus of andesites, basalts, andesite-basalts, grano-diorites, porphitites serve as soil-forming rocks.
Climate	Moistening rate: 1,0-1,2.
Climate	Black or brown-fulvous colouring of humus horizons with light-brown tint in lower layers.
Structure	Well expressed clumpy-granular structure (upper horizons).
Mechanical composition	Average and heavily loamy.
Chemical composition	Characterized by weekly expressed wash water regime, rather high humic factor (9%-18%), carbonates not available in the entire soil profile, weak sub-acid or neutral reaction: pH H2O=6.0-7.0, pH KCl=5.1-6.2.
Usage	Used in general in haymaking and pastures, rarely for agricultural crops like potato, barley and perennial grasses.

3 Fulvous forest

Area(ha)	133000
Location	These soils normally occupy the north-eastern and north-western shady slopes of mountains between 1300m and 2000m above sea level, and on alight slope they reach 2250m above sea level.

soil-forming rocks	Soil-forming rocks are represented by volcanogenic, sedimentary, and volcano-sedimentary deposits which are covered with loamy-clay layer of different power.
Climate	These soils are formed in conditions of moderately warm, rather humid climate. Average annual temperature of air: +4 - +7^{0}C, sum of temperature over 10^{0}C no more than 1500-2500, annual average precipitation: 570mm-750mm, moistening rate: 1,0-1,5.
Climate	Light-fulvous colouring of soil profile with predominance of yellowish-orange and light orange and light-straw tints, week differentiation of soil profile.
Structure	Granular small-walnut or large-walnut (in lower horizons).
Mechanical composition	Pulverescent-muddy loamy-clay, except for those groups of soils that are formed on products of eolation of porphyrites, granodiorites, etc., poor in alkalis.
Chemical composition	Humus content is 4%-8%, week provision of assimilable nitrogen and phosphorus, good provision of potassium, lack of external indications of podzols, pH H_2O=4.6-5.9.
Usage	Used mainly as timberland
4 Pre-purulent-carbonate	
Area(ha)	15000
Location	These soils occur in separate massives in mountain-fulvous and partially mountain brown forest lands. They are disseminated within the range of 1300m-2250m above sea level.
soil-forming rocks	These soils have been formed on rocks containing a considerable amount of calcium carbonates (limestones, marls, marly limestones).
Climate	These soils are formed in conditions of moderately warm, variably humid climate.
Climate	Black-brown colouring of humus-accumulative and dark-fulvous-brown transitional horizons.
Structure	Small-walnut-granular structure of upper and clumpy-walnut structure of transitional horizons, as well as significant gleization of the entire profile.
Mechanical composition	Mainly loamy and clay.
Chemical composition	These soils are distinguished by large content of humus (in upper layers: 7.4-11.3%), in leached soils pH H_2O=7.0-7.4.
Usage	Mainly used for pastures and haymaking, with partial processing.
5 Brown forest	
Area(ha)	564000
Location	These soils are disseminated within the range of 500m-1700m above sea level, and on the southern dry slopes they reach to the point of 2400m.
soil-forming rocks	Products of deflation of pophyrites, dolomites, marls, limestones, grain conglomerates, tuf-breccia, grano-diorites serve as soil-forming rocks. They are mainly represented by dealluvial and eluvial-dealluvial carbonates and leach loams, rare clays with 1.5m-2.0m and more capacity.
Climate	These soils are formed in conditions of moderately warm, variably humid climate. Annual average air temperature: +8-11^{0}C, sum of temperature over 10^{0}C no more than 2450-3600, annual average precipitation: 450-560мм, moistening rate: 0,70-0,75.

Climate	Brown colouring of humus-accumulative horizons, considerable capacity and differentiation of genetic horizons.
Structure	Small-clumpy-granular structure of upper horizons and walnut-clumpy in central horizons.
Mechanical composition	Loamy and clay.
Chemical composition	Humus content is 9%.9-14%, weak provision of assimilable nitrogen and phosphorus, average and good provision of potassium, pH H_2O=6.6-7.8.
Usage	Used for cereal crops, tobacco, vineyard, fruits and subtropical planting.
6 Mountain black earth	
Area(ha)	718000
Location	These soils are common at 1300m-2400m above sea level.
soil-forming rocks	Developed on different natural rocks: basalt, andesite-basalts, adesite-dacites, porpherites, tf-breccia and their carbonate products of deflation.
Climate	Characterized by rather high heat resources. Annual average air temperature: +3-7,5^{0}C, sum of temperature over 10^{0}C no more than 1400-2700, annual average precipitation: 450mm-750mm, moistening rate: 0,70-1,40.
Climate	Characterized by black and dark-grey colouring, with precise differentiation of genetic horizons.
Structure	Granular-clumpy structure
Mechanical composition	
Chemical composition	Humus content: 4.8%-7.5%, pH H_2O=5,3-7,3.
Usage	Distinguished with rather high productivity.
7 Meadow-black earth	
Area(ha)	13000
Location	Common for the black earth zone at 1500m-2200m above sea level. Unlike the black earth, meadow-black earth soils are formed in conditions of close to bedding of ground waters by seasonal soaking of the upper part of the profile. These soils are widely disseminated in high-water beds and terraces of rivers.
soil-forming rocks	These soils have been formed on alluvial pebbles, clay sands and sand clays loamy sands as well as dealluvial drifts.
Climate	
Climate	Morphological structure of meadow-black-earth soils is analogous to the structure of alkali black earths, however peculiar hydrological conditions contribute to increase in their humidness and deep gleization. Meadow-blachearth soils, unlike the black earths, thanks to lusher vegetation, have thick and dense mat. In marsh and meadow-marsh soils, ground waters are 50cm-70cm deep, while in meadow-black soils they are within the range of 1.5m-2,0m, and in prairie black soils - 10m-15m.
Structure	
Mechanical composition	These soils are not homogeneous. In most of the cases, humic horizons are relatively heavy, and towards the parent rock, the mechanical composition of sol becomes lighter.
Chemical composition	Humus content in humic-accumulative layer ranges within 10%-13%. pH H_2O=5.5 - 6.6.

Usage	Mainly used as natural hayfield and pastures, while arable lands occupy insignificant areas and are used under spring wheat and barley.
8 Mountain chestnut	
Area(ha)	242000
Location	Located between 1250m and 1900m above sea level.
soil-forming rocks	In this zone, natural rocks are represented by rubbly-stony eluvial and elivial-deaaluvial carbonated loams and dealluvial rubbly carbonate loams.
Climate	The climate is dry, continental. Annual average air temperature is +8-10^{0}C. Sum of temperature over 10^{0}C rather high 2200-3350. Sum of annual average precipitation: 320mm - 470mm, annual poistening rate: 0,4-0,5.
Climate	Volcanic chestnut soils characteristically have chestnut colouring and precise differentiation genetic horizons.
Structure	Characterized by rather thick composition, pulverizated-flimsy-clumpy structure and availability of carbonate-cemented horizon.
Mechanical composition	Characterized by multi-coloured composition conditioned by change in lithological conditions of relief elements as well a impact of interflow eolation and impact of irrigation. Mountain chestnut virgin lands are characterized by high stoniness and are mostly skeletal.
Chemical composition	Humus content ranges within 2.2% in light-chestnut soils up to 4% in dark-chestnut soils. pH H_2O=7.4-7.6
Usage	Under normal humidity conditions, these soils ensure rather high yields.
9 Mountain fulvous semi-desert	
Area(ha)	152000
Location	Located between 900m and -1250m above sea level.
soil-forming rocks	Soil-forming rocks are represented by eluvial, eluvial-deaaluvial rubbly or fragmental-rubbly carbonates, often plastered with loams
Climate	
Climate	These soils have greyish tint in the surface, fulvous-chestnut in transitional horizon and a light-straw-whitish colouring in illuvial layer. Soils formed on fragmental-rubble elluvial-carbonate loam of lava rocks, in most of cases have carbonate cemented horizon, with capacity of up to 35cm.
Structure	Distinguished by week structuring.
Mechanical composition	Have light mechanical composition.
Chemical composition	Humus content is 1.8-2.1%, pH H_2O=6.7-8.0.
Usage	In case of melioration and proper economic usage, productivity of these soils can significantly increase.
10 Irrigated meadow-fulvous semi-desert	
Area(ha)	53000
Location	Occupy the lowest (800m-950m above sea level) inclines-flat part of Ararat basin.
soil-forming rocks	On alluvial, allivial-proluvial, alluvial-lacustrine sediments, young soils with signs of meadow soil-forming are formed. On territories where soil-forming is proceeding in hydromorphic conditions, meadow-marsh and meadow soils are developed, while on territories where soils are cut off the ground nutrition, meadow soils are developed.
Climate	

Climate	For meadow-marsh soils, developed peat horizon is characteristic with gleization in the central part of the profile.
Structure	
Mechanical composition	Meadow soils are characterized by multi-coloured mechanical composition, meadow soils are distinguished by heavier mechanical composition.
Chemical composition	Humus content of meadow-marsh soils is 8%-22% and more, pH H2O=8; meadow soils are characterized by the largest content of humus (in turfy layer: 6.0%-7.0%), sometimes carbonated, pH H2O=6.5-8.2. Considerable part pf the meadow soil profiles is humic. Mostly non-carbonated. Humus content is 2.1-4.9%, pH H2O=7.6-8.0.
Usage	Meadow soils are mainly cultivated.
11 Floodland-terraced	
Area(ha)	48000
Location	These soils are developed in high-water beds of mountain rivers Aghstev, Getik, Pambak, Masrik, Vardenis, Gavaraget, Marmarik, Hrazdan, and others, as well as on the coastal plain of lake Sevan (In gardenias region).
soil-forming rocks	On alluvial, allivial-proluvial, alluvial-lacustrine sediments, young soils with signs of meadow soil-forming are formed. On territories where soil-forming is proceeding in hydromorphic conditions, meadow-marsh and meadow soils are developed, while on territories where soils are cut off the ground nutrition, meadow soils are developed.
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Usage	Meadow soils are mainly cultivated.
12 Saline-alkali hydromorph	
Area(ha)	29000
Location	Saline-alkali soils of Ararat Valley are developed amongst irrigated meadow-brown soils and are mainly of a hydromorphic origin. Located at 850m-900m above sea level.
soil-forming rocks	These soils have been formed on alluvial-proluvial stratified sediments of river Araks.
Climate	Precipitation: 250mm-300mm, moistening rate: 0,3.
Climate	
Structure	
Mechanical composition	Distinguished by average or heavy mechanical composition and non-even distribution of fine-particle fractions on profile.

Chemical composition	Lithological-mineralogical composition of alluvium and вличние ... different degree mineralized ground waters have contributed to formation of soda, soda-chloride, soda-sulphate-chloride saline-alkali soils. Waters in Arazdayan prairie are distinguished with strong mineralization (up to 30g/l-50g/l) and soda-sulphate-chloride composition. Saline-alkali soils in Ararat Plain are distinguished with considerable carbonization, with sometimes magnesium carbonate predominating in the content; weak humic content, and high alkalinity, pH H2O=10.1. Most of these soils have high content of exchange natrium reaching in a number of soils and subsoils up to 25mg-30mg.экв in 100g of soil.
Usage	Heavy mechanical composition, high alkalinity, conditioned by considerable content of normal soda and exchange natrium, not only add a number of negative physical-mechanical and water-physical features to saline-alkali soils in Ararat Plain but also hinder the implementation of regular ameliorative measures for land improvement purposes practiced in other regions of the country and abroad.
13 Poleo-hydromorph poured saline	
Area(ha)	23000
Location	Poleohydromorphic poured saline alkali (speckled) soils are disseminated in eastern and south-eastern outskirts of Yerevan, stretched from Nork-Dzhrvezh ridge o river Azat and occupy the topographical marks of 850m-1300m above sea level.
soil-forming rocks	Soil-forming+D30 rocks of poleohydromorphic poured saline soils are represented by slightly-carbonated and deeply plastered residual-saline-alkali, slightly skeletal, strongly packed on surface layers, considerably cracked variegated clays
Climate	
Climate	These soils are characterized by homogeneous structure of profile, normally with week differentiation of genetic horizons, red or yellow colouring.
Structure	
Mechanical composition	Characterized by clay or heavy-clay composition. Mainly saline, gypsiferous, equally uniformly carbonated, chinked and packed.
Chemical composition	Humus content in the horizon makes 0.82-1.36%, pH H_2O=7.8-8.5.
Usage	In semi-desert zone, the worst agronomic features are characteristic for poleo-hydromorphic poured saline soils. They can be successfully used in production after proper ameliorative preparation.
	14 Soils of Lake Sevan
Area(ha)	18000
Location	In view of secular records of water in Lake Sevan used for irrigation and energy, the level of water is lowered, as a consequence of which, on the coastal strip considerable areas with young soil are freed, composition and the features of which are largely conditioned by physical-chemical and biological processes underway under water. Here, mainly three groups of soils are being formed, which have different trends of soil-forming processes: humid-meadow sandy, weakly developed sandy-pebble and shell-limestone, desertified. Significant areas (approximately 15000 ha) are occupied by weakly-developed sandy-pebble soils, which make an uninterrupted strip that stretches around the coasts of L. Sevan.
soil-forming rocks	

Climate	
Climate	
Structure	
Mechanical composition	The basic peculiarity making the soils under consideration different from others is the significant accumulation of the fine particles. Mechanical fractions with diameter of 0.05mm-0.01mm in upper horizons often reach to 30%-40%, in some cases - up to 46,8%. Physical clay often reaches to 40% of the pit-run fines of the soil mass, but the main part of the soils is characterized by sabulous mechanical composition, where physical clay does not exceed 4%-7%.
Chemical composition	Humus content makes 0.3-0.5%. Amount of carbonates: up to 67%.
Usage	Productivity of soils is not high, with a poor water regime. The main measures of water regime regulation and increase in productivity of soils is claying and irrigation by the method of sprinkling.

In the semi-desert natural-soil zone, brown semi-desert soils are disseminated in a narrow strip in the lowland part of Ararat basin where they represent the bottom level of vertical soil zones. Dry continental and hot climate, sparse vegetation cover and rich in base cations lava deposits have led to formation of underdeveloped, low exchange capacity, deeply gypsiferous soils with stony carbonate profile, where the relief is mainly represented by hilly-wavy lava plateau; the erosive-denudation type of relief is also found. Parent rocks are represented by eluvial, eluvial-dealluvial, rubbly, fragmental-rubbly, calcareous debris, often plastered with loams. There are well-formed illuvial-cemented horizons in the middle part of the soil profile. Low humus content and coarse texture make the soils vulnerable to both natural and anthropogenic erosion which is marked by wide dissemination of eroded soils. The mainly brown semi-desert soils of Armenia are non-alkaline and have well-formed carbonate horizon and coarse texture.

Irrigated meadow-brown soils are largely disseminated in the semi-desert natural-soil zone as intra-zonal soils. The latter occupy the lowest (800m-950m a.s.l.) sloping-plain part. These soils originate from quaternary pebble-sandy and sandy-loamy deposits. As a result of the impact of continuous irrigation, meadow-brown soils have formed a hard agri-irrigation horizon which has a high biological activity. Currently, part of these soils does not have influence of ground water and have switched to automorphic water regime. The rest of irrigated meadow-brown soils are characterized by semi-hydromorphic water regime. These soils show deep salinization. Soil formation is performed in conditions of weak capillary-ground moistening. The level of fresh or slightly-saline ground water is observed between 1.5m and 4.0m. The process of gleization is lack in these soils. The soils have brown-chestnut or grey-chestnut colour of the middle horizons and insignificant differentiation on genetic horizons.

In the dry-prairie natural soil zone, mountainous-chestnut soils are spread; they occupy the average (1,250m-1,900m a.s.l.) altitude of the Ararat basin, Arpa cavity and the territories of wavy sloping plateau and stubs. Mountainous chestnut soils are formed under semiarid, comparatively warm and dry continental climate, under the cover of fescue vegetation, with a considerable participation of xerophyte.

Mountainous chestnut soils are formed on weathering products of lava which have rubbliness colour, medium-loamy texture, and lack of carbonate cemented horizon. Over 60% of the area of mountainous chestnut soils have been exposed to erosion. Chestnut soils are mainly characterized by chestnut (chestnut-grey in the surface) colour; clear differentiation on genetic horizons; rather dense composition; powdered - flimsy – cloddy structure; availability of carbonate cemented horizon, under which fragmented – rubbly eluvium of effusive rocks are extended.

Part of mountainous chestnut soils are formed after disappearance of forest vegetation on weathering products of sedimentary-volcanogenic deposits. These soils have mellow composition, light rubbly-stony texture and absence of cemented horizons. About 80% of the area of mountainous chestnut soils is eroded.

Mountainous black soils (zonal type), as well as meadow-blacksoils, flood land-terraced soils (inta-zonal types), and Lake Sevan soils are developed in the prairie natural-soil zone,.
The black soil zone is characterized by rather high heat resources and a long period of plant growth. The precipitation varies within 450mm-750mm, with the precipitation-evaporation ratio of 0.7-1.3. The vegetation is represented by grass – feather grass – fescue groups, with predominance of meadow-prairie cereals (humid subzone), grass-fescue associations with insignificant share of turf-forming types (dry subzone). Mountainous black soils of Lori prairie, Shirak plateau, and Aparan array are formed on lake deposits and are hydromorphic in origin. As a result of further aridization, soils obtained features of prairie group. These features are used for identify soil subtypes and species.

Modern regular carbonate mountainous black soils are developed from weathered products of the basic and medium (neutral) lava. The regular carbonate mountainous black soils have illuvial-cemented horizons in some regions located on lower altitude and warmer climatic subzone.
It is important to notice that black soils of post-forest origin (Tegh, Gugark and partially Lori arrays) are distinguished by mealy-micellar forms of carbonates. Mountainous black soils formed under prairie vegetation have mealy and mealy-dot ted forms of carbonates.

A considerable part of mountainous leached black soils developed in pre-peak positions of knolls and hills are distinguished by abundance of fragmental-slaggy matter in the soil profile. These soils have carbonate bedding in the topsoil. In the process of development, carbonates are leached and appear in a deep horizon of mountainous leached black soils.

About 80% of mountainous black soils occupy undulated plains and slopes and have fine texture. These soils are normally slightly eroded.
Mountainous black soils have black and dark-grey colour, clear differentiation of genetic horizons, granular-cloddy structure, high content of organic matter, neutral or weakly acid reaction, loamy-clay texture, saturation by cations and carbonates in typical and regular subtypes.
Meadow-black leached soils and – less often – calcareous soils are intra-zonal types developed in the zone of mountainous black soils. These soils are found on pre-terraced territories and lowlands with high water table.

The forest natural-soil strip occupies the medium and lower (500m-2,400m a.s.l.) mountainous part of the Little Caucasus ridge. The zonal types of this strip are brown forest and cinnamonic forest soils. Intra-zonal soils are represented by turfy-calcareous soils. Large arrays of forest soils are found in north-eastern and south-eastern regions, where they occupy almost all sloping-beam territory of deeply fragmented mountains of Little Caucasus. They are developed in small insulas on surface and ravine-beam territories of the ridges of Volcanic plateau. The total area of the soils of forest genesis is 712 thousand hectares, of which 58% are under woody-shrubby plantations. From the total area of soils of forest group, 19% are represented by brown, 2% are sod-carbonate, and 79% are cinnamonic forest types.

Brown forest soils occupy the north-eastern part of Armenia. They are formed under beech-hornbeam forests that are here and there modified by humans. Depending on hydrothermic regime and the composition of soil-forming rocks (acid or neutral), two soil subtypes are formed: brown forest strongly unsaturated and brown forest weakly unsaturated soils. Parent rocks are volcanic, sedimentary and volcanogenic-sedimentary deposits which are covered by loamy-clay casing of different capacity. Illuvial clays (washing) occur in the profile of brown forest soils. The soils are distinguished by pulverescent-silty loamy-clay texture, average, sometimes increased content of organic matter (4%-8%), and acid reaction (pH_{KCL}: 4.6-5.9).

As a result of land use (grazing and felling), brown forest soils of the upper zone of forests are modified and degraded. The aridization process leads to development of turfy process and formation of mountainous-meadow soils. Evolution of soils in forest territories leads to the development of black soils features.

Cinnamonic forest soils are formed under xerophytic deciduous forests including Georgian, Oriental, and Araks oaks, oriental hornbeam, field maple, and junipers. We consider brown colour of cinnamonic leached soils as a relict which is inherited from the preceding brown soil formation process.

The relief of the zone of mountainous cinnamonic forest soils is characterized by a large number of uplands in the form of hills and comb-shaped forms of watershed, as well as cut-outs and ridges going down to gorges and valleys of rivers. The main parent rocks are weathered products of porphyrites, dolomites, marls, limestones, conglomerates, sandstones, tuf-breccia, and granodiorite. They are mainly represented by dealluvial and eluvial-dealluvial carbonate and leached loams, and less often – by clays with capacity of 1.5m-2.0m and more.

Changes in the forest cover and land use in the forest zone resulted in significant change of the soils. These changes make a revision of the soil classification essential, e.g. reveal new families and species of soils which cause the change of soil subzones boundaries.

The mountainous-meadow natural-soil zone occupies mountainous arrays located higher than 2,200 m a.s.l. and has two genetic soil types: mountainous-meadow and mountainous-meadow-prairie.
Mountainous-meadow soils occupy the highland part of the Armenian Volcanic Plateau and the Little Caucasus within the range of 2,200-4,000 m a.s.l. These soils are formed under cold, often severe and humid climate under alpine and sub-alpine – predominantly humid and mesophilous – meadows, where dwarf cereal-grass and grass-cereal-legume crop groups are found.

The diagnostic characteristics of the soil are: the presence of peaty layer; cinnamonic-brown (dark cinnamonic) colour of humus horizons; high content of organic matter; acid reaction; low saturation; strong leaching; low volume and specific weight of upper horizons; and weak differentiation of genetic horizons. The soils have acid reaction (pH_{HCL} 3.8-5.3), low cation exchange capacity, high content of humus which abruptly decreases with depth.

The mountainous-meadow zone is characterized by short plant growth period, high precipitation, significant variation in temperature and the wetness of air and soil. Year-around excess water (with humidification coefficient of 2.0-2.5) causes leaching regime that contributes to downward migration of soil-forming products from the soil profile.

The territory of mountainous-meadow soils has diverse feature, which is caused by difference in the relief. Soils on slanting and well-moistened slopes and watersheds have dense turfy layer; while soils on the slopes of southern exposition have rubbly profiles.

Mountainous meadow-prairie soils are formed on the average height zone, on the elevation of 2,200m-2,700m a.s.l. and make up transition soil zone between the mountainous-meadow subalpine soils and mountainous-prairie or forest-prairie soils. The soil zone has weak continentality of climate;

availability of meadow-prairie and subalpine vegetation; and concentration with alkalis in soil-forming rocks. The soils show black and dark cinnamonic colour of humus horizon; high content of humus; cloddy-granular structure; weak-acid reaction.

Mountainous meadow-prairie soils are represented by two subtypes that are distinguished by conditions of soil formation as well as by morphological and physical-chemical characteristics. Soils have well-defined cloddy-granular structure, high content of humus, and weak-acid reaction.
Overall, the territory of the meadow-prairie zone is used for haymaking and as pastures. In some places soils are ploughed and used for growing potatoes, barley and perennial grasses.

A brief overview of soil development and distribution illustrates that Armenia has a large diversity of soil types and subtypes which are specified by morpho-genetic, chemical, biological, and other characteristics. The dissected diversity of soils is in agreement with a diversity of bioclimatic and lithological-geomorphologic conditions of soil formation. In addition, the soils of the country demonstrate of long-term historic influence of land use. In some places, anthropogenic factors appear being the leading in the modern evolution of the country's soils.

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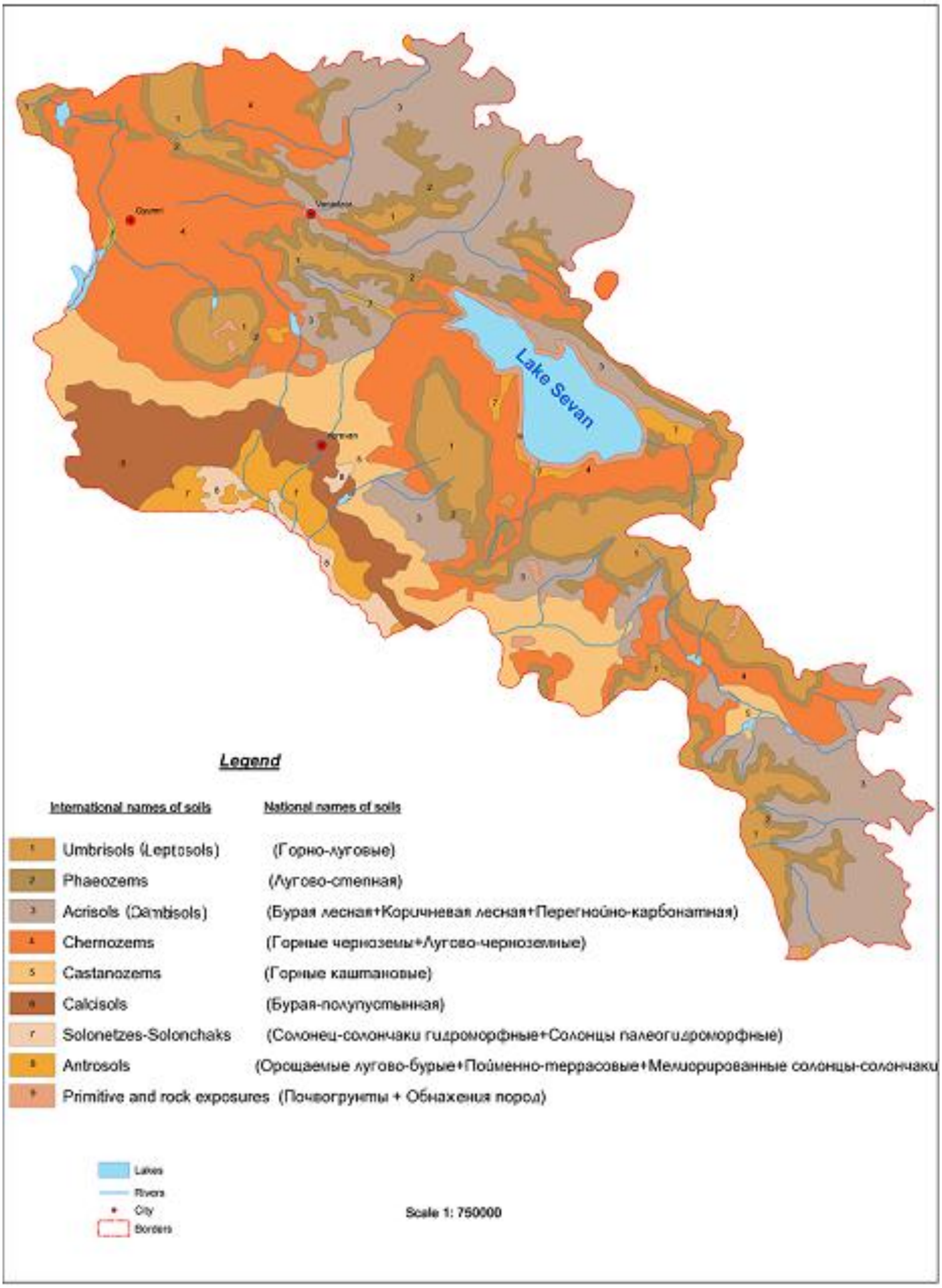

Figure 1. Map of soils of Armenia

Chapter II.
SOIL RESOURCES of AZERBAIJAN

SOIL RESOURCES of AZERBAIJAN

Amin Ismayilov[1]

ABSTRACT. In the article we are going to look through the issues in regard with the integration of soil-geographical data base into European Database 1:1.000.000. At the present time integration into the European and international organizations are under process in many spheres including educational. From the point of globalization the principally important issue is the formation of adequate soil-information space which will provide the extension of the European Soil Database involving countries of Mediterranean, North Africa and Caucasus. The purpose of the present article is the scientific analysis of soil-geographical data of Azerbaijan Republic for research of perspectives for integration into soil-geographical Database of European Union.

The current stage of the inventory of soil resources of Azerbaijan on the national level is closely linked to the country's process of adaptation to the conditions of the new geopolitical realities.

Therefore, we can say that the integration into a single soil-geographical space of Europe is one of the important tasks in Azerbaijan Republic. In modern conditions, soil information must first be unified and focused on integration of international community. A fundamentally important aspect of the problem is the need to format compatibility of national and international land-information spaces, which will be integrated into the European soil data base. For obtaining this result it is necessary to achieve comparability of criteria and the results of soil studies and assessments of the quality of soil and resource potential on an international level. It should be mentioned that, over many decades, the requirements for soil and Information Management in different countries were not the same. Even in some selected countries these requirements sometimes are being changed under the influence of dynamics happening in the result of new scientific-practical tasks.

Each stage of development was characterized by a kind of formulation of the problem and naturally requires specific soil investigations of the total soil-geographical descriptions to large-scale soil surveys to identify soils suitability for agricultural and food base of the region.

The improvement of soil researches in Azerbaijan had its own characteristic features. First of all, it is characteristic for the big difference in requirements existing in diversified agricultural soil researches of Azerbaijan.

As an example, soil investigations of irrigative-amelioration projects are much different rather than soil investigations related with anti-erosion activities of tea farm etc. Other particularity was related with the exceptional variety of soil. Azerbaijan has almost all types of soil that can be found in post-Soviet Union. These circumstances have directed efforts of soil scientists of Azerbaijan for identification of soil components' variety and determination of their main grades and for solving special issues, mainly amelioration characteristics.

At the same time it was required to study soil genesis which relatively less developed in deeper. Generally, a big scope of work was done in regard with study of soil in Azerbaijan. A lot has been done

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regarding use of research results of these studies for the solution of various practical tasks as well. A lot of scientific reports, sketches, maps mainly describing soil conditions of private areas of republic had been prepared. Nevertheless, there is no such work which would colligate the researches. Relevance of the issue caused by variety and big volume of the source information. In the most cases existing fund materials are stored in various formats and unfit the scientific analysis. Therefore, the development of adequate soil-data space is important. It will resolve above mentioned problems in order to extract mutual social-economical benefit in the conditions of globalization. In view of above, we had made an effort to describe the situation in that field, to analyze the existing soil-geographical data in order to use it in the European Soil Database integration process with 1:1000 000 scale.

Keywords: Azerbaijan, European Soil Database, soil, soil classification, digital mapping, soil information

INTRODUCTION The Republic of Azerbaijan is a country in the South Caucasus. Located at the cross roads of Eastern Europe and Southwest Asia, it is bounded by the Caspian Sea to the east, the Russian republic of Dagestan to the north, Georgia to the northwest, Armenia to the west, and Iran to the south. The Nakhchivan Autonomous Republic (an exclave of Azerbaijan) borders Armenia to the north and east, Iran to the south and west, and Turkey to the northwest(Figure 1).

A series of roads of international importance passes from Europe through Azerbaijan to the Central and East Asia. The territory from north to south stretches 400km, west to east -500km. Country is located between 38° 25-41°55 north latitude and 44° 50 - 50° 51 eastern longitudes.

Figure 1. Map of Azerbaijan

Locating in the junctions of Europe and Asia, the Republic has unique geopolitical and geographical location. From the ancient times until present days still has great importance for international, economic and cultural relations. Since ancient times favourable natural and geographical climate of Azerbaijan area facilitated settlement of people. It is known that antique authors gave information in their compositions regarding Azerbaijan borders, geographical position, rivers, settlements, local tribes, Caspian sea that it had no connection with any other sea. According to Gullustan (1813) & Turkmenchay (1828) agreements Azerbaijan was divided into two empires: Northern Azerbaijan joined Russia and Southern Azerbaijan joined Iranian Shakh's territory. Later in the history of Azerbaijan appear new concepts like Northern Azerbaijan (a.k.a Russian Azerbaijan) and Southern Azerbaijan (a.k.a Iranian Azerbaijan). As a result of liberation movement on 28 of May 1918 first democratic republic has been established on the east of Northern Azerbaijan – Democratic Republic of Azerbaijan. Being the first parliamentary republic in the history of Azerbaijan, Democratic Republic of Azerbaijan was an example of democratic, legal and worldwide government of whole East. Democratic Republic of Azerbaijan which existed in 1918-1920 was first democratic republic in Muslim east. As a result of Soviet Russian military aggressions the Democratic Republic of Azerbaijan fell down. It was the end of Azerbaijan governmental independence in Northern Azerbaijan. On 28 of April 1920 it was announced to establish the Soviet Socialistic Republic on the territory of Democratic Republic of Azerbaijan (Azerbaijani USSR). In 1920-1991 Azerbaijan was the part of Soviet Union as one of 15 united republics. On 18 of October 1991 by adoption of the act of constitution "About governmental independence of Azerbaijan Republic" Azerbaijan republic regained its independence.

According to the information by Governmental Statistics Committee as of 1-st of April 2010 population of Azerbaijan Republic is 9 mln people.

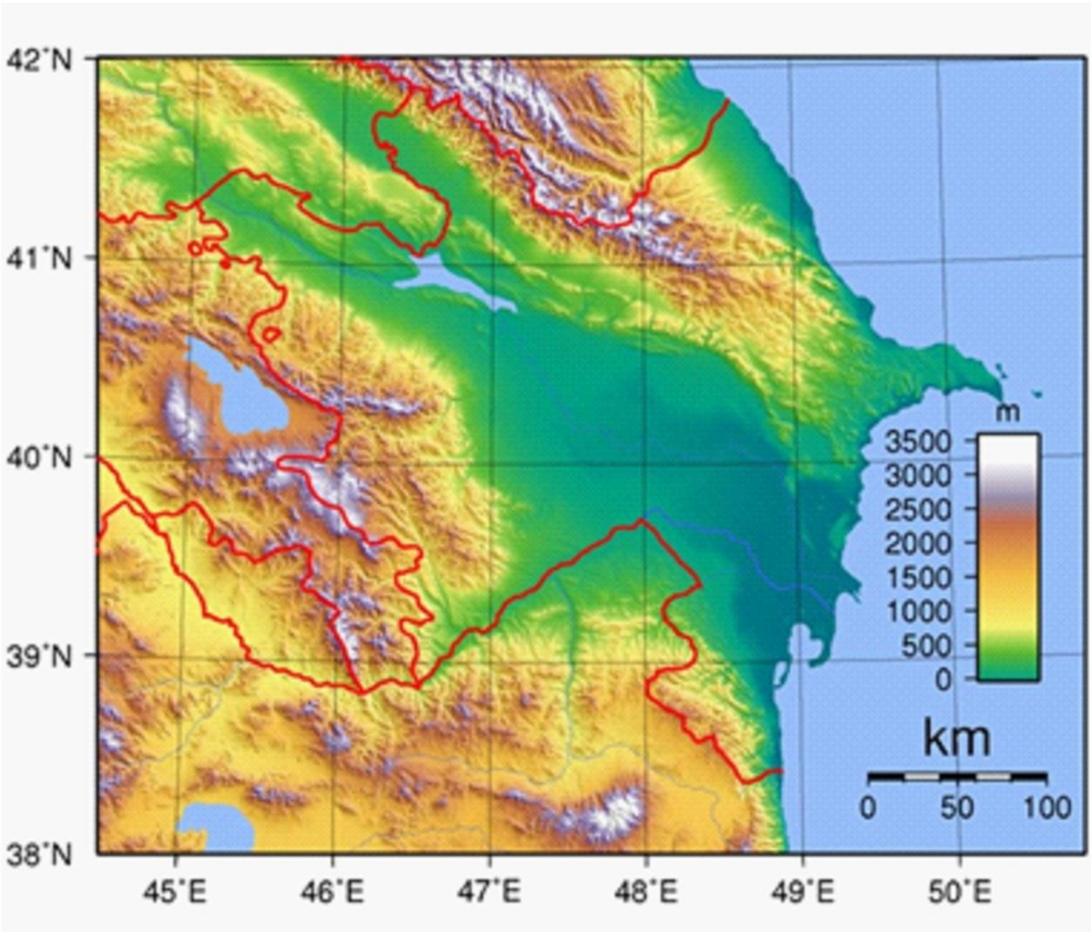

Figure 2. Physical map of Azerbaijan

Territory

86,42 thousands square km (12% of area covered by forests, 1,7% - water, 54,9% -agricultural lands, including 30,6%- pastures and hay makings, 31,4%-other .

Relief

Azerbaijan Republic is various. Two forms of landscape are predominating: lowlands and highlands. About 60% of Azerbaijan territory is mountainous territory. Average elevation is 400m. The amplitude of lands height is bouncing in between 26, 5 м (Caspian lowlands) below sea level to 4466m altitude (Bazarduzu top). South-Eastern part of Caucasus belongs to Azerbaijan (Figure 2). Mountains are mainly formatted of Jurassic and Cretaceous period depositional, that less exposed to denudation. Badlands and mud volcanoes are typical for Mining areas. Small Caucasus covers South-Western and western part of Republic and has low elevation, consists of ridges and meadows and mountainous territory with complicated structure. Small Caucasus was formed out of Jurassic and Cretaceous period solids. Talish Mountains located on the Southeast of the country. Basically, it’s formatted of third period deposits. Kura-Araz valley covers the territory in between Great and Small Caucasus, and Taish Mountains. It occupies the central part of Republic being the biggest intermountain lowland on the South Caucasus. Lowlands between the rivers Kura and Araz is divided into 5 valleys: Mughan valley, Mil valley, Karabakh valley, Shirvan valley and Salyan valley. Samur-Devechi valley located in the north of the Absheron Peninsula, on the shore of Caspian sea and bases on Qusar sloping plain. Narrow band of the Lankaran lowlands located to the south of Absheron Peninsula along the slopes of Talish Mountains. Most part of lowland territory is located below the sea level.

Climate

Relief, geographical location and Caspian Sea have a big influence on the climate. Half-desert climate, dry prairie climate, sub-tropical, fine and cold climates are observed in the territory. Dry sub-tropical climate is typical for Absheron & Kura-Araz lowlands. Humid sub-tropical climate is observed on the south of Talish Mountains, typical for foothill areas & Lankaran lowlands. Fine climate is observed on the areas covered by forests highlands of Grand and Small Caucasus and split on dry, moderately warm and dry, moderately – warm wet and cold one. Cold climate is observed on the high mountain ridges, tops of Great and Small Caucasus, alpine zones and meadows. When the average annual temperature on the lowlands is 15° C, in the mountain areas it could vary up to 0° and lower. On July the temperature in the lowland areas is about 27 °. In the mountainous areas reaches up to 5 °. Maximum can be equal to 43°, minimum down -30°. Fallouts are also unevenly distributed across the country. During the year, on the Absheron Peninsula and the band of Araz Nakhchivan AR rainfall is less than 200 mm. Fallout in Kura-Araz lowlands is about 200-300mm, and in the north-eastern slopes of Small & Great Caucasus fallouts equal to 600-800 mm.

On the southern slopes of Grand Caucasus, highlands of 2000-2500 meters fallouts can reach 1200-1500mm. The highest rainfall happens in the south of Lankaran lowland and the slopes of the Talish Mountains, 1200 - 1700 mm. The prevailing winds on the northland (Absheron Peninsula), southwest (Kura-Araz lowlands) & south (Lankaran lowlands) directions.

Vegetative cover

Azerbaijan Republic is characterized by a rich and rare flora. On a relatively small area there are almost all common types of plants existing in the world. Types of plants on the territory of Azerbaijan make up 66% of all plants in general over the Caucasus. Along with widespread plants in the Caucasus and other parts, flora of Azerbaijan has enough of growing only in Azerbaijan and typical to its comparatively small area of about 240 endemic types. Dissemination of the vegetation caused by physical and geographical formation of the region, climate of modern lands, vertical zoning and a lot of other influences.

Total area of Azerbaijan forests is 1.21 mln hectares. 989,5 thousand hectares are the territory covered by Forests that makes 11,4% of total territory. Approximately 0, 12 hectare falls as per capita population which is 4 (0,48 ha) times less than average index in the global scale. Although Azerbaijan forest area is small, it is rich by its views. Forest has 435 types of different trees and bushes, 70 out of these trees are endemic ones. Broadleaf forests are typical for all territory of the Republic. Such types of forests are the most spread on the average-mountainous parts of Great and Small Caucasus and Talish Mountains. In many places at an altitude of 600-1600 meters it form a single zone. On other parts forests are in the form of meadows and lanes. Forests consist of three tree types of the trees-beech, hornbeam and oak. They cover 82,6 % of all forest areas. In addition to them there are a lot of other trees - maple, linden, alder, poplar, willow, elm and many other broad-leaved trees.

Land resources, land use

As in all CIS countries, after the collapse of the Soviet Union, Azerbaijan was in the process of reforming the political and economic systems, and establishment of a sovereign independent state. Republic has entered into a new socio-economic and political formation, set a course for the reform and development of market relations, including the implementation of land reform. Adopted land reforms about farms on initial stage (1990-1995) land code, legislation of “the farm” “Kolkhoz (Collective Farms) and Sovkhoz (State Farms) reforms”, Land Tax and others, played a major role in the creation of new economic management, and in consolidating land rights for individuals and legal parties. These legislations had created preconditions for the development of new land relation in republic. This stage of land development relations associated with the adaptation of land legislation in market conditions

Second stage of land relations development is related to the Law of Azerbaijan Republic "On Land Reform"(1996). This law was the most important piece of legislation in the sphere of land relations in our country. Three types of property are defined When land reform is adopted in the Republic:

- land is left as governmental property (governmental property);
- land transferred to the municipality (Land belonging to municipality):
- land passed into private ownership;

As a result of the land reform, fertile lands available in 2042 collective farms in Azerbaijan were distributed to the rural population.

Land tenure in Azerbaijan Republic which consist of 8.64 mln ha of land, 4.91 mln.ha or 56.9% were transferred to governmental property, 2,03 mln.ha or 23.5% to municipality, 1.70 mln.ha or 19.6% went to private property. That means that 870 thousand families or 3.44 mln people became land owners (Figure3).

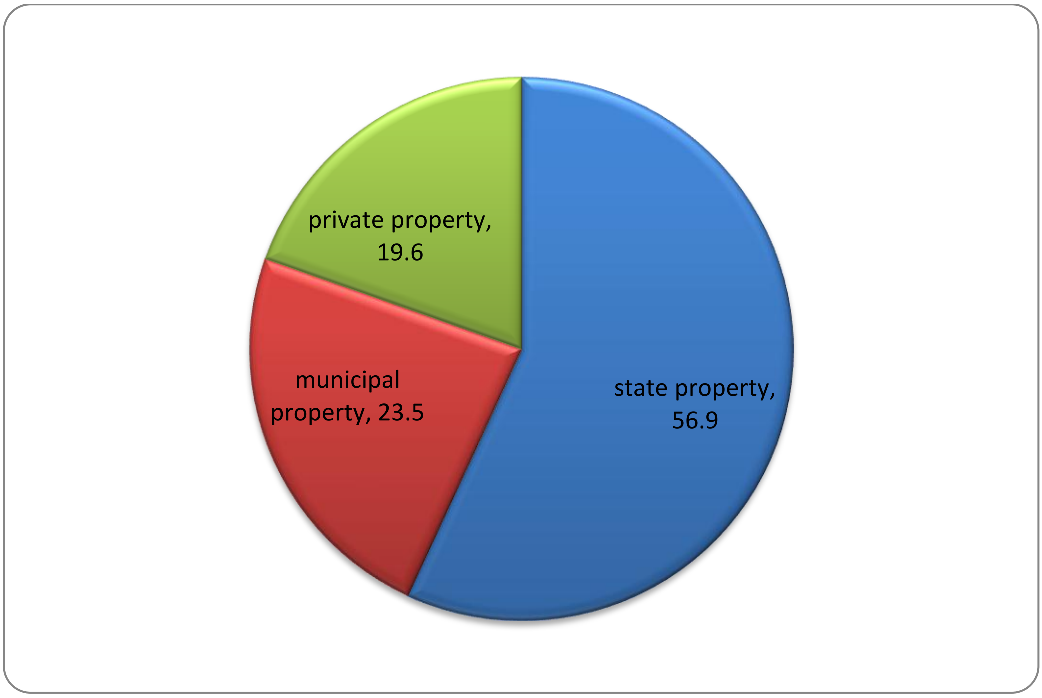

Figure 3. Land Tenure in Azerbaijan

Governmental lands include following:

- the lands where Governmental authorities locates;
- the lands where the objects of Governmental authorities locate-objects of the mining industry approved mineral deposits, of the Unified Energy System places, pipelines, transportation facilities, communications and defence facilities, state border lines, the most important objects of Amelioration and Water farm.
- Lands for pastures at summer and winter times, camps and drift ways and livestock;
- Forest fund lands (Kolkhoz and Sovkhoz woods included);
- Water-farm lands located in Azerbaijan sector of Caspian sea;
- Environmental and nature reserve, improving and recreational, historical and cultural lands, also lands that is under the legislation and economic activity is forbidden.
- Lands that belong to research and educational institutions, its bases for experiments, machine testing stations, governmental variety testing services, seed and breeding farms.
- Lands constantly used by the governmental facilities or those which has governmental construction projects. Specified lands are the exclusive property of the state; it can be transferred for use and sale in accordance with the legislation. Land within the relevant administrative territory, except for the ones that left in the state ownership and transferred to private ownership, are transferred to the municipality.

Lands transferred to municipality are as follows:

- Lands under common use;
- Lands under use of individuals and legal parties;

Reserve lands

Lands under common use are the lands located under the mountains, settlements and rural settlements, squares, roads, parks, water farms, stadiums, courts, etc. Also the lands of pastures used by population for its livestock's, local roads, shelter belts, water farm facilities, hydro technical structures and similar facilities of the common use.

Lands under the use of individuals and legal parties are the long-term rent municipal lands or for permanent use.

Municipality's reserve fund lands are:

- Lands allocated to the long-term development of human settlements;
- land transferred to municipal ownership as a result of reform, the land being in constant use by the state farms, collective farms and other agricultural enterprises;
- land transferred to physical and legal persons for the short-term use;
- The lands right for permanent or long-term use for physical and legal persons were denied;
- other lands not transferred to the permanent use and as property to other parties

According to the legislation the reserve fund land can be determined by municipality and put under common use or rented by physical and legal parties of Azerbaijan Republic. Management of lands under municipal ownership is controlled by municipalities.

Following lands are transferred as private facilities:

- lands under the legal use by the citizen for their cooperative, individual and collective villas, under the authority of the state dacha farming,;
- privatized state and collective farms land

Land under the legal use of citizens under their individual houses, sites, individual, collective and cooperative villas, under authority of state dacha farming, donated to them by the due process of law.

COUNTRY SOIL INFORMATION and DATA

The history of soil survey in Azerbaijan has period more than a century ago. The beginning of soil science development in Azerbaijan is considered to be from 70's of XIX century. Just then famous educator and naturalist G.B.Zardabi has started publishing his work about soils. His work was dedicated to soil-forming factors, soil fertility, soil characteristics and so on. At the beginning of the XX century less attention was paid to the soil science issues. One of the features of the historical period of soil science in Azerbaijan at that time was the fact that very limited studies were amounted to the evaluation of soils for tax policy and identifying soil resources. First information about soils of Azerbaijan was described in geographic surveys of travellers. Soil surface covering was extremely weak, just like essential element of the geographical landscape.

1871. In the work of I.Kovalevsky who has visited Azerbaijan in 1869-1870. (Eldar valley and Samukh) on the proposal of "Society of land acquisitions in the Caucasus", the first, and very fragmentary information on soil and environmental conditions had appeared.

1898 . Caucasus reconnaissance trip is the classics of Russian soil science V.Dokuchaev and is considered as the beginning of the scientific study of soils in Azerbaijan. He compiled an overview and a brief description of the soil cover of the Kura-Araz lowlands and the slopes of Great & Small Caucasus and noted observation of vertical soil zones.

Due to threatening sizes of salinization of irrigated land in 1890 under the guidance of prof. P.S. Kossovich, a detailed study of soils in Mugan was carried out and it can be asserted that the work of the expedition was the first substantive study of Kura-Araz lowland's soils.

1900 -1910. Professor. Dokuchaev's work results served as the first "push" to a number of regional soil surveys in Azerbaijan. Initially, these studies were conducted to bonitiration of land and soil amelioration of desert steppes. Among first researchers of Azerbaijan soil who used V.V. Dokuchayev's idea as the basis of their work, it should be mentioned people like M.F. Kalinin ,
During that period development of activities for soil salinization on the Mughan steppe in Azerbaijan Mughan saline station was established..

1910 —1920. Soil researches in Mil and part of Shirvan steppe (S.A. Zakharov V.A. Romanov and others). Complexity of soil depending on mesorelief, soil salinity level and ground water depth has been studied. This completes the pre-revolutionary period of soil study in Azerbaijan. Soviet Power establishment in Azerbaijan has determined new stage in soil research development. In the first years of Soviet Power establishment due to necessity of studying and revealing the soil resources, amelioration, saline soil study and splitting republic to the regions wide regional researches have been started.

1920—1925. With the direct participation and guidance of prof. VP Smirnov-Loginov the soils of Absheron and the south-eastern tip of the Small Caucasus Mountains within Nagorno-Karabakh were investigated. As a result first articles and soil maps of these regions were published. The results of V.V.Dokuchayev's work had big influence on S.A. Yakovlev's and S.A. Zakharov's work, who has started the development of genetic classification of soils of Caucasus as the first ones. In 1925 due to Azerbaijan zoning work under guidance of prof. S.A. Zakharov general soil investigation was carried out. Soil investigation for Azerbaijan zoning work in 1925 promoted more detailed soil classification development.

1925 – 1930. The start of wide soil-geographical researches in Azerbaijan. Two large expedition crews start their activity. One of them was organized under the leadership of prof.S.A. Zakharov including prof.S.I. Turemnov, prof. I.Z.Imshenetcki, V.V.Akimtcev and others. Expedition crew had been spent more than a year and a half for continuous soil research of entire territory of Azerbaijan in order dividing it into the natural historical rayons which would be used for economical zoning of the republic. As a result "prof. S. Zakharov's Proceedings in Azerbaijan soil expedition" has been published. Every single one of it is representing the independent soil study of certain physical-geographical regions of Azerbaijan. The first consolidated soil map have been published as well.

Another, second expedition crew in Mughan which was under guidance of prof. L.L. Nojin. Mughan experimental station carried out its researches of soil of other parts (rayons) of Kura-Araz lowlands – Mill and Karabakh steppes. Large-scale surveys of individual sections of the Kura-Araz lowland which were made up for irrigation projects were carried out by the Expedition crew of Mughan experimental station as well. At those period great achievements belongs to prof S.A. Zakharov in the study of Azerbaijan soil. Besides the fact that he was the leader of the majority of soil expeditions, he has published a number of large and valuable works on the description of soils surveyed areas. It should be also noted that prof. S.I. Turemnov's has done considerable contribution in Azerbaijan soil study. Soil expedition headed by him has covered the whole territory of the Kura-Araz lowland, made the first soil regionalization of the massif and has developed a soil classification that is used partially nowadays. Prof. S.I. Turemnov has made up the first map of East Transcaucasia plains' soils salinity. Acad. V.R. Williams has visited Mughan & Lankaran lowlands for consultation regarding amelioration and development of subtropical cultures' issue. Conclusions of Acad. V.R. Williams on the causes of salinity of Mugan and the conditions of its development had great importance in amelioration of Mugan steppe issues. Soils of Gobustan, Khizi, Qusar etc. regions have been studied by prof. Smirnoff-Loginov.

1930 - 1935 . Much more attention is paid to the study of soil fertility, soil chemicals, salinity of irrigated land, etc. Mughan saline Experimental Station has strengthened its researches in irrigated regions of Azerbaijan. Large scale soil researches have been performed in the northern part of Lankaran rayon, for determination of the development prospects of subtropical cultures. In order to apply chemicalization in cotton producing regions, soil studies have been started. As a result of unfolded soil and soil-agrochemical researches of cotton producing areas, soil scientists did compiled an agricultural industrial classification of the soils of cotton producing areas in the country. The organized sector of the Azerbaijani branch of Soil Science of the USSR (AzFAN, 1934), in its early years had limited its study in some theoretical issues and partially produced some soil studies.

Later, sector made valuable contributions to the composite soil mapping and soil-geographical feature article of Azerbaijan also Lankaran rayon soil features. A bit later by soil science sector a deep study of physical and chemical nature of the soil in Lankaran region and investigation of soil in southeast Shirvan was carried out.

Lankaran lowland soil investigations carried out in 1935 by Soil Institute of the Academy of Sciences after V.V. Dokuchayev under the guidance of akad. B.B. Polinov & prof A.A. Zavalishin, gave a considerable material for humid subtropical soil characteristics of Azerbaijan. Physiographic conditions of humid subtropical zone were described as a result, characteristics of soil and its component types and soil types in the genetic and agricultural industrial terms as well. Some conclusions regarding tea development culture in Lankaran area.

1935 – 1940. Soil Science Sector AzFAN organizes an expedition to study dry subtropical regions' soil and its leading cotton-culture. A research has covered poorly studied parts of the Shirvan steppe, starting at Pirsaat valley to Kurdamir rayon, Caucasus Mountains river valleys. The process of soil formation on specific geomorphologic elements has been studied. The role of mud volcanoes in the soil salinity revealed, structure and role of groundwater and river water, produced studies on the classification of black soil and brown soils and so on have been determined the dimensions of land reserves that are suitable for development In the course of these studies. On the basis of all the obtained materials from Branch of Soil Science in 1939 salinity gradation maps were made up. To reveal lands suitable for cultivation of tea large-scale studies & have been performed in 1941 by the soil scientists and agrochemical study of soil of Alazan-Agrichai valley within Azerbaijan.(by R.V.Kovalyov). Mountainous rayons researches were carried out. (Khanlar & Kedabek regions and others) in order to determine soil massifs for rain fed agriculture. Due to Samur-Devechi Channel project, detailed soil survey have been performed in lowland watershed Velvelichay Atachay, in order to develop a series of recommendations regarding amelioration for the development of land reclamation. (K. A. Alekperov, M. E. Salayev). After establishment of Academy of Sciences of Azerbaijan SSR, Institute of Soil Science and Agricultural Chemistry of the Academy continued its work on the study of soils in the mountainous regions of Grand and Small Caucasus and the Kura-Araz lowlands. (G A. Aliyev,V. R. Volobuyev, M. E. Salayev and others).

1945–1950. At that period a special soil researches was carried out partly for development of individual objects for crops and industrial crops, partly for researches of soil funds and preparation of soil map. These studies include soil surveys in the lower reaches of the south-eastern slope of the Greater Caucasus and the region Gonagkend (G.Aliyev)

As a result of the regional soil studies under the guidance of Professor. V.P Smirnov-Loginov consolidated soil map of the territory of Azerbaijan was compiled. In time of preparation of this map initial information of previous researches was used.(by V.R. Volobuyev, B.A. Klopotovskiy & M.E. Salayev). Study of "Azerbaijan Soil" as well which was a map description context that was made up under guidance of prof. V.I. Smirnov-Loginov. Consolidated soil map reflects not only a detailed geographical location of soil types of the Azerbaijan SSR, but also contains data on the ameliorative featured soils, based on salinity degree. Later a summary of soil and climatic characteristic of Azerbaijan was composed, developed a map with typical classified areas of the country by land climate and other natural conditions. Generalized materials specifying soils of Mughan and Salyan steppes in terms of amelioration are summarized in the book under the name of "Soils of Mughan-

Salyan Massive and its amelioration” (by V.R. Volobuyev). Actions on the study of the causes and processes of soil salinity and measures that must be developed to struggle this phenomenon has been taken and continues.

In the postwar years (1945), soil studies in Azerbaijan get particularly widespread. Implementation of a set of works related to the construction of a grand Mingachevir hydro system caused a large soil amelioration research in the Kura-Araz lowlands.

Azerbaijani soil scientists detailed soil-geographical, geomorphologic and profile-station research in the Karabakh steppe. (M. E. Salayev, К. A. Alekperov, V. R. Volobuyev).

Soil researches were carried out in South Mughan and Salyan steppe. Extensive soil-geographical researches were made in Mil valley and in the band of Karabakh steppe foothills, was study of physical properties of water and the main soil types of the study area. Held Kura-Araz expedition by Soil institute after V.V. Dokuchayev of USSR’s Science Academy, under the guidance of prof. V.A.Kovda, has carried out an extensional soil researches and soil keys study of soil keys in Salyan steppe, Mughan, south-eastern Shirvan, Mill steppe. Water and physical properties of soils studied in details as well.

Besides the regional researches the expedition paid attention to physical-chemical issues related to genesis and classification of soils in the Kura-Araz lowland. Erosion studies in mountainous and foothill areas, on Apsheron have been started. Researches on quantify drain and soil erosion have been started together with studying of soil erosion in geographical terms.

1951 – 1955. In connection with the further issues of the tea farm development in Azerbaijan, Lankaran and Zakatala soils has been studied. For each kolkhoz and for every zone extended maps were made, maps of soils good for tea, fund has been determined suitable for the development soil for tea as well. Systematic compilation of the list was a notable contribution to the classification of soils in Azerbaijan. That particular work was done by the team of scientists and was the result of researches on inventory of lands and consisting of Azerbaijan consolidated soil map with 1:200 000 scale. Soil-amelioration researches were carried out in order to study the efficiency during amelioration activities. Collective work of soil scientists named “Soils of Azerbaijan SSR” was published.
Prof.V.R.Volobuev based on soil maps as well as on geological and geomorphologic data, in 1953 has highlighted mainly the following soil areas that are still used today in Azerbaijan (Figure 4):

Major soil areas of Azerbaijan
I. The soil region of the Greater Caucasus.
II. The soil region of the Lesser Caucasus.
III. The soil region of the Kura- Araz plain.
IV. Lankaran soil region.
V. Nakhichevan soil region.

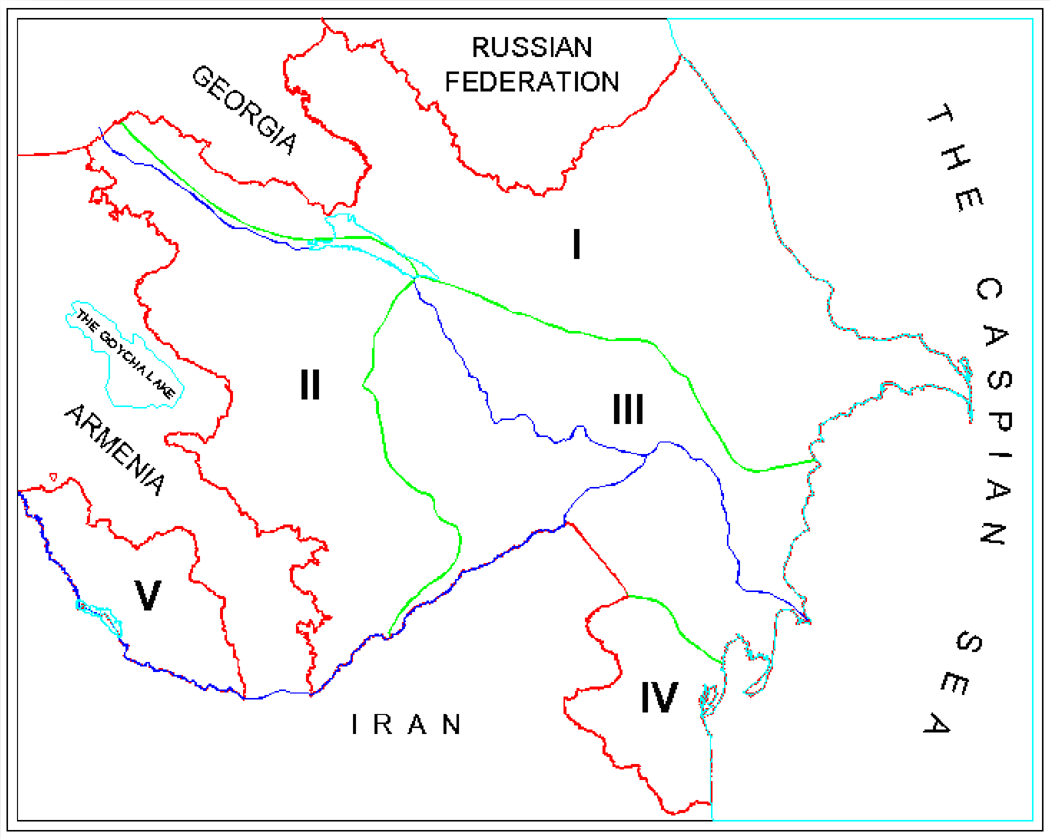

Figure 4 . Major soil regions of Azerbaijan

<u>1955 – 1970</u> Soil map of Azerbaijan in a scale of 1: 500 000 has been published (by K.Alekperov, G.Aliyev, V.Volobuyev)[1] . On the soil map of Azerbaijan in a scale of 1: 500 000, which is the most detailed national soil inventory, more than 100 cartographic items were indicated(Figure 5). The legend of the map consists of 3 parts:

- Soils of the lowlands and plains (contains 68 nomenclature units)
- The soils of the mountains (contains 36 nomenclature units)
- Geological formation (8 categories)

Monographs on the soil of Great Caucasus (by G.Aliyev), Small Caucasus (by M.E..Salayev), Kura-Araz lowlands (by V.R. Volobuyev), Lenkaan area (by R.V. Kovalyov), Araz surrounding lowlands (by Sh.G.Gasanov), systems and nomenclature of soils in Azerbaijan (by G.Aliyev,V.Volobuyev et al.) had been published at that period. Scientific work of M.R.Abduyev "Soils with dealluvial forms of salinity and issues of their amelioration" became an event in soil science of Azerbaijan. First monograph about Azerbaijan soil erosion was published in 1961 (by K.A. Alekperov) and aqueous - physical characteristics of the soil had been thoroughly studied (by R.G. Mamedov)

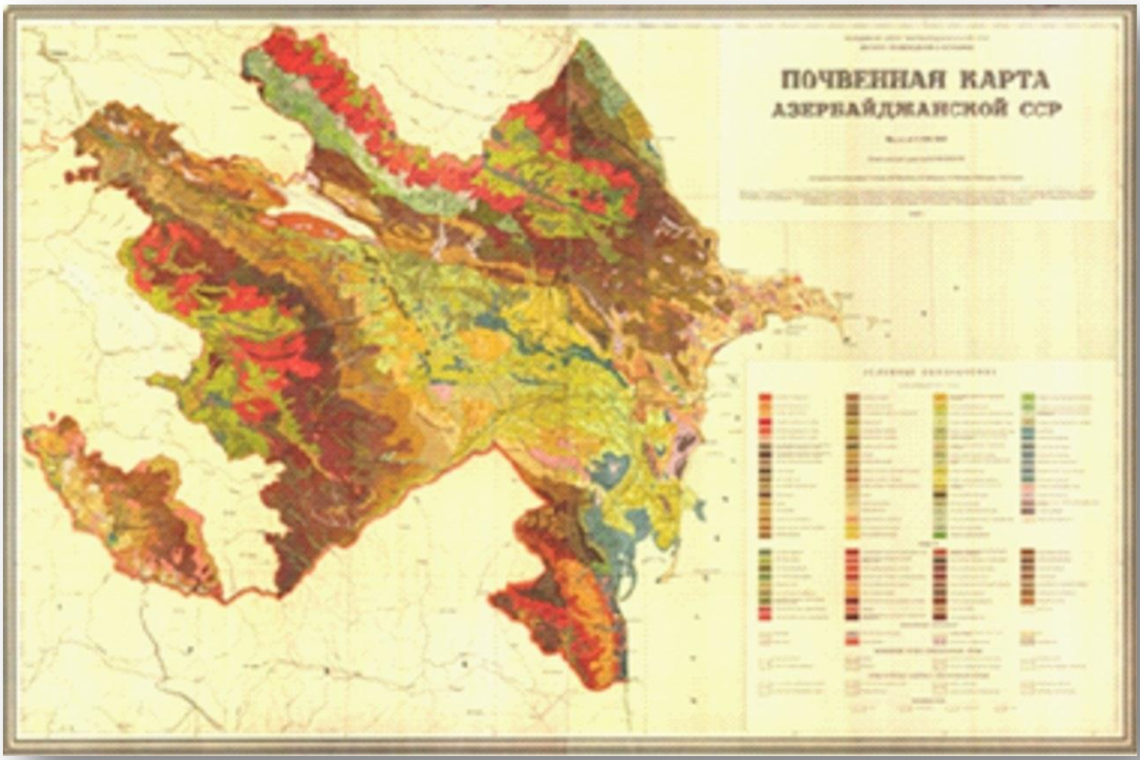

Figure 5 . Soil map of Azerbaijan in a scale of 1: 500 000 (1957)

Starting from 1970. Monograph on "Accelerated amelioration of saline clay of Azerbaijan" was published by prof. M.R. Abduyev in 1977. Prof. Sh.G.Gasanov in his monograph on "The Genetic Features and soil evaluation of south-western Azerbaijan" has considered in detail the major geographic regularities, the genesis, the most important diagnostic features of morphogenetic features of soil toxins.

In 1991 by M.E.Salaev a monograph on the diagnosis and classification of soils have been published, where the author has considered and critically reviewed previously proposed combined classification of soils in Azerbaijan and the Caucasus. Regional lists of systematic soil and generalized soil and soil-cartographic materials on separate major regions of the country, fund materials sheet of Caucasian state soil map of the USSR and materials on a large scale study of soil farms in Azerbaijan Republic [3]. Out of big amount of classifying schemes on republic, as a basis of new classification of soil following information was included by M.E. Salayev: classification of Azerbaijan soil (by Zakharov 1943), Caucasus soil classification (by Zakharov 1954), systematic list of soils in Azerbaijan (by Aliyev, Alekperov, et al., 1969); «Soil classification and its diagnosis in USSR» (1977); program of maps of state soil (1971). A deep research on soil mineralogy was carried out (by Iskenderov), on biochemistry and humification (S.Aliyev), on genesis & geography of Azerbaijan forest soils (by B.Gasanov) . Azerbaijan soil-erosion map was prepared by K.A. Alekperov (Figure 6).

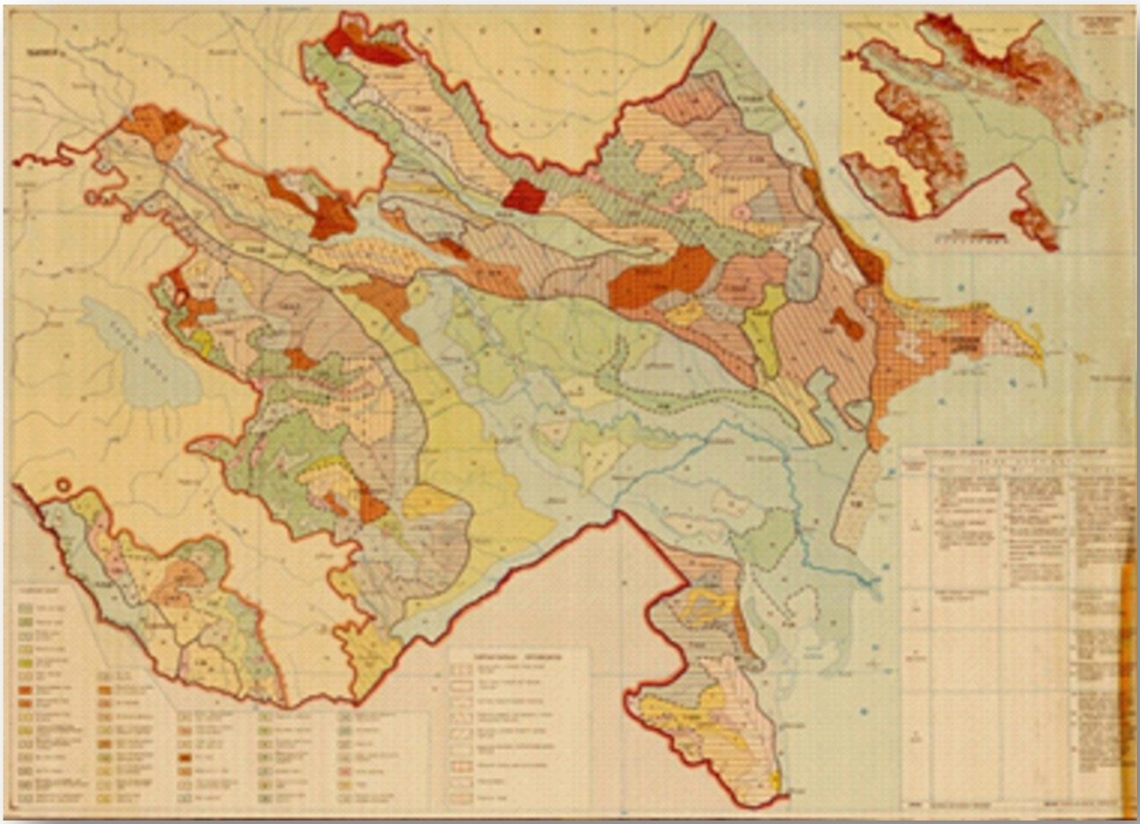

Figure 6. Soil-erosion map of Azerbaijan

At that period a qualified assessment of soils had been commenced and main principals and methodological recommendations on soil evaluation had been conducted (by Sh Gasanov, G. Mamedov). The new diagnostics, taxonomy and classification of irrigated soils of Kura - Araz lowlands of Azerbaijan have been offered (by M.Salayev, M.Babayev), soil fertility issue was widely explored (G.Mamedov). Soil map of Azerbaijan in a scale of 1: 600 000 have been prepared (G..Aliyev and others)(Figure 7) . The soil map of Azerbaijan in a scale of 1: 600 000 includes 44 taxonomic units[2].

Starting from 1990, the first time in Azerbaijan work on the development of the conceptual foundations of soil science was begun by A.Ismayilov. During that period automated information system of Azerbaijan soil have been created, conducted researches on the creation of the soil data base and the preparation of digital thematic maps in GIS environment, and this was the beginning of the modern trends in soil science of Azerbaijan [4,7]. It was already noted that starting from the beginning of the XX-th century land researchers have been implemented in a systematic way. During the last century the research of the republic’s soils has been covered fully. The results of many years’ activities of soil scientists have been reflected in the maps produced in different years. Besides the land maps, the maps of land erosion, lands ecological valuation, agro-production grouping of lands, salting of lands have been produced by different scientists. These maps are very important due to their purpose and time of issuance. They are also actual issues today. These maps are of big importance for revealing the changes which took place in earth soil in tens of years. Along with positive aspects the maps prepared in traditional way have also some imperfections. Land maps prepared by means of simple technology carry only presentation character.

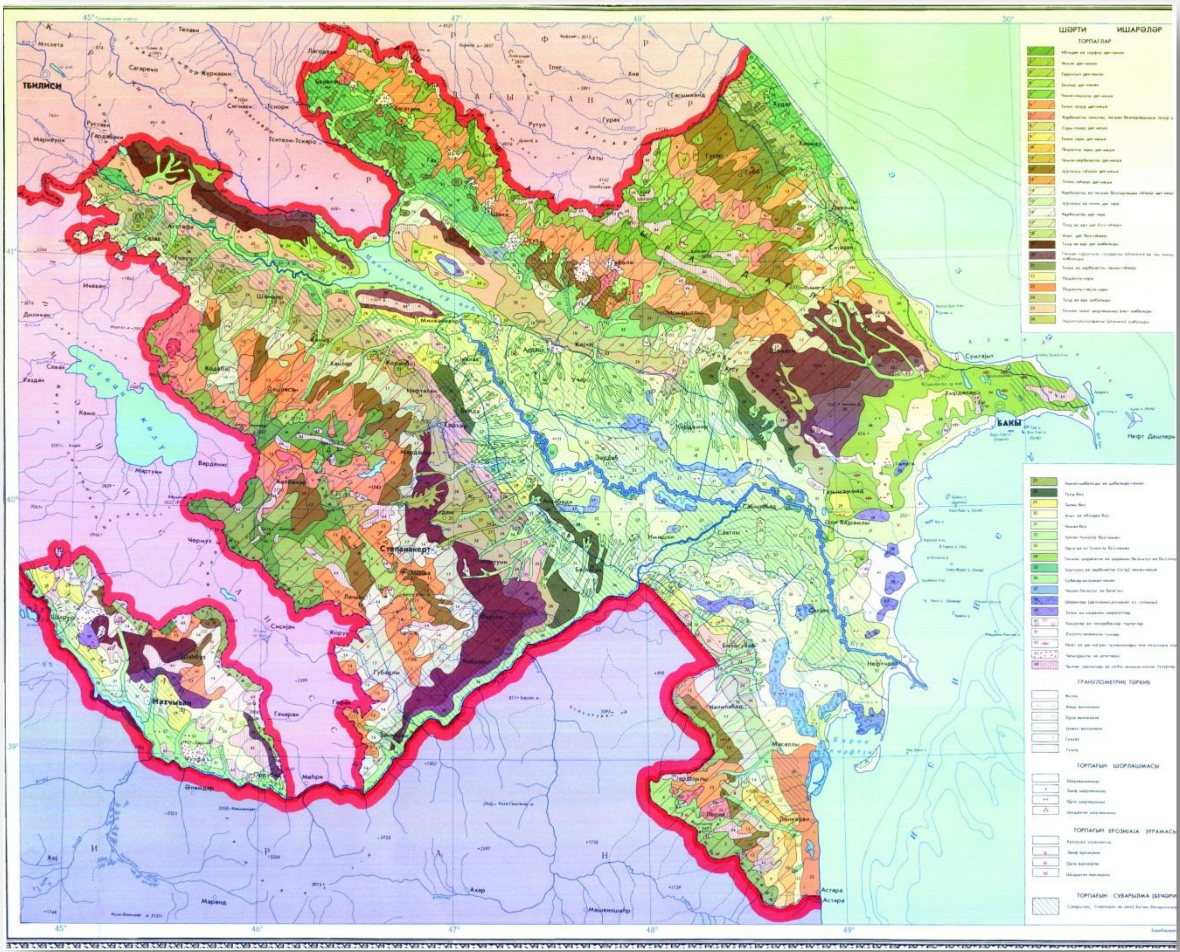

Figure 7. Soil map of Azerbaijan in a scale of 1: 600 000.

To measure the square of the object reflected in the map or to receive the data according to polygon creates difficulties. It is very difficult to identify any changes which took place in soil with time on the basis of such maps. In order to liquidate such imperfections, it has been suggested to produce in electronic format digital maps for land surface of Azerbaijan. Digital maps carry besides connection with certain co-ordination system multi-functional character. The first project of electronic land map was prepared on the basis of AutoCad. The privileges of this project are the following:

-dynamics of the objects reflected on the electronic map;

- definition of length and square measurements in automatic way and with high accuracy;
- automation of transfer to different scales and printing;
- collection of the information on the map on different levels considering their specifications;
- to carry on monitoring observations transparently together with changes taking place in earth soil;
- to achieve additional possibilities for planning of economical use of lands and forecasting;
- to co-ordinate land data base directly with its dissemination area;
- to widen the possibilities of systemization and dissemination of mapping materials about soil;

Lots of necessary information are used for preparation of soil maps. In preparation of soil maps with simple technology data characterizing (attributes) different soil taxons, are applied to the map in form of report or explanatory. Only digital soil map gives opportunity to combine these works. For co-ordination of soil data base with corresponding contour reflected in the land map it is proposed to issue the new variant of electronic soil maps on the basis of ArcGIS [10,11]. The proposed new project has all the above-mentioned privileges. Only using this variant it is possible directly to see on the monitor the comprehensive information about selected land unit. Issuance of such maps is important as from science point view as well as from practical point of view. The soil map of Azerbaijan with correlation WRB, in a scale of 1: 600 000 was carried out [5] the digital version of the same map have been created as well, where every single taxonomic soil unit has separate data layer(Figure 8) .The above list of Azerbaijan soils studies shows soil survey for selected periods of the history and extent of soil study as a science. Present work does not intended to be a full review of the list of works in soil science of Azerbaijan.

SOIL THREATS

Total area of agricultural land in Azerbaijan is 4.56 million hectares, 1.43 million hectares of which are irrigated lands. Deep scientific research of the richest nature of Azerbaijan, and its soil especially, allows the most efficient use of earth fund. Therefore, the experts have focused on the study of the processes of erosion, becoming saline, desertification and land degradation .Soil erosion – is one of the common factors of the ecological environment, causing great damage to agro-economics of Republic. Determination of the degree of soil erosion and vegetation degradation of steppe landscape ecology is a daily problem. Studies of Azerbaijani scientists identified both natural and anthropogenic factors that have influence on the development of intensive erosion.

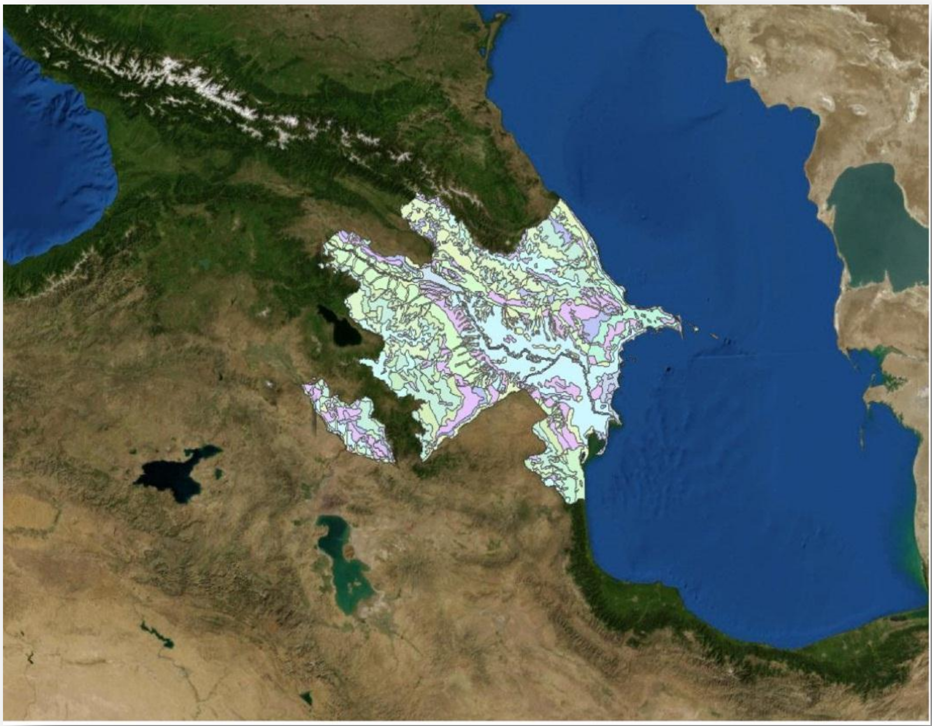

Figure 8. Soil map of Azerbaijan with correlation WRB, in a scale of 1: 600 000

According to the report of The World Bank (European and Central Asian Region) deficient land management practices makes the possibility that the effects of drought will lead to other disasters more likely. Azerbaijan territory 42.5% threatened by the erosion due to deforestation and poor land management, 33.7% of cropland, 68.1% of summer pastures, 15.2% of pasture meadows, 15.9% fruit orchards, 23.9% of vineyards and 26% of forest. The eroded lands are more easily carried away by landslides, which often accompanied by the flood after the drought. Semi deserts occupy 15% of the whole country territory and cover the eastern and western parts of the Kura-Araz lowlands and by Araz plain of Nakhchivan. The process of desertification accelerated during the second half of the twentieth century due to anthropogenic impacts. Since the second half of the twentieth century, as a result of mining activities, development of heavy industry, transportation, oil industry, production of organic and mineral resources, a process of pollution and degradation of soils over large areas have been commenced. Wide scale of dissemination of polluted and degraded soils, creates the need for training of projects for their rehabilitation. It is known from the experience of other countries that sometimes a high rate of the industry development leads to undesirable consequences, such as disruption and destruction of the topsoil. Rarely during the laying of roads and pipelines, on-site of pre-existing areas of fertile agricultural plant cultivation, massive forests, pastures, and meadows, careers polygons unsuitable layers of anthropogenic disturbed areas appears. Usually as a result of anthropogenic impacts terrain hydrology is being changed, destroyed or topsoil is contaminated, and vegetation is destroyed. For example, forest suffers by deforestation and livestock grazing. Sometimes farmland is expanded due to deforestation. The Absheron peninsula and other coastal areas are among the most environmentally unfavorable areas of the country due to severe air, water and soil pollution. Air pollution happens due to industrial emissions, discharges by Baku, Sumgait and other cities. A major source of the sea pollution is oil and refining industry. Particularly there is a need in large scope research projects in the field of soil reclamation on the Absheron Peninsula, Particularly on the Absheron Peninsula, there is a need conducting large research projects in the field of soil reclamation, which is caused by technogenic destruction of mining, processing and transportation of oil, gas and other mineral resources. In the recent years relevant organizations work actively to eliminate the sources of pollution. In some cases, plants those existing as a source of pollution had been shut down or modernized.It should be noted that, during the recent years projects for the protection of environmental resources are actively carried out. 14 reserves (National parks) and 20 sanctuaries had been established in order to preserve some areas of natural forest, relict flora and rare animals.

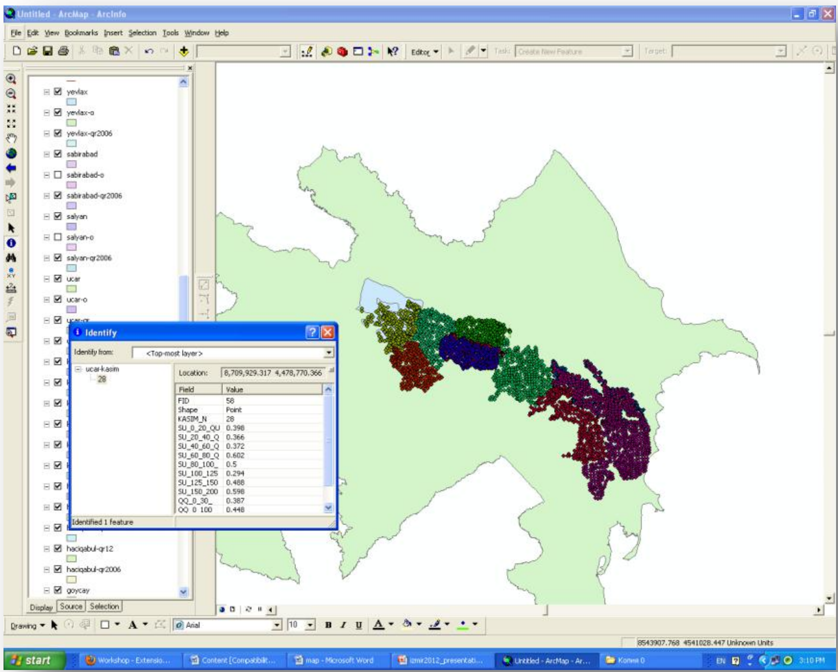

Figure 9. GIS of Kura - Araz lowlands soils

During the collapse of the Soviet Union, works on land amelioration, construction and exploitation, irrigation and drainage of the networks were left without funding and the whole system was collapsed. In the process of land reform, which was conducted in 1997 land was fragmented. Landlords, who owned lands with a size of 2.1 ha, were not able to carry out the amelioration and erosion control measures; As a result the range of saline and eroded land has been increased. Currently, 508 270 ha of lands under the agricultural turnover of the republic and are saline. Out of these, 385,037 hectares – are slightly salty, 102,110 ha of medium-are saline, 21,123 ha – are highly saline soils. Totally 11.2% of agricultural land had been affected by salinity. These figures show that the land that require amelioration, occupies an important place in the total area of agricultural land. Despite the fact that, during the 20th century Research on saline lands in Azerbaijan were carried out repeatedly, it is almost impossible to find the results of the investigations today. The main reason is that all these information was in hard copy and was kept by different organizations or different people. As a solution for the situation in the years of 2003 -2006. we have investigated the possibility of the development of GIS soil of Kur - Araz lowlands based on the modern information technology and the ability to organize monitoring for saline soils. Data on soil profiles, as well as test results of the analysis were recorded to database and displayed as separate data layers on a digital map (Figure 9).

At the same time, it should be noted that this work doesn’t met the requirements of integration in the European Soil Database. Because, in the present work, used local methods to determine salinity and the use of local scale salinity, which are very different from European [6,8]. To resolve these discrepancies, we can use special correlative communications which you can move from one unit of measurement to another. Such experience is observed in Azerbaijan

FUTURE PROSPECTS and INTEGRATION STUDIES

The current stage of the Azerbaijan soil resources inventory on supranational level is closely linked with the processes of adaptation of the country to the conditions of new geopolitical realities. It is of fundamental importance to preserve and develop the national scientific and practical traditions and their harmonious integration with the European Union (EU) soil inventory [13,14]. With respect to the joint analysis of soil resources of
Azerbaijan and the EU there are objective difficulties:

They can be divided into 2 groups:

1. Common difficulties. These include the following:
   - difference in scientific and methodological approaches, methods of soil mapping
   - difference in terminology and the language barrier.
2. Local difficulties:
   - Inaccessibility (sometimes unavailable) of the primary data;
   - Hard copy form of soil data sources;
   - A large variety of map and attribute data
   - Lack of vector spatial and attribute data
   - Technological difficulties. Low level of information technology use (software and hardware) in soil studies;
   - Non-perception of modern approaches research in soil science by some experts, including the use of IT

Currently, the process of integration into the European and international structures for many fields including the scientific ones is under process. On the background of globalization, fundamentally important factor is formulation of adequate soil-information space which would provide a solution of actual problems in order to extract the mutual social and economic benefit. It is obvious that the achievement of the integration of the international community with the old traditional methods is impossible. It is positive that today more and more people are realizing the need to use information technology in soil studies and location of Azerbaijan on an important geographical position and has great potential for the implementation of modern concepts in the efficient use of land resources. Based on the above, we can say that the integration into a single soil-geographical space of Europe is one of the urgent tasks for Azerbaijan [9, 12]

The use of European soil standards in Azerbaijan will enable to carry out a joint analysis of the land, to develop a common policy and common agricultural monitoring, unified assess the quality of the environment. As its known the database provides complete analytical characteristics for typical soil profiles. Special attention should be paid to the correlation of national classifications of soils with mapping units of European geographical database. The geographical location and climatic conditions of Azerbaijan makes the use of its soil resources an area of diverse international interests, including joint production of agricultural products. Therefore, formation of adequate soil information space that would provide a solution to the listed and other issues in order to extract the mutual social and economic benefits of globalization is becoming critically important. A perfect example is land reform in Azerbaijan, which was formed as a result of fundamentally new land relations. The purpose of land reform was to create a qualitatively new relationship of land ownership based on economic freedom and social justice, the development of market economy, food supply, and the improvement of social welfare. It is naturally that mentioned process of the land reform was characterized by the kind of problem-setting and, of course, require specific investigations of soil in total and geographical descriptions in more detailed studies to large-scale soil surveys.

Modern stage of development of Azerbaijan has its own specifics of a change in demand for soil information in connection with the collapse of the Soviet Union and the disintegration of soil-resource space, the destruction of the state monopoly on the ground, the trends in the appearance of the land market, which activates the modification process and the transformation of land use systems in line with the economic principles of their domestic and export market. In these conditions, soil information must first be unified and focused on solving problems that arise in a dynamic market (internal and external) environment. A fundamentally important aspect of the problem is the requirement of format compatibility of national and European soil information spaces, which will allow the use of models' common system for assessing and monitoring land-resource potential. The objective is to achieve the comparability criteria and results of assessments of soil quality and resource potential on the European level.

. All this will provide the basis for the formation of a single economic space within the limits of which you can implement the agreed policy for soil with the best social-economic and environmental results. Our goal should be the representation of the new digital soil data base made up for Azerbaijan. This task is feasible, but it is necessary to implement various projects to create a new database of soil data meeting the requirements of European Soil Database 1:1.000.000 scale.

CONCLUSIONS

In the article issues of possibility of Azerbaijan integration into soil and geographical space of the European Union have been discussed. Azerbaijan occupies an important geographical position, and has great potential for the implementation of modern concepts in the efficient use of land resources. In the article the questions of possibility of Azerbaijan integration into soil and geographical locations and climatic conditions of Azerbaijan makes use of its soil resources an area of various international interests, including issues of agricultural products joint production, trans-boundary transport of pollutants, development of the overall strategy of basin land use, etc. Occupying more than 8.6 million hectares, the region has great potential for the implementation of the concept of the efficient use of land resources. Features of the region appear that its topsoil formed by a huge variety of factors of soil formation and bio-climatic conditions which is vary in a very wide range. Relief is represented by lowland plains, located below sea level, and high mountains of southern Great and Small Caucasus. Granulometric and mineralogical composition and age of the parent rocks have also a huge variation. A noted specific condition of soil formation determines the enormous variety of soil forms. The diversity of soil traditionally nominated among the most important tasks of the inventory soil resources. Complex research in Azerbaijan began in the last years 20th century, when the scientific expeditions in the field of geology, geography, botany, soil science have been organized. As a result of these researches maps of different scales, scientific atlases were created. It is shown that the application of the European soil standards in Azerbaijan, will carry out a joint analysis of the land resources, to develop a common policy and common agricultural land use monitoring, unified assess the quality of the environment. Azerbaijan soil data base provides a fairly complete analytical description for typical soil profiles. However, the differences in approaches, analytical methods, and a measurement that have been existed and exist to this day do limit the integration. For these reasons, the attribute information about the soils of Azerbaijan are different from European standards.

Considering this, we can come to conclusion that one of the actual issues for post-soviet soil scientists also for Azerbaijan ones in modern conditions, is development of a database of soil data in the format of geographic information system of soil EC, its structure and development of the correlations soil map legend of the region in a certain scale (for Azerbaijan, 1:1 000 000) with soil list that is used in EC.

At present time, international organizations are interested in a comprehensive common classification required to produce a large-scale soil maps of the world, which can be used for assessment and management of land resources in each country, and for focused and well managed fertility. Realizing the importance of integration problem in soil and resource issues at the international level, the Azerbaijani soil scientists must actively support «Extension of The European Soil Database to Mediterranean and Caucasian Countries» project. For this it is primarily required to develop a new digital database of soil data, compiled in the territory of Azerbaijan in the format of geographic information system of soil EC. To prepare the correlation of Azerbaijan soil legend in a scale of 1:1000 000 with the list of soils used in EC system. Connection to the the European Soil Database are assessing the suitability and land productivity of individual countries on the basis of unified internationally accepted standards using the latest information technologies based on geoinformatics, integrated modeling, connected with the means of remote sensing of the new generation

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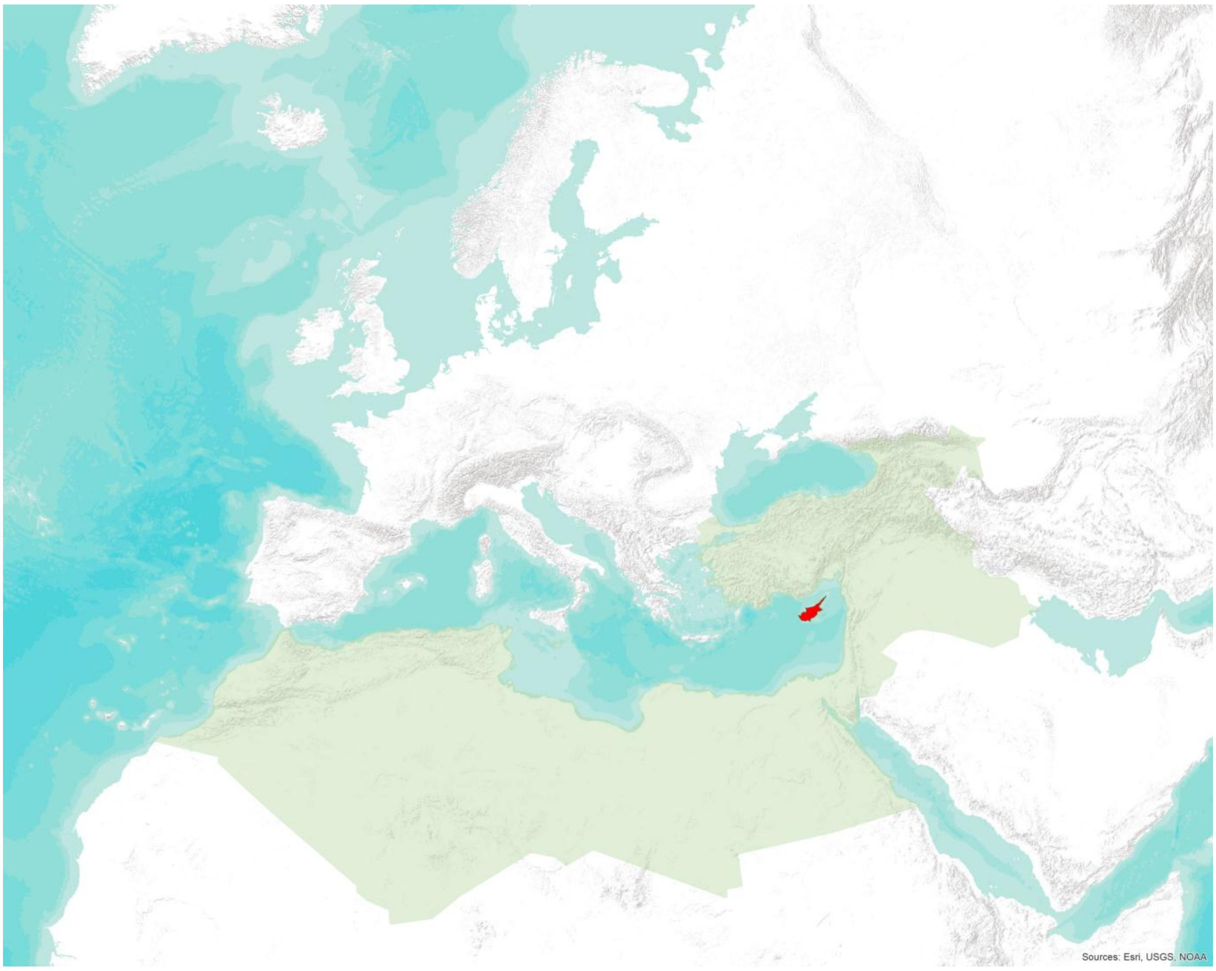
Chapter III.
SOIL RESOURCES of CYPRUS



SOIL RESOURCES of CYPRUS

Zomenia Zomeni, Adriana Bruggeman,[1]

ABSTRACT

The soils of Cyprus are unique due to the geological complexity, the intense Mediterranean climate and the long presence of man on the island. The geology of Cyprus is dominated by the Troodos Ophiolite, which is a fragment of a fully developed oceanic crust, consisting of plutonic, intrusive and volcanic rocks and chemical sediments. Sedimentary formations cover the coastal plains in the south and the intermountain plain in the north. An incomplete set of soil surveys and maps at a scale of 1:25,000 have been prepared in the 1960s and 1970s, with the soils classified based on their formation, origin and parent material. These maps formed the basis of the development of a digital soil map of Cyprus at a scale of 1:250,000, where the soils were classified according to the World Reference Base of Soil Resources. A soil geochemical atlas of Cyprus at a sampling density of 1 sample per km^2 has been recently completed. The soils of Cyprus are under various threats, including erosion, salinisation, landslides, pollution, soil sealing, and low organic matter and soil biodiversity. Efforts to link existing soil information to the soil mapping units and soil typological units are currently undertaken.

Keywords: Cyprus, soils, ophiolite, Eastern Mediterranean

INTRODUCTION

The Mediterranean is a unique semi-closed sea basin with distinct climate, geomorphology, and soils. It has steep mountains and infilled valleys, extensive coastal zones with significant additions of Saharan dust (Yaalon, 1997) and a rich Quaternary seismic and human history. All these attributes contribute to the Mediterranean being a significant field laboratory for studying Quaternary environments. It has rightly been referred to as "a sea behaving as an amplifier of the palaeoclimatic and palaeoceanographic signal" (Cita et al., 2006).

Cyprus, the third largest Mediterranean island (9,250 km^2), is notable for its geodiversity and tectonics, both of which have created a unique landscape and natural environment. The island is divided into many physiographic/geomorphologic regions which owe their creation to the tectonic evolution of the island creating an intense topography very unlike the topography in nearby Egypt or Israel. Robertson et al. (1995) could not have made a more representative statement about the geology of Cyprus when stating that "one of the most fascinating aspects of eastern Mediterranean geology is the very rapid Plio – Quaternary uplift of the Troodos ophiolite, Cyprus". In light of this very strong but also very true statement, this review attempts to contribute further to our understanding of this unique place.

The Troodos Mountain Range is the main geomorphologic feature of the island of Cyprus. It covers an area of about 3200 km^2 and its highest peak, Olympus, has an elevation of 1951 m. The topography of the island is controlled by its four geological terranes (Figure 1). The first one is the Troodos terrane with the smaller Arakapas sequence, the central bedrock unit of the island, consisting of pieces of a 90 million years old ophiolite. An ophiolite is a piece of oceanic crust formed at a mid-oceanic spreading ridge. The uniqueness of Cyprus is that the ophiolite has being uplifted above sea-level and forms the core of the Troodos Mountains making it easily accessible to

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geologists. Its well-preserved structure and stratigraphy makes the Troodos ophiolite one of the most thoroughly studied ophiolite complexes in the world.

The Troodos ophiolite includes all components of an ophiolitic sequence, an ultramafic core consisting mainly of serpentinized harzburgite, cumulate rocks, a sheeted dyke complex, and a volcanic sequence of mostly pillowed lava flows, topped with iron and manganese rich sediments. Its core forms a distinct moon–like barren landscape of highly fractured rock blocks of harzburgite and serpentinized harzburgite covered by very shallow and rocky soils. High peaks and ridges of young v–shaped valleys in diabase bedrock is the predominant feature in the Kykkos Mountains of western Cyprus, the topography being strongly controlled by ongoing weathering and erosion of these rocks.

The pillow lavas host the Cyprus-type massive sulphide deposits. Cyprus produced copper from the mining and smelting of these cupriferous sulphide ores in Antiquity. Copper was of vital importance to the historical and socio-economic development of Cyprus both in ancient and in modern times. The early development of the copper industry in Cyprus, followed by its expansion and duration for more than 3,000 years, is evident from ancient and historical references but also archaeological findings. Ancient mining workings such as shafts and galleries can be found widespread across the island. A great variety of mining tools were discovered by geologists and mining engineers during the re-operation of some of these mines at the beginning of the 20th century. However, the most impressive evidence for the extent of the ancient copper industry in Cyprus is the widespread occurrence of ancient slag heaps. More than 50 such heaps have been found scattered mostly in the pillow lava outcrops in the periphery of the Troodos Ophiolite. These slags were the byproduct from the smelting of metallic copper over a period of at least 3,000 years.

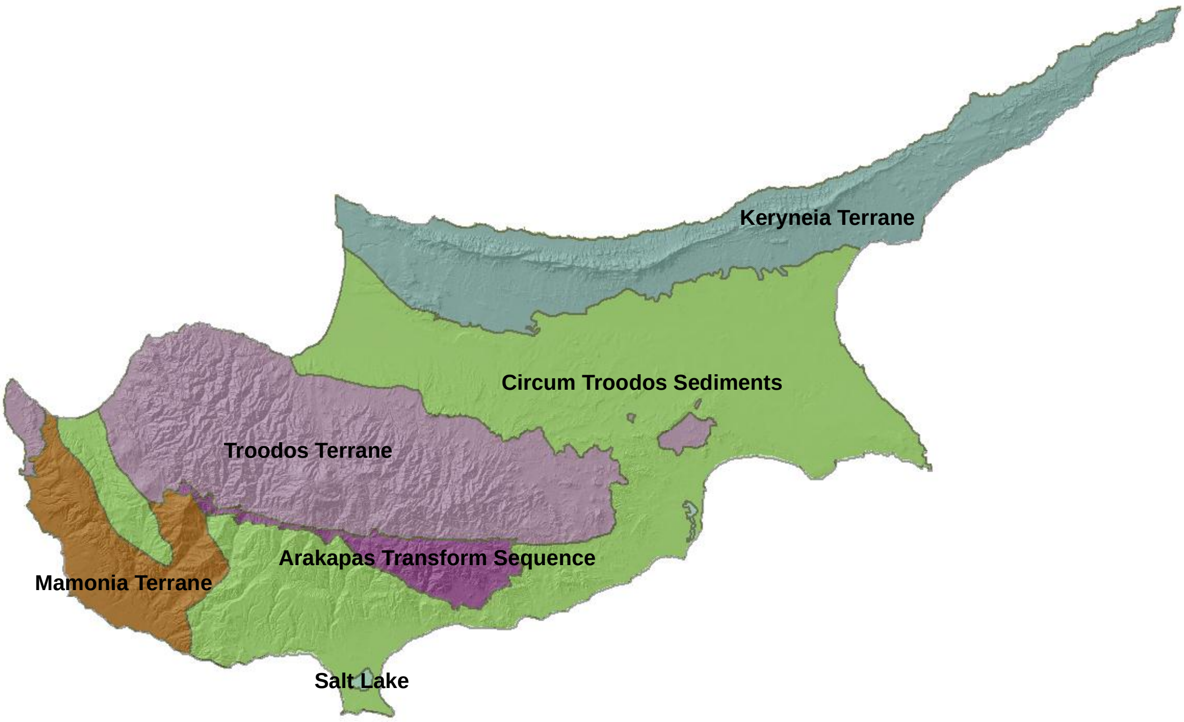

Figure 1. Major geological and tectonic zones of Cyprus.

The Mamonia terrane consists of sedimentary rocks and basalts formed 200-70 million years ago as a result of collision with the Cyprus plate 70 million years ago in an area now represented in the southern part of the island. This terrane includes groups of igneous, sedimentary and minor occurrences of metamorphic rocks with deformation being quite intense as they have been severely broken and folded during their emplacement. Their juxtaposition formed thick and extensive clay rich mélanges which host these allochthonous rocks. A 5-km wide and well exposed melange zone in the western part of the island presents an erosional window into this suture zone.

The base of the Circum-Troodos sedimentary succession is marked by the 750-m thick Kannaviou Formation consisting of clays and sandstones. This formation is extensively exposed in western Cyprus. Still at the bottom of the Tethyan Sea until about 30 million years ago, the Troodos and Mamonia terranes are topped with chalks and cherts of the Lefkara Formation, the first carbonate sediments. Equivalent to the Lefkara Formation in the south is the Lapithos Formation in the north, which is the oldest autochthonous unit in the Kyrenia zone.

Repetitive white chalk-and-marl bed morphology dominates the Lemesos region in the south. These carbonates (Pachna Formation) have been source rock for building material on the island since Antiquity. Highly terraced agricultural land known as Omodos viticulture country forms classic chalk and marl topography with radial and trellis drainage on south facing beds, their dip attributed to the uplift of the Troodos ophiolite mountains. The Larnaca region is distinct for its low hills of white Lefkara Formation chalks and gypsum dissolution features over the gypsum lowlands.

In Karpasia, structural complexity with many north- south-trending faults, together with the erodibility of the highly sandy Kythrea flysch are responsible for the rough topography and geomorphological uniqueness of this peninsula that forms the northeastern part of the island. Collision of more continental crust in the north (20-10 million years ago) gives rise to the intricate and precipitous mountain peaks of the Keryneia zone consisting of a complex assemblage of exotic limestone blocks, thick sandy flysch (Kythrea Formation) and limited metamorphic and igneous rocks. It forms a narrow, steep-sided chain of mountains that rise abruptly from the surrounding lowlands. The oldest rocks are Permian limestones, flanked to the south by the broad lowlands of the Mesaoria Plain.

The Keryneia region has very precipitous crystalline limestone mountain peaks in the central range, hummocky and mainly bedding-dip controlled, north- and south-facing slopes of Kythrea flysch beds and an extensive coastal marine terrace range. These limestones are characterized by karst topography including karst caves and many water springs. The east-draining river system of Pediaios is responsible for the extensive flat lowlands and marshlands of the northern part of the Ammochostos region. In the southern Ammochostos region, a high-lying platform with red, well-developed terra rosa soils constitutes a unique part of this southeastern region with very thick and fertile soils.

In the central and southern lowlands, sequences of gypsum beds are known as the Kalavasos Formation and mark an important rock sequence found in most coastal Mediterranean regions, caused by the Messinian Salinity Crisis, a 2,000-m drop in the Mediterranean sea-level which occurred about 7-5 million years ago. The reestablishment of the sea-level 5 million years ago is responsible for marly deposits across the whole Mediterranean basin. Locally, the marls were deposited in the shallow seas which today form the central and coastal lowlands.

More specifically, the Mesaoria region, forming the central plain between the Troodos mountains in the south and the Keryneia range in the north consists of broad and gentle foothills, eroded into mesas and valleys which develop into two major river systems, one draining west and one draining east. Thick coarse alluvial fans formed predominately along the north and south Mesaoria Plain feeding material into the Pediaios, Serrachis and Ovgos rivers. The Morfou coastlands and marshlands are dominated by the Serrachis and Ovgos deltaic deposits in the west and the Pediaios deposits in the Ammochostos area in the east. These deltaic deposits, composed of thick gravel beds, host the most valuable aquifers in Cyprus. Wide flood plains are the main characteristics of the present landscape in the Mesaoria. At the two coastal margins of this central plain, thick deltaic, aeolian and beach deposits of prograding coastlines form what are today the lowlands of Morfou Bay in the west and Ammochostos Bay in the east. Pleistocene uplift and repeated sea level rise and fall, laced the coastal landscape with flights of uplifted marine terraces and the valleys with fluvial terraces.

Recent (last 3 million years) surficial processes have contributed to the formation of this very diverse present landscape. Uplifting and faulting have made significant imprints on the landscape. Rapid uplift increases the power of rivers. This uplift increased markedly 2 million years ago. Uplift on Cyprus can be attributed to two geological processes. Firstly the serpentinization of the ophiolite core creating a dome feature centered about the highest peaks of the Troodos mountains. This hydration process transformed most of the harzburgite into serpentinized harzburgite, increasing the volume and decreasing the density of these hydrated rocks and finally causing domal uplift. Secondly, the tectonic regime of the eastern Mediterranean has added a significant vertical component to the resultant vector of the Cyprus plate.

The erosion of the mudstones around Lefkosia and the formation of stand-alone mesas are strong indications of the uplift and river erosion of the island. Another strong indicator is the intense river erosion of the Troodos Mountains and the deposition of thick alluvial fans on the plains. The large boulders derived from Troodos ophiolitic rocks, contained in these gravel deposits are indicators of the erosional and transportational capacity of the rivers. Figure 2 shows a simplified map of these deposits, which also host the most productive and cultivated soils.

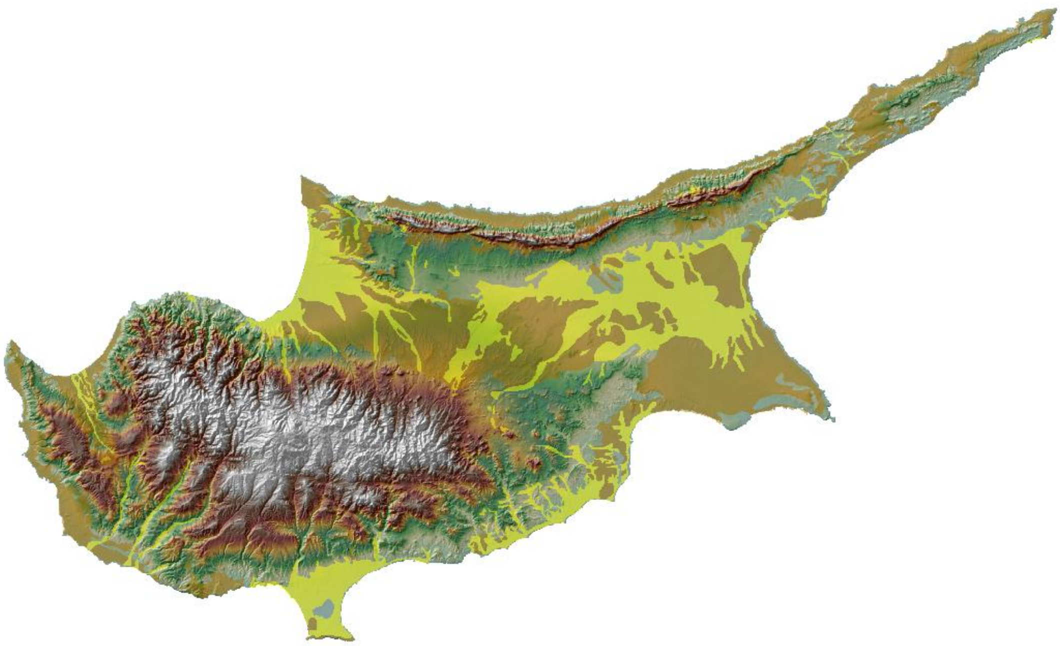

Figure 2. Quaternary units (last 2 million years) on Cyprus develop mostly on the central and coastal lowlands. Pleistocene deposits are shown in brown and Holocene (last 11,000 years) alluvium and colluvium deposits in yellow. Map is adapted from the 1:250,000 geological map of Cyprus (Cyprus Geological Survey, 1995).

Climate and Vegetation

The Mediterranean climate is characterized by rainy, sometimes with excess rainfall, winters and warm, dry summers with moisture deficits (Yaalon, 1997). This is a short and accurate description for the climate on the island of Cyprus. The mean annual precipitation over the country is approximately 470 mm (1970/71-2011/12) and occurs primarily from November to March (CMS, 2012). The winter temperatures on the coast range from 0^{o} C to 25^{o} C and, from 25^{o} C to 45^{o} C in the summer. The soil temperature regime on the coast is thermic and the moisture regime xeric. This climate was established about 2.3 million years ago as deduced from pollen data (Suc, 1984).

The Köppen-Geiger climate classification identifies the climate of Cyprus as temperate with dry and hot summers in the western part of the island and as an arid hot steppe in the eastern part (Peel et al., 2007). According to Rivas–Martinez bioclimatic classification, shown in Table 1, the island has a Mesophytic to Xerophytic–oceanian bioclimate with zones ranging from thermo–Mediterranean–semi arid in the lowlands to Supra-Mediterranean humid in the Troodos Mountains (Barber and Valles, 1995; Andreou and Panayiotou, 2004).

Table 1. Bioclimatic zones of Cyprus (after Pantelas, 1996). M stands for the mean of the daily minimum temperature of the coldest month in the year.

Altitude (m)	Bioclimatic zone	Precipitation (mm)	M (^{o}C)
<100	Arid hot	<400	>6
<100	Arid mild	<400	3-6
0-300	Semi-arid hot	400-600	>6
300-400	Semi-arid mild	400-600	3-6
400-900	Semi-wet mild	600-900	3-6
900-1150	Semi-wet cool	600-900	0-3
1150-1500	Cool wet	>900	0-3
>1500	Cold wet	>900	<0

Figure 3 shows the vegetation cover of Cyprus. The main crops are barley, which is often grown as fodder and harvested green, olives, vines, and potatoes, followed by fruit and nut trees, and citrus (Cystat, 2012). Barley, potatoes and citrus are grown in the plains, while olive, vines, fruit and nut trees are found in the foothills and mountains. Approximately 18% of the agricultural land is irrigated (Cystat, 2012). The total agricultural land in the Republic has decreased substantially over the past decades, from 200,500 ha in 1995 to 133,400 ha in 2010 (Cystat, 2007; 2012).

The flora of Cyprus is composed of 1.950 indigenous and adventive species, subspecies, varieties, forms and hybrids. From these, 140 are regarded as endemics (Tsintides et al., 2002; Department of Forests, 2008). The distribution of the different forest types are presented in Figure 4 and Table 2. Garigue vegetation (predominantly low shrubs) is found on degraded and sloping soils. In areas with higher potential, garigue is succeeded by maquis (evergreen sclerophyllous shrubs). Pine trees, especially the indigenous Calabrian Pine (*Pinus brutia*), are the dominant forest tree species used in afforestation and reforestation projects. Black pine is found at higher elevations, i.e. above 1200 m.

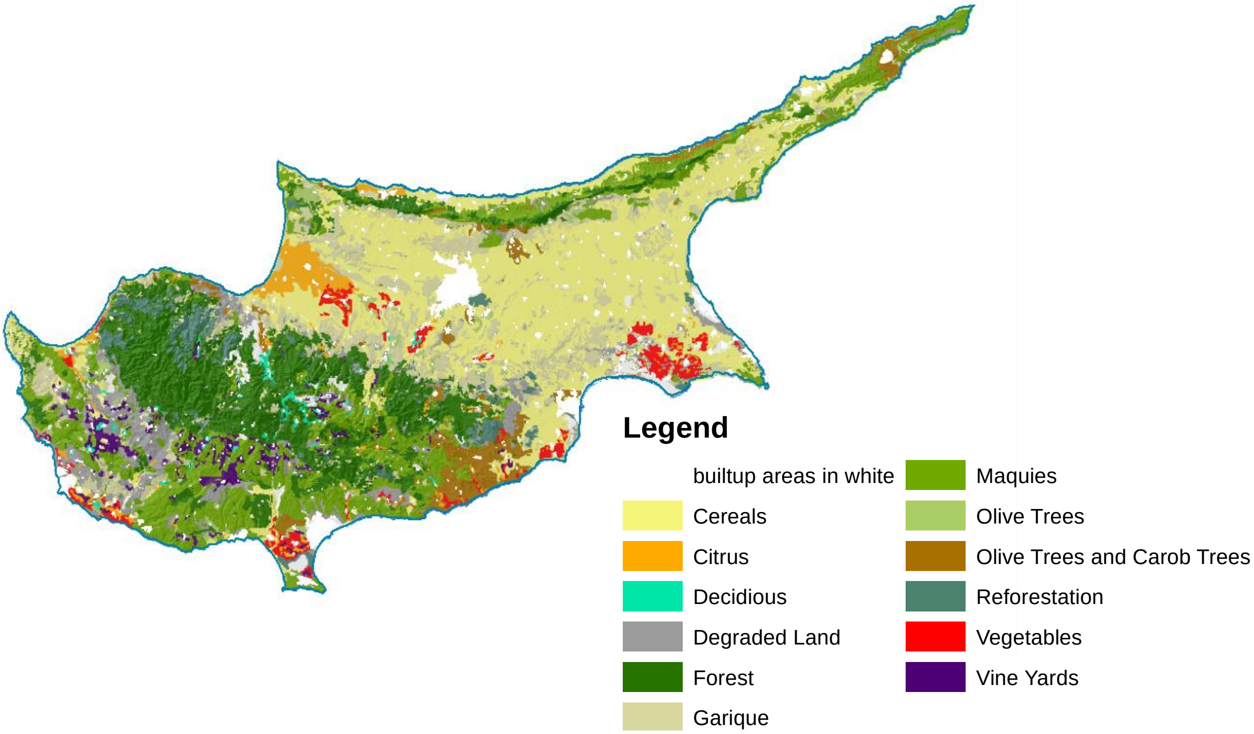

Figure 3. Vegetation map (Data from Ministry of Agriculture, Natural Resources and Environment).

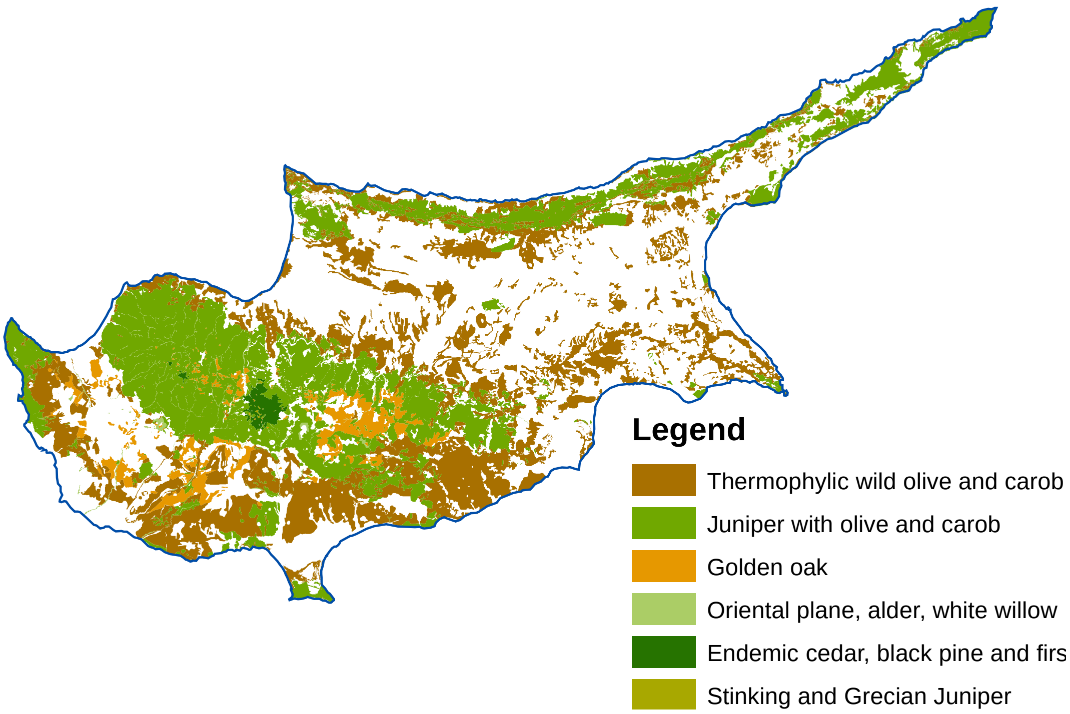

Figure 4. Cyprus forest types as listed in Table 2.

Table 2. Forest types according to Quezel classification (from Department of Forests, 2005**)**

Name in Quezel classification	Local description of forest type	Predominant areas of occurrence
Olea and Ceratonia Maquis	Thermophylic wild olive and carob	From sea level to 600 m, from Akamas to southern Troodos foothills and the northern Pentadaktylos range
Mediterranean Conifer forest of Calabrian pine and Phoenician juniper maquis	Juniper with olive and carob	From sea level to 450-m elevation, in Akamas, Episkopi, Akrotiri, Cape Kormakiti, Cape Greco and Karpasia
Sclerophyllous evergreen forest of golden oak and Kermes oak	Golden oak	From 400-1700 m elevation on steep slopes, typically on talus slopes in Troodos ophiolite rocks
Deciduous riparian forest and semi-deciduous oak woodlands	Oriental plane, alder, white willow	Along streams, rivers, confined to valleys between 600-1100 m elevation
Mountain forest of Cyprus cedar and black pine	Endemic cedar, black pine and firs	Highest peaks of Troodos and Tripylos forest in Pafos forest
Oro-Mediterranean stage stands of arborescent junipers	Stinking and Grecian Juniper	Highest peaks of Troodos mountains, Chionistra (1700-1952 m elevation), Madari and Papoutsa (1400-1650 m)

Land Use and Land Suitability for Agriculture

Recent Land use maps are based on the CORINE classification system and were prepared by the Ministry of Agriculture, Natural Resources and Environment, more specifically the Remote Sensing section of the Department of Forests (Figure 5). Data was mostly based on previous mapping improved with the use of updated satellite images.

The land suitability and potential cropping pattern map of Cyprus was prepared in order to present the main agricultural productive zones on the island with their potential problems. This map was completed in 1999 at a scale of 1:250.000 based on data and records from an older land use map (Land Suitability Map, Department of Agriculture, 1971) and more recent soil mapping. To prepare the Land Suitability Classification map (Figure 6) the following factors were considered:

- Soil physical properties (texture, structure, bulk density, infiltration rate, etc.);
- Soil chemical properties (lime content, pH, salinity);
- Soil depth;
- Anticipated productivity;
- Expenses required for land levelling or reclamation;

Five suitability classes resulted with most of the data being derived from detailed soil maps at 1:25.000 scale (the map evidently has more detail in these areas). These classes are numbered from

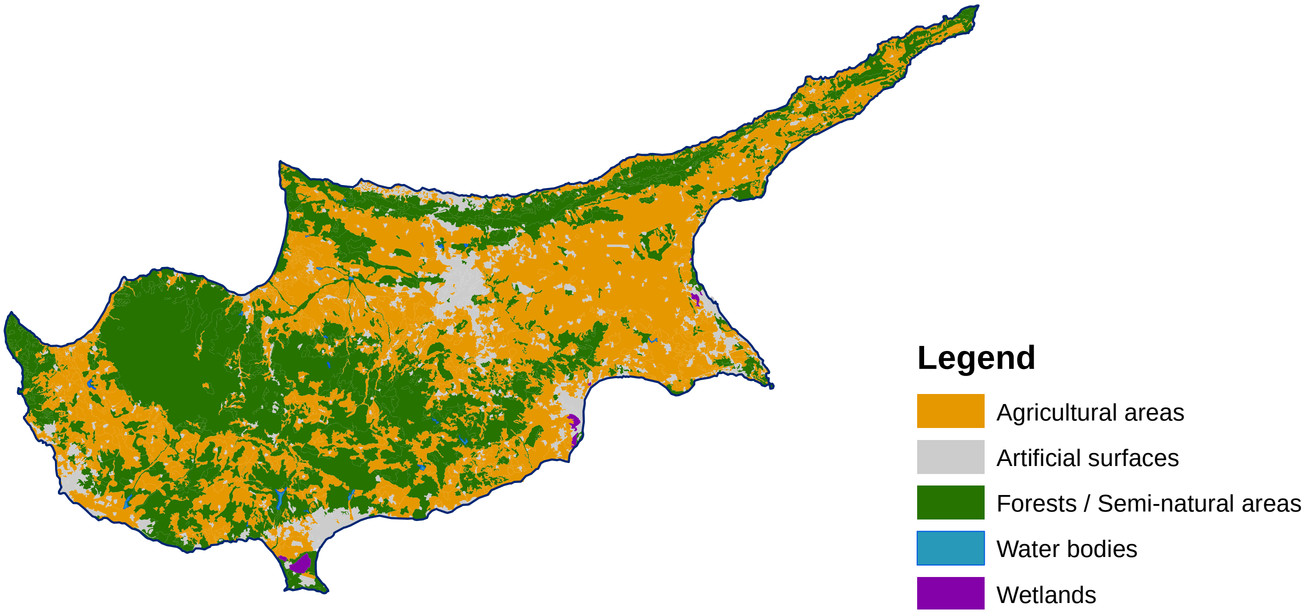

Figure 5. Land Use Map of Cyprus showing only Level 1 classification (CORINE 2006).

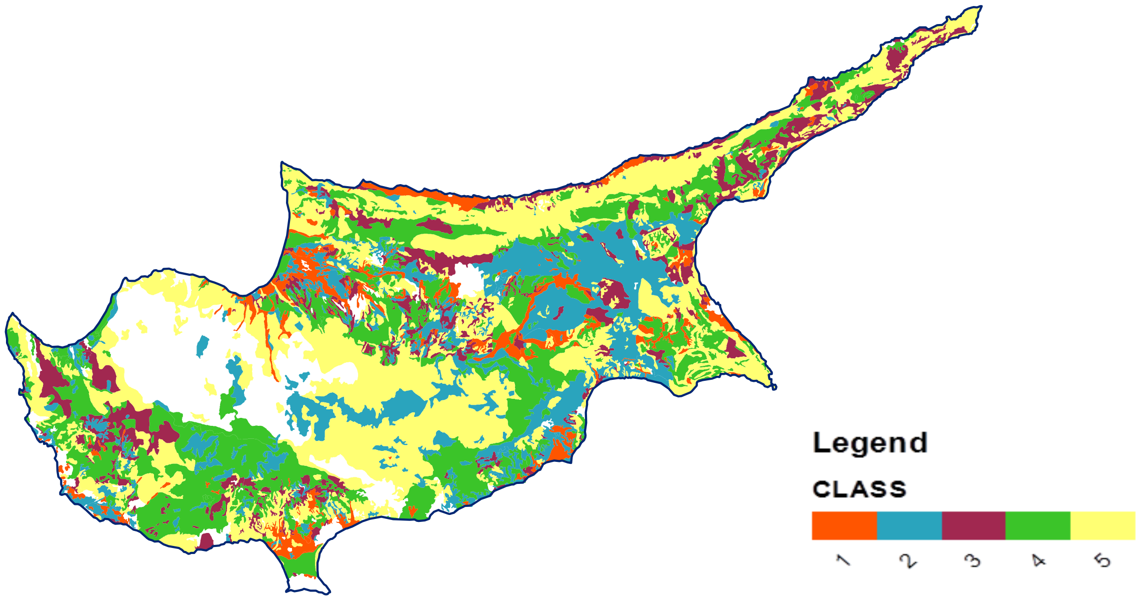

Figure 6. Land suitability map (Department of Agriculture, 1971).

I-V, in decreasing order of land suitability. Classification makes an assumption for availability of water for irrigation. Besides that, each suitability class indicates the crops that can be successfully grown on each class of soils (Table 3).

Table 3. Land Suitability Classification (Department of Agriculture, 1971).

Class	Class description with limitations
I	This class has no limitations. Although these soils differ in their origin, physical and chemical characteristics, they have many common properties. These soils are suitable for any kind of crop without limitations as far as soil productivity and expenses are concerned considering that climatic conditions are not limiting factors for any specific crop.
II	This class includes soils belonging to various soil series having slight to moderate limitations in regard to slope, lime content or soil physical properties. When the existing limitation is only due to slope, no limitation on crop selection exists. The soils included in this class are mainly suit-able for deciduous trees, vines and vegetables.
III	This class includes soils having serious limitations mainly in soil depth, physical properties and/or slope. Due to the above limitations tree crops should be avoided in those areas. Vegetables, however, can be successfully grown.
IV	This class includes soils having unfavorable soil conditions especially shallow soil depth. These soil conditions lead to severe limitations in productivity, (2nd order), in crops, (3rd order) or in expenses, (3rd order). The soils of this class should not be normally irrigated, but in case of land shortage, these areas may be used for shallow rooted vegetables.
V	The soils included in this class are completely un-suitable for irrigation due to very severe limitations. The class includes bare rocks or rocks covered with a thin soil layer in pots or soils having unfavorable physical and chemical conditions.

COUNTRY SOIL INFORMATION and DATA

Legacy Soil Information

In Cyprus there is no specific soil institution or research centre. The Agricultural Research Institute (A.R.I.) is the only one scientific agricultural centre in the country. The institute includes in its activities some research in soil science mainly in soil productivity and soil fertility. Various research actvities on fertilization, recycled water use and many other relevant sectors have been established. Furthermore, A.R.I. cooperates closely with different centers and institutions in Europe and the Middle East region.

The Soil and Water section of the Department of Agriculture in the Ministry of Agriculture is the only government entity responsible for soil mapping and other relevant soil activities. A water use improvement project, which provided the farmers with technical and financial assistance to convert from traditional surface irrigation methods to modern irrigation methods, has been run by the Department of Agriculture since 1965. Between 1986 and 1999, on average 148 soil samples have been analyzed per year for wilting point and 175 for field capacity (Phoicades, 2002).

Soil survey mapping on the island has focused on the needs of agriculture - irrigation, land consolidation projects, land suitability, pasture and range, and watershed soil conservation. Most of the soil series maps have been mapped on the 1:25,000 scale. Ten out of forty possible sheets have been mapped to date and are described in the following sections.

Digital Soil Resources

By far the most detailed soil reference on the island are the ten 1:25.000 scale soil sheets, which are always accompanied by a land suitability map. These maps are populated by thousands of polygons and two of them, the Pafos sheet (Soteriades and Koudounas, 1968) and the Polemi sheet (Figure 7) (Markides, 1973) are accompanied by extensive soil memoirs. These ten soil sheets form the basis for the best digital soil information on the island and are available in a GIS environment. This dataset consists of thousands of polygons and are attributed by as many as 40 different soil series in the area they cover. Figure 8 presents the location of the ten soil sheets on the 1:250,000 soil map.

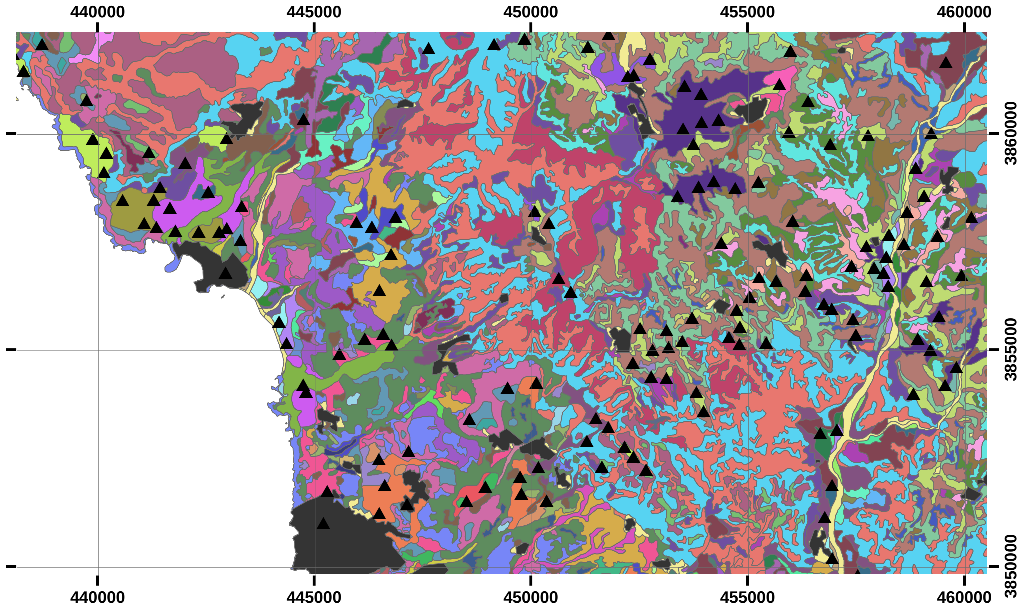

Figure 7. Example of the 1:25.000 scale map of the Polemi sheet (Markides, 1973) in western Cyprus.

Soil Classification

Distributed on the landscape with close association to bedrock lithology, the soils of Cyprus vary between leptosols, regosols, gypsisols, solonchaks, solonetz, vertisols, and cambisols, based on the World Reference Base (WRB) soil classification system (FAO et al., 1989). Soils on the island of Cyprus are generally poor in organic matter (Koudounas and Makin, 1981; Grivas, 1988) and closely associated to parent material and landscape position. The units shown in Figure 8 are only a generalized approximation of the soil diversity on the landscape.

Parent material varies between areas were soils form as residuum, that is they are formed in place from bedrock parent material, or were soils form on transported materials such as alluvial deposits (alluvial fans and deltas), colluvial deposits (slope deposits), aeolian deposits (sand dunes and desert dust), marine deposits (sands and gravels) and lake and estuarine deposits (silts and clays) (Figure 9). Soil formation on the island is controlled primarily by parent material and landscape position and vegetation type. Table 4 shows the main soil associations on Cyprus and Figure 10 shows a simplified model of these associations.

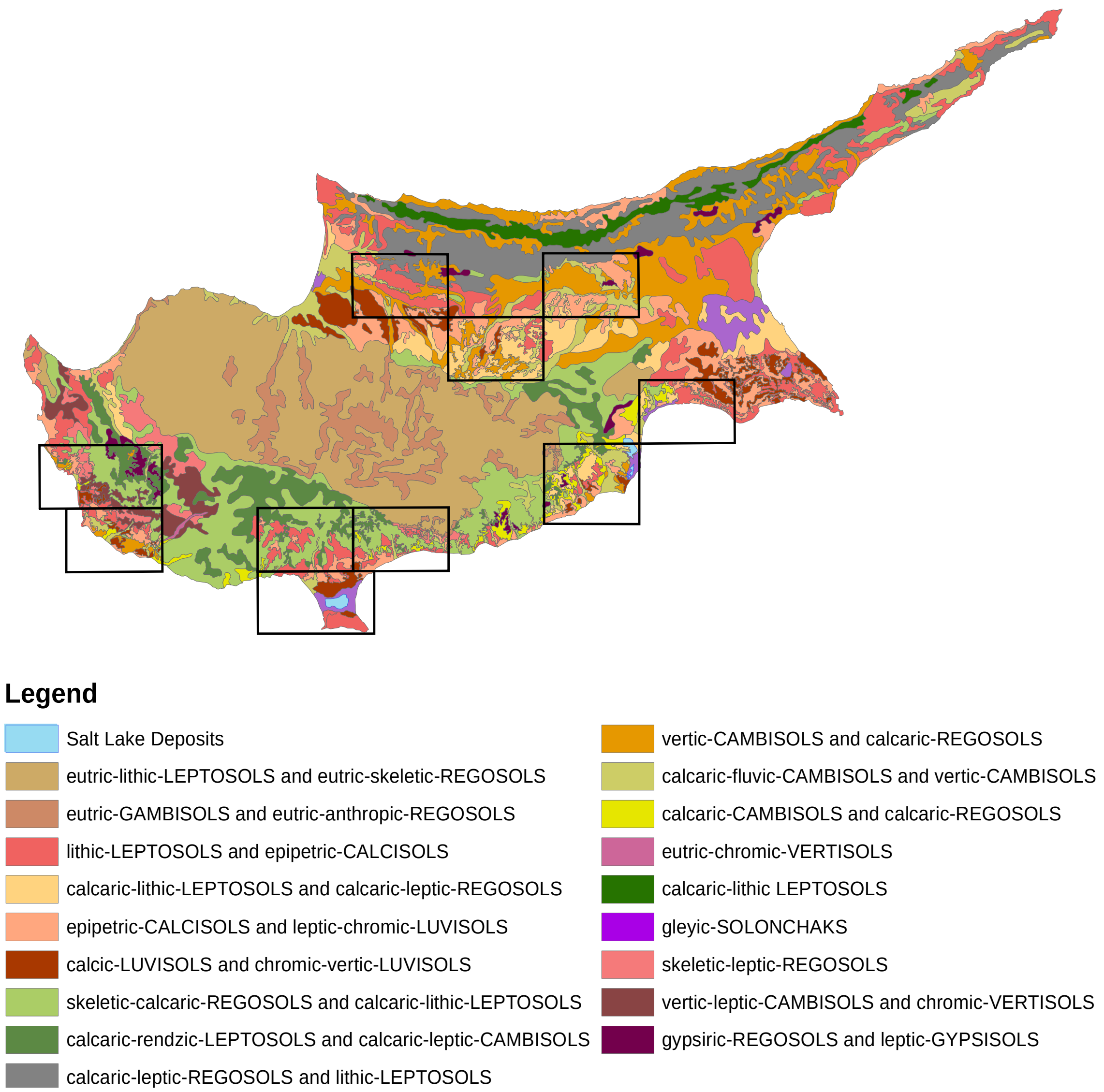

Figure 8. Soil map of Cyprus (1:250,000) and availability of soil maps at the 1:25,000 scale, from the Soil Map of Cyprus (Soil and Water Use Section, Cyprus Department of Agriculture, 1999).

Table 4. Main soil associations on Cyprus from the Soil Map of Cyprus (Soil and Water Use Section, Department of Agriculture, 1999).

Soil Groups	**Major characteristics and associations**
calcaric-CAMBISOLS and calcaric-REGOSOLS	Forming in coastal river valleys which have numerous fluvial terraces with continous additions of alluvial and aeolian inputs
calcaric-leptic-REGOSOLS and lithic-LEPTOSOLS	Thin and calcareous soils on colluvium forming on the Kythrea Flysch of the Keryneia Terrane
calcaric-lithic-LEPTOSOLS and calcaric-leptic-REGOSOLS	Sandy soils on Gelasian sandstones of the Athalassa Member of the Nicosia Formation, gravelly and cemented sands, but may contain some associations of Pleistocene red soils
calcaric-lithic LEPTOSOLS	Forms in karst topography on Keryneia Terrane crystalline limestone outcrops
epipetric-CALCISOLS and leptic-chromic-LUVISOLS	Broad Pleistocene surfaces of marine terraces or fluvial fans with thick accumulations of calcium carbonate
calcic-LUVISOLS and chromic-vertic-LUVISOLS	Same as above but topped by thick and red soils (terra rosas) forming premium agricultural land
eutric-chromic-VERTISOLS	Clay-rich deep colored fertile soils forming on fluvial terraces and alluvial plains consisting of materials derived from clayey Mamonia Terrane lithologies
eutric-GAMBISOLS and eutric-anthropic-REGOSOLS	Formed on gravelly fluvial terraces and talus slopes on the Troodos mountains; terrace- produced anthropic soils on slopes
eutric-lithic-LEPTOSOLS and eutric-skeletic-REGOSOLS	Thin gravelly soils on Troodos Terrane diabase and gabbro lithologies and extrusive sequence, silty clay loams of 1.5-4.6% organic matter (Robins, 2004)
gleyic-SOLONCHALKS	Soils in Holocene marshes and estuaries, (“lichines country”), saline soils with a high water table, saturated most of the year, salt pan topography with salt-tolerant shrubs and grasses
gypsiric-REGOSOLS and leptic-GYPSISOLS	Formed on gypsum outcrops of the Messinian Kalavaso Formation, thin and poor for cultivation; mostly used for viticulture in Pafos region; regosols form on the slopes
lithic-LEPTOSOLS and epipetric-CALCISOLS	Infertile, stoney thin soils on steep and extensive slopes of the Circum – Troodos carbonate mountains; poor in organic matter
calcaric-rendzic-LEPTOSOLS and calcaric-leptic-CAMBISOLS	Forming on flat south-facing slopes in Pachna formation carbonate rocks (used to be referred to as rendzina soils)
skeletic-calcaric-REGOSOLS and calcaric-lithic-LEPTOSOLS	In association with the above but forming on slopes mostly on loam colluviums
vertic-CAMBISOLS and calcaric-REGOSOLS	Soils forming on young alluvium of the broad and flat Mesaoria plains; mostly used for growing cereals
calcaric-fluvic-CAMBISOLS and vertic-CAMBISOLS	Same as above but forming on older alluvial terraces; better developed horizonation, clay content and structure
vertic-leptic-CAMBISOLS and chromic-VERTISOLS	Soil catenas in Mamonia Terrane; deep colored soils on clay-rich formations; prone to landslides, poor agricultural value
skeletic-leptic-REGOSOLS	Same as above but thinner and undeveloped soils on slopes

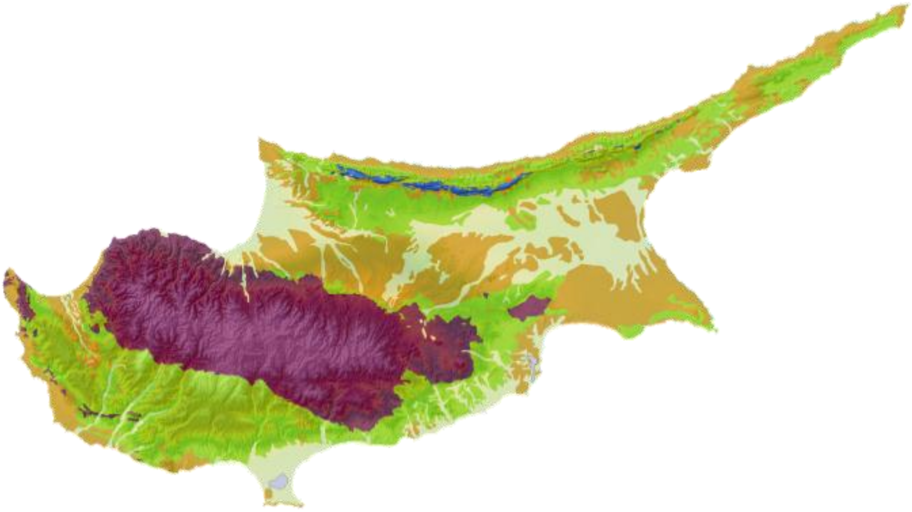

Figure 9. Soil parent material on Cyprus, includes ophiolitic rocks (purple), carbonate rocks (green), crystalline limestone (blue), Pleistocene fluviomarine terraces (brown) and Holocene fluviomarine sediments (yellow).

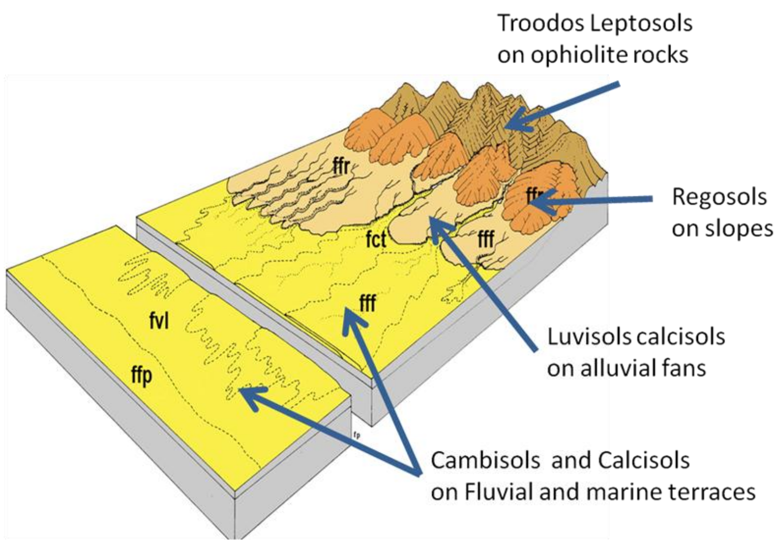

Figure 10. Simplified landscape – soil model for Cyprus with figure adapted from Peterson (1981). Map facies initials (e.g. ffp) refer to map units of Noller (2009).

Soil Surveys

In Cyprus systematic soil studies and soil classification started in 1957, aimed at collecting information and data about the physical and chemical properties of soils. The first soil classification system used was based mainly upon the formation, origin and parent material of the soils. The first efforts to map the soils of Cyprus used topographical sheets at scale 1:5,000. The next step in soil mapping was the preparation of the General Soil Map of Cyprus at a scale of 1:200,000. The soil classification system adopted was based mainly upon the formation, origin and parent materials of the soils, as with the previous mapping.

A study of calcareous soils was carried out in cooperation with the Federal Institute for Geosciences and Natural Resources, Hanover, Germany (Luken and Grivas, 1988). About 36% of the total area of Cyprus is categorised as having slightly to high calcareous soils. Many of these surveys were carried out by different soil scientists using in many cases different soil taxonomic systems. They were working on aerial-photos at scale 1:10,000 and preparing a soil map at scale 1:25,000.

a. Soil map of Cyprus 1999, 1:250.000
b. Reconnaissance soil map of Cyprus 1961, 1:125.000
c. General soil map of Cyprus 1970, 1:200.000
d. Calcareous soils of Cyprus 1987, 1:250.000
e. Soil maps of Cyprus, 1:25.000, 10 sheets
f. Land Suitability maps of Cyprus, 1:25.000, 17 sheets

The main purpose of each soil survey project was to cover the most fertile soils and all the agricultural development areas. The majority of the existing soil maps were prepared mainly for agricultural purposes. For soil mapping and other relevant soil activities, the Soil and Water Section of the Department of Agriculture is the only government section responsible.

Accordingly, soils were classified mostly as Red, Sedentary and Alluvial or Colluvial soils. Usually an examination of the main horizons, A, B, C, D, together with soil physical and chemical analyses, was carried out in order to classify the soils of these groups into soil series identified by local names. The new soil map of Cyprus, printed in 2002 at scale 1:250,000 (Figure 8), is based on previous classifications and was adjusted to the new FAO classification system (FAO et al., 1998). During the last decades interest in soil surveys and mapping has been very limited due to the continuously diminishing contribution of the agricultural sector to the economy of the country - it is currently about 4% of the GNP.

Using the newly secured data, a digital soil map of Cyprus has been prepared at scale 1:250,000 in collaboration with the remote sensing centre of the Ministry of Agriculture. An extension of this work has been preparation of a soil map of Cyprus at scale 1:1,000,000 based on the creation of soil associations of the main group of soils. In areas where soils have not been surveyed, other methods have been used, such as extrapolation, photo interpretation and the general soil map of Cyprus.

Soil Monitoring

Monitoring activities are concentrated on establishing Nitrate Vulnerable Zones (NVZ) as required by the EC Nitrates Directive. A map showing the NVZs at a scale of 1:250,000 is in the final stage of preparation (Figure 11).

Figure 11. Nitrate-vulnerable zones (data from the Cyprus Geological Survey digital geodatabase), data is incomplete for the occupied territories in the north of the island)

A Geochemical Atlas of Cyprus project was recently completed by the Cyprus Geological Suvrey on the basis of the principles and protocols established under IGCP Projects 259/360 and the FOREGS Geochemical Atlas of Europe. It has been conducted at a relatively high density of one sample site per km^2 (Figure 12). Samples consisted of the <2 mm fraction of top soil (0–25 cm) and sub soil (50–75 cm) of 5,516 sites. The Cyprus Geological Survey archives samples from all points. Samples were analyzed for over 60 elements by aqua regia, ICP-MS and INAA in Australia and Canada. Major elements were analyzed by XRF and CS-analyzer, and soluble ions by ion chromatography at the Cyprus Geological Survey laboratories. In addition, electrical conductivity and pH were measured. The geochemical data have been integrated with other spatial data provided by the GSD in their GIS digital geological databases (Cohen et al., 2011. 2012).

Current Soil Mapping Efforts

The digital database of soil and environmental data and maps developed by the Geological Survey Department is being used to develop a new 1:50,000 soil map, which will also include soil physical attributes. An intelligent predictive modelling and mapping approach, based on random sampling and a tree classification approach (Cutler et al., 2007) will be used. Selected field checks will be made to evaluate the approach. This research activity is part of the The AGWATER project, which is co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research Promotion Foundation.

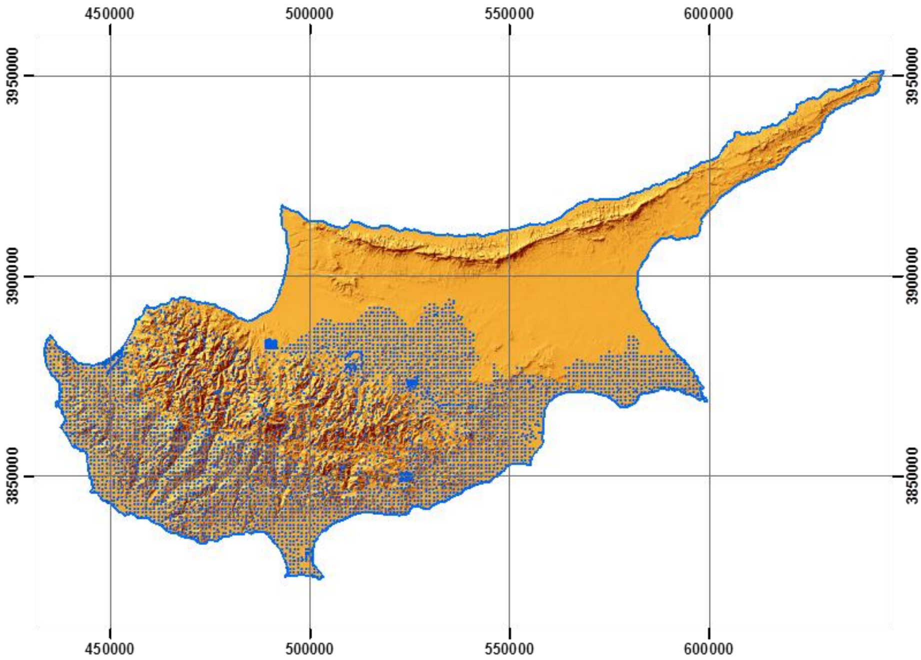

Figure 12. Sampling sites for the Geochemical Atlas of Cyprus (Cohen et al, 2011)

SOIL THREATS

Erosion

Erosion has been taking place in Cyprus since ancient times. The development of copper mines and the cutting of trees for fueling these mines as well as for ship building, has had an important effect on the landscape. Forest areas have been replanted but these pine forests are under an increasing thread of forest fires. During the past decasde 273 fires have burnt 1280 ha of state forests (Department of Forests, 2012), which cover a total area of 129,000 ha.

Land management such as the establishment of terraces and contour banks has always received attention in the rural mountains of Cyprus. In the early half of the 20th century, land owners could form Soil Conservation Divisions for carrying out large scale soil conservation works, with the Government subsidizing up to half of the cost (Christodoulou, 1959). Soil was sometimes also transported and added to rocky land for the development of irrigated lands (Christodoulou, 1959). Under a comprehensive program for soil conservation and land management, supported by FAO and the World Food Program, 1000 ha of land has been bench-terraced by Government of private machinery, each year, since 1968 (Michaelides, 1988). However, over the past 30 years (1981-2010), the area cultivated with grapes and almonds has decreased by 78% and 43%, respectively, (Cystat, 1983; 2012). These crops are mainly grown in the mountains and foothills of the Troodos complex, especially on terraces. The abandonment of these terraces is resulting in the erosion of cultivated mountainsides, sometimes generating a domino effect of terrace destruction along the slope.

Few experimental erosion studies have been conducted in Cyprus. During the 1980s, seven standard Wischmeier plots (22.13 by 1.83 m, 9% slope, fallow) were established at representative soils on different geologic formations (Luken et al, 1988). The observed five-year average annual erosion ranged between 3.5 to 32.8 ton/ha/yr. The lower erosion rates were measured at well-structured, reddish (chromic) soils, while the values exceeding 10 ton/ha/yr were measured at the light colored (ochric) soils with surface sealing. Zaimes et al. (2012) measured one season of erosion from 10 by 5 m experimental plots on highly sloping land (35-40%) in a pine forest (Pinus brutia) in the Troodos mountains. They found an annual soil erosion of 21 kg/ha/yr for the 20 most intense precipitation events, under an annual precipitation of 1073 mm.

Decline in Organic Matter

Cyprus soils are typically referred to as being "poor" in organic matter with little other characterization. Organic matter (plants, microbes, animals) is the most poorly known parameter in the soil forming formula for the soils on Cyprus.

Soil Contamination (Local and Diffuse)

Elevated values of soil copper (Cu) values, relative to surrounding environments, have been found up to 2 km away from (former) copper mining operations and in the main urban areas (Cohen et al., 2012). The same authors also found high levels of lead (Pb) in the topsoil of the main urban areas. The popularity of hunting has also resulted in anomalous high Pb values, with some soil samples containing actual shot gun pellets (Cohen et al, 2012).

An older project by the Cyprus Geological Survey which was completed around 2004 mapped and classified all the potentially contaminated sites on the island (Figure 13). The most common classes included mineral workings, ancient and modern, husbandry and some industries. Sites were classified according to the CAT and NACE codes.

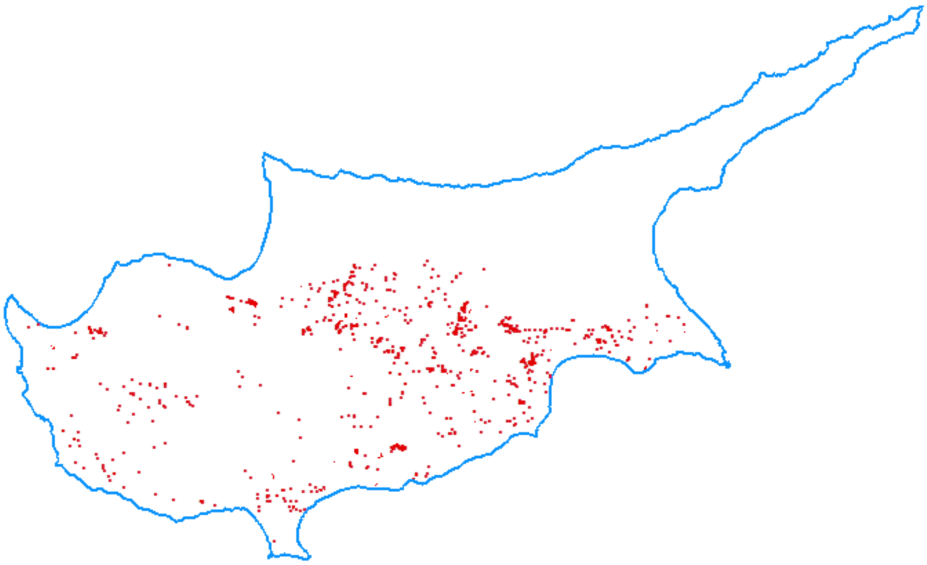

Figure 13. Contaminated sites (data from the Cyprus Geological Survey digital geodatabase, data is incomplete for the occupied territories in the north of the island)

Soil Sealing and Soil Compaction,

Cyprus has a relatively high rate of urbanization. Urbanised areas and wide roads form the main points of sealing (Figure 14). Based on the 2000 and 2006 CORINE land use maps, artificial areas, including residential as well as non-residential areas, increased with 2.6% per year (EEA, 2010). Conventional machinery ploughing especially the way it is practiced in the valleys were cereals are grown contributes to some degree of compaction.

Figure 14. Primary areas of soil sealing (data from the Cyprus Geological Survey digital geodatabase).

Decline in Soil Biodiversity

There are no studies on the soil biodiversity of Cyprus. However, the thick litter layer that can be observed in forests and natural areas and the low organic matter content in agricultural soils (Orphanos, 1973) indicate a generally poor level of soil biodiversity. Due to precipitation constraints, the plains are mainly cultivated with barley. This extensive mono-culture also negatively affects the soil biodiversity.

Salinisation

Quaternary marine and fluvial terraces along the coastal zone of Cyprus form the primary fertile agricultural land on the island. Extensive water extraction from coastal aquifers using deep boreholes (many of them drilled without a license or pumped beyond permitted quantities) has contributed to sea water intrusion and salinization of these coastal agricultural soils. Twelve of the nineteen groundwater bodies, which have been delineated for the River Basin Management Plan of the Water Framework Directive, suffer from salt water intrusion (WDD, 2011). This is putting large areas of agricultural lands at risk of salinisation. The salinisation processes in the Akrotiri aquifer on the south coast have been described and modelled by Milnes (2011).

Floods and Landslides

The Republic counts more than 80 dams and reservoirs, which have contributed greatly to the reduction of flood hazards on the island. However, poor maintenance, diversion and artificial filling of drainage ways and the increase of paved areas in urban agglomerations do at times create flooding.

The extensive exposures of Kannaviou Formation and Mamonia Complex mélange in the west of the island (Figure 15) has for years contributed to very landslide prone geometry. In the late 1960s and early 1970s, about 6 villages were abandoned and relocated by a government – funded project in the Pafos district. Analysis of the landslide inventory data highlights the relationships between lithology, topography and tectonic structure of the study area. The Geological Survey Department developed a GIS-based landslide inventory using aerial photograph interpretation, field mapping and ground investigation; in order to catalogue landslide distribution, assess the levels of landslide susceptibility, hazard and risk across the western part of the island.

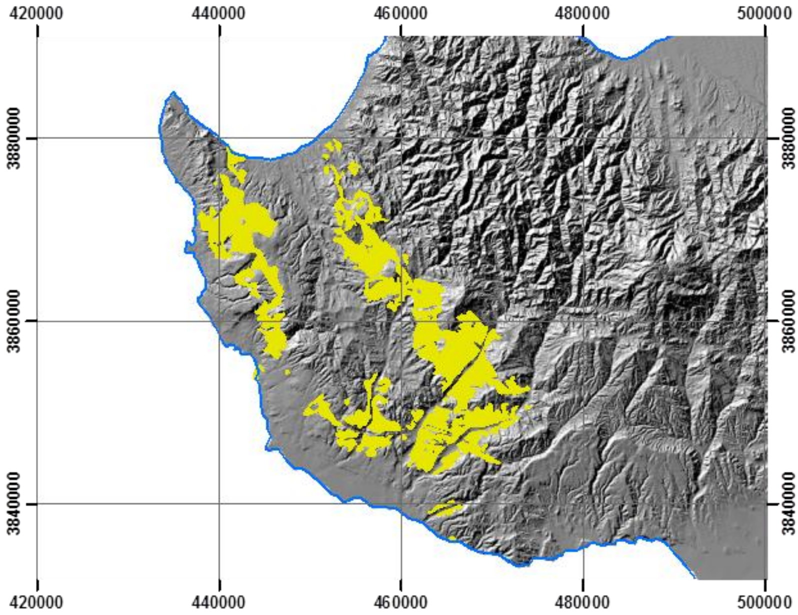

Figure 15. Landslide-prone areas in western Cyprus (Pafos district).

Combining the results from the data analysis, landslide susceptibility factor analysis and terrain classification helped develop a set of landslide susceptibility maps and associated terrain classification attribute tables. The intention is that this mapping and the associated terrain classification attribute table could provide a useful input in the town planning process.

FUTURE PROSPECTS and INTEGRATION STUDIES

Future Plans on Soil Resources

The use of the revised classification system (FAO et al., 1998) seems to have improved the classification structures by the introduction of Soil Groups, Diagnostic Horizons, properties and materials. Using this terminology and coding, soils can be classified to a lower category level in an international system, which obviates the need to use local names of soil series names.

The development of a new 1:50:000 soil map, with the help of an intelligent predictive modeling and mapping technique, including the linking of soil physical attributes, will expand and increase the functionailty of the Cyprus soil database. Problems that occur by the use of different scales can be overcome through using digital mapping. Surveys can be carried out at different detailed scales without any difficulty in the eventual printing of any scale map.

Data Integration with the European Soil Database

Available digital soil data from Cyprus could be integrated with the European Soil Database. Current efforts to develop a new 50:000 soil map, which will link available soil data to soil mapping units, could contribute to the harmonisation of the digital Cyprus soil database with the European Soil Database.

CONCLUSIONS

The soils of Cyprus harness the limited and variable Mediterranean precipitation and support the rich, natural and agricultural biodiversity of the island. Geological complexity, morphotectonics, a unique flavour of Mediterranean climate and the long presence of man have all lead to a diverse soilscape and geoecology. The geology, which is dominated by the central Troodos Ophiolite complex and its surrounding sedimentary plains, provide the diverse parent materials for these soils. Detailed soil surveys have been conducted in the 1960s and 1970s, with an important focus on agriculture. The resulting 1:25,000 maps covered about one fourth of the island and did not use an international classification system. These maps formed the basis of the 1:250,000 digital soil map of Cyprus, which reclassified the soils according to the World Reference Base of Soil Resources. Common soils in Cyprus are Regosols, Leptisols, Cambisols, Luvisols, Vertisols, Solonchaks and Gypsisols. A soil geochemical atlas of Cyprus, which collected and analyzed one topsoil (0-25 cm) and one subsoil sample (50-75 cm) at a regular one-km^2 grid has been recently completed. Efforts have been made to digitize all soil data and work is ongoing to link all existing soil information to the soil mapping units and soil typological units.

ACKNOWLEDGMENTS

Acknowledgments are due to all the people of the Ministry of Agriculture, Natural Resources and Environment who at various times have contributed to our knowledge about soils either by soil mapping, sampling, testing or by integrating soil information in agricultural projects, Quaternary geology studies, geomorphology and/or geoarchaeology. Special thanks are due to the fundamental contributors, especially Markides, Soteriades, Grivas, Koudounas, Luken, Pantazis, Noller and Cohen.

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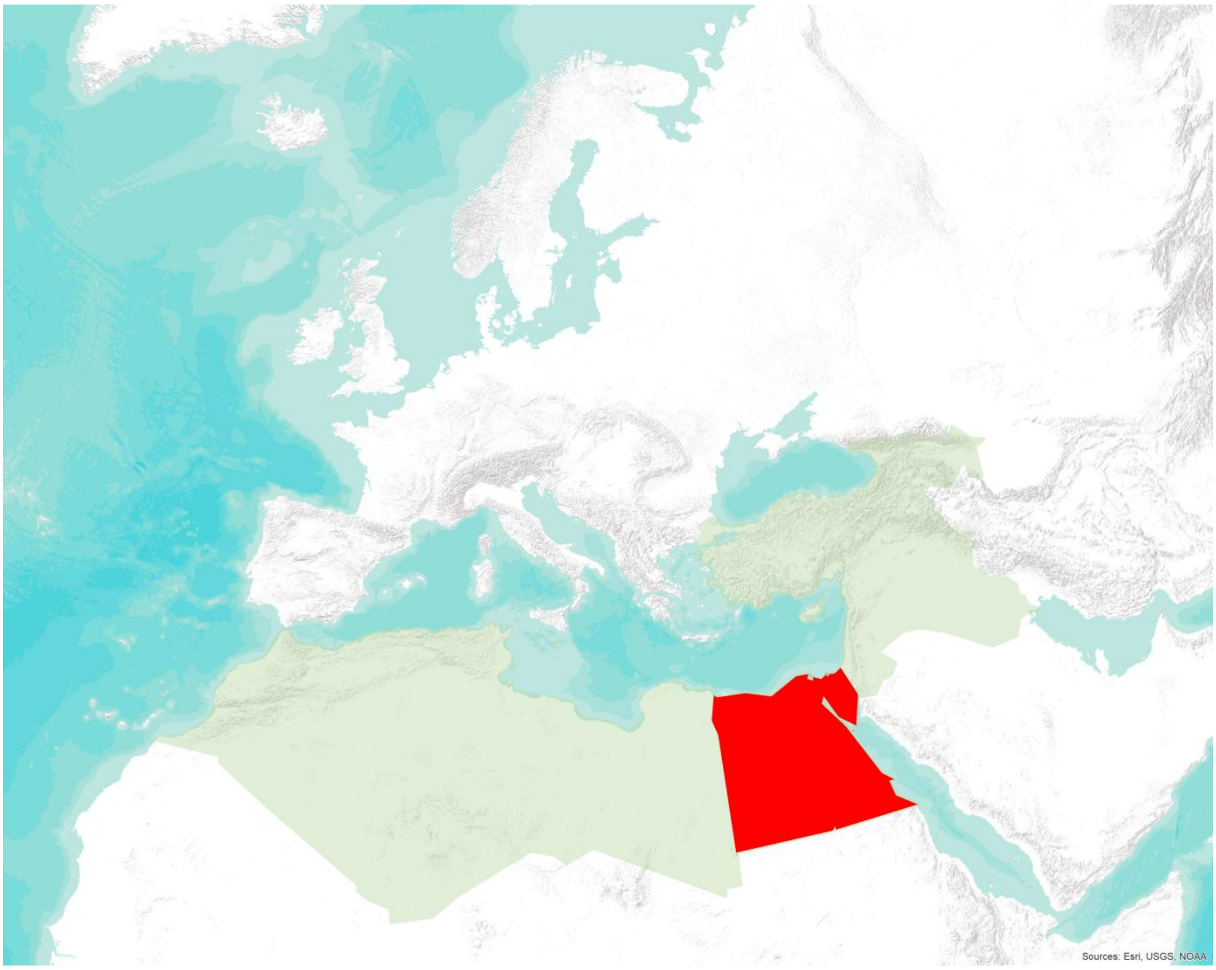
Chapter IV.
Soil Resources of of Egypt



Country Report of Egypt

Mostafa M. Kotb[1]

ABSTRACT

Egypt has a limited base of cultivable land resources. The cultivated area is about 3% of the total area of Egypt (3.2 million hectares). Statistics from the Ministry of Agriculture and Land Reclamation indicate an increase in the agricultural land: from 5.67 million feddans (feddan = 0.42 hectare) in 1950 to about 6.62 million feddans in 1982. According to an estimation of the Ministry of Public Works and Water Resources, Egypt's cropland area is of about 7.3 million feddans, based on the annual quantities of irrigation water, in addition to an area of 0.2 million feddans outside the Nile basin in the Egyptian territory in 1991. Due to the rapid population growth, the average per capita share in agricultural land decreased from 0.29 feddan in 1950 to 0.14 feddan in 1990 and dcreases with time

Remote sensing (RS) can provide valuable and timely information about natural resources and environment as an important basis for sustainable development. Geographic Information systems (GIS) can provide effective tools for decision makers. Both RS and GIS techniques are important geometric tools which are extensively utilized in developed countries. However, in developing countries, the utilization of such advanced technologies differs from one country to another because of one or more of the following reasons: lack of tools and infrastructure; inadequate training; lack of coordination between aid agencies; too much emphasis on technology push rather than demand-led application; restrictions and regulations; and lack of basic information and maps.

Different remote sensing and land information as well as geographic information systems were used for land resources assessment and evaluation. Landsat-based soil maps of most Egypt were produced of at different scales in some authorities, institutes and Egyptian universities.

In this project it is plan to introduce a country digital map through working together with European Commission Joint Research Centre Land Resources Management Unit Ispra. We hope to be more beneficial for our countries and to be further cooperation between the Mediterranean countries.

Keywords. Land resources, Agricultural land, digital soil map, Egypt.

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INTRODUCTION

General Situation

Egypt is located in the north-eastern corner of Africa between latitudes 21^{O} and 31^{O} North and longitudes 25^{O} and 35 ^{O} East with a total area of 1,001,450 km^{2}; the country stretches 1,105 km from north to south and up to 1,129 km from east to west. It is bordered in the north by the Mediterranean Sea, in the east by the Gaza Strip, Israel and the Red Sea, in the south by Sudan and in the west by Libya, (Figure 1).

The Nile River, in an area of about 40,000 sq km (15,000 sq m), where the only arable agricultural land is found. The large areas of the Sahara Desert are sparsely inhabited. About half of Egypt's residents live in urban areas, with the majority spread across the densely populated centres of greater Cairo, Alexandria, and other major cities in the Nile Delta.

Figure 1. Modified after El-Nahrawy

Geography

The great majority of Egyptians live near the banks of the Nile River, in an area of about 40,000 sq km (15,000 sq m), where the only arable agricultural land is found. The large areas of the Sahara Desert are sparsely inhabited. About half of Egypt's residents live in urban areas, with the majority spread across the densely populated centers of greater Cairo, Alexandria, and other major cities in the Nile Delta.

Egypt's is almost square-shaped total area of about 1 million square kilometres. The average altitude is 50 ft below sea level; the highest point being Mount St. Catherine at a high of 8,668 ft and the lowest the Qattara Depression at 436 ft below sea level. The Nile Delta is the only delta in Egypt and is 100 miles long, 155 miles wide and triangular in shape. There are five major oases in Egypt: Farafra, Bahria, Dakhla, Khargah and Siwa oases.

Climate

The climate in Egypt is generally moderate; it is mostly hot or warm during the day, and cool at night. In the coastal regions, daytime average temperatures range between a minimum 14 ºC in winter and maximum 30 ºC in summer. In deserts the temperatures vary considerably, especially in summer; when they may range from 7 °C at night, to 52 °C during the day. While the winter temperatures in deserts do not fluctuate so wildly, they can be as low as 0 °C at night, and as high as 18 °C during the day. Egypt receives less than 80 mm of precipitation annually in most areas, although in the coastal areas it reaches 200 mm. It hardly ever rains during the summer. The evaporation rates (1500-2400 mm/year) and a little rainfall (5-200 mm/year).

Land Resources,

Hasan and Abdelhafez (1999) mentioned that the cultivated area of Egypt amounts to almost 8 million acres, or 3.2 million hectares. This is considered as one of the oldest agriculture areas in the world. The agricultural land of Egypt is as old as history, but is entirely dependent on the Nile water and for this reason has received substantial budgetary support.

The soils of Egypt comprise the alluvial soils of the Delta and Valley, the calcareous soils along the coastal littoral of Egypt, the soils of the Eastern and Western Deserts as well as the soils of Sinai Peninsula. The major alluvial soils were formed from the suspended solid matter of the Nile, which were deposited every year during the flood season. The suspended matter of the Nile is formed from the disintegration of the eruptive and metamorphic rocks of the Ethiopian plateau through physical, chemical and biological weathering factors.

Hanna, 1995 stated that Egypt is counted among the world's poor countries in cropland base. The presently cultivated area constitutes about 3% of the total area of Egypt (245 million feddans). Statistics from the Ministry of Agriculture and Land Reclamation (MOALR) indicate an increase in the agricultural land: from 5.67 million feddans in 1950 to about 6.62 million feddans in 1982. According to an estimation of the Ministry of Public Works and Water Resources (MPWWR), Egypt's cropland area is of about 7.3 million feddans, based on the annual quantities of irrigation water, in addition to an area of 0.2 million feddans outside the Nile basin in the Egyptian territory in 1991. These figures conform, to a great extent, with those of MOALR for the same year. Most of these croplands are classified under the second and third grade (%45.5 and 38.5% respectively) representing good and fairly good lands. First grade lands constitute about 9.2% of the total area of cultivated lands while low quality lands (fourth grade) constitute about 9.6% (Arab League, Arab Organization for Agricultural Development 1992).

Land Use

The cultivated area of Egypt amounts to almost 8 million acres, or 3.2 million hectares. Soils in the Nile River and Delta are silt-clay mixtures of good quality, deposited during thousands of years of Nile flooding. The total cropped area is estimated at approximately 5.8 million ha with a cropping intensity of 180 percent. Most of the newly reclaimed desert areas use modern irrigation practices such as drip and sprinkler systems. Gehad, (2003) mentioned that the seasonal and annual productivity and total production of each crop, at the district level, particularly starting from the late 1950's. selected figures are given in Table (1).

Recent advances in agricultural technologies, irrigation and farming practices results in significant increases, which may mask any soil deterioration.

Table 1. Summary of Total Farm Production of Raw Agricultural Commodities in Selected Years (figures are in '000 tons).

Crop Groups	Years				
	1952*	1983	1987	1991	1997
Major field crops*	8.980	20.122	21.093	32.486	36.235
Vegetable crops	1.840	7.039	9.964	11.086	14.363
Fruit crops	0.894	3.020	3.668	4.016	6.352
Totals	11.714	30.181	34.625	47.588	56.950

* Include cereals, oil crops, fiber crops, sugar crops and pulses, production of green animal fodder average 50 mill. Ton.annum^{-1} not included. **Source:** National Council for Production and Economic Affairs. Annual Report 1998

The aim of land use planning in Egypt is reusing the land in such a way that crops were cultivated in relatively large areas, reducing waste in land resources, minimizing and organizing pest control on a large scale, improving mechanical operation on the farm. Table (2) showed the land use in Egypt.

Table 2. Land Use in Egypt

Land Use	Area 1000 ha.	% of Total Area
Total Area	100 145	--
Land Area	99 545	99.40
Agricultural Area	3 291	3.8
Arable Land	2 825	2.82
Permanent Crops	466	0.46
Permanent Pasture	--	--
Non Arable & Non-Permanent	96 254	96.12
Arable & Permanent Crops	3 291	3.29

Source: FAO STAT 2000

El-Nahrawy stated that in 2002, 99.8% of cropland was irrigated. Even the small, more humid area along the Mediterranean coast requires supplementary irrigation to produce reasonable yields. Irrigation potential is estimated at 4 420 00 ha, whereas the total area equipped for irrigation in 2002 was reported at 3 422 178 ha, with 85% in the Nile Valley and Delta. Surface irrigation was practiced on 3 028 853 ha in 2000, while 171 910 ha were under sprinkler irrigation and 221 415 ha under localized [drip or trickle] irrigation. Surface water was the source for 83% of the irrigated area in 2000, while 11% (361 176 ha) of the area was irrigated with groundwater in the provinces of Matruh, Sinai and the New Valley. The remaining 6% (217 527 ha) was irrigated with mixed sources. The power irrigated area was estimated at 2 937 939 ha in 2000. On the other hand, the area planted to fodder crops decreased from 28.1% in 1970/74 to around 18.9% of the cropped area in 2007 (SADS, 2009). This decrease is due to the high competition between wheat and berseem during the winter season on the available cultivated area, Table 3.

Table 3. Changes in area harvested by crop group (in M ha.)

Crop group	Year 1980/84		Year 1990/91		Year 2000/01		Year 2006/07		Year 2007/08		Year 2008/09	
	area	%	area	%	area	%	area	%	area	%	area	%
Cereals	2.00	42.6	2.25	46.2	2.65	46.1	2.96	43.7	2.97	42.4	2.98	42.9
Legumes	0.14	2.9	0.15	3.2	0.17	3.0	0.12	1.8	0.11	1.6	0.13	1.9
Fibres	0.48	10.2	0.40	8.3	0.31	5.4	0.27	4.0	0.25	3.6	0.22	3.2
Sugar crops	0.11	2.4	0.13	2.6	0.19	3.3	0.21	3.1	0.23	3.3	0.25	3.6
Oil crops	0.08	1.8	0.03	1.9	0.12	2.1	0.03	0.4	0.02	0.3	0.02	0.3
Fodder crops	1.28	27.3	1.13	23.1	1.18	20.7	1.18	17.4	1.15	16.4	1.17	16.9
Fruit	0.17	3.6	0.23	4.8	0.48	8.4	1.37	20.2	1.4	20.0	1.43	20.6
Vegetables	0.43	9.2	0.48	9.9	0.70	11.0	0.63	9.4	0.87	12.4	0.74	10.6
Total	**4.58**	100	**4.81**	100	**5.75**	100	**6.77**	100	**6.37**	100	**6.94**	100

Source: Economic Affairs Department, Agricultural Statistics Bulletin (2009), Ministry of Agriculture, Cairo, Egypt.

COUNTRY SOIL INFORMATION and DATA

Legacy Soil Information

Egypt is divided into four major zones**;**

The Nile Valley and Delta extends from north of the valley to the Mediterranean Sea and is divided into Upper Egypt and Lower Egypt: extending from Wadi Halfa to the south of Cairo and from North Cairo to the Mediterranean Sea. The River Nile in the North is divided into two branches, Dumiat (Damietta) and Rashid (Rosetta) which embrace the highly fertile agricultural lands of the Delta. The River Nile is the longest river in the world, stretching for around 4,187 miles. Egyptians depend primarily on the Nile as a source for water to drink and to irrigate their crops.

The Western Desert Extends from the Nile Valley in the East to the Libyan borders in the west, and from the Mediterranean in the north to Egypt's Southern borders. It is divided into: The Northern section, which includes the coastal plane, the northern plateau and the Great Depression, Natroun Valley and Baharia Oasis; and the Southern section, which includes Farafra, Kharga, Dakhla, and El-Owainat in the far south.

The Eastern Desert extends from the Nile Valley in the West to the Red Sea, Gulf of Suez, and Suez Canal in the East, and from Lake Manzala on the Mediterranean in the North to Egypt's border with Sudan in the south. The Eastern Desert is marked with the Eastern Mountains that extend along the Red Sea with peaks that rise to about 3000 feet above sea level. This desert is rich with Egyptian natural resources; which include various ores such as gold, coal, and oil.

The Sinai Peninsula is almost triangular in shape, with its base at the Mediterranean to the North and its tip southward at Ras Mohammed, the Gulf of Aqaba lies to the East and the Gulf of Suez and Suez Canal to the West.

The Nile Valley and the Delta occupy about 33,000 square kilometres, which account to less than 4% of the total area. The Western Desert occupies an area of about 671,000 square kilometers, the Eastern Desert occupies about a quarter of the total area of Egypt at 225,000 square kilometers, and The Sinai Peninsula occupies about 61,000 square kilometres. Egypt's total population is estimated at 84.5 million (2010), with an annual population growth rate of 2% (2010-2015).

Digital Soil Resources,

A Geographic Information System (GIS) has been in use at the Executive Authority for Land Improvement Projects (EALIP) since 1997, and a GIS-based soil database was used for production of maps and other related materials on soil salinity, sodicity and water table level, and on gypsum and subsoiling requirements. Information from soil and plant tissue analysis was added to the database, and GIS was used to prepare the base map. The presence and location of particular macro- or micronutrient deficiencies were determined from the maps. EALIP produced information maps for subsoiling, gypsum requirement, water table depth and salinity for the whole country at the district level (1:100,000), for one governorate at the village level (1:25,000) and for three governorates at the basin level (scale 1:2,500). Work is now ongoing to produce these maps at a scale of 1:2,500 for the all relevant areas in the country. The information is being used for the planning of gypsum application and subsoiling, FAO 2002.

Gehad, (2003). Stated that GIS's provide new tools to collect, store retrieve, analyses, and display spatial data in a timely manner and at law cost. At EALIP, the soil database was provided to the GIS for production of maps and other related materials for use in different activities:

- *Soil salinity, sodicity and water table level maps were produced.*
- *Gypsum, subsoiling requirements, and application planning for the studied areas.*

The application of GIS in soil degradation data were available at EALIP since 1997, where a project entitled "Strengthening the information capacity of the Executive Authority for Land Improvement Projects" was implemented through the cooperation between FAO and EALIP.

In this concern, EALIP produced the information maps for subsoiling, gypsum requirement, water table depth and salinity for the whole country on the district level (1:100,000), one governorate on the village level (1:25,000) and three governorates on the basin level (1:25,00). The work is going on now to produce these maps on the basin level for the whole country.

Gad and Ali (2011) pointed out that achieving such detailed digital land resources database for local administrations is a great step towards the implementation of sustainable development and management programs. It is characterized by its comprehensiveness, geographical accuracy and updatability. In the current Era of distinctive progress in information technology, such data can be handled, enhanced and exchanged by different users and authorities. The most striking findings noticed was the urban encroachment on the account of most fertile soils; hence shrinkage in areas of high agricultural capabilities. On the other hand, urbanization doesn't extend largely to low capable land. It was also noticed that a common unbalance between irrigation and drainage system networks is often and may lead to progress of salinization and land degradation.

Ali and Kotb (2010) mentioned that today there is great demand for accurate soil information over large areas from environmental modelers and land use planners (both urban and rural) as well as more traditional agricultural users of soil resource inventories. All those users want interpreted information; that is, soil properties or behavior directly relevant to their application. The soil information so generated was interpreted for various purposes like land capability classification, land irrigability assessment, crop suitability studies, management of watersheds, prioritization of watersheds etc. Rossiter, (2005). In recent years thematic mapping has undergone a revolution as the result of advances in geographic information science and remote sensing. For soil mapping archived data is often sufficient and this is available at low cost. Green, (1992) stated that integration of Remote Sensing within a GIS database can decrease the cost, reduce the time and increase the detailed information gathered for soil survey. Particularly, the use of Digital Elevation Model (DEM) is important to derive landscape attributes that are utilized in land forms characterization, Brough (1986) & Dobos, (2000).

GAD, et al (2008) concluded that the digital mapping of land resources encouraged by the progress of Geographic Information System (GIS) and data provided by satellite images. Such approach may preserve in the investment spent in soil and other thematic mapping, as the digital maps are more granted compared with analogue ones. Updating and manipulating the digital thematic maps are accessible and economically effective. Usage of the digital maps and their attribute tables assist the decision support systems and may result in obtaining maps required for controlling sustainable development projects.

Soil Classification,

Hamdi and Abdelhafez (1999) mentioned that according to US Soil Taxonomy (Soil Survey Staff, 1996), three soil orders have been found for the soils of Egypt: Entisols, Aridosols and Vertisols. Table 4 gives detailed information at suborder and great group level for the three soil orders.

Table 4. Classification of the soils of Egypt at order, sub-order and great group level according to the US Soil Taxonomy.

Order	Suborder	Great Group
Entisols	Fluvents	Torrifluvents
		Ustifluvents
	Orthents	Torriorthents
	Psamments	Torripsaments
		Quartzipsamments
	Aquents	Psammaquents
Aridisols	Argid	Natrargids
		Durargids
	Orthids	Salorthids
		Salids
		Calcids
		Gypsids
		Calciorthids
		Camborthids
		Gypsiorthids
Vertisols	Torrerts	Torrerts

Soil Surveys

Hamdi and Abdelhafez (1999) pointed out that soil survey in Egypt has been established since 1958 within the Ministry of Agriculture, particularly in the Soil and Water Research Institute. The persistent need for the pedogenic classification of alluvial soils of the country was repeatedly emphasized by a number of recommendations and resolutions at different local congresses and conferences.

An association map for the soils of Egypt has been published by Ghaith and Tanios (1965). The map has been initiated through the compilation of a number of studies carried out by the staff members of the Soil Survey Department of the Institute, particularly by Dr. Ghaith and his collaborators. The map was prepared using the reconnaissance survey carried out by the FAO in association with the

Soil and Water Research Institute as well as with the Egyptian General Desert Development Organization.

The delineated soil associations are divided as follows:

1. Soils on flat or level land;
2. Soils on undulating and rolling land;
3. Soils on dissected and mountainous land.

The Academy of Scientific Research and Technology has financed a project for the preparation of the "Soil Map of Egypt" at scale 1:100,000 for the cultivated areas. Therefore, a group of soil experts from the Universities, Ministry of Agriculture, National Research Centre and the Desert Research Centre was set up to perform this task. Hence, colored soil classification maps for the cultivated areas in Egypt have been published, at scale of 1:100,000. The accompanying soil report of the map contains: Description of profiles; Geology and geomorphology; Different soil analyses and methods; Morphology and soil formation; and Classification of soils according the US-Soil Taxonomy at the Family Level (Soil Survey Staff, 1999).

Due to the population increase, the country faced a serious problem, which urged the government to launch a program to increase the cultivated area annually by about 60,000 ha. Also, the two major projects, namely the Peace Canal and Toshky Projects, will add 251,100 and 202,500 hectares respectively to the cultivated areas.
The main pillar for sustainable agricultural development in Egypt remains the horizontal expansion by reclaiming huge areas in the southern part of the country, namely Toshky, East Owaynat, Darb El Arba'een with a net result of cultivating 1.3 million hectares more. Also, the socalled vertical expansion is applied, by adopting high yielding crop varieties of good quality and short duration. Improvements of the surface irrigation systems used in the old cultivated lands are carried out, as well as the introduction of new systems of irrigation will strengthen the Egyptian agriculture.

In the eighties, a Centre for remote sensing was established at the Soil and Water Research Institute, financed by the Ministry of Agriculture and UNDP, which enabled the staff members to get acquainted with the theory and application of remote sensing techniques. Hence, a number of areas in the dessert, having high priorities, have been surveyed and Soil and Land Use maps were prepared. The selected areas are Bourg El Arab, West Nubariya, Nubariya Extension and North Sinai, Figure 2.

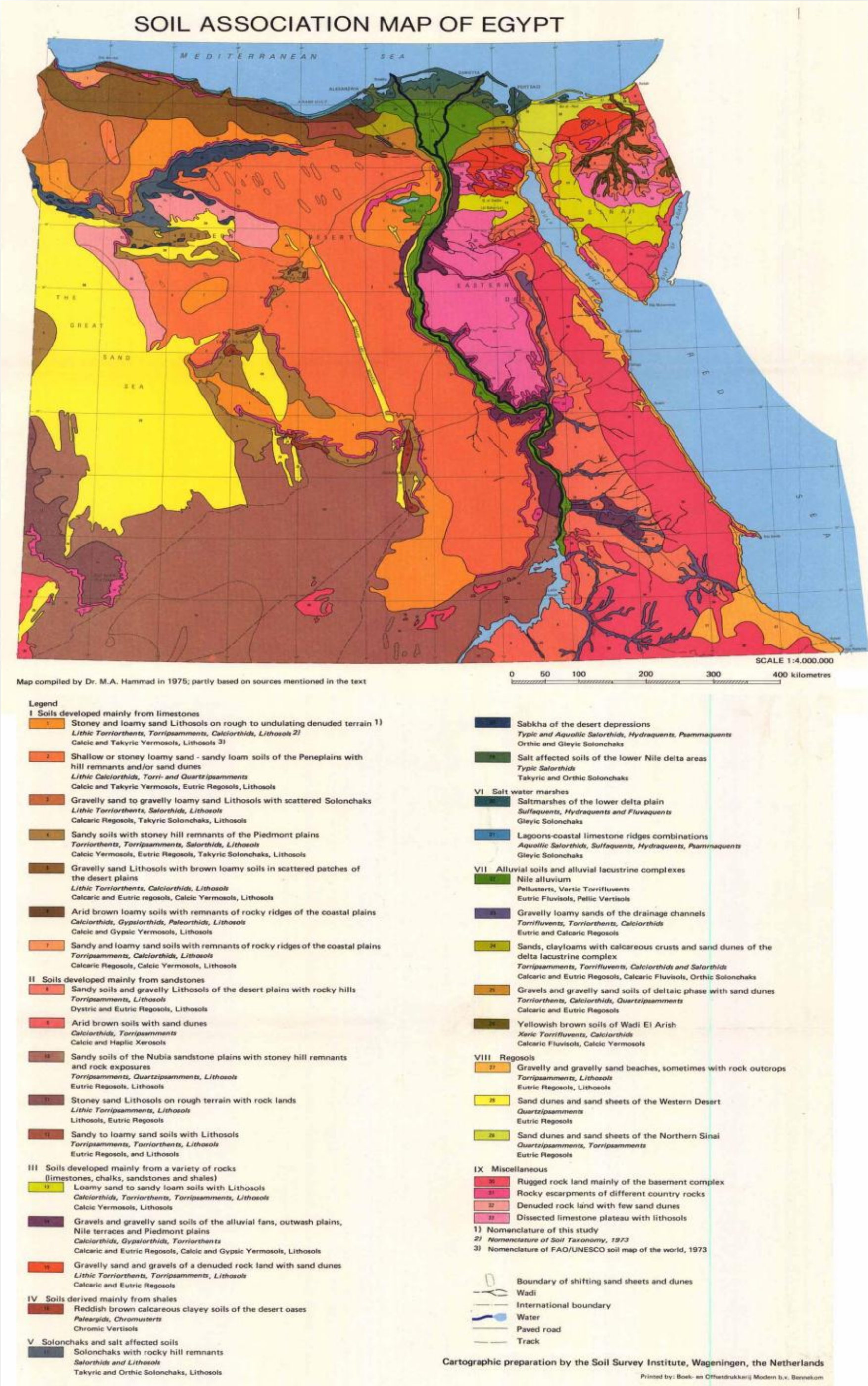

Figure 2. Soil map of Egypt. After Hamdi 1975.

Egypt and the Nile are synonymous and inseparable words. In the recent times population pressure, industrial development as well as infrastructure work had caused encroachment on the river. Since the construction of the High Aswan Dam in 1964, harnessing the stream of the Nile, the river has been transformed into a low-energy river. Floods no longer occur, but the pollution of the river has increased. In the light of these changes, a number of concepts have been taken concerning the Nile and the environment.

The soil map of Egypt at a scale of 1:2,000,000 published (1964) by the FAO High Dam Soil Survey, is considered a good base for subsequent detailed studies. This project aimed to survey the soils which planned to be irrigated by the water that will save after the construction of the High Dam, Figure 2.

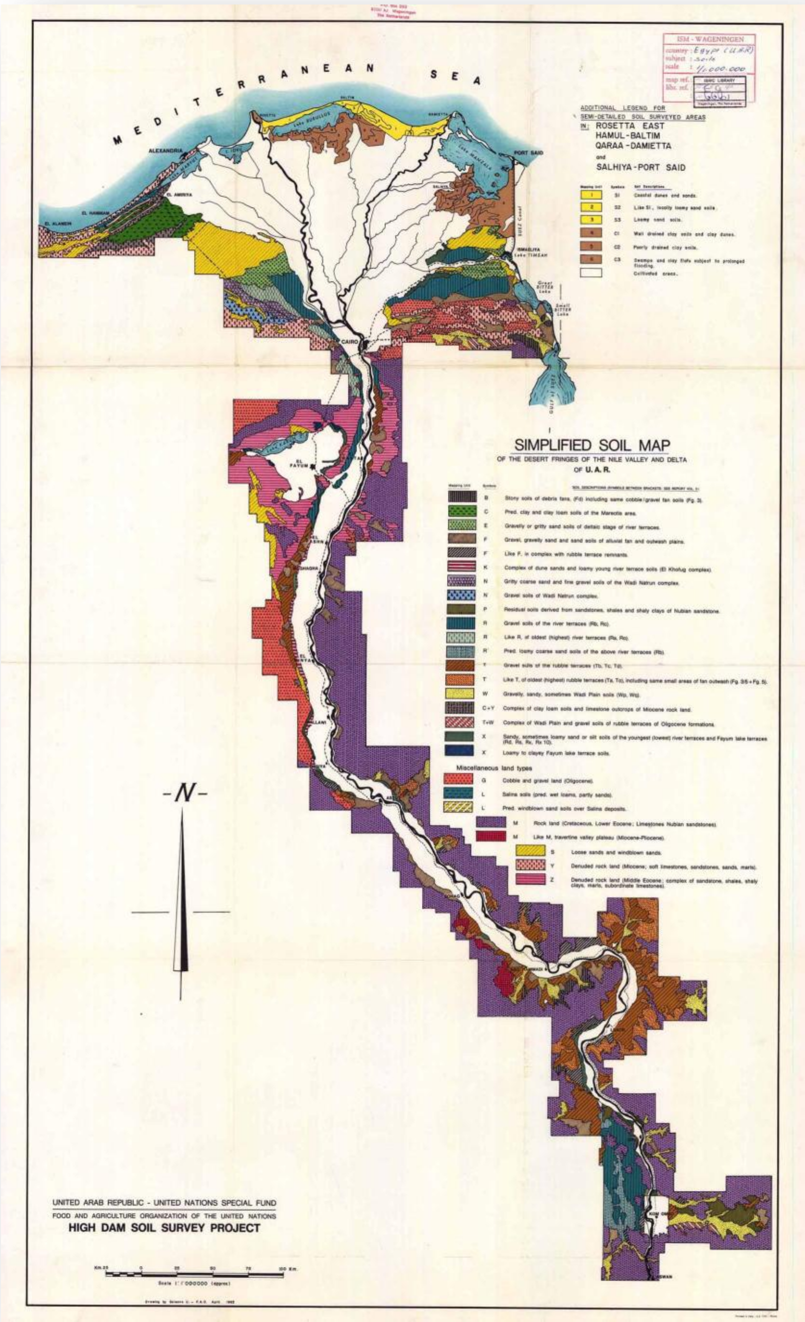

Figure 3. Soil map of Egypt. Source: FAO High Dam Soil Survey

Gehad, (2003). Mentiond that the soils in the old-irrigated areas in the Nile valley and delta are described as young alluvium. The depth varies between 5 and 50 meters depending on location relevant to the main course of the river. Textures of the deep, homogenous profiles are generally, light in the south and in fields close to the river and change gradually to heavy northwards and away from the course. Salinities is generally low in the south but increases northwards towards the lakes and the Mediterranean sea, which alkalinity is a characteristic dominating feature, Figure 4.

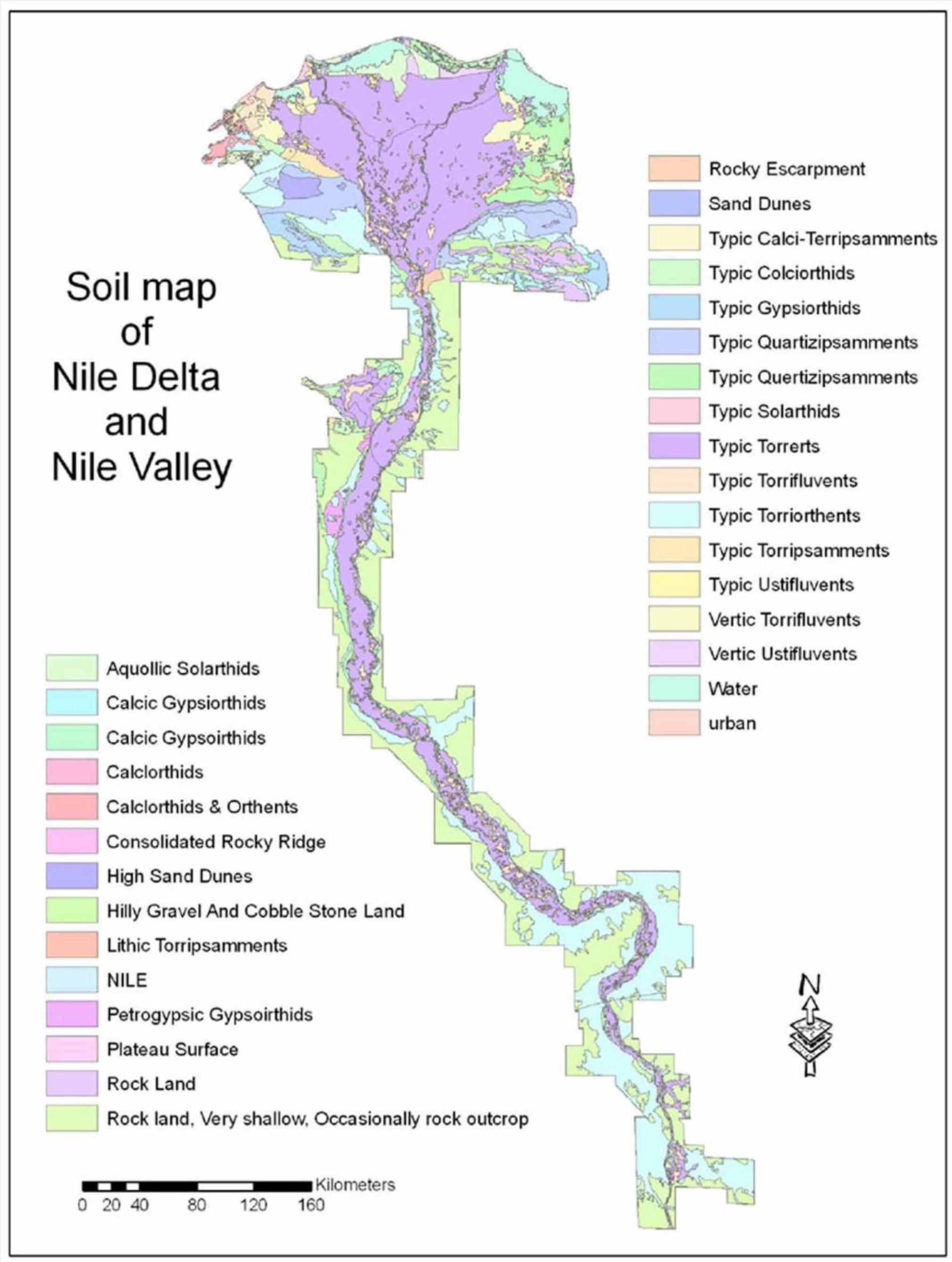

Figure 4. Soil map of Egypt. Source: Gehad, (2003).

Soil Monitoring,

Gehad, (2003). Stated that a soil and crop monitoring programme was initiated to measure the physical impact of soil improvement on soil properties and crop yields. These studies covered 10% of the improved area either in the old land or recently in the old-new lands, and continued for four years.

The monitoring plan included crop yield determinations for four seasons after application of soil improvement program.

Evaluation of the effects of soil improvement can be carried out by:-

A- Changes in soil properties

1- Results indicated that application of sub- soiling ploughing and addition of gypsum beside drainage had a general depressive effect on the bulk density.
2- The study also reveled that application of sub-soiling and addition of gypsum beside tile drainage provided the best results for decreasing water table level.
3- The application of both gypsum and sub-soiling to the soil caused a decrease in soil pH. Generally, the soil pH was decreased from more than 8.5 to less than 7.8 when gypsum was applied with successive water leaching.
4- Concerning the combined effect of gypsum application and leaching by using drainage system and sub-soiling ploughing, on the soil salinity, obtained results generally showed a decrease in the values of electrical conductivity (EC) through the soil profile from more than 16 ds/m to less than 6 ds/m.
5- Both ESP and the pH of the soil were decreased from more than 30 to less than to 10 meq/100g soil and from more than 8.5 to less than 7.8, respectively.

B - Crop yield improvement

Data in the following table presents the effect of soil improvement on crop production. The obtained data generally should that subsoiling and gypsum application with drainage system increase that yield during the first three years after soil improvement.
It is clear from the results that the effect is noticed for three years but in the fourth year it decreased.

Current Soil Mapping Efforts

Many authorities and authors in Egypt since a long time ago try to update and modify the old hardcopy maps to be in a digital formats and introduce a data base (data bank) at a local level those such as Ministry of Agriculture, Academy of Scientific Research, Ministry of Irrigation and Public Work, National Authority of Remote Sensing And Space Science, National Research Center, some Egyptian Universities.

SOIL THREATS

Erosion

Egypt's Mediterranean coast and the Nile Delta have been identified as vulnerable to sea level rise. A recent study concerning fresh water resources in Egypt, including vulnerability assessment concluded that while the impact of climate change on the Nile Basin could not yet be predicted, there are indications that the impacts will be significant and severe. Any decrease in the total supply of water, coupled with an expected increase in consumption due to the high population growth rates and the rise in the standards of living could have drastic impacts. All climate change scenarios considered resulted in simulated decreases in wheat and maize yields: climate change may bring about substantial reductions in the national grain production. As for cotton, it is clear that seed cotton yield will be increased gradually to arrive at its maximum by the year 2050 due to the expected impact of climate change (i.e. when temperatures rise by between +2 °C and +4 °C). If climate change adversely affects crop production under the normal CO_2 concentration, Egypt would have to increase food imports.

In Egypt water erosion is recognized by different degree of severity; some of them occurs in the eastern desert of Egypt and in the north coastal shore areas due to the heavy short rain shower. The eroded materials are loaded away to low areas.

The severity erosion is high found in the north costal shore of the Mediterranean where the water current effect by the same way effect of global climate changes on the coastal line of the Nile Delta, Kotb and Elewa (2009).

Decline in Organic Matter
In general organic matter content in the soils of Egypt is very low (less than 2%) this due to the arid climate conditions which accelerate the decomposition of organic residual of crops and over cutting of plant residual.

Soil Contamination (Local and Diffuse)
One of the most important sources of soil contamination with heavy metals is mineral fertilizers. In Great Cairo City, different factories get rid of large amounts of wastewater, which contain heavy metals without adequate treatment as sewage. With expected water deficiency, sewage water is planned to be used for irrigation in some areas. In addition, metals can be introduced into the soil from various human activities involving processing, manufacturing of paints and pigments, atmospheric emission from motor vehicles, incineration of municipal solid wastes and combustion of coal … etc. Fawkia Labib Bahna (2006) investigated the pollution and heavy metals contamination in Egypt and obtained that the concentration of heavy metals in Sinai soil samples are free from contaminated pollutant with heavy elements. Regarding Abou-Rawash soils, although the concentration of total content is multiple (2 times for Cr, 10 times for Hg, 6 times for CD) of permissible toxic level ,yet effective available content for plant is less than the toxic level

Soil Compaction,
Compaction induced by machinery use which reduces water storage and conduct and make soil less permeable to plant roots; compaction is recognized mainly in the north Nile Delta due to the increase of the clay content in the alluvial soils and mismanagement.

Decline In Soil Biodiversity,
Biodiversity decline, induced by soil contamination, erosion, Salinization and sealing. In Egypt the soil contamination cause severe problem as well as the salinization due to over cultivation and reuse of drainage water and see water intrusion.

Salinisation,
The salinization occurs in Egypt due to over cultivation and reuse of drainage water and see water intrusion. This occurred in Egypt in 1970 when the High Dam was built. The change in the level of ground water before the construction had enabled soil erosion, which led to high concentration of salts in the water table. After the construction, the continuous high level of the water table led to the salinization of the arable land. Salinity from irrigation can occur over time wherever irrigation occurs, since water contains some dissolved salts. When the plants use the water, evaporation occurs; the salts are left behind in the soil and eventually begin to accumulate. Salination from irrigation water is also greatly increased by poor drainage and use of saline water for irrigating agricultural crops.

Floods and Landslides

Egypt in the 20 century was surfing from high floods causing sever problems till the High Dam was constructed which keep Egypt away from high floods. Only some few small high floods occur in the Eastern Desert from time to time depends on the climate durations causing some troubles in areas around some main dry valleys especially in the Upper Egypt.

FUTURE PROSPECTS and INTEGRATION STUDIES

Future Plans on Soil Resources

The continuous increase of human pressure on our limited natural resources, including water and cultivated area requires proper management of such resources. To achieve this goal, it is important to have good knowledge of soil characteristics, their distribution as well as of the existing fresh water. Therefore, there is a need for a system that can supply us with accurate and timely information on soil and water resources. This support is essential to promote a sustainable agricultural development and enhance food security in Egypt.

Concerning the future intervention, the establishment of land and water resources database should be welcomed in order to introduce and better arrange the huge existing information to the internationally cooperation in the field of soil sciences especially in our region South the Mediterranean and Middle East.

Satellite data, with the aid of computer categorization and classification and supplemented by ground truth data, proved to be valuable in providing up-to-date information on regional land use patterns in the traditional agricultural area. Also, repetitive satellite coverage proved to be very helpful in monitoring changes. For the desert area,

The soil information system supports the national efforts of Egypt to promote sustainable agricultural development and enhance food security. Realizing the importance of accurate and readily available information, the Information and Decision Support Centre (IDSC) of the Egyptian Cabinet of Ministers started setting up national natural resources databases as part of the Natural Resources Program In 1992, (Abdel Rahman, 1992).

Data Integration with the European Soil Database

We believe that the European South Mediterranean, North Africa and Middle East should be one scientific unit in the future.
To improve the soil databases in Egypt, a number of equipment and materials are needed to strengthen the capability of our research institutions.

- Training the staff on compilation, digitizing and dissemination of useful information of soils and terrain, including collection of data from the different institutions;
- Arrangement of the data according to the European standards as a reliable reference for soil information;
- Production of new soil maps using the European Soil Database guidelines;
- Continuous up-dating of the database system and of the hardware equipment.

CONCLUSIONS

In Egypt we face many challenges such rapid population increasing limiting in land and water resources, desertification and poverty. In order to overcome of those problems we have to follow-up modern and optimum ways to improve our resources and keep them away from degradation for the next generation by application of sustainable natural resources development methods.

The mapping of land resources is the first task before any future activates in the field of land use for such sustainable development. All information about our resources should be sorted in digital ways and be saved in data bank (databases) to be in suitable formats for a farther uses.

Acknowledgement

It is our pleasant duty to express sincere appreciation to the European Commission Joint Research Centre Land Resources Management Unit Ispra (VA) ITALY, for this kind invitation to attend this meeting aiming at the establishment of the Euro-Mediterranean of digital soil map for all the countries of our region.

Special thanks are due to both Prof. Panos Panagos and Prof. Yusuf Yigini for their kind and useful co-optations.

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Chapter V.
SOIL RESOURCES OF GEORGIA

SOILS OF GEORGIA

Tengiz F. Urushadze, Giorgi O. Ghambashidze[1]

ABSTRACT

Georgia has a variety of soils types which is caused by a diversity of the combination of soil-forming factors changing in a short distance. Due to this fact the founder of the soils science V.V. Dokuchaev named Georgia as a "Museum of soils in the open air". It is thought that some of the world soils were described in Georgia first e.g. Cinnamonic (Cambisols Chromic), Meadow-Cinamonic (Cambisols Chromic), and Yellow-Brown Forest (Acrisols Haplic). In fact the evidence of the changes of soils with the altitude (the law of the vertical soil zonality) has been formulated by V.V. Dokuchaev in Caucasus.

INTRODUCTION

Georgia is a sovereign state in the Caucasus region of Eurasia. Located at the crossroads of Western Asia and Eastern Europe, between latitudes 41°07' and 43°35'N, and longitudes 40°05' and 46°44'E, with an area of 67,900 km2, its population is almost 4.7 million. It is bounded to the west by the Black Sea, to the north by Russian Federation, to the south by Turkey and Armenia, and to the southeast by Azerbaijan. The Likhi Range divides the country into eastern and western halves. Historically, the western portion of Georgia was known as Colchics while the eastern plateau was called Iberia. The capital of Georgia is Tbilisi, one of the most ancient cities in the world, dating some 1500 years back into history, is well known for its sulphuric thermal spas.

Georgia is mountainous country, with 53.6% of the territory covered by mountains, 33.4% by foothill areas and 13% by lowland. Vertically, the territory rises up to the highest mountain is Shkhara peak (5201 m). The biggest rivers are – Mtkvari (Koura) and Rioni. Blend of alpine zone of Caucasus and subtropical of the Black Sea seaside, volcanic plateau Djavakheti, lakes, beautiful sea and ski resorts, impressive views, mineral and thermal spas, numerous monasteries and temples attract numerous tourists. Thanks to the diverse landscape ranging from humid seashore subtropics to snowy mountains, Georgia allows experience of all four seasons of year in very short span of time.

The climate of Georgia is extremely diverse, considering the nation's small size. There are two main climatic zones, roughly separating Eastern and Western parts of the country. The Greater Caucasus Mountain Range plays an important role in moderating Georgia's climate and protects the nation from the penetration of colder air masses from the north. The Lesser Caucasus Mountains partially protect the region from the influence of dry and hot air masses from the south as well.

Much of western Georgia lies within the northern periphery of the humid subtropical zone with annual precipitation ranging from 1,000–4,000 mm. The precipitation tends to be uniformly distributed throughout the year, although the rainfall can be particularly heavy during the autumn months. The climate of the region varies significantly with elevation and while much of the lowland areas of western Georgia are relatively warm throughout the year, the foothills and mountainous areas experience cool, wet summers and snowy winters, snow cover often exceeds 2 meters in many regions.

Eastern Georgia has a transitional climate from humid subtropical to continental. The region's weather patterns are influenced both by dry, Caspian air masses from the east and humid, Black Sea air masses from the west. Annual precipitation is considerably less than that of western Georgia and ranges from 400–1,600 mm.

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Georgia traditionally has well-developed livestock and plant production. The country is characterized by its complex landscape and diversity of soil conditions. The country is divided into 13 zones, each with specialized agriculture oriented at viticulture, horticulture, fodder production, livestock production, suburban agriculture, tea growing, subtropical 2 crops and tobacco production. The major industries are viticulture, tea and fruit (especially citrus) production. Vines and wheat are of especial interest, as Georgia is considered to be the origin of vines. Scientists believe that Transcaucasia is the place of origin of wheat; some 12 species and 30 subspecies of wheat, of which two, Makha and Zanduri, are found only in Georgia.

About 43% of the territory (3 mln ha) is used for agriculture, from which about 0.8 mln ha is arable land and the rest consists from pastures and haylands. Around 40% of the country area is covered by forests, including 600 thousand ha of old growth, and it forms the national wealth of the state.

COUNTRY SOIL INFORMATION

Georgia is among the countries having very diverse soil types within a small area, stipulated by vertical zonality consisting from five climatic zones. The major soil types spread in Georgia are the followings: Mountain-Meadow (Leptosols), Brown Forest (Cambisols Eutric), Cinnamonic (Cambisols Cromic), Alluvial (Fluvisols), Raw Humus Calcareous (Leptosols Rendzic), Yellow Brown Forest (Acrisols Haplic), Meadow Cinnamonic (Cambisols Chromic), Subtropical Podzols (Luvisols Albic), Yellow Soils (Acrisols Haplic), Red Soils (Nitisols Ferralic), Black (Vertisols), Grey Cinnamonic, Meadow Grey-Cinnamonic (Cambisols Chromic, Cambisols Chromic), Chernozems (Chernozems), Bog (Gleysols), Raw Humus Sulphate and Salt (Gypsisols, Solonetz, Solonchaks). Distribution of the major soil types are shown on the map (Figure 1).

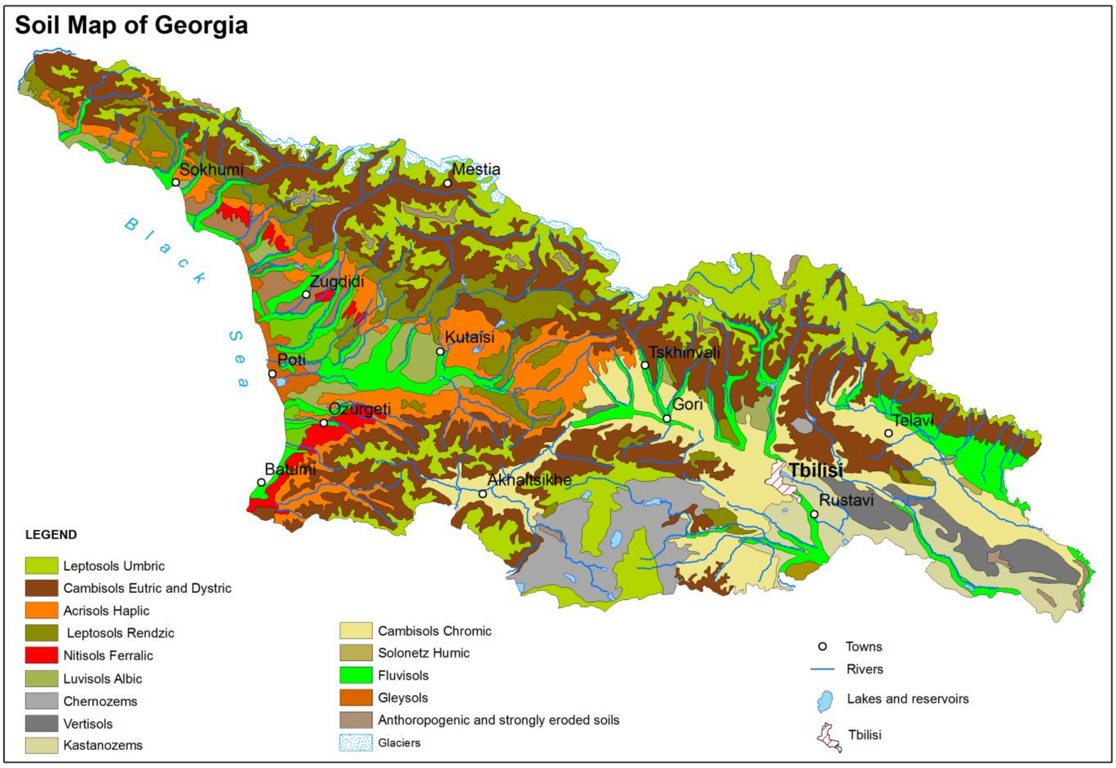

Figure 1. Distribution of the major soil types in Georgia

The Soil Map of Georgia at the scale 1:500 000 was published in 1998. The map was composed by more than 50 scientists and practitioners. It was the first map with the legend where soils nominations according to the World Reference of Soil Resources (WRB) were indicated along with national classification.

Mountain-Meadow soils (Leptosols) are absolutely dominant. Total area of the soils is 1 758 200 ha i.e. 25,1% of the total territory. These soils are spread from 1800 (2000) meters to 3200 (3500) meters above sea level (a.s.l.). These soils border Leptosols (upper zone) and Cambisols (lower zone). Mountain-Meadow (Leptosols) soils (Figure 2) are characterized by average and low capacity, sod horizon from surface, loam and clay texture, acid and weakly acid reaction, high content of humus and deep humus penetration, fulvate and fulvate-humate type of humus, low and moderate capacity of absorption, unequal distribution of separate fractions and total oxides, siallitic type of the weathering of minerals, predominance of hydro mica and chlorite in clay minerals, higher content of silicate iron.

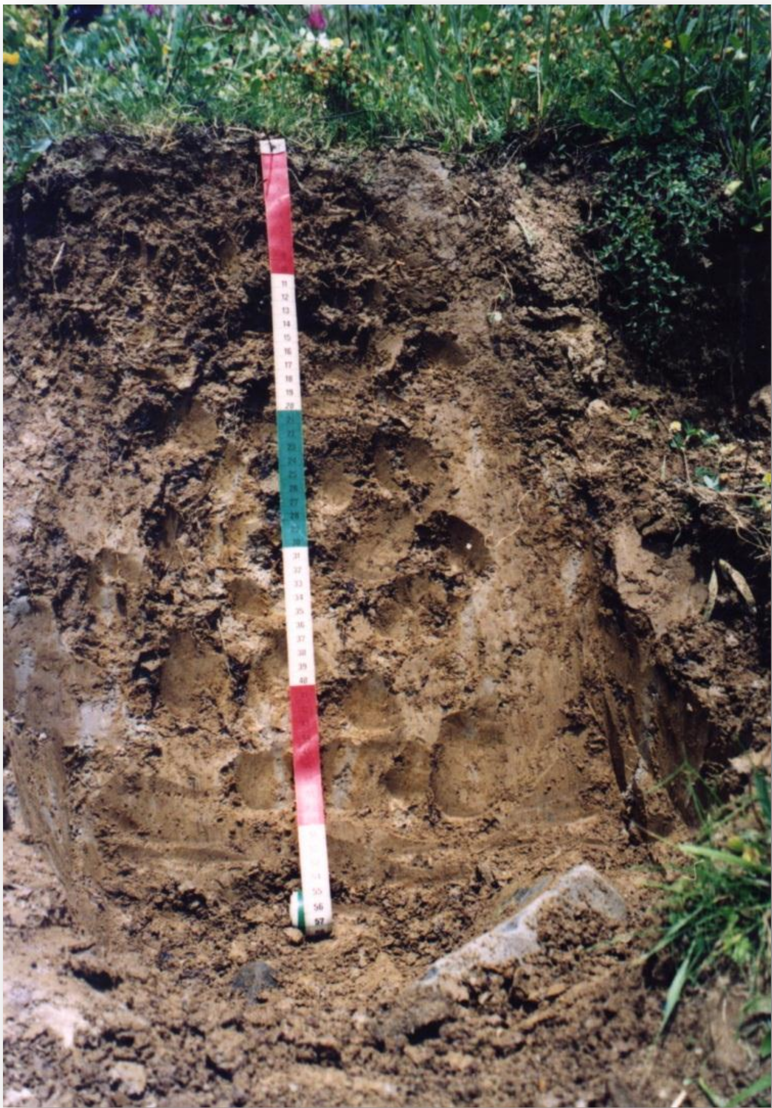

Figure 2. Mountain-Meadow (Leptosols) soils

Total area of Brown Forest (Cambisols Eutric) soils is 1 329 000 ha i.e. 18,1 % of the total territory. They are found in both West and East Georgia from 800 (900) meter to 1900 (2000) meter a.s.l.

These soils border Acrisols Haplic and Leptosols in West Georgia and with Cambisols Chromic in East Georgia. Brown Forest (Cambisols Eutric) soils (Figure 3) have weak differentiation on genetic horizons (except brown forest podzols), more or less monotonous brown colour, litter horizon, weakly acid and acid reaction, kaolization (clayzation) of all depths of profile, weakly intermix of clay), more or less uniform distribution of SiO_2 and R_2O_3 (except brown forest podzols), high content of mobile iron, moderate and high content of humus, fulvate type of humus, ciliate type of the weathering of mineral part, predominance of hydro mica, montmorillonite and mica-montmorillonite in clay minerals.

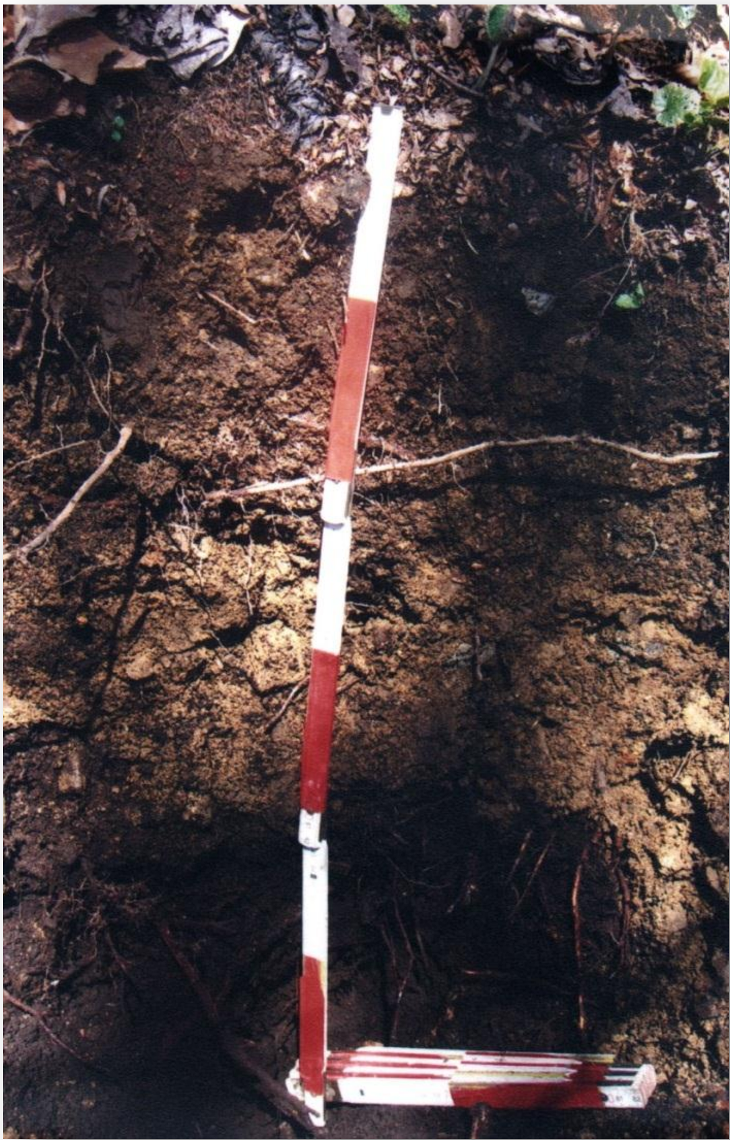

Figure 3. Brown Forest (Eutric Cambisols) soils

Cinnamonic (Cambisols Cromic) soils make 6 218 847 ha, i.e. 8,9 % of the total territory. Cinnamonic (Cambisols Cromic) soils are spread in forest-steppe zone of East Georgia, mainly at the altitude of 500 (700) – 900 (1300) a.s.l. These soils border meadow-cinnamonic (Cambisols Chromic), Grey-cinnamonic (Cambisols Chromic), Black (Vertisols) and Brown Forest (Cambisols Chromic) soils. Cinnamonic (Cambisols Cromic) soils (Figure 4) are characterized by dark-brown and brown colour of humus horizons, small lump and grainy structure, weakly alkaline or neutral reaction, moderate content of humus, deep penetration of humus, humate type of humus, presence of carbonate, kaolization (clayzation), considerable capacity, stability of total chemical content in soils and clay fraction, predominant silicate iron on non-silicate, predominant montmorillonite and hydro mica in clay minerals.

Total area of alluvial (Fluvisols) soils in Georgia is 5 733 897 ha (8,2 %). They are formed on all the territory of the country in different natural zones. Alluvial (Fluvisols) soils (Figure 5) are characterized by acid, neutral or alkaline reaction in relation with river basins. In these soils content of humus is average or low. Content of nitrogen is high or average; absorption capacity is low or average. One of the diagnostic indexes of these soils is stratum constitution (in first of texture). In spite of this, distribution of main oxides both in soils and clay fraction is more or less equal. The clay minerals are presented in wide range – montmorillonite, kaolinite, haluazite, hydro mica and others. Content of silicate iron sharply predominates non silicate iron.

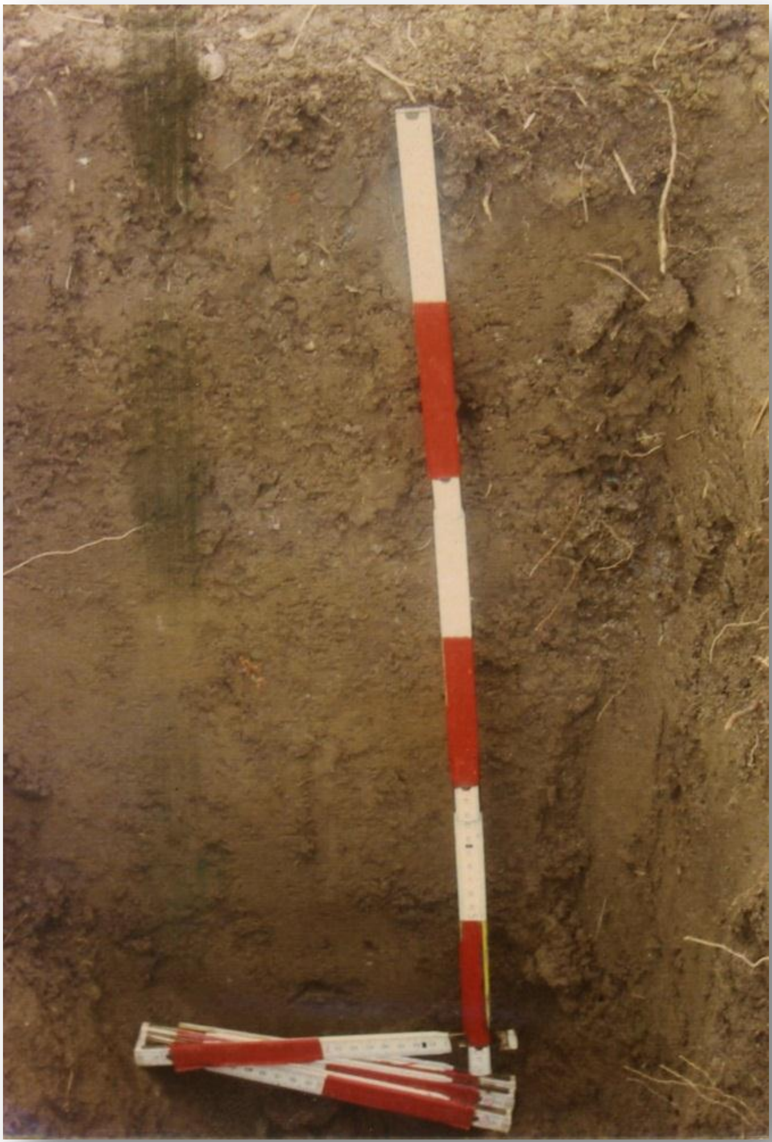

Figure 4. Cinnamonic (Cromic Cambisols) soils

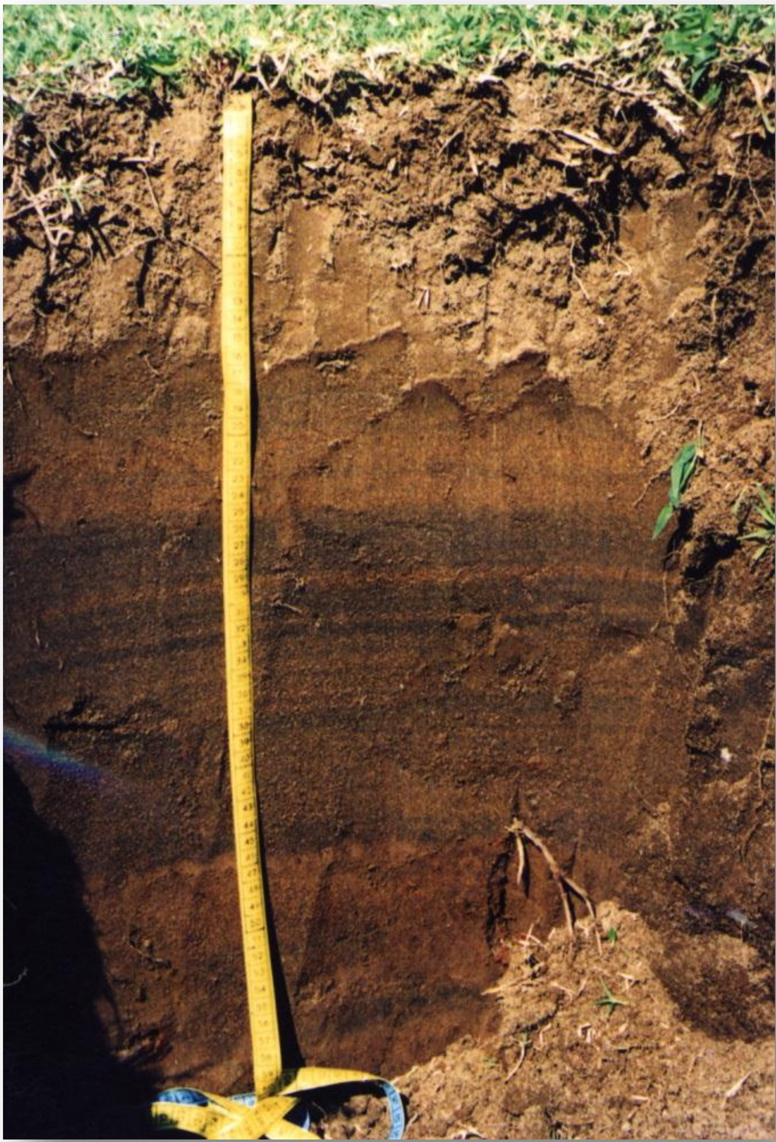

Figure 5. Alluvial (Fluvisols) soils

Total area of Raw Humus Calcareous (Leptosols Rendzic) soils in Georgia is 4 030 480 ha (7,1 %). Raw Humus Calcareous (Leptosols Rendzic) soils (Figure 6) are characterized by neutral or weakly alkaline reaction; content of humus is moderate or low; at the same time the soils which were developed on marl stand out with less content of humus. Soils have deep distribution of humus; type of humus – fulvate. Content of carbonate varies at a large extent. Exchange complex is saturated with bases. Absorbed calcium makes 92% of the total amount. The soils on the buhr are characterized by clay texture, while on marl – by loam texture.

Figure **6.** Raw Humus Calcareous (Rendzic Leptosols) soils

Total area of Yellow Brown Forest (Acrisols Haplic) soils in Georgia is 4 529 358 ha (6,5 %). Yellow Brown Forest (Acrisols Haplic) soils (Figure 7) are characterized by insignificant shift of clay fraction, acid reaction, which supports the mobilization of iron and as a result, formation of iron-organic complex. The earth silicon has uniform distribution in soil, which is correlated with the increase of content of sesquioxides and uniform distribution with ferralitic weathering, certain mobility of humus substance, noticeable increase of fulvate acids, and the increase of the content of non-silicate iron.

Figure 7. Yellow Brown Forest (Haplic Acrisols) soils

Meadow Cinnamonic (Cambisols Chromic) soils make 1 841 357 ha i.e. 2,6 % of the total territory. Meadow Cinnamonic (Cambisols Chromic) soils (Figure 8) are characterized by weakly alkaline or alkaline reaction, content of humus in arable horizon is low, soil profile has deep humus horizon, coarse and medium texture, the sum of absorbed bases is low. This is directly connected with mineralogy of clay fraction, where hydro mica predominates. Certain increase of the sum of absorbed bases is in relation with clay formation; clay formation is well expressed; silicate iron is predominant over non silicate iron.

Subtropical Podzol (Luvisols Albic) soils make 2 983 833 ha, i.e. 4,3 % of the total territory. These soils (Figure 9) are characterized by acid, neutral and alkaline reaction, moderate content of humus, deep humus horizon, type of humus is fulvate. Exchange complex is saturated or not saturated by bases. Reaction of soils and consequently, saturation or non-saturation is in relation with chemistry of ground waters. Soils have loam and clay texture. Humus and eluvial horizon are poor in thin fractions. According to the total chemical analysis basic oxides are characterized by eluvial-illuvial differentiation. As a rule content of silicate iron predominates over non silicate iron.

Figure 8. Meadow Cinnamonic (Cambisols Chromic) soils

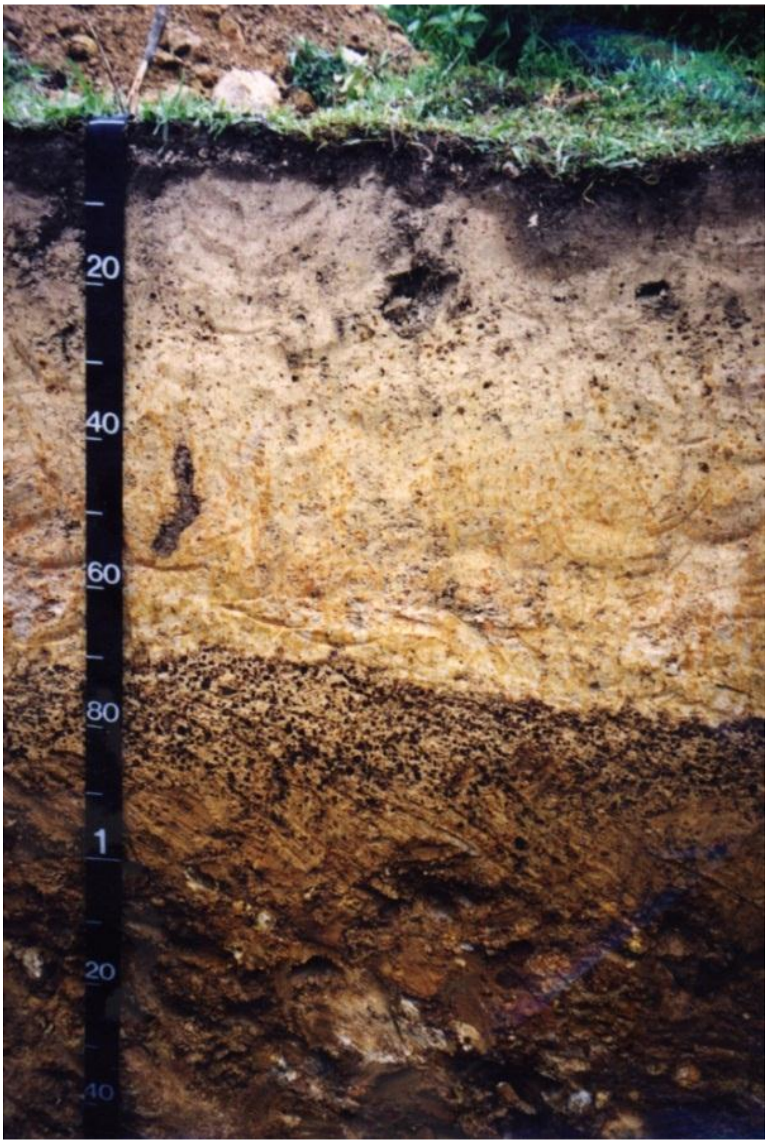

Figure 9. Subtropical Podzol (Albic Luvisols) soils

Yellow (Acrisols Haplic) soils make 2 898 034 ha, i.e. 4,1 % of the total territory. These soils (Figure 10) are characterized by acid reaction, low or moderate content of humus, in the deep layers humus reduces sharply, absorbed complex is not saturated by bases, but non-saturation degree considerably changes. The texture in deep layers changes insignificantly. Content of amorphous iron is small, but non silicate iron – sufficiently high. According to the total chemical analysis main oxides are distributed unequally. In clay fraction the ratio $Si0_2$: R_20_3 changes considerably and indicates both ferralitic and siallitic weathering.

Figure 10. Yellow (Haplic Acrisols) soils

Red (Nitisols Ferralic) soils make 1 533 393 ha, i.e. 2,2 % of the total territory. Red (Nitisols Ferralic) soils (Figure 11) are characterized by acid reaction, content of humus moderate or high; type of humus is fulvate; exchange capacity is low or medium. In exchange cations as a rule predominates exchange hydrogen. Texture is heavy loam, clay and heavy clay. Soils are poor in silica and bases and rich in sesquioxides. Mineralogical part is characterized by ferralitic weathering. Clay minerals are represented with kaolinite, haluazit, hetit and hibsit. Silicate iron predominates over non silicate iron. Different forms of iron are distributed in soil profile more or less equally.

Black (Vertisols) soils make 2 507 539 ha, i.e. 3,6 % of the total territory. Black (Vertisols) soils (Figure 12) are characterized by black colour of humus horizon, presence of carbonate – illuvial horizon, maximum of carbonate in depth 60-120 cm, clay texture, according to the total chemical analysis of soil and clay they are characterized by uniform distribution of main oxides, predominant in clay minerals are smectite, hydro mica and chlorite; accumulation of non-silicate and crystallized iron in the middle part of a profile, but amorphous - in the top part; content of humus is moderate, humate type of humus, weakly alkaline reaction, in some case certain accumulation of labile soluble salts and gypsum, signs of compact.

Figure 11. Red (Ferralic Nitisols) soils

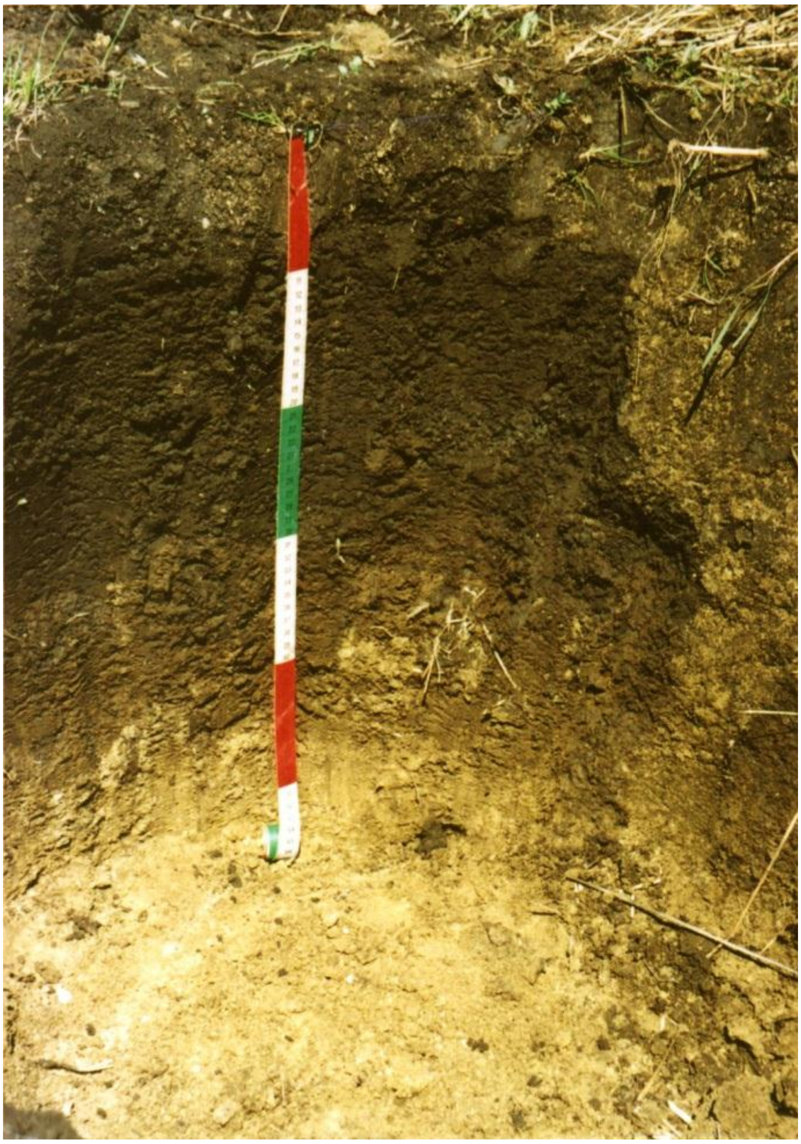

Figure 12. Black (Vertisols) soils

Grey Cinnamonic, Meadow Grey-Cinnamonic (Cambisols Chromic, Cambisols Chromic) soils make 1 841 357 ha, i.e. 2,6 % of the total territory. These soils (Figure 13) are characterized by weakly alkaline or alkaline reaction, low content of humus, high clayzation of soil profile, with maximum content of clay in the middle part of soil profile, equal distribution of main oxides, base saturation, predominant silicate iron over non silicate iron, weakly alkaline or alkaline reaction, carbonate in whole profile and powerful, well-expressed carbonate - illuvial horizon.

Figure 13. Grey Cinnamonic, Meadow Grey-Cinnamonic (Chromic Cambisols, Chromic Cambisols) soils

Chernozems (Chernozems) make 1 618 394 ha, i.e. 2,3 % of the total territory. Chernozems (Chernozems) are characterized by clay or heavy clay texture; distribution of clay in the top part of the profile (Figure 14) is more or less equal, but in lower part it reduces. Content of humus is high and in some cases reaches 10 %. Chernozems are characterized by weakly acid, neutral or weakly alkaline reaction. Soils are base saturated. In exchange cations sharp predominant is calcium. According to the chemical analysis main oxides are characterized by more or less equal distribution.
Bog (Gleysols) soils make 687 138 ha, i.e. 1,2 % of the total territory. These soils (Figure 15). are characterized by weakly alkaline or neutral reaction, high content of humus, heavy texture in whole profile, high dispersion, in exchange cations sharp predominant is exchange calcium; according to the total chemical analysis main oxides are distributed unequally, which shows its alluvial nature. Bog soils are characterized by the increased content of different forms of iron. At the same time amorphous iron is accumulated in the top part of profile, and crystal iron –in the bottom.

Figure 14. Chernozems

Figure 15. Bog (Gleysols) soils

Raw Humus Sulphate and Salt (Gypsisols, Solonetz, Solonchaks) Bog (Gleysols) soils make 215 858 ha i.e. 0,1 % of the total territory. These soils (Figure 16) are characterized by fine texture. Most part of them belongs to clay. In exchange cations the predominant is calcium, but sodium and magnesium is in sufficiently content. The content of humus is low; the later reduces with the depth sharply. Clay minerals are presented by montmorillonite as well as hydro mica. According to the total chemical analysis main oxides are characterized by unequal distribution.

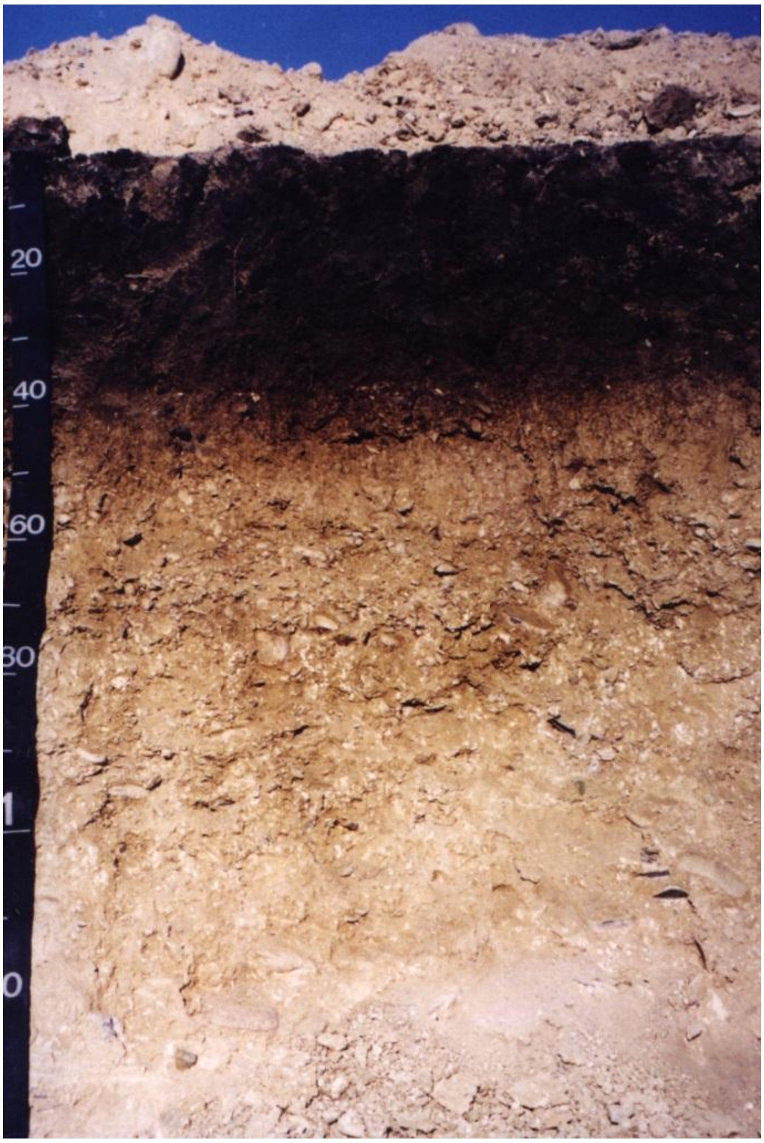

Figure 16. Raw Humus Sulphate and Salt (Gypsisols, Solonetz, Solonchaks) Bog (Gleysols)

The soils of Georgia are characterized by different fertility which is described by 5 categories: very poor, poor, moderate, rich and very rich. The decreasing range of the supply of nutritious elements (nitrogen, phosphor and potassium) of main soils of Georgia was composed.

According to the total forms of nutritious elements: Mountain-Meadow – Leptosols, Chernozems – Chernozems > Brown Forest – Cambisols Eutric > Alluvial – Fluvisols > Raw Humus Calcareous – Leptosols Rendzic, Red Soils – Nitisols Ferralic, Raw Humus Sulphate and Salt - Gypsisols, Solonetz, Solonchaks > Cinnamonic – Cambisols Chromic, Meadow-Cinnamonic - Cambisols Chromic, Grey Cinnamonic – Cambisols Chromic, Meadow Grey-Cinnamonic - Cambisols Chromic > Black – Vertisols > Subtropical Podzols - Luvisols Albic.

According to the available forms (hydrograph nitrogen, absorbed phosphor, exchangeable potassium): Mountain-Meadow – Leptosols > Meadow-Cinnamonic - Cambisols Chromic > Cinnamonic – Cambisols Chromic, Grey Cinnamonic - Cambisols Chromic > Red Soils – Nitisols Ferralic > Black – Vertisols, Raw Humus Calcareous – Leptosols Rendzic, Brown Forest – Cambisols Eutric, Alluvial – Fluvisols > Subtropical Podzols - Luvisols Albic, Chernozems – Chernozems, Raw Humus Sulphate and Salt - Gypsisols, Solonetz, Solonchaks.

According to the total and available forms, the following decreasing line of soils of Georgia was recognized: Mountain-Meadow – Leptosols > Meadow-Cinnamonic - Cambisols Chromic > Brown Forest – Cambisols Eutric, Red Soils – Nitisols Ferralic, Chernozems – Chernozems, Black – Vertisols, Cinnamonic – Cambisols Chromic, Grey Cinnamonic - Cambisols Chromic > Raw Humus Calcareous – Leptosols Rendzic > Raw Humus Sulphate and Salt – Gypsisols > Alluvial – Fluvisols > Subtropical Podzols - Luvisols Albic.

SOIL THREATS

Among the main soil threats, as defined by European Union, soil erosion is the most critical for Georgia. Nearly 35 percent of agricultural land is degraded as a consequence of water and wind erosion that affect mountain areas and crop fields, particularly in eastern Georgia. Modern techniques for cultivating steep plots, such as terraces and buffer strips, are not commonly applied. Wind erosion and desertification have become a critical issue in eastern Georgia due to overgrazing and the recent decline in rainfall in the region.

Salinization is probably the second major soil threat in Georgia affecting soils of eastern Georgia. Large-scale secondary soil salinization is due to non-observance of irrigation rules and dates.
Soil pollution also takes place in some industrial areas of Georgia, especially in the vicinity of metal mining sites soils are severely affected by pollution with heavy metals through irrigation water and atmospheric deposition.

Agriculture plays insignificant role is soil pollution, as over-fertilization does not seem to be an issue in Georgia; the price of fertilizers has sharply increased in the last 15 years and, consequently, their consumption has dropped.

FUTURE PROSPECTS and INTEGRATION STUDIES

In 2002-2006 the realization of Cadastre and Land Register Project co-financed by KFW had great significance in soil survey and evaluation. In the framework of this project large groups of soil scientists were retrained according to modern standards. The international classification of soils (WRB) was studied and discussed in the field and cameral conditions. The working version of "World Reference Base for Soil Resources" was translated into Georgian and published in 2005. The textbook on field investigation of soils was also prepared and published in 2006.

In 2005 and 2006, a public educational campaign was launched among farmers to address soil erosion causes and possible preventive measures, and a set of guidelines was published. Georgia passed the Law on Soil Protection in 1994; the Law on Amelioration of Soils in 1997; and the Law on Soil Conservation and Reclamation in 2003. Georgia also ratified the UN Convention to Combat Desertification in 1999. In February 2007, a Code of Good Agricultural Practices was prepared and submitted to the government for review and approval. The Code contains legislation, recommendations, and advice for practitioners in the agricultural sector to reduce the negative effects of farming on the environment; to make rational use of natural resources, water, soil, and air, and to promote environmentally friendly practices nationwide.
Several research projects covering issues of soil classification and soil contamination were financed by Shota Rustaveli National Science Foundation in last years. Those research projects enrich information on current soil status and define measures for soil reclamation.

Recently digital soil database was prepared by support of Joint Research Centre (JRC) of European Commission to integrate soil information of Georgia into European soil digital database. It was a great step forward to consolidate and organize a huge volume of scientific data into a single and useful database.

ACKNOWLEDGMENTS

Authors would like to thank Shota Rustaveli National Science Foundation of Georgia for financial support in soil research and also to Joint Research Centre (JRC) of European Commission for support in preparation of soil digital database of Georgia.

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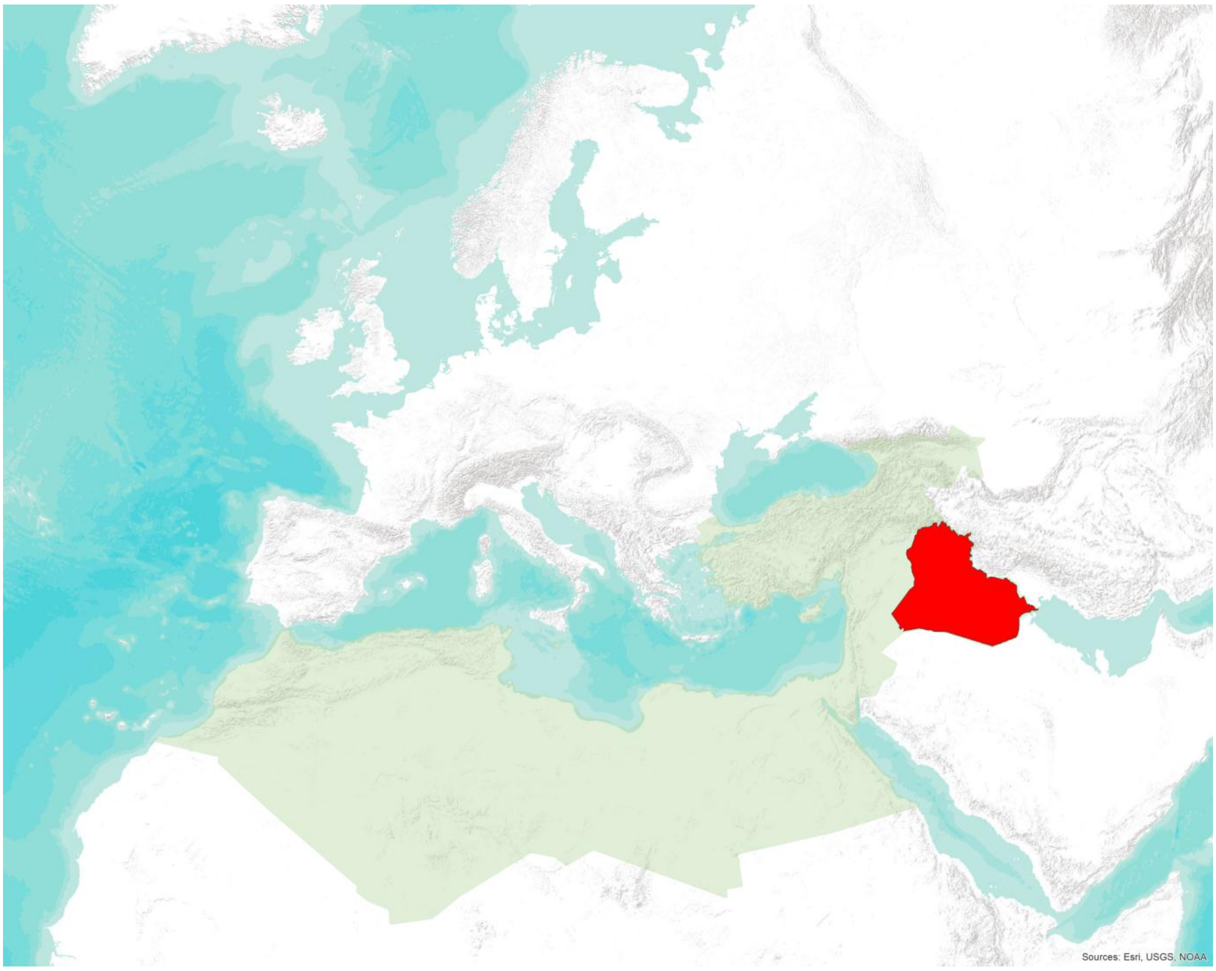
Chapter VI.
SOIL RESOURCES OF IRAQ



SOIL RESOURCES OF IRAQ

Ahmad Salih Muhaimeed[1]

Abstract:
The total area of Iraq is about 435 square Kilometers located between longitudes 38 45 and 48 45 E , and between 29 5 and 37 15 N. Iraq can be divided in to four main physiographic regions, each with its specific conditions, namely Desert (39%) , Mesopotamia (30%) , Mountains(21%) and the undulating region (10%). land use in Iraq can be broken down into 5 agricultural landscape categories: Cultivated (rain fed and irrigated), range or scrub land, desert and forest. The work of soil survey and classification in Iraq was started before 1950. At this point in time, the number and type of soil units in Iraq are incomplete due to the lack of semi-detailed or detailed surveys covering all of Iraq. Non-systematic work of soil survey has been the dominant type of work to date. Only 35% of Iraq is considered covered by a semi-detail survey. About more than 35% from the Iraqi area was covered by Semi-Detail soil survey work with 1:50 000 to 1:25 000 soil maps. Digitized soil maps were done for many areas in Iraq . How ever ,there is no general soil map covering the whole country up to now ,using soil Taxonomy or other system. So the need for detail soil survey and developing soil map with large scale are very necessary . Iraq has soils which are markedly different from one another. In general, the degree of soil development decreases from northern to southern Iraq as represented by the differences in morphological, physical, chemical and mineralogical properties. Most of the soils of the Mountains, Foothills, and Jezira are considered developed soils include Mollisols , Inceptisols and Entisols. While , in the meddle and southern regions the dominant soils are Entisols and Aridisols. Six processes of soil degradation are usually recognized . These are water erosion, wind erosion, excess of salts, chemical degradation, physical degradation and biological degradation.

Key words: soil development, soil survey, soil mapping Land resources.

Introduction:

Iraq with a total land of 435 square Kilometers is located between longitudes 38 45 and 48 45 E, and between 29 5 and 37 15 N. In length from north to south it approximates 1000Km and in width about 500Km. Iraq is not far away (about 400km) from Mediterranean sea on the west and about 1000km from the red sea on the south west and almost the same distance from black sea on the north and practically touching the Arabian Gulf at its southern limit. . Iraq can be divided into four main physiographic regions , each region has its specific geological , hydrological and climatologically conditions , and consequently specific soil conditions (Figure **1) .**

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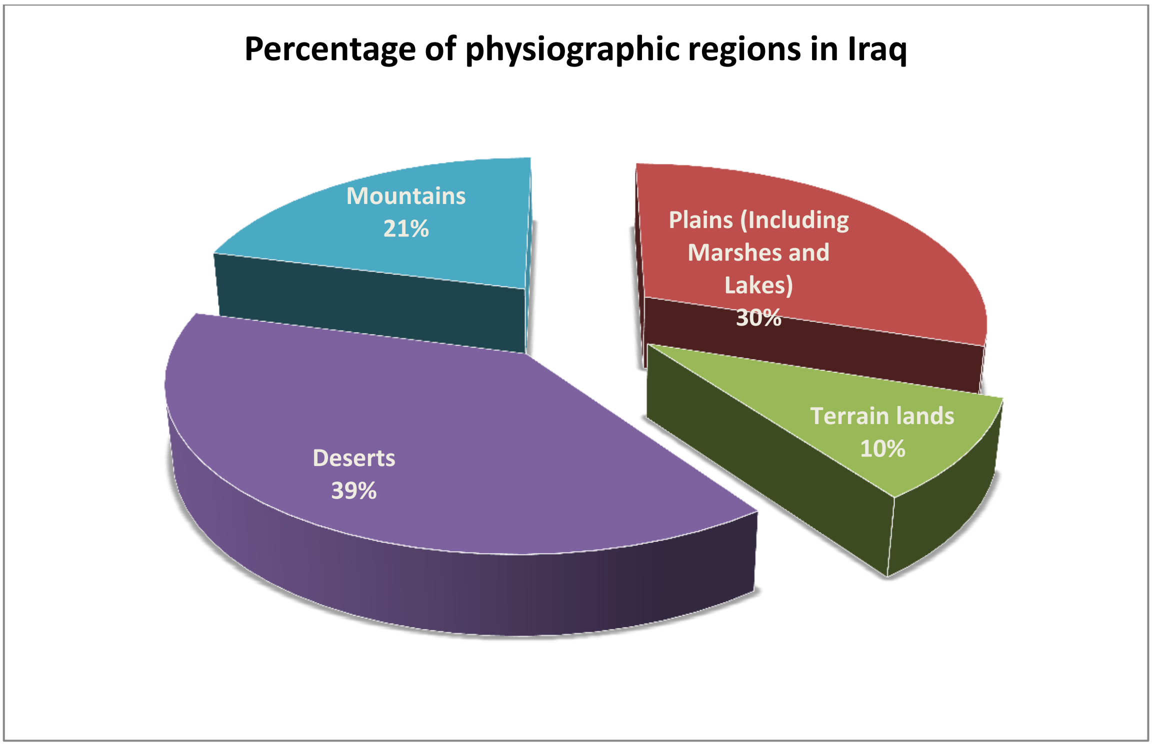

Figure 1. Percentage of physiographic regions in Iraq .

land use in Iraq can be broken down into 5 agricultural landscape categories: Cultivated(27%) (rain fed or irrigated), range or scrub land (27%), desert(42 %) and forest (4 %) (Al-Tikritietal,1981).

Physiographic regions of Iraq :

1-Mountains Region :
Mountains cover an area of 92,000 km2, or about 21 percent, of the total area. The mountain region extends mainly in the northern and north-eastern parts of the country. The mountains consist mainly of parallel anticline ridges separated by elongated synclinal valleys. But they are united by narrow gorges, the outlets of the drainage of the interior basins. The mountains, for the greater part, are eroded and the detritus material has been deposited in the valleys and in the area in front of the mountains. The climate of this region is characterized by cool-moist winters and mild dry summers (Walter and Leith, 1960). Diurnal and seasonal temperature fluctuations are less compared to the rest of Iraq. Annual rainfall is between 700 and 1200 mm or greater, while the annual temperature ranges from 10 to < 20º C. According to Guest (1966), the mountains region includes the forest vegetation zone which merges gradually into a steppe zone dominated by Savannah, represented mainly by Pistacia and other small trees. Most have been eradicated by continuous cultivation and harvesting for wood and fuel. The forest zone is characterized by Quercus Aegilops and Pistacia Bhingulz, Quercus Infectoria and pine Juniper oak forest.

2--Undulating Region :-
This area is comprised of a fairly hilly landscape, located south and west of the mountain region. It covers an area of about 42,000 km2, or nearly 9.6% of Iraq's total area. Although there are some similarities with the former region, general landscape differences stand sharp. The area is somewhat folded in the later phase of folding. It consists of low parallel hill ridges, wide shallow valleys and extensive plains, in which various streams have cut their valleys. In general, average altitude varies from 200 to 1,000 meters. Local relief ranges from a minimum of 200 to a maximum of 800 meters

per square kilometer. Beds of gravel, conglomerate and sandstone make up the area. It can be divided, in terms of geomorphic landforms structure, surface rocks and degree of erosion process, into a number of plains, plateaus, mountains and hill ridges. The southern edge of the mountain range is a highly dissected part. Climatic conditions of this region are characterized by a Mediterranean climate with warm dry summers and cool moist winters, with mean annual precipitation ranging from 400 to 700 mm and mean annual temperature from 20 to 22.5º C. Dominant natural vegetation is an open Savannah, primarily Pistacia and other small trees, with most eradicated by continuous cultivation. Other areas support luxurious grasses dominated by Poa bulbosa and Hordeum bulbosum (Guest, 1966).

3-The Mesopotamian plain:

It is the plain of the twin rivers, the Tigris and the Euphrates ,referred to in ancient times as Shinar and later on called Al-Sawad(i.e., black lands), because of its high agricultural productivity. The plain is located in central and southern Iraq with a number of distinct landscapes. The undulating lands are to the north, the western plateau to the west, Zagros mountains to the east and the Persian Gulf to the south. The plains (including marshland and lakes) cover an area of 132,500 km2, or 30.2% of the total area of Iraq. It has a northwest-southeast orientation, trending in the same direction of the Tigris, Euphrates and Shatt al-Arab. Geologically, the plain occupies the southern part of an extensive geosycline. It was filled up during the quaternary and recent geological periods. Besides sediments carried by the twin rivers, some material of aeolian origin, blown out of the desert, is accumulated and mixed with fluvial deposits.   Most of the plain appears to be dead flat. The climate is worm and dry with mean annual precipitation less than 150mm and more than 22 C.

4-The Desert Region:

This is the largest physiographic region in the country. It occupies an area of 171,817 km2, or about 39.2% of Iraq's total area. The surface rises gradually from 120 m in the east to 700 m in the west. Surface drainage takes a general west-east direction, but streams bring large amounts of water from Sinjar Mountain to be drained southward to the Wadi Tharthar, which has been used to store excess Tigris water diverted near the Samarra Barrage. It was lately connected with the Euphrates and the Tigris by two feeding canals to divert enough irrigation water back to both rivers. Within this very extensive region, there are a number of different plains; Al-Widian (valleys), Jezira (island), al-Hijara (rock), al- plains; Al-Widian (valleys), Jezira (island), al-Hijara (rock), al- Hamad and Dibdibba. The differences are based on physical factors such as relief and rock formations. Al-Widian Plain developed in an area of limestone and gypsum rock ranging from level to undulating with shallow to rather deep valleys. In the northern Widian area is the large Ga'ara de are common. Plateaus are small in number, and the best known are those of Mosul and Kirkuk. The surface of Mosul plateau is dissected by shallow valleys with hills rising to 400 meters above the sea surrounding valleys Fertile soils together with an adequate amount of winter rain provide a good basis for agricultural land use. The Climate is very hot and dry. . with low rainfall generally < 75 or 100 mm which is not sufficient to maintain continuous plant cover.

Iraqi Soil Information

Soil Formation:

Iraq has soils which are markedly different from one another due to differences in soil forming factors (Buringh, 1960). In general, the degree of soil development decreases from northern to southern Iraq as represented by the differences in morphological, physical, chemical and mineralogical properties. Most soils in Iraq are of secondary origin, consisting of materials transported from the place of weathering and accumulated somewhere else. In Iraq materials are deposited by wind, braided rivers, estuary rivers, sea, and irrigation (Buringh, 1960).

Most of the soils of the Mountains, Foothills, and Jezira are considered developed soils due to the effects of local environmental, biological, and geological conditions, which are known for high activity of some pedogenic processes responsible for soil development. The Jezira (Upper Mesopotamian Plain) is an old alluvial soil in which mainly gypsum was deposited. At the present time, it is a large desert and steppe area. In the valleys and especially on some terraces there are deeper fertile soils. These soils have well-developed horizons showing differentiation in such features as color, structure, and organic matter. Most effective pedogenic processes in these regions are desalinization, decalcification, eluviation, illuviation, pedoturbation, melanization, and calcification (Muhaimeed and Sulaiman, 1990, Muhaimeed, 1994; Al-Agidi, 1986, Muhaimeed et al., 2000) as well as geological processes including erosion and deposition.

The Deserts occupy a large part of the country and are mostly underlain by limestone and gypsum. Large areas have pavements or wind accumulated material. Petrogypsic horizons (Soil Survey Staff, 1999) are common in the desert of Iraq (Dregne, 1976) which lies mostly west and north of the Euphrates. Surfaces are coarse-textured where the petrogypsic layer is not exposed and are strongly calcareous. Deep wadis have been etched into the flat desert areas during the pluvial periods in the Pleistocene.

The Lower Mesopotamian Plain is a plain of aggradation where parent material consists mainly of river sediments except near the coast of the Arabian Gulf. This plain comprises about 25% of the total area of Iraq of which 75% is considered salt-affected in varying degrees (Saliem, 1997). A high water table covers most of this area. Besides the fluvial sediments carried by the Twin Rivers, some eolian material blown out of the deserts is accumulated and mixed with these sediments. In some locations, river sediments have been subjected to wind erosion and new fluvi-eolian deposits have been formed, whereas sediments in and around present and old lakes and some large depressions are of lacustrine origin (Buringh, 1960). Most soils are alluvial except those in the most northern sections where the fluvial terraces exist in which a Reddish-Brown soil has developed. Alluvial soils generally occur in the river plains and have various stratified layers with little or no profile development. Some general soil characteristics are as follows: (1) stratification in the soil profile, consisting of layers with different textures often linked to differences in mineral composition; (2) high spatial variability in a horizontal direction; (3) high carbonate content; and (4) presence of gypsum in most soils, typically 1-3%, occasionally ranging from 30 to 60%. In the Desert and Mesopotamian Plain regions, salinization, gypsification, and calcification are considered the most effective processes.According to chemical composition ,Iraqi soils classified in to three types : Calcerous , Gypsiferous and Saline soils. The following is the general description of these soils :

Calcerous Soils :

Most Iraqi soils contain significant amounts of carbonate. Refer to Soils Bulletin No. 21 (1973) for soil carbonate in the different physiographic regions of Iraq. Nevertheless, there are little data concerning this important component. Most surface soils contain 15 to 35% with a few having <15% or >35%. Carbonate mineral content of the subsurface horizons is usually > 25% and reaches 50% in some deep soil horizons (Altaie et al., 1969). These authors also reported that the soil of the Mesopotamian Plain contain about 20 to 30%, and in general coarse-textured levee soils contain less carbonate than finer-textured soils. Under certain conditions, the carbonate mineral content in the Lower Mesopotamian can be as high as 60% in the sub-surface layers as found in the marsh soils of Hor Albu-Hajar (Al-Kaysi, 1983).

Pedologists have recognized that carbonate minerals are among the first to be affected during soil formation. Dissolution, translocation, and eventual removal or re-precipitation of carbonate minerals as layers, nodules, and concretions have been variously characterized and often serve as distinguishing profile characteristics. In a detailed micromorphological examination of calcareous soils in Iraq (Altaie, et al., 1969), carbonate was found in the following forms: fine calcite, intercalary crystals, crystal chambers, crystal tubes, sheets, calcitans, neocalcitans deposited around some pores, amorphous deposits as a result of high water levels in southern Iraq as well as soft lime nodules and petrocalcic layers. Refer to Al-Kaysi (1983) for detailed information on forms of carbonate minerals in thin section of some Iraqi soils. For additional information as related to carbonate mineralogy, specific surface area, and reactivity, refer to Abedi and Talibudeen, 1974ab; Al-Khateeb et al., 1986; Muhaimeed and Younis,1988;; Al-Sinjari, 2000; Nafawa, 2002.

Gypsiferous Soils:
These soils occur in vast areas of Iraq, about 8.8 million hectares or approximately more than 25% of the total country. These soils are associated with a geological substratum of the lower formation of the middle Miocene containing gypsum and anhydrite interlayer and with Pleistocene terraces of rivers. Regional distribution and gypsum content of these soils arecharacterized by Saliem (1997) as follows:

1-In the northern part of Upper Jezira with rainfall > 350 mm, slightly gypsiferous soils (generally < 10% gypsum) are formed over a gypsum bed rock, occupying about 0.74 million hectares.

2- In the southern part of Upper Jezira with rainfall 250-350 mm, the gypsiferous alluvial soils are formed over gypsum and anhydrite rocks of the Lower Fars. Soils occupy about 1.34 million hectares and are moderately to highly gypsiferous, ranging from <1% gypsum in the upper horizons to > 50% in gypsic horizons.

3- Lower Jezira with rainfall <250 mm is characterized by gypsum desert where primary gypsum bedrock is a common outcrop, covering about 3 million hectares.

- Soils of the Pleistocene terraces of the Tigris and Euphrates are highly gypsiferous, reaching 90% in some gypsic and petrogypsic horizons and occupying about 3.7 million hectares.

5- In soils of the Flood Plain, secondary gypsum occupies about 10 million hectares, ranging from <1 to 3% and occasionally moderately gypsiferous (30%).

Saline Soils:
The principal process in the soils of central and southern Iraq is salinization, with about 50 to 70% of the soils affected. The origin of the salts varies widely in Iraq, with some present in the parent rock or produced as a result of the weathering of these rocks, with the naturally low rainfall concentrating these salts. Elsewhere, they originate from sea spray or from efflorescence on the denuded surface of other saline soils, wind blow, or are contained in irrigation or flood waters and in this arid climate resulting in salt accumulation in the soil. The salts have moved upwards in the soil profile through capillary action from the mineral ground waters which are often highly salt concentrated. These salts may accumulate in the soil surface and form efflorescence gray or white color with an accumulation of sodium chloride or sodium sulfate or the salt of magnesium or calcium and black or dark brown soil surface formed by sodium carbonate and dissolved humus. The Tigris and Euphrates carry large quantities of salts. Excessive irrigation and flooding, poor surface and subsurface drainage, and high water table tend to concentrate the salts near the soil surface (Eloubaidy et al., 1993).

In general, soil salinity increases from Baghdad south to the Gulf, severely limiting productivity in the region south of Al Amarah. Salinity is reflected in the lake Bah al Milh in central Iraq, southwest of Baghdad.

Traditionally, the classification of salt-affected soils has been based on the soluble salt concentrations in extracted soil solutions and on the exchangeable sodium percentage (ESP) in the associated soil (Bohn et al., 1979). Historically, saline soils have been defined as having salt contents >0.1%, EC > 4 dS m-1, ESP <15%, and pH <8.5; sodic (alkali) soils usually have an ESP >15%, low salt contents, EC <4 dS m-1, and pH 8.5 to 10; and saline-sodic (saline-alkali) soils usually have properties of both saline and sodic soils with appreciable contents of soluble salts, ESP > 15%, and EC >4 dS m-1 (U.S. Salinity Laboratory Staff, 1954). In Soil Taxonomy, the ESP and sodium adsorption ratio (SAR) are used as diagnostic criteria for natric horizons (Soil Survey Staff, 1999). Early on, the terms saline, alkali, saline-alkali as defined by the U.S. Salinity Laboratory Staff (1954) were used in Iraqi. The terms alkali, saline-alkali, and saline-sodic are terms no longer used in Soil Science Society of America (SSSA) publications (SSSA, 1997). The term saline as defined by SSSA (1997) is a non-sodic soil containing sufficient soluble salt to adversely affect the growth of most crop plants with a lower limit saturation extract EC (ECe) conventionally set a 4 dS m-1 at 25º C. Sensitive plants are affected at half this salinity and highly tolerant ones at about twice this salinity. The term sodic soil is a non-saline soil containing sufficient exchangeable sodium to adversely affect crop production and soil structure under most conditions of soil and plant type. The SAR of saturation extract is at least 13.

In general, there are two groups of salt-affected soils, Shura and Sabakh soils. Shura soils are considered as saline-sodic as defined by the U.S. Soil Salinity Laboratory (1954) with EC > 4 dS m-1, pH <8.5, and SAR > 15. These are Solochaks by the Russian system (Crust and Puffy Solonchaks) according to morphological concepts and Active Solonchaks according to hydrological concepts. The dominant salts are NaCl, Na2SO4, and MgSO4. Shura soils are distinguishable based on their morphological features. Generally, the surface is covered with a white or light colored crust of easily soluble salts. These soils are characterized by a high salt content and are slightly alkaline (pH 7.9 – 8.2). Shura soils frequently have different soil textures, and smectite is the dominant clay mineral. Shura soils have been divided into groups by their dominant chemical composition as follows: (1) NaCl Shura soils have a white or light colored surface due to accumulations of large quantities of NaCl with cohesive crusts which consist of fine granular mixtures of salt; (2) Na2SO4 Shura soils have surfaces that are puffy and loose and have white needle-shaped salt accumulations; (3) MgSO4 Shura soils have puffy, loose layers but without needle-shaped salt accumulations in the upper part of the horizon. Sabakh soils are also considered saline-sodic with the same basic chemical criteria as the Shura soils. The Russian classification of these soils is Active Solonchaks (Kovda, 1973) according to hydrological concepts and Wet Solonchaks according to morphological concepts. These type saline soils also frequently have different soil textures with a high content of organic matter and gypsum in the surface horizon. The pH ranges from 5.0 to 8.2 with smectite being the dominant clay mineral (Al-Hussani, 1984). The dominant salts in these soils are MgCl, CaCl, MgNO3 and CaNO3 that are highly hygroscopic, absorbing water and thereby keeping the soil surface very moist and making it dark in color. Refer to Buringh (1960) for detailed information in regards to these types of soils in Iraq.

Soil Survey and Classification:

The work of soil survey and classification in Iraq was started before 1950. Most of the works were done by foreigner person or companies for specific purposes . Weist ,1954, attempted to classify Iraqi soil according to soil texture and their suitability for crop production. The most common work done at that time by Buringh,1960 .He proposed 18 great groups in Iraq using the old US soil classification system. Upon completion of the exploratory soil map for Iraq, as follow: Desert, Red Desert, Sierozem, Reddish Brown, Brown, Chestnut, Reddish Chestnut, Chernozem, Solonchack, Solonetz, Soloth, Terra Rosa, Rendinza, Hydromorphic soils, Lithosols, Regosols, Alluvial soils and Man-made soils. Figure 2 shows the distribution of the 18 great soil groups in Iraq according to Buringh,1960.This work still considered the most common and useable reference .

After 1965 ,the state board for soil survey and land reclamation was established in order to take care the responsibility for the works of soil survey and classification in Iraq. About more than 35% from the Iraqi area was covered by Semi-Detail soil survey work with 1:50 000 to 1:25 000 soil maps. Digitized soil maps were done for many projects in Iraq . How ever ,there is no semi detail or general soil map covering the whole country using US Taxonomy , up to now. But there is an attempt to create soil map at sub group level for Iraq. This work hopefully will be done with in the next few months using the available data about the Iraqi soil classified using the US Taxonomy and RBD systems. There are other attempts done foreigners organization such as FAO and USDA to create soil map for Iraq using some available and Remote sensing data . The following figures show some dominant suborders which suppose to be exist in Iraq .Figures 3 and 4 indicate the presence of some suborders belong to Alfisols which can not be for under the dominant Iraqi conditions mainly climatic and geological factors. The need for semi detail work covering the whole of Iraq is very important in order to verify the works which have been done before and to create new soil maps at different scales.

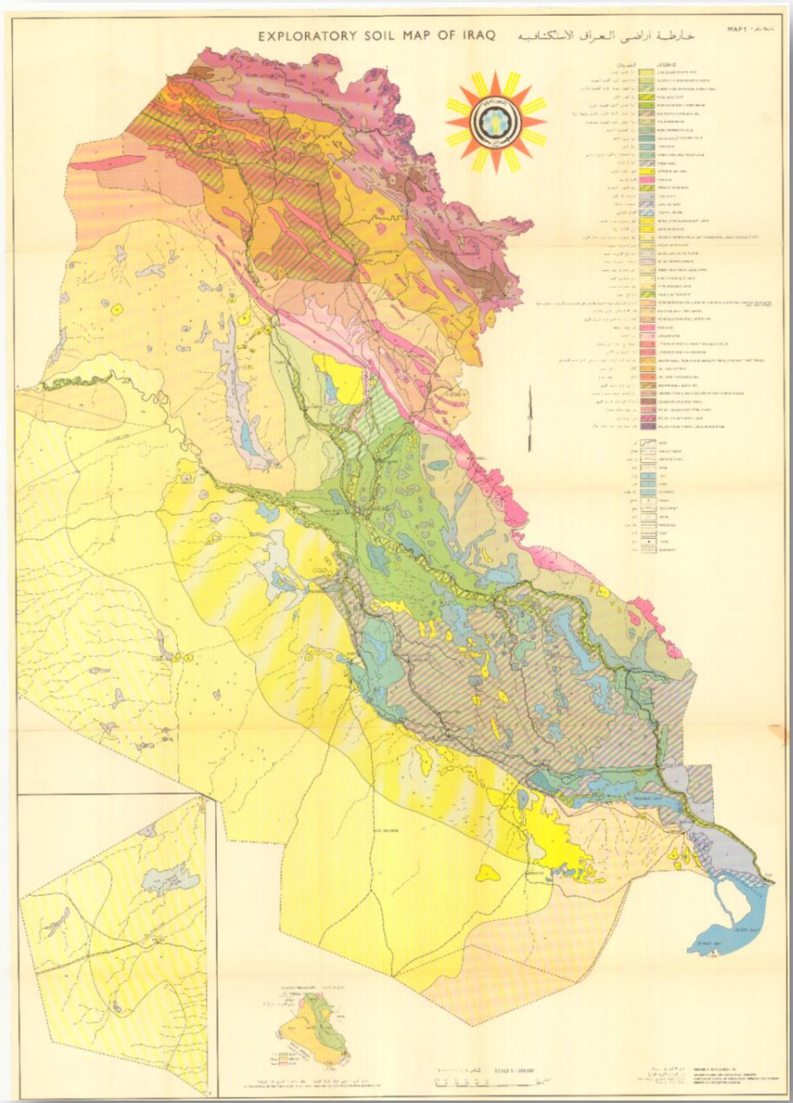

Figure 2. Soil great groups in Iraq (Buringh ,1960).

Altaie (1968) conducted a study of the regional soil surveys, selecting and describing 60 representative soil profiles from all physiographic regions of Iraq. These 60 pedons were classified to three soil orders (Altaie, 1968 and Altaie et al., 1969) as defined by U.S. Soil Taxonomy (Soil Survey Staff, 1960) as follows: Aridisols, Entisols, and Vertisols. Since then, soils classifying as Mollisols and Inceptisols (Soil Survey Staff, 1999) have also been found in Iraq (Hussain and Shali, 1979; Al-Agidi, 1986; Muhaimeed, 1991, 1994; Muhaimeed et al., 2000; Muhaimeed and Mohammed, 2001). Other data are also available for over 200 pedons. Database entry, georeferences and classification of all these pedons are being prepared and will be presented in a publication to be developed .The following description for the five soil order which have be recognized in Iraq.

1-Aridisols:

The concept of Aridisols is based on limited soil moisture available for the growth of most plants. In areas bordering deserts, the absolute precipitation may be sufficient for the growth of some plants. Because of runoff or a very low storage capacity of the soils, or both, however, the actual soil moisture regime is aridic. Because of an extreme imbalance between evapotranspiration and precipitation, many Aridisols contain salts.. The accumulation of salts is the second most important constraint to land use. Many soluble precipitates may be eliminated or changed in concentration through irrigation. In Iraq, Aridisols occur in the dry regions. Some of these soils are found in the Western Desert, some of which are recognized over limestone and on the middle and high gypsiferous Tigris and Euphrates terraces. Some soil suborders pertinent to Iraq are the Calcids (calcic or petrocalcic horizon is normally within 50 cm of the soil surface), Gypsids (gypsic or petrogypsic horizon within 100 cm of the soil surface without an overlying petrocalcic horizon), Salids (accumulations of salts more soluble than gypsum); Argids (argillic or natric horizon with no gypsic, petrogypsic, petrocalcic, or salic horizon within 100 cm of soil surface); and Cambids (cambic horizon within 100 cm of soil surface and no other diagnostic horizon, i.e., petrocalcic, gypsic, calcic, unless upper boundary of such horizon is 100 cm or more below soil surface) (Soil Survey Staff, 1999). Some dominant subgroups found in Iraq are Typic, Aquic, and Lithic Haplocalcids; Typic, Lithic, and Leptic Haplogypsids; Typic, Calcic and Gypsic Aquisalids; Calcic Haplosalids; Typic Calciargids; and Typic Gypsiargids. Refer to Soil Survey Staff (1999) for detailed description and criteria for these soils and diagnostic Horizons.

2-Enitisols:

Entisols are soils with little or no evidence of the development of pedogenic horizons. Most Entisols have no diagnostic horizons other than an ochric epipedon. A few that have a sandy or sandy-skeletal particle-size class have a horizon that would be a cambic horizon were it not for the particle-size class exclusion. Very few Entisols have an albic horizon. Entisols may have any mineral parent material, vegetation, age, or moisture regime and any temperature regime, but they do not have permafrost. The only features common to all soils of the order are the virtual absence of diagnostic horizons and the mineral nature of the soils."The following great groups were recognized in Iraq:

-Psammaquents , Xerarents ,Xerofluvents, Fluvaquents , Torriarent , Torrifluvents ,Torripsamments , Xeropsamments , Torriorthents and Xerorthents

3-Inceptisols:

Inceptisols include a wide variety of soils. In some areas these soils have minimal development, whereas in other areas these soils have diagnostic horizons that merely fail the criteria of other soil orders. They have many kinds of diagnostic horizons and epipedons. They can have an anthropic, histic, mollic, ochric, plaggen, or umbric epipedons. The most common horizon sequence is ochric epipedon over a cambic horizon with or without an underlying fragipan. Three great groups were found in Iraq : Haploaquepts , Calcixerepts and Haploxerepts.

4-Vertisols:

Vertisols are clayey soils that have deep, wide cracks for some time during the year and have slickensides within 100 cm of the mineral soil surface. These soils have long been well known for their characteristic color ,cracks they produce during the dry season, and the difficulty of their engineering properties. Vertisols occur in many areas in Iraq but are mostly located in low-lying depressions of central and northern areas, the intermountain alluvial valleys and terraces in the North and in the Mosul-Erbil-Kirkuk plains. Typically, these soils are deep and clayey, with shrink-swell processes resulting in cracking during the dry season. Vertisols in Iraq are associated with Mollisols in semiarid regions and with Aridisols in arid regions. Some suborders pertinent to Iraq are the Torrerts and Xererts, the former of arid climates and the latter of Mediterranean climate, typified by cool wet winters and warm dry summers. and rice, provided excessive soluble salts are not present (Altaie, 1968). Vertisols have unique morphologies, with horizonation often so weakly expressed that the profile appears to be the same throughout because of self-mixing, resulting from the shrinking and swelling of the clay with drying and wetting. Textural differences in the profile may be minimal, with horizon differentiation primarily based upon color and structure. Vertisols in Iraq are associated with Mollisols in semiarid regions and with Aridisols in arid regions. Some suborders pertinent to Iraq are the Calcitorrerts, Gypsitorrerts, Calcixerrerts and Haploxererts, the former of arid climates and the latter of Mediterranean climate, typified by cool wet winters and warm dry summers. Refer to Soil Survey Staff (1999) for detailed description and criteria for these soils.

5-Mollisols:

Mollisols commonly are very dark-colored, base-rich mineral soils of the steppes. Nearly all of these have a mollic epipedon, and many have an argillic, kandic, or natric horizon. Many of these soils developed under grass and many apparently were forested. Mollisols occur in the northeastern mountain area particularly on the footslope plain of intermountain valleys. Poorly drained Mollisols seem be present in the marshy area in southern Iraq . In Iraq, some suborders of Mollisols are the Xerolls and Aquolls, and some subgroups include Typic Calcixerolls and Pachic Argixerolls.

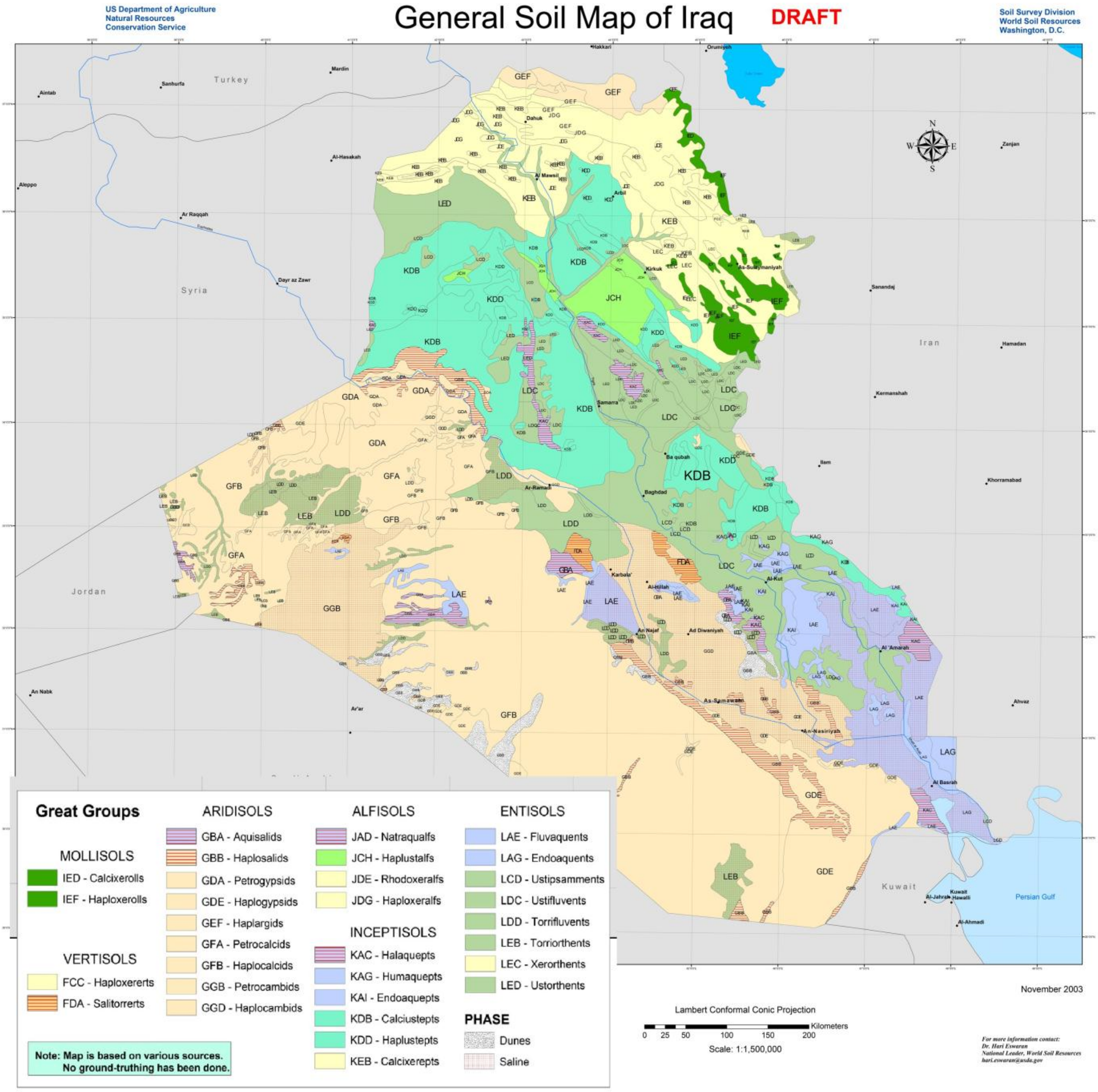

Figure 3. General Soil map of Iraq

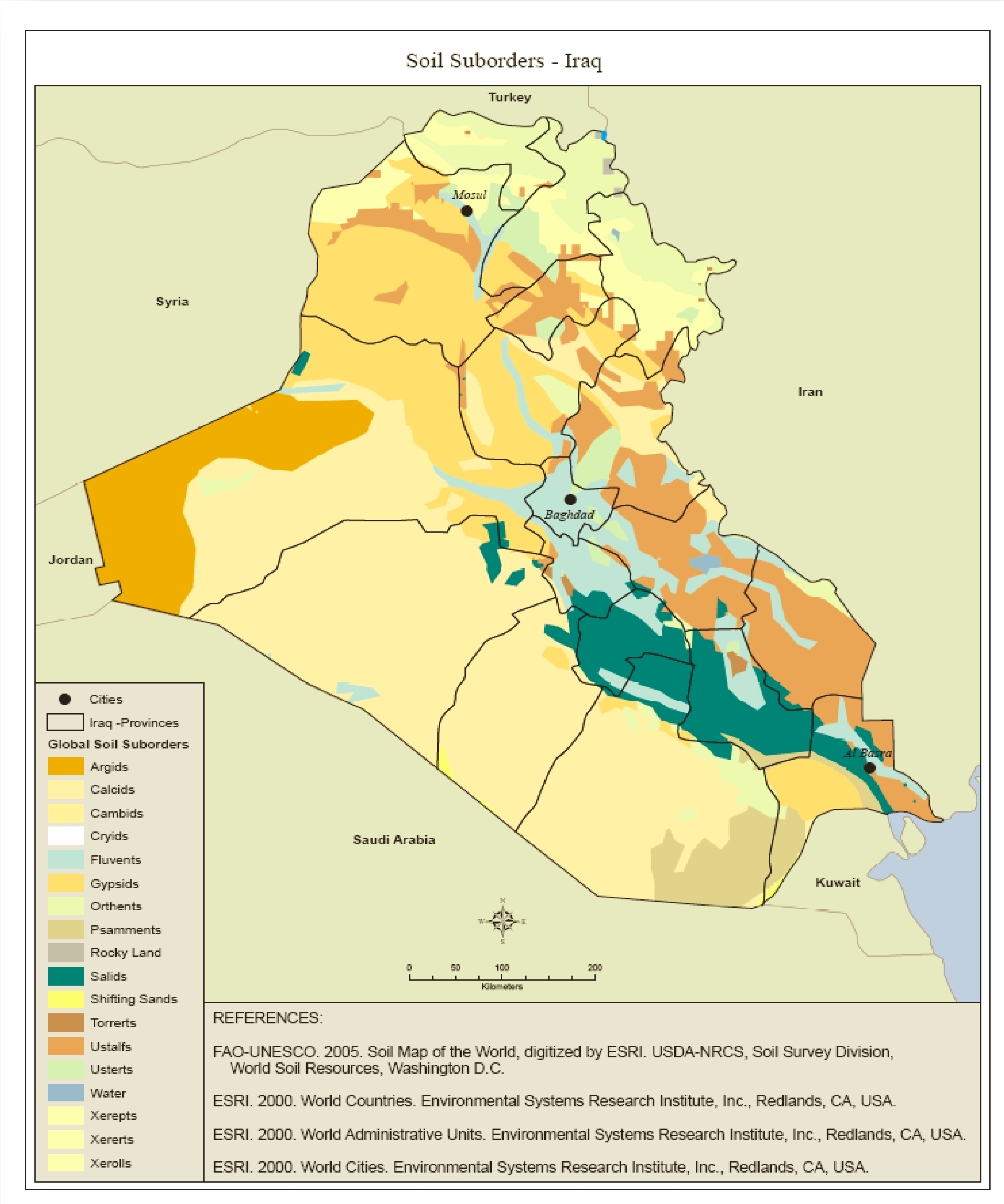

Figure 4. Soil suborders in Iraq (USDA-NRCS,2005)

Soil Degradation in Iraq:

Six processes of soil degradation are usually recognized. These are water erosion, wind erosion, excess of salts, chemical degradation, physical degradation and biological degradation. Water erosion consists of splash, sheet and gully erosion, as well as mass movements such as landslides dominated in Mountain region. Wind erosion is the removal and deposition of soil by wind active in the Desert region. Excess of salts consists of processes of the accumulation of salt in the soil solution (salinisation) and of the increase of exchangeable cations on the cation exchange of soil colloids. Chemical degradation comprises a variety of processes related to leaching of bases and essential nutrients and the build-up of toxic elements. Physical degradation consists of a negative change in properties such as porosity, permeability, bulk density and structural stability. A decrease in infiltration capacity and plant-water deficiency are common effects. Biological degradation is the increase in rate of mineralization of humus without replenishment of organic matter. These six processes interact in such manner that soil degradation will affect plant productivity in a number of ways simultaneously (Stocking, 1995). According to Oldeman et al. (in: Ghassemi et al., 1995) human induced soil degradation processes can be grouped in two categories. The first concerns soil degradation by displacement of soil material, due to water and wind erosion. Water erosion comprises of loss of topsoil and terrain deformation. Common phenomena are the formation of rills, gullies and badlands. Wind erosion includes loss of topsoil, terrain deformation and over blowing. The second category considers physical and chemical soil deterioration. Physical deterioration includes compaction and crust forming, water logging and subsidence of organic soils. Chemical deterioration comprises of loss of nutrients and/or organic matter.

More than 40 % of Iraqi land area is desert, and an increasing part of the permanent pasture areas is subject to erosion because of reduced vegetation cover. Additionally, much of the crop land is losing its inherent productivity due to poor agricultural practices and over exploitation. The direct loss of agricultural land is most acute around urban centers, where established agricultural land is being lost to alternative uses, including urbanization.

Salinity is one of the most serious degradation processes in the central and southern Iraq lands .More than 70 % of the irrigated agriculture lands in the central and southern Iraq have been abandoned in the recent years and causing yield declined between 30 to 60 % as a result, mainly ,of salt accumulation by salinization process. The level of soluble salt is to high which interferes with the growth of most crop plants due to the increase in soil osmotic pressure. This leads to convert most of the highly productive land to very saline type dominated by tolerant natural vegetation like Tamarix , Shoch and Agoul. Salinization process lead to the formation of different types of salt affected soils according to the dominant type of salts. All salt affected soils have an Ece ranging from less than 4 ds/m to more than 200 ds/m mainly in the soils of southern Iraq

Future Prospects and Integration Studies:

At this point in time, the number and type of soil units in Iraq are incomplete due to the lack of semi-detailed or detailed surveys covering all of Iraq. Non-systematic work of soil survey has been the dominant type of work to date. Only 35% of Iraq is considered covered by a semi-detail survey (Zager et al., 1988), and as such there is a great need for more detailed work. Soil survey is considered the first step in any development project and the basis of land evaluation (present and potential agricultural value of the land).There are different types of soil data are available including: soil maps, salinity maps, land use, Geological, Metrological Land cover and topographic maps. The problems are most of the available data are in a hard –copy maps and tables, and there is no soil data base development.

The main interest in Iraq has been to suggest a system that is able to predict the suitability for irrigation and for agricultural main crops on these irrigated lands. The MoWR have planned to cover about 50000 ha /year by semi detail work and starts to build soil data base through digitizing the available soil maps . One suggested work started about two years ago by some experts in soil survey in Iraq to develop general soil map for the country of Iraq with 1:000 000 scaled soil map as a first step for developing semi detail map with 1:50000 scale. More than 200 sites covering most of Iraq area were selected and general soil data were collected for more than 200 pedons represent the dominant soil types exist in Iraq and they are in GIS format (Figure 5). The soils were classified using both US and WRB systems. This work planned to be done with in the next few months .The collected data are available to be used by the GPS work as have been explained in the workshop in Amman ,Jordan.

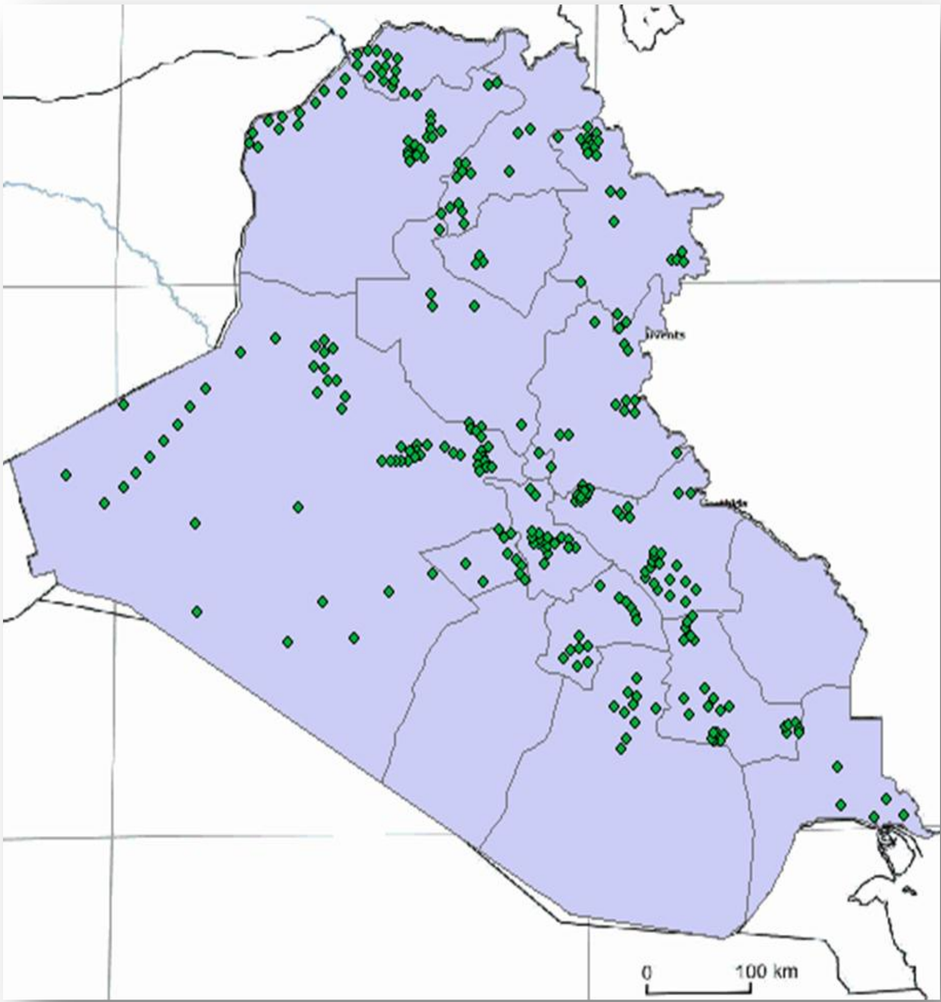

Figure 5. Location of the selected pedons in Iraq.

CONCLUSIONS :

1-The dominant climate in Iraq is dry conditions in southern and center regions ,while it is semi arid to sub humid in the northern region.

2-Iraqi soils show different degrees of development according to the dominant local conditions mainly climatic and geological conditions.

3-There is no detail soil survey work done yet covering the whole Iraqi area , but there is a semi detail work covering more than 35% of Iraqi land.

4-US systems are used to classify the soils in Iraq .

5-According to soil survey works done ,The dominant soil in Iraq are : Aridisols , Entisols , Inceptisols , Mollisols and Vertisoils ,with 26 great groups.

6-Six soil degradation processes were recognized. These are water erosion, wind erosion, excess of salts, chemical degradation, physical degradation and biological degradation.

6-The need for semi detail soil survey covering the total area of Iraq with soil map with 1:50 000 to 1:25 000 scales.

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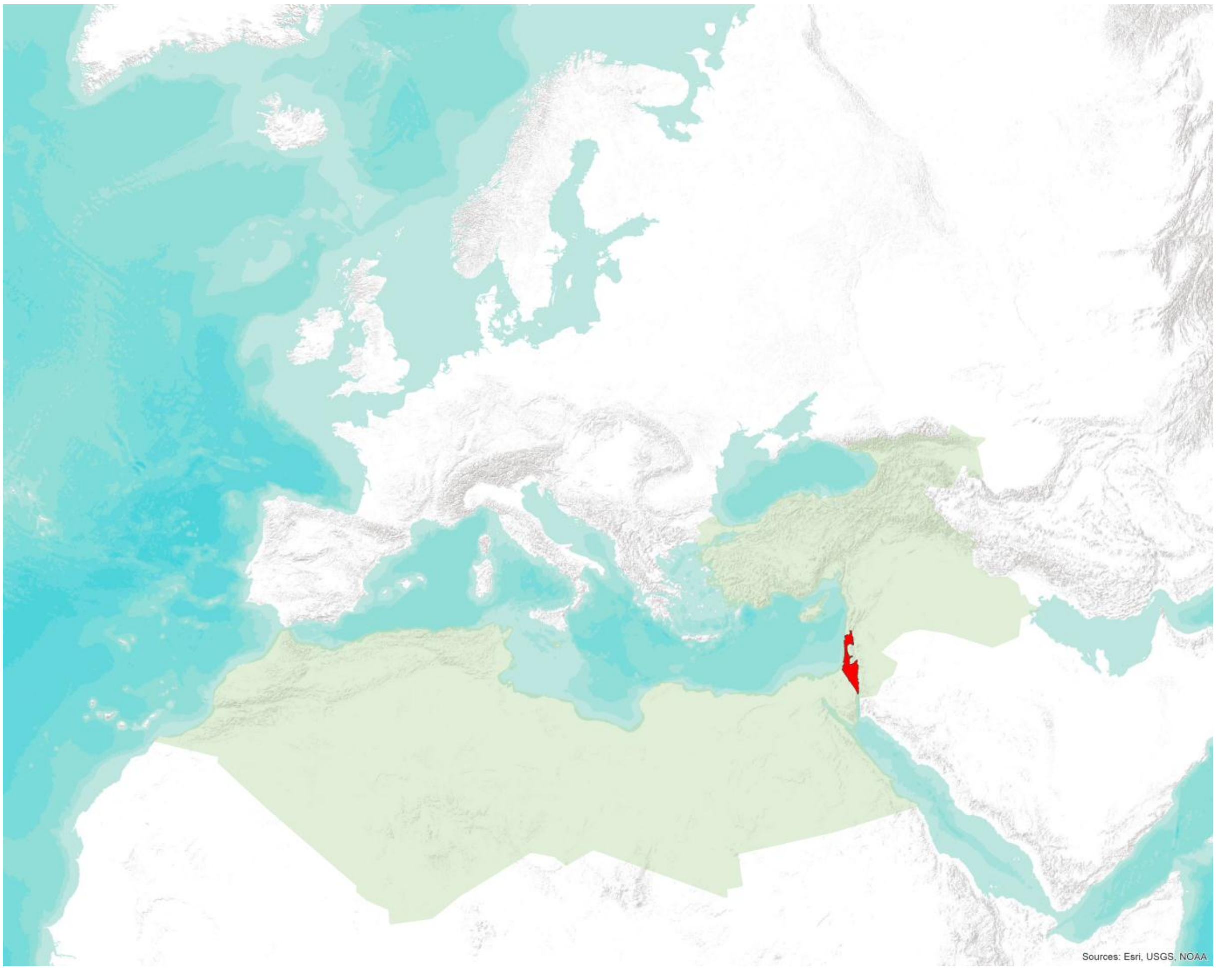
Chapter VII.
Soil Resources of Israel



Soil Resources of Israel

Onn Crouvi[1], Ram Zaidenberg[2], Michael Shapiro[2]

Abstract
Due to Israel's unique geographic location, at the transition zone between the Mediterranean region and the great deserts of Arabia and the Sahara, it holds various climatic regions, from hyperarid desert, to arid, semi-arid and Mediterranean climate regions. Together with complex geologic history, variable lithology and topography, and high rate of dust accumulation into all soils, the soils of Israel are diverse and vary on small scales. The main soil classification used in Israel is based on 23 soil associations; paper and digital maps are available at regional and local scales, and soil profile DB exists for the southern part of the country. Main soil threats in Israel are soil erosion by water, salinization, and soil sealing. Integration of the Israeli soil data into the European soil DB will be based on the 1:500,000 digital soil map of Israel. For the integration process the soil map will be updated according to recent changes in soil characteristics. In addition, Israeli soil classification will be translated into the WRB and FAO classifications, and the areal coverage of each soil typological unit in every soil mapping unit will be estimated. For the soil profile DB we will use the existing DB of southern Israel, and build a new DB for the central and northern parts of the country.

Keywords: Israel, Mediterranean, Negev Desert, Soil erosion, Soil association

Introduction
The total area of Israel is approximately 22,000 km^2 (excluding the west bank and Gaza) of which 21,643 km^2 are land areas. Israel is located at the transition zone between the Mediterranean region and the great deserts of Arabia and the Sahara. It may be divided into three main geographic units, each unit running north to south (Figure 1a): the coastal region in the west, having undulating to hilly topography; the mountain region in the center, and the easternmost Arava, Dead-Sea and Jordan valleys. There are numerous dissecting valleys and several plateaus, especially in the SE part of the coastal region, and in the NE part of the mountain region. The above geographic divisions coincide to a large extent with the geologic structure and lithologic units of Israel (Figure 1b): the coastal region is characterized mainly by Quaternary lacustrine, fluvial and eolian sediments; the mountain region is composed of series of anticlines and synclines that are characterized mostly by marine Cretaceous sedimentary rocks, such as limestone, dolomite, chalk, and chert; the Jordan, Dead-Sea and Arava valleys are part of the Dead-Sea Transform, and are characterized mostly by Quaternary lacustrine, fluvial and eolian sediments. In the far south, Pre-Cambrian magmatic and metamorphic rocks, as well as sandstones are exposed. In northern Israel, Quaternary basalt flows characterized the plateaus.

Israel can be separated into three main climatic zones that extend for the most part east-west: a humid and sub-humid Mediterranean climatic region in the northern part of the country (mean annual rainfall > 500 mm); semi-arid (300-500 mm yr^{-1}) and arid (80-300 mm yr^{-1}) zones in the central part; and extremely arid zone (<80 mm yr^{-1}) in the far south region of the country (Figure 1c). About half of the land area of Israel are deserts (The Negev and Judean Deserts), with less than 200 mm yr$^{-1.}$ Rainfall in Israel occurs mostly during the winter, with some rainfall events in spring and fall. Summer is warm and dry.

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The land and natural resources in Israel can be divided to three main groups (Michael Beyth, GSI, Personal communication, 2012): 1) Raw materials for fertilizers and metallurgy – potash, phosphate, magnesium, brome, and copper; 2) Hydrocarbons - offshore gas and inland oil shale; and 3) Raw materials for constructions – building aggregates, limestone, gypsum and clay for cement industry, ornamental limestone, tuff for construction and agriculture, sandstone for construction material. About 5% of the total land area of Israel is composed of built areas, including residential, industrial and commercial areas (but excluding military areas). Open spaces occupy the rest of the country, and can be divided as following (percentage out of total land area): Mediterranean natural vegetation – 15%, desert natural vegetation – 56%, forests - 4%, and agriculture – 20% (Bar-Or and Matzner, 2010).

The distribution of soils in Israel is determined mostly by the recent geological history, lithology and topography, steep climatic gradients and active human activity over the past 100 years. The most characteristic landscape attributes are high proportion of mountains with steep slopes, significant additions of proximal and distal dust to all soils of Israel, and a large proportion of limestone and other calcareous rocks as soil parent material (Yaalon Dan, 1997). Soils developed on solid parent materials include: soils developed on basalts and tuffs are located in the Golan Heights and in the Galilee; soils developed on various carbonate rocks - in the Galilee, the Samarian and the Judean Hills, and in the Negev; soils developed on granites - in the southern part of Israel. Other soils are formed on loose material: sandy soils are common in parts of the Negev and the Coastal Plain; loessial soils – mostly in the northern Negev; clay soils in the central and northern parts of the Coastal Plain, and in depressions in northern Israel (e.g., in the Jezreel Valley). Soils developed on red colored sandy deposits are abundant in the Coastal Plain; high calcareous silt soils – in the Jordan Valley and in the vicinity of the Dead Sea; soils developed on gravel and pebble deposits – in the Arava Valley. Most soils located in the deserts are saline.

Characteristic soil behavior features are moderate weathering with leaching of mostly 2:1 clays into B horizons (Luvisols), hematite-induced reddening of the clays due to summer dehydration of free iron oxyhydroxides, carbonate dissolution and accumulation in calcic horizons (Calcisols) in semi-arid regions, and development of Vertisols, mostly in lowlands, where deep layers of swelling/cracking clays have deposited. Shallow soils on nearly bare slopes, due to erosion, are frequent (Leptosols, Cambisols) (Yaalon Dan, 1997).

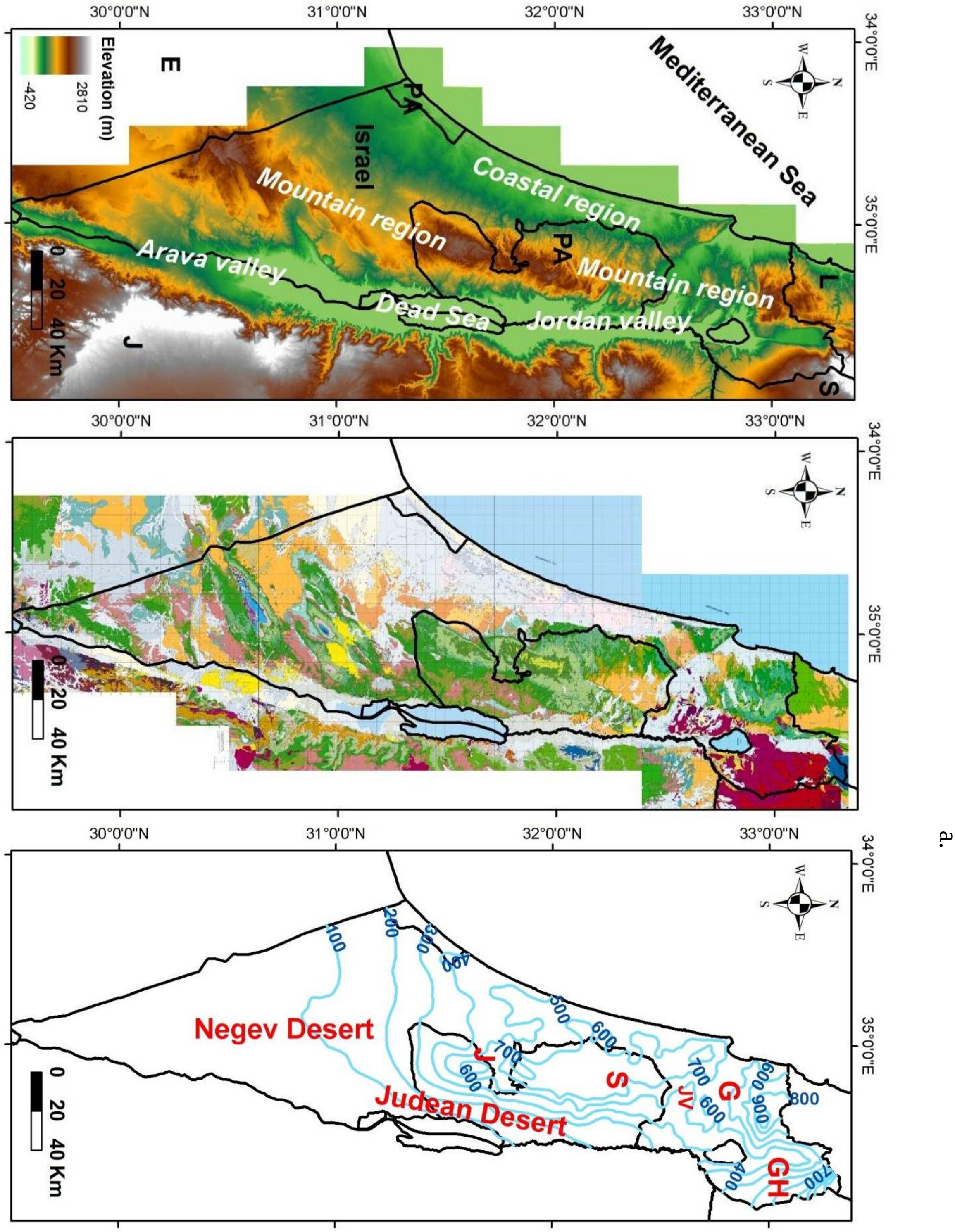

Figure 1. Location of Israel and surroundings. a) Topographic map of Israel (Hall, 1993), with the main geographic divisions of Israel. E – Egypt, J – Jordan – Syria, L – Lebanon, PA – Palestine Authority. b) Geological map of Israel (Sneh et al., 1998a, b; Sneh et al., 1998c, d).Quaternary units appear in grey color and are abundant in the coastal region, in the Arava, Dead-Sea and Jordan valleys and in other smaller valleys; Green and orange colors are Cretaceous and Eocene sedimentary rocks, mainly carbonates. Basalts appear in red color. c) Average annual rainfall for Israel (Israel Meteorological Service, 1990), with minor geographic divisions. J – Judean hills, S- Samarian hills, JV – Jezreel Valley, G – Galilee, GH – Golan Heights.

Country soil information and data

Legacy Soil Information

The soils of Israel are mapped in different scales, depending on the purpose of the mapping effort. Maps in scales of 1:1,000,000, 1:500,000 and 1:250,000, cover the entire country, and provide a regional framework of soil geography (Ravikovitch, 1969; Dan and Raz, 1970; Ravikovitch, 1970; Dan et al., 1972; Dan et al., 1976). These maps are based on data from more detailed maps. Soil maps in scale of 1:50,000 exist for the entire area of Israel, and were produced mostly during the 1970's. These maps are being used for regional planning, land use and development. Soil maps in 1:20,000 available for central and northern Israel (without the Negev Desert and the Palestine Authority area), and were producced during the 1950's, as an early effort in estimating suitable areas for agriculture development. Soil maps in 1:10,000 are available for the northern Negev and the southern part of the coastal plain, as these areas are under intensive agriculture usage for many years. Over 400 very detailed soil maps in scales of 1:2,500 to 1:5,000 are available for specific locations. These maps are used to provide the land owner or farmer with soil map for detailed agricultural planning.

In the course of many years of soil mapping, applied agricultural soil surveys, and pedologic research, numerous soil profiles have been studied across Israel. Detailed soil descriptions, together with laboratory analyses results (i.e., grain size, carbonate content, cations and anions concentrations, clay minerals), are available in books (Dan et al., 2007; Singer, 2007), Ministry of Agriculture and Rural Development (MARD) internal publications (e.g., Dan et al., 1981; Koyumdjisky et al., 1988), reports (e.g., Gerson et al., 1985), journal articles (e.g., Dan and Yaalon, 1982; Amit and Gerson, 1986), and theses (e.g., Eisenberg, 1980).

Digital Soil Resources

The soil maps of Dan and colleagues, in scales of 1:500,000 and 1:250,000 (Dan and Raz, 1970; Dan et al., 1976) are available in digital format (digital format defined here as vector data layer in ArcMap format). In addition, all the 1:50,000 and 1:20,000 soil maps were recently digitized and stored as digital maps at the Department of Soil Conservation and Drainage (DSCD), the MARD.

A digital soil profile database is available for the arid and semi-arid regions of Israel, and it is stored at the Geological Survey of Israel (GSI). It is composed of data of over 300 soil profiles gathered from published reports, papers, theses, and field surveys (Crouvi et al., 2004) (Figure 2) and stored in Access format. The soil DB consists of two linked tables: a) main table with information on the location of the soil profile (e.g., coordinate, climate, topography), and b) horizons table, with information for each soil horizon (e.g., color, grain size, EC, mineralogy). The DB was used in the past to model grain size distribution across the Negev Desert (Crouvi et al., 2007).

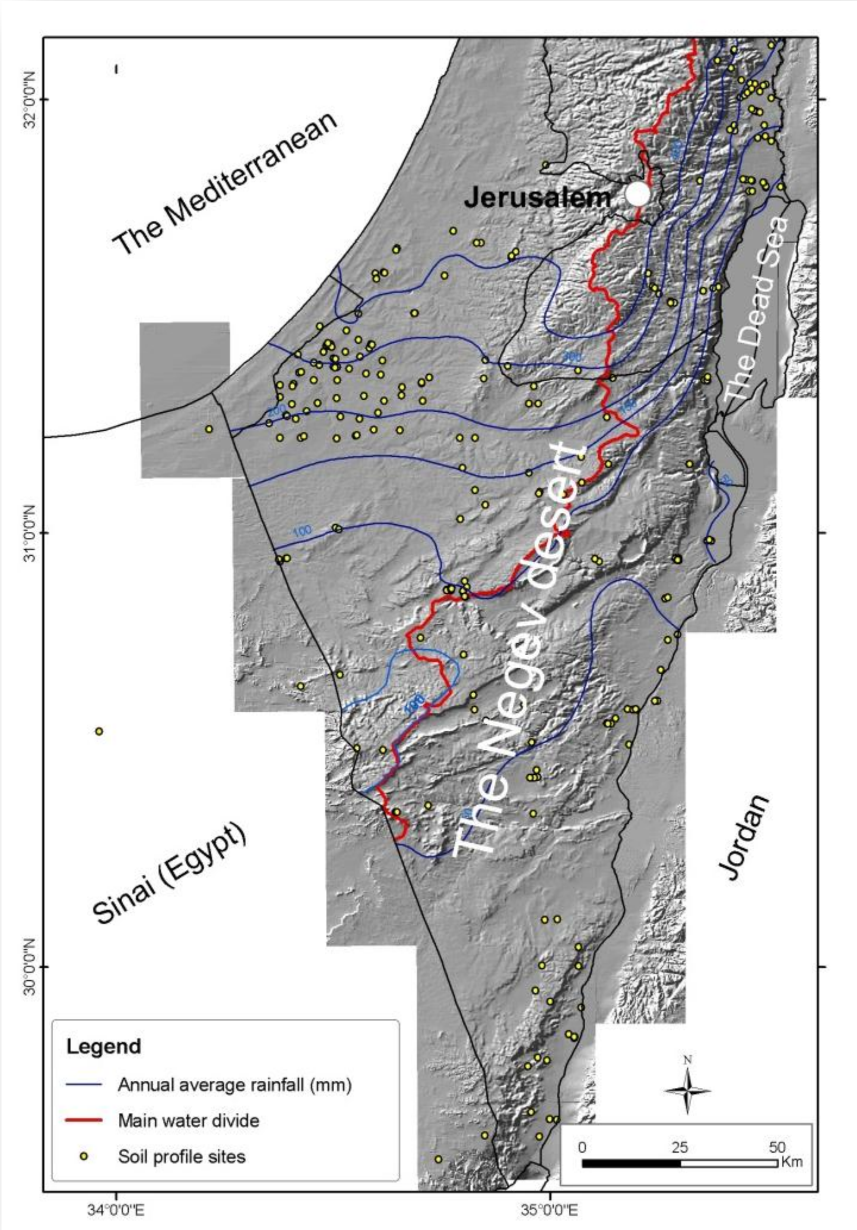

Figure 2. Location of >300 soil profiles that comprise the Israeli arid soil profile DB (Crouvi et al., 2004).

Soil Classification

Early mappers of Israeli soils already realized the difficulty in adequately separating the various soil mapping units (Singer, 2007). Because of the complexity of landscapes associated with rapid lateral changes in lithology, the soils frequently present intricately interwoven mosaics. The numerous classification systems proposed in the past for the soils of Israel were mostly determined by the dependency of the soils formed on climate and lithology (Singer, 2007). One of the first maps of soils in Israel was published by Strahorn (1928) who used soil series for his classification, based on geomorphological and geological units. About 20 years later, Reifenberg (1947) published a schematic soil map based on the soil chemical characteristics, lithology and climate. A decade later, a more comprehensive classification system was published by Zohary (1955) using a phytogeographic approach.

Modern soil classifications of Israeli soils were published during the 1960's and 1970's, adopting two different approaches (Singer, 2007): 1) The first approach, led by Ravikovitch from the Hebrew University, classified the soils according to 24 **soil types**, which led to the establishment of general soil maps at scales of 1:250,000 and 1:500,000 (Ravikovitch, 1969, 1970) (Figure 3). The differentiation of the 24 soil types recognized is based on soil forming factors, mainly climate, physiography and parent material. The types are grouped into six soil groups, which constitute the highest classification level, according to similar soil forming factors. 2) The second approach, led by Dan and Koyumdjisky from the Volcani Institute of Agricultural Research, suggested an amended soil classification system of **great soil groups** (Dan and Koyumdjisky, 1959, 1963) (Figure 4). The highest category is the soil order, distinguished according to the main soil forming factor of predominant influence. Four soil orders were classified: climatogenic, lithogenic, fluviogenic (and eolian) and hydrogenic soils. Faced with the complexity of landscapes, Dan and collaborators introduces the "soil association" as the basic mapping unit for large-scale soil maps. Soil associations are defined as geographic associations of soil units which are distributed in a landscape segment according to a definite pattern related to the physiographic, lithological, and microclimatic conditions (Dan et al., 1972). The 34 soil units that comprise the various soil associations are nearly all at the great soil group or subgroup level of the classification. The concept of soil associations is based on the recurrent pattern of soil distribution in many areas of Israel. These soil distribution patterns are created by specific combinations of various landscape elements, such as lithology and physiography. The 23 soil associations (Table 1) are divided into 2 major groups: those of subdued mountains and high plateaus, and those of the low plateaus and plains, which include all the major agricultural areas. The relatively large number of soil associations is due to the great variation in environmental conditions over a small area. The names of the great soil groups are, to a large extent, the internationally accepted ones and have been adopted on the basis of comparisons between the morphological characteristics and pedogenic conditions of Israeli soils and those of the appropriate level soil groups in the U.S. and Europe (Table 1). A subgroup category is also added to allow for intergrade soils between the great groups.

Due to various historical reasons, the soil classification of Ravikovitch was abandoned and current soil mapping follow the soil classification made by Dan and Koyumdjisky.

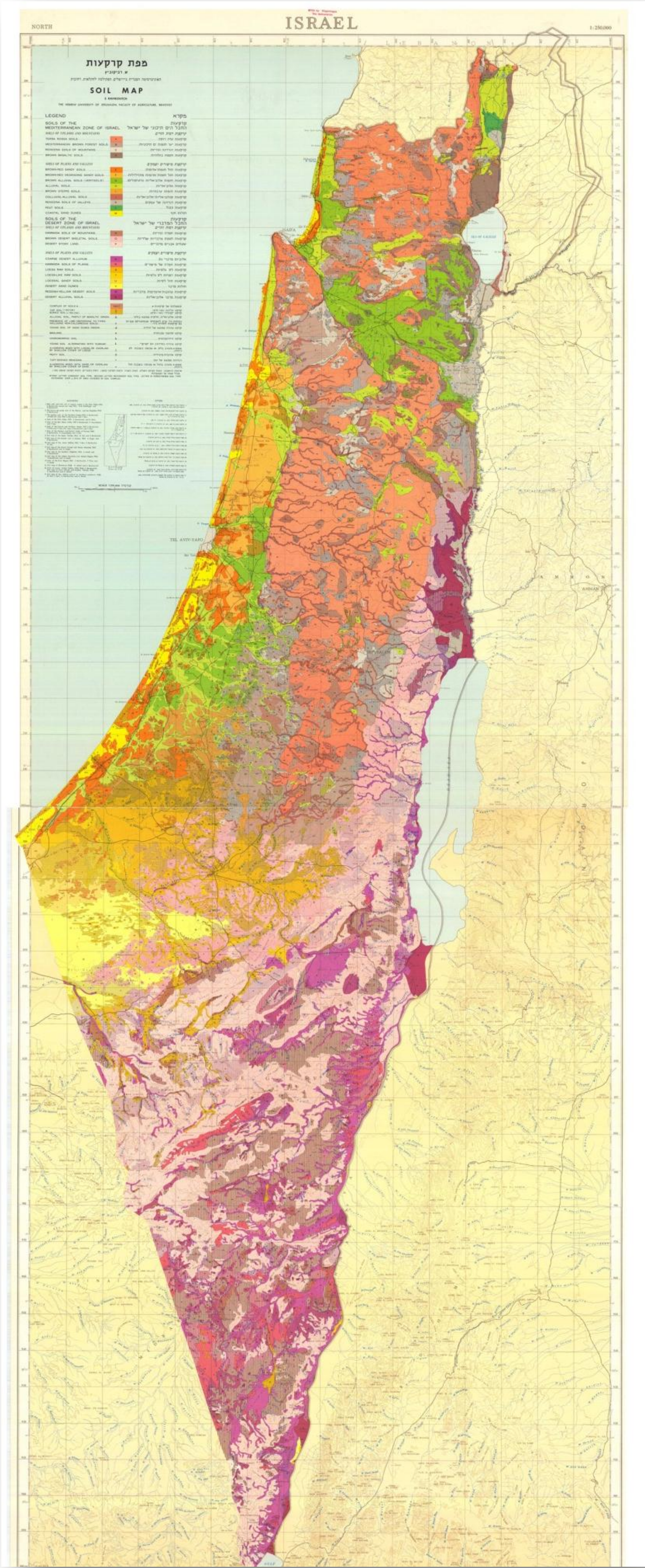

Figure 3. Soil map of Israel, in 1:250,000 scale (Ravikovitch, 1969)
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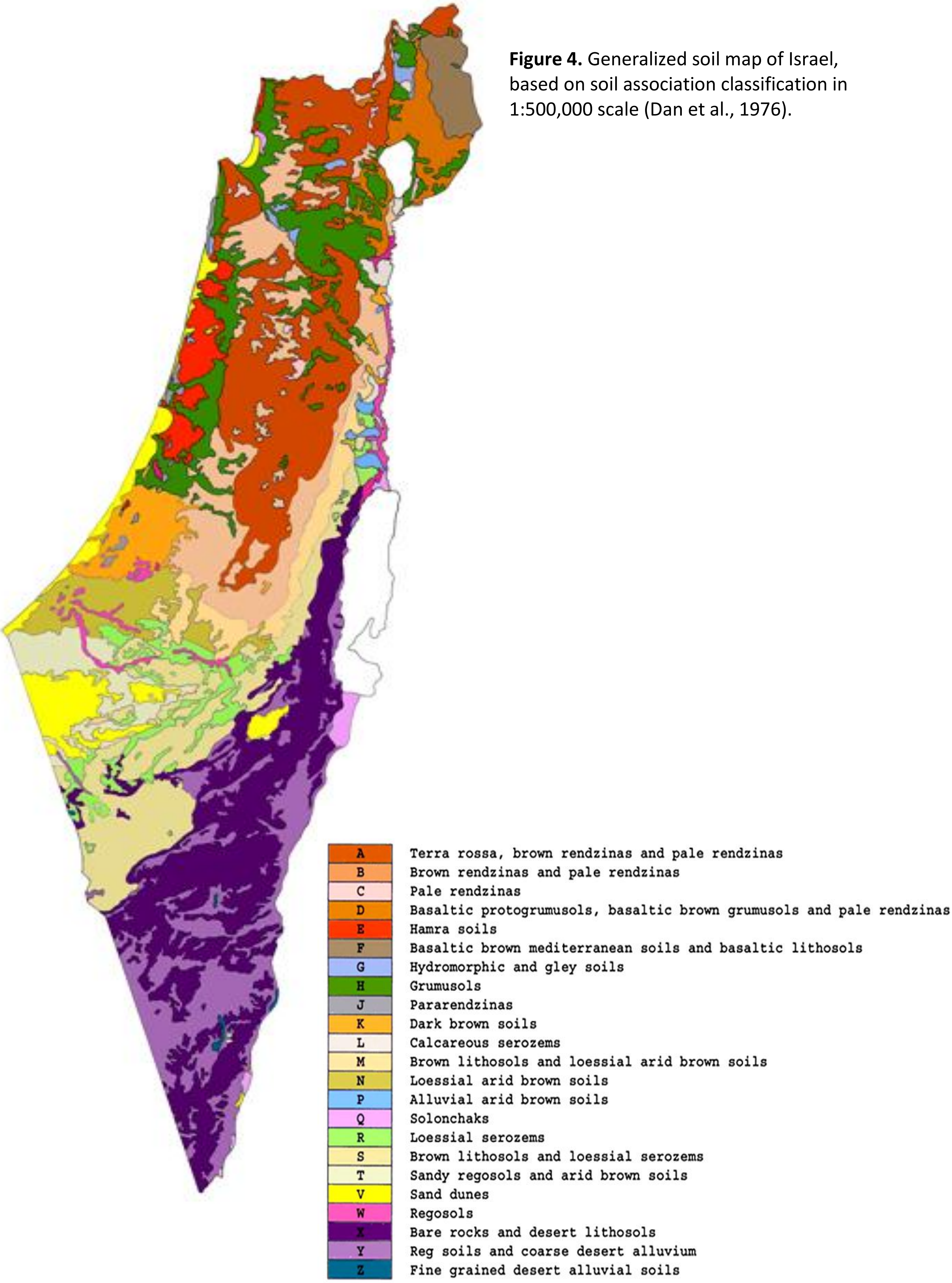

Figure 4. Generalized soil map of Israel, based on soil association classification in 1:500,000 scale (Dan et al., 1976).

Table 1. Soil association classification of Israeli soils (Dan and Koyumdjisky, 1979), and correlation of these soils with European and American soils (Dan and Yaari-Cohen, 1970; Dan et al., 1976).

Map code	Soil association	FAO equivalent	USDA equivalent	Area out of total terrestrial area (%) *
A	Terrra Rossas, Brown Rendzinas and Pale Rendzinas	Luvisols, Cambisols, Lithosols, Rendzinas	Xerochrepts, Haploxerolls, Argixerolls, Rhodoxeralfs, Xerorthents	14
B	Brown Rendzinas and Pale Rendzinas	Rendzinas, Lithosols,	Haploxerolls, Xerorthents	11
C	Pale Rendzinas	Lithosols, Rendzinas	Xerorthents, Haploxerolls	1
D	Basaltic Protogrumusols, Basaltic Brown Protogrumusols and Pale Rendzinas	Lithosols, Rendzinas, Cambisols, Phaeozems, Vertisols	Xerorthents, Haploxerolls, Xerochrepts, Xererts	2
E	Hamra soils	Luvisols	Rhodoxeralfs	3
F	Basaltic Brown Mediterranean soils and Basaltic Lithosols	Luvisols, Lithosols, Vertisols	Haploxeralfs, Haploxerolls, Rhodoxeralfs, Xerorthents, Xererts	1
G	*Hydromorphic and Gley soils*	*Gleysols, Histosols*	*Hapalquents, Hapalquepts, Saprists*	*Grouped with unit H*
H	Grumusols	Vertisols	Xererts	9
J	*Pararendzinas*	*Rendzinas, cambisols, Lithosols*	*Haploxerolls, Xerochrepts, Xerorthents Xeropsamments*	*Grouped with unit E*
K	Dark Brown soils	Luvisols, Cambisols, Vertisols	Haploxeralfs, Xerochrepts, Chromoxererts, Rhodoxeralfs	4
L	Calcareous Serozems	Cambisols, Xerosols, Yermosols, Gleysols, Lithosols	Xerochrepts, Calciorthids, Gypsiorthids, Haplaquepts, Torriorthents, Haploxerolls	1
M	Brown Lithosols and Loessial Arid Brown soils	Lithosols, Fluvisols, Xerosols	Torriorthents, Haploxerolls, Torrifluvents, Xerofluvents, Haploxeralfs, Xerochrepts	2
N	Loessial and Arid Brown soils	Xerosols, Fluvisols,	Haploxeralfs, Xerochrepts, Torrifluvents,	4

			Xerofluvents, Palexeralfs	
P	*Alluvial Arid Brown soils*	*Xerosols*	*Palexeralfs Haploxeralfs, Xerochrepts, Haplargids, Camborthids*	*Grouped with unit N*
Q	*Solonchaks*	*Solonchaks*	*Salorthids*	*Grouped with unit Z*
R	Loessial Serozems	Yermosols, Fluvisols	Haplargids, Calciorthids, Paleargids, Torrifluvents	3
S	Brown Lithosols and Loessial Serozems	Lithosols, Yermosols	Torriorthents, Haploxerolls, Haplargids, Calciorthids, Paleargids	11
T	Sandy Regosols and Arid Brown soils	Arenosols, Xerosols	Quartzipsamments, Torripsamments	4
V	Sand dunes	Arenosols	Quartzipsamments, Torripsamments, Haploxeralfs	5
W	Regosols	Regosols, Lithosols	Xerorthents, Torriorthents, Haploxerolls	1
X	Bare Rocks and Desert Lithosols	Lithosols, Fluvisols, Solonchaks	Torriorthents, Torrifluvents, Torripsamments, Gypsiothids	16
Y	Reg soils and coarse Desert Alluvium	Fluvisols, Solonchaks	Torrifluvents, Torripsamments, Gypsiothids	9
Z	Fine-grained Desert Alluvial soils	Fluvisols	Torrifluvents	1

*Calculation of areal distribution for each soil association is based on a digital version of the soil association map in scale 1:500,000 (Dan et al., 1976) (Figure 4). During the course of the preparation of the digital map, several soil association groups were combined with other, more widespread soil groups, and thus their areal distribution cannot be measured.

Soil Surveys

Soil surveys are conducted by the DSCD on a local scale (1:2,500 to 1:5,000) based on requests. Demand for soil surveys mostly comes from agricultural needs, such as soil surveys for specific agricultural use. Each soil survey includes describing and sampling of representing soil profiles (10-40 soil pits per survey), analyzing soil samples for texture, pH, EC, SAR, and carbonate content, delineating mapping units according to the soil classification used in Israel (Dan et al., 1964; Dan and Koyumdjisky, 1979), and representing these mapping units into 3-5 mapping units of relative fitness of the area to the specific agricultural demand. These soil surveys are conducted routinely across Israel.

Soil Monitoring

There is no regular monitoring of soil properties in Israel. The DSCD revisit locations where detailed soil surveys were conducted in the past. In these areas, the quality and success of past surveys are estimated, and soils are monitored for changes in soil depth and other properties.

Soil salinity is monitored mainly in Jezreel Valley by the Soil Erosion Research Station of the MARD.

Current Soil Mapping Efforts

Current efforts are concentrated on mapping of different irrigated agricultural plots used for citrus orchards, avocado plantations, olive groves, vineyards and so on. The main aim of these efforts is to estimate the negative influence of soil cover destruction factors such as erosion, salinization, alkalization and water logging, and to assign map units of different suitability to the planned plants (see also soil surveys section).

Data Quality

The regional maps (1:250,000 – 1:500,000) (Ravikovitch, 1969; Dan and Raz, 1970; Ravikovitch, 1970; Dan et al., 1976) were produced based on detailed soil maps (1:50,000); thus, their quality is considered to be high, taking into consideration the appropriate generalization that took place during the up scaling of the maps. Yet, as these maps represent the location and characteristics of soils at the 1960's - 1970's, they do not accurately represent current soil characteristics in places where soil erosion had been intensive.

Soil Threats

Soil Erosion

In Israel soil erosion is a major environmental and agricultural threat, as 70% of the total agricultural land is susceptible to soil erosion by water (Zaidenberg et al., 2006; Hadas et al., 2009). For example, in northern Israel soil was eroded in places to a degree that it cannot be used for agriculture anymore; in other places the soil was entirely eroded, leaving bare rock surface (Hadas et al., 2009). Rates of soil erosion by water have been studied sporadically in Israel, mainly at hillslope to small watershed scales (i.e., few tens of meters to few km) (e.g., Inbar et al., 1998; Avni, 2005; Svoray and Ben-Said, 2010). Regional susceptibility of soils to erosion by water was recently assessed qualitatively (Zaidenberg et al., 2006; Wittenberg and Malkinson, 2011), yielding mapping units with relative susceptibility to water erosion (Figure 5). These assessments were used to learn on the economic consequences of soil erosion for agriculture (Hadas et al., 2009).

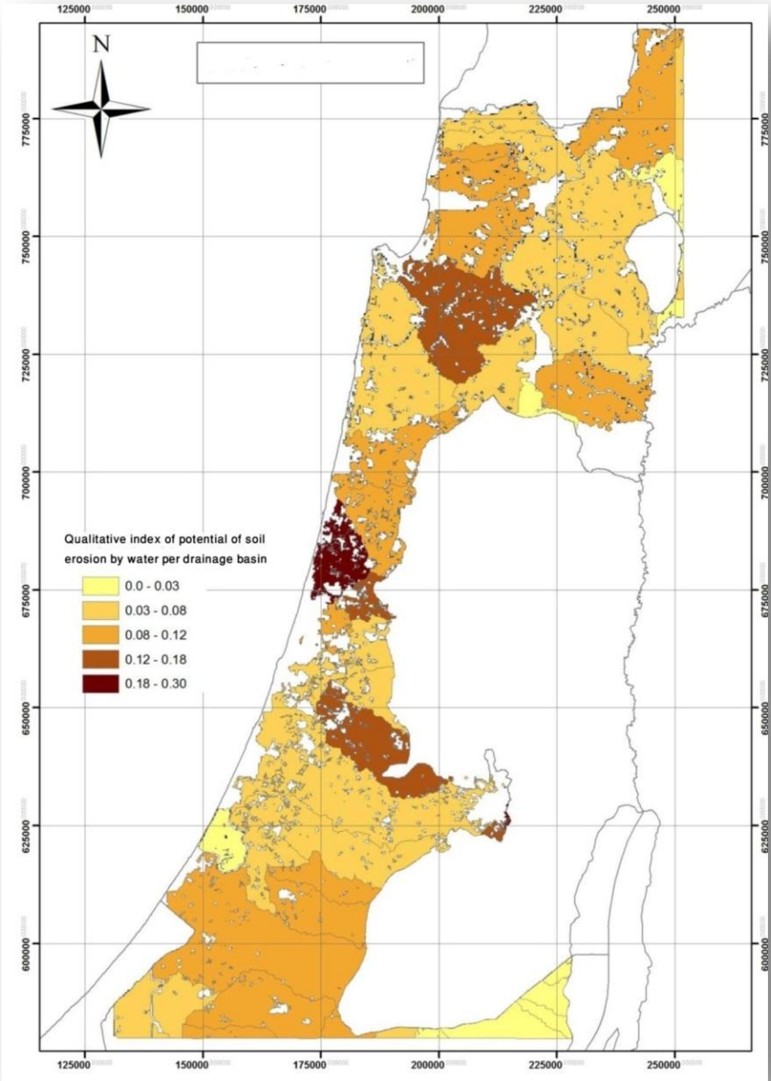

Figure 5. Qualitative index of potential of soil erosion by water, per drainage basin. Higher index values suggest higher potential of soil erosion (Wittenberg and Malkinson, 2011).

In general, wind erosion occurs mostly in southern Israel, where natural vegetation is scarce. Disturbed surfaces, mostly in the deserts, can increase the susceptibility of the surface to wind erosion. Recent studies have addressed the susceptibility of different soils to wind erosion in few localities in the Negev Desert (e.g., Bacon et al., 2011; Katra et al., 2012), and found variability in erosion susceptibilities among different soil groups. On a regional scale, Yaalon and Ganor (1966) estimated susceptibility of soils to wind erosion in the Negev Desert.

Salinization

Soil can be defined as saline if within any part of a profile depth of 120 cm an electrical conductivity of the soil extract exceeding 0.2dSm^{-1} at 25°C has been recorded (Singer, 2007). Saline soils are widely distributed in the southern and central parts of the Negev, where rainfall is below 300 mm yr^{-1}. In southern Negev (<100 mm yr^{-1}) the soils are moderately to highly saline, with salt content of up to 30%. In northern Negev (100-300 mm yr^{-1}) the soils are slightly saline; here the soil texture becomes an important factor in determining soil salinity. The source of salts in this region is

atmospheric dust. The limited rainfall in these areas prevents complete leaching of the salts to the groundwater, and thus the salts accumulate in the soil profile.
Large concentrations of saline and alkaline soils occur in northern Israel, in the transversal valley system that connects the shores of the Mediterranean Sea in the west with the Jordan Valley in the east (i.e., Jezreel Valley). In many of the Vertisols that are common in these valleys, the groundwater table is close to the surface; saline groundwater, irrigation with treated water, and poor drainage conditions are here the major factors for soil salinity (Benyamini et al., 2005; Mirlas, 2012). Saline soils are also widespread in the Dead-Sea - Jordan Valley, where saline groundwater and saline parent material are the major factors in salinization, although rainfall exceeds 400 mm yr^{-1}.

Soil Sealing

Urbanization is the primary factor of soil sealing in Israel. The population in Israel has grown tremendously during the 20^{th} century (and continuous in the 21^{th} century): from 1948 to 2001, the population multiplied by a factor of 8 (Bar-Or and Matzner, 2010). Accordingly, urban areas have been expending to natural/agriculture areas, sealing the soils and preventing groundwater recharge. It is estimated that urban areas increased by a factor of 17 from 1948 to 2001. As most of the population is located in central and northern Israel, mainly along the coastal plain, soil sealing occurs mainly in those areas. Despite the fact that urban areas are currently about 5% of the total terrestrial area of Israel, when not considering the less-populated Negev Desert, these percentages can reach to 14%.

Soil Contamination

According to the Ministry of Environmental Protection, more than 1,000 sites with prominent soil and water contamination were identified in Israel. Most of the sites are located in highly populated areas, such as the coastal plain of Israel. The contamination is mostly caused as a result of inefficient technologies used in the past for the removal of solid waste and industrial wastewater, and for storage and transport of gasoline and hazardous materials. The main sources of soil contamination in Israel are gasoline stations, manufacturing plants, automobile repair shops (garages), and military Industries. Car pollution is another source of soil contamination, mainly through the addition of lead to soils adjacent to main roads (e.g., Teutsch et al., 2001).

Sinkholes

More than a thousand sinkholes have developed along the western coast of the Dead Sea since the early 1980s, more than 75% of them since 1997, all occurring within a narrow strip 60 km long and <1 km wide (Yechieli et al., 2006). This highly dynamic sinkhole development has accelerated in recent years to a rate of ~150– 200 sinkholes per year. The sinkholes cluster mostly over specific sites up to 1000 m long and 200 m wide, which spread parallel to the general direction of the fault system associated with the Dead Sea Transform (Abelson et al., 2003; Yechieli et al., 2006). Research employing borehole and geophysical tools reveals that the sinkhole formation results from the dissolution of an ~10,000-yr-old salt layer buried at a depth of 20–70 m below the surface.

The entire phenomenon can be described as a hydrological chain reaction; it starts by intensive extraction of fresh water upstream of the Dead Sea, continues with the eastward retreat of the lake shoreline, which in turn modifies the groundwater regime, finally triggering the formation of sinkholes (Yechieli et al., 2006). The sinkholes have destroyed beaches, nature reserves and agricultural fields in the area.

Landslides

Landslides in Israel have occurred in historical earthquakes and extreme rainstorms. Recently, landslide hazard was quantitatively assessed at a local scale (Katz and Crouvi, 2007; Salamon et al., 2009) and at national scale (Crouvi, 2001; Katz and Almog, 2006; Katz et al., 2008; Katz, 2012). At a local scale, anthropogenic soil-like material, located mostly in ancient cities (e.g., Zefat, Jerusalem), was found to be mechanically weak, and thus susceptible to slope failure (Katz and Crouvi, 2007). At a national scale landslide susceptibility is assessed through examination of geotechnical strength of soils and rocks, combined with slope steepness and direction (Katz and Almog, 2006; Katz et al., 2008; Katz, 2012). The products of these assessments are series of 1:200,000 maps that shows 10 relative-hazard grades of landslide susceptibility (Figure 6). High susceptibility to landslide occurs mostly along the mountain region of Israel, at the cliffs along the western seashore of the Dead-Sea, and at few localities along the coastal cliff of the Mediterranean Sea.

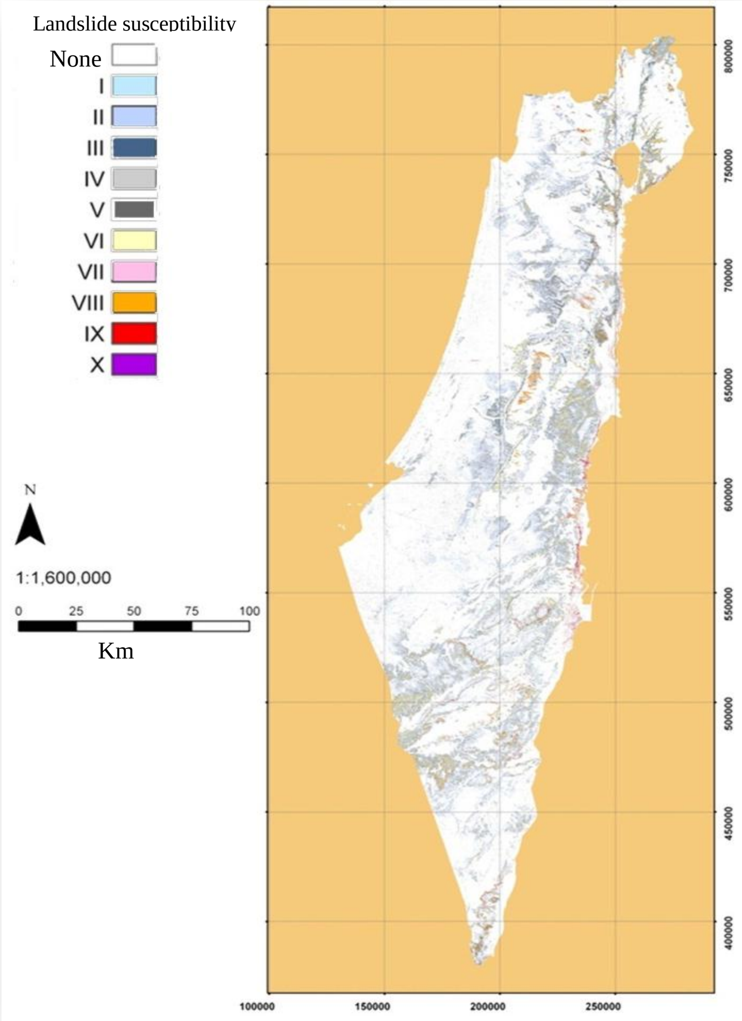

Figure 6. Landslide susceptibility map of Israel .
(Katz and Almog, 2006; Katz et al., 2008; Katz, 2012)

Floods

Most floods events occur in the arid regions of Israel, the Negev and Judean Deserts; major flash floods in these areas have caused in the past losses in infrastructure, property and life. Owing to the soil properties, lack of vegetation cover, and high rainfall intensity, sheet flow can be easily generated; runoff events in minor catchments can be generated from rainfall of only a few mm in depth, whereas runoff in wadis draining larger catchments requires rainfall events of at least 10-20 mm in depth (Ben-Zvi and Shentsis, 2000). Major floods have been related to specific synoptic types (Kahana et al., 2002).

Soil Compaction

Soil compaction poses a threat to agriculture soils in places where high wheel pressure is in use. In most places this problem can be minimized by appropriate farming procedures, such as driving along specific paths, and using low pressure wheels. There is no regional assessment of this phenomenon in Israel.

Decline in Soil Biodiversity

As soil biodiversity can be threatened by soil erosion, salinization, sealing and compaction, it is expected to decline in areas that are affected by these processes. Yet, beside local examination of soil biodiversity, there is no regional assessment or monitoring plan aimed to evaluate decline in soil biodiversity in the soils of Israel.

Decline in Organic Matter

Content of organic matter in the soils of Israel is generally low, as a function of the arid, semi-arid and Mediterranean climates of the region. Thus, decline in organic matter is not considered as a soil threat in Israel, and it is not monitored.

Future prospects and integration studies

Future working plan on soil resources includes digitizing local soil maps that were produced during soil surveys (> 400 maps in scales of 1:2,500 to 1:5,000). In addition, all soil profile descriptions and laboratory analyses results that were obtained during years of studying soils in Israel will be digitally stored, including the verbal description of the soil profile (>1,000 soil profiles). The soil profile database will be linked to GIS, and could be questioned through spatial analysis techniques.
Integration of the Israeli soil data with the European soil DB will be based on the generalized soil map of Israel, produced from the 1:500,000 soil map (Dan et al., 1976) (Figure 4). Yet, as this map is based on data gathered more than 30-40 years ago, there are areas in the soil map that do not accurately represent the current status of the soil. For example, areas in northern Israel that underwent severe soil erosion changed their soil characteristics since the time of map publication. In places, the soil association might have been changed. Our challenge in the integration process will be to try and to locate these areas, and to update the soil mapping unit accordingly. Another challenge that we are facing is the transformation of soil association units used in the Israeli soil classification, into Soil Typological Units (STU), that are based on both the World Reference Base (WRB) and the 1990 FAO-UNESCO Soil Revised Legend. For example, calcisols are abundant in the semi-arid region of Israel, but do not exist in the Israeli classification (Figure 4; Table 1). During this project we will focus on finding the best way to transform the Israeli soil classification into the classifications used in the European soil DB. In addition, there is limited information on the internal distribution of STU in the Soil Mapping Units (SMU) (Dan and Raz, 1970). We will invest time and efforts in deciding which and how many STU appear in each SMU, and in estimating the percentage of area each STU covers in the SMU.

For the soil profile DB we will use the existing Israeli soil DB for the arid and semi-arid regions (Crouvi et al., 2004) (Figure 2), and published information on soil profiles for central and northern Israel (Koyumdjisky et al., 1988). For the former, we will transform the existed DB (Crouvi et al., 2004) into the European soil profile scheme, whereas for the latter will involve manually input of soil profiles data directly to the DB using the Excel sheets provided.

Conclusions

The integration of Israel soil data into the European soil DB will involve the following steps:

1. Israel digital soil map (1:500,000) will be updated in areas that are known to be affected by soil erosion or other degradation processes. As the digital map is based on field data acquired 30-40 years ago, updating this map is important for any future usage of the data.
2. Israeli soil classification, which is based on 23 soil associations, will be translated into the WRB and FAO classifications. There is no single correlation scheme for this procedure, as a single soil association unit is equivalent to several WRB and FAO soil groups. Thus, each SMU will be treated separately according to its specific characteristics (climate, topography, and lithology).
3. For each SMU the percentage of areal coverage of the different STU will be evaluated. Also for this procedure, each SMU will be examined separately.
4. Soil profile data will be based on the existing Israeli soil profile DB for the southern part of the country, and on new input data from published materials for the rest of the country.
5. For each STU, measured soil profile will be selected from the new soil profile DB. Estimated soil profile will be used either from measured soil profile, or from a combination of several measured profiles.

We expect that the integration process will be successful and we are looking forward to see the complete harmonized soil map and spoil profile DB for Europe and the Middle East. This important contribution will enable continuous quantitative modeling of soil characteristics and soil threats over vast areas, and will provide important data for policy makers in the near future.

Acknowledgments

We thank Dr. Rivka Amit and Dr. Michael Beyth, both from the GSI, for their helpful comments on the text.

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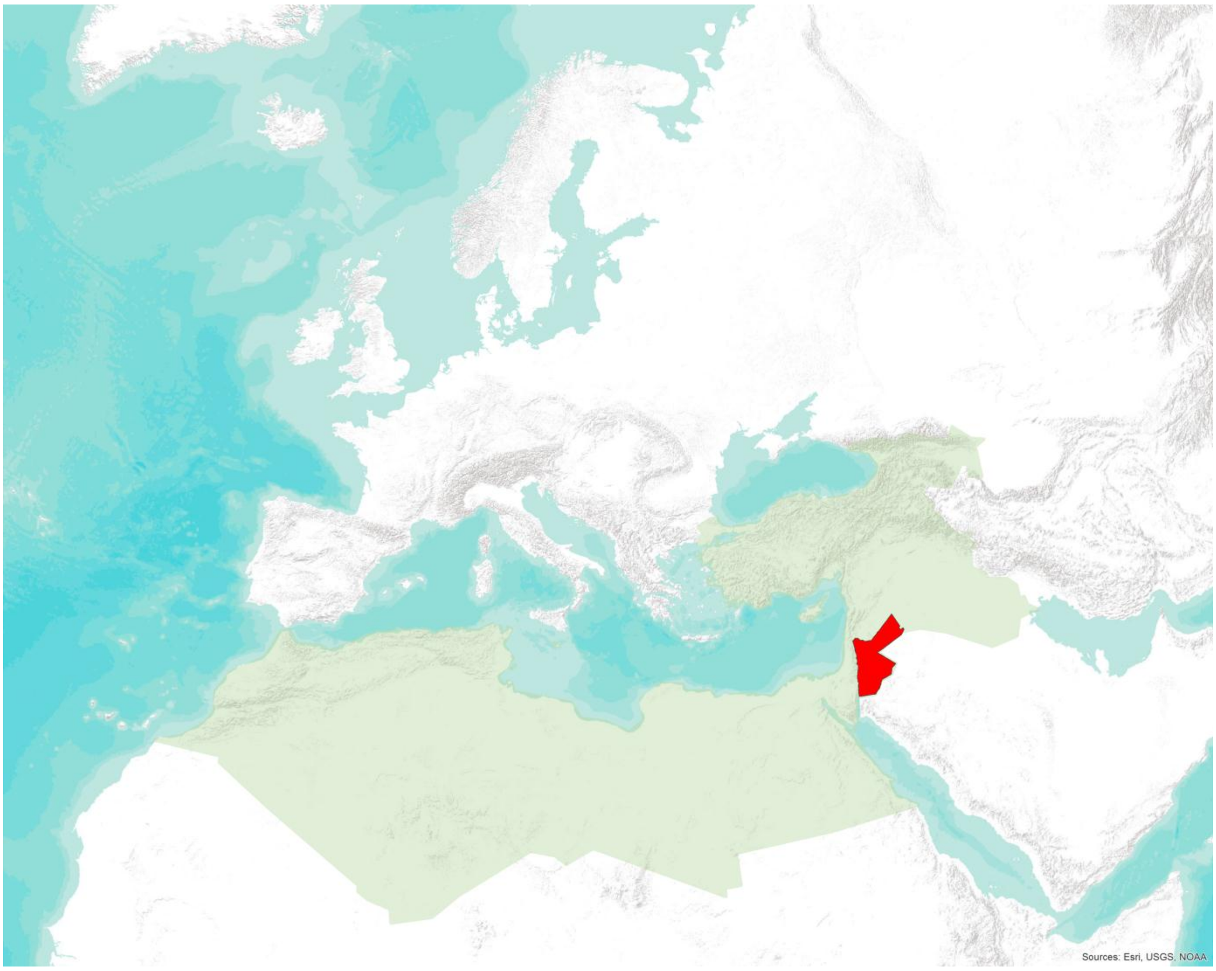
Chapter VIII.
Soil Resources of Jordan



The Hashemite Kingdom of Jordan
Soil of Jordan

Dr. Mahmoud Hasan Al Ferihat[1]

1. General features

The Hashemite Kingdom of Jordan is located between latitudes 29º - 33º N and longitudes 35º - 39º E. The total area is about 89,200 Km² (Fig1).

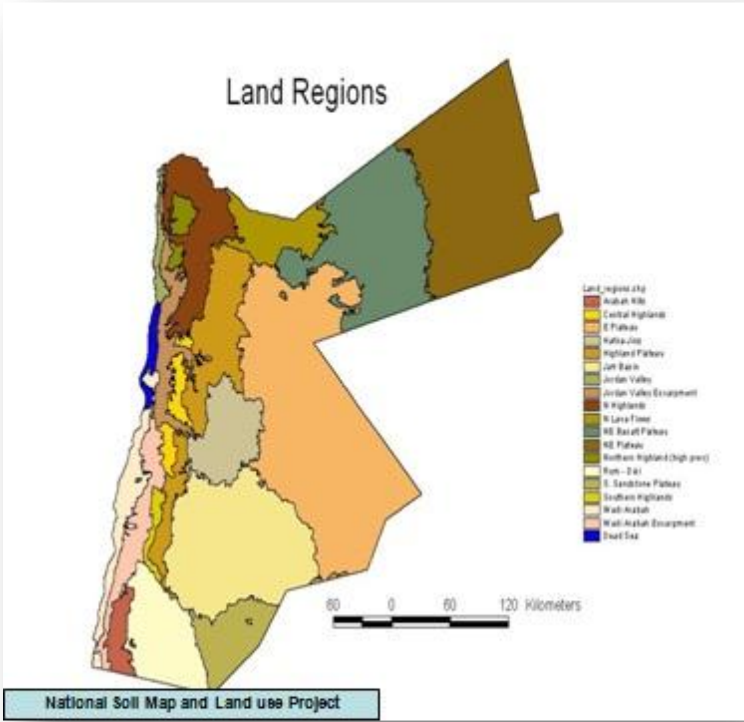


Figure 1. Land Regions in Jordan

Climate

Jordan occupies a position on the eastern margins of the Mediterranean climatic zone of the eastern Mediterranean. More than 85% of the country receives less than 200mm annual precipitation which increases from East to West and from South to North. A maximum annual rainfall level of 600mm occurs at the North- West corner of the country (Fig.2). Average temperatures show a reverse pattern; they increase rapidly from the dissected plateaus to the very low level graben, increase gradually from the dissected plateau to the eastern margins of the eastern desert, and decrease gradually from north to south in line with increasing altitude. Annual and monthly values for evapotranspiration occur in the desert with an annual total of 2427mm for Ma'an and 2325mm for Rweishid in the northeast of the country. In the highlands, annual values vary from 1485mm at Rabba to 1343mm at Shoubak: highest monthly values occur in July and the lowest monthly values occur in January for all the country.

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Recent information indicates that Jordan was subject to several climatic changes during the Quaternary. The last episode of climatic changes, which prevails at the present time, caused the development of unfavorable conditions for plant growth and led to removal of the plant cover. This makes the desertification process a real threat to the agricultural lands in Jordan.

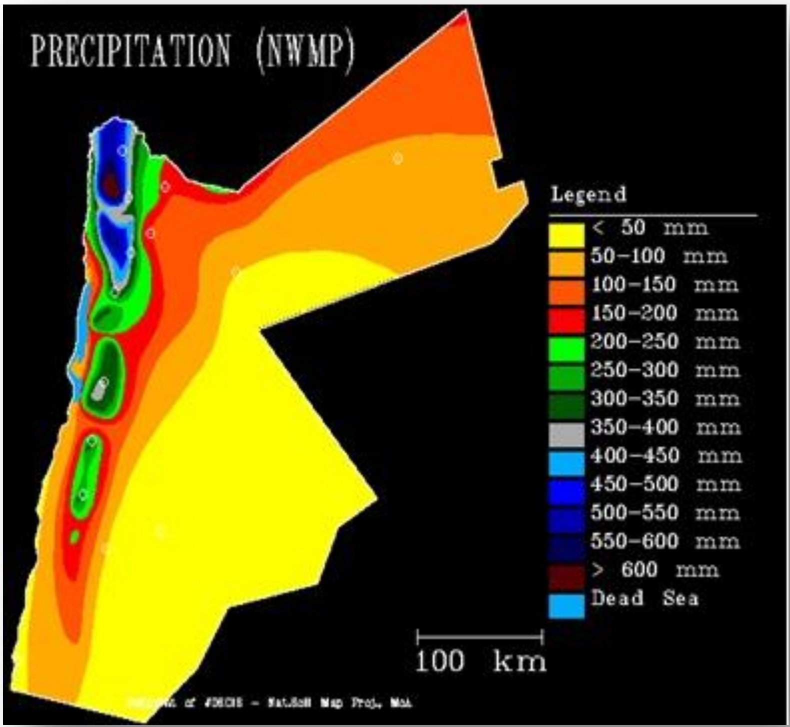

Figure 2. Annual Precipitation in Jordan

Geology and Geomorphology

The geological history of Jordan has been outlined by D. J. Burdon (1959) and F. Bender (1974). In these studies descriptions were given of the stratigraphy, structures and tectonics of the country. Epeirogenic movements during middle Cambrian, Triassic, Jurassic, Createaceous and the Oligocene resulted in marine transgression and regression. As a result, different strata of sandstone, limestone, marls and dolomite of different ages and thickness were deposited over a Precambrian Basement of crystalline and metasidement rock.

Rifting, uplifting and formation of the Dead Sea commenced during the Tertiary and was accompanied by eruption of flood basalts on the Jabal Al- Arab. During successive stages of uplift in the Cainozoic, the Jordan River opened its course and its rejuvenated tributaries, cut back to the east into the Jordan plateau. The erosion products that resulted from a steady rejuvenation of the drainage network were deposited in the Pleistocene Lake Lisan and later as alluvial fan systems in Jordan Valley and Wadi Araba. Their processes continue today in the Dead Sea Rift and in enclosed depressions of the Sirhan and Jafr Basins that lie in the east of Jordan.

Land Use

Jordan’s agriculture has a long history and farming goes back some 3000 years and earlier as shown by discoveries at various old settlements. It is known that the population in ancient times was larger than it is now. Large areas of land were reclaimed and utilized. In areas around old settlements many examples of Roman terraces, cisterns and reservoirs still exist. It is apparent, for example, in the Madaba, plain area south of Amman, that a sophisticated system of water harvesting and storage was dried. This has been long abandoned. On the margins of the Steppe zone remnant of forest cover and olive presses testify to a former greater extent of humid conditions than exist at present.The currnt land use map of jordan shwon

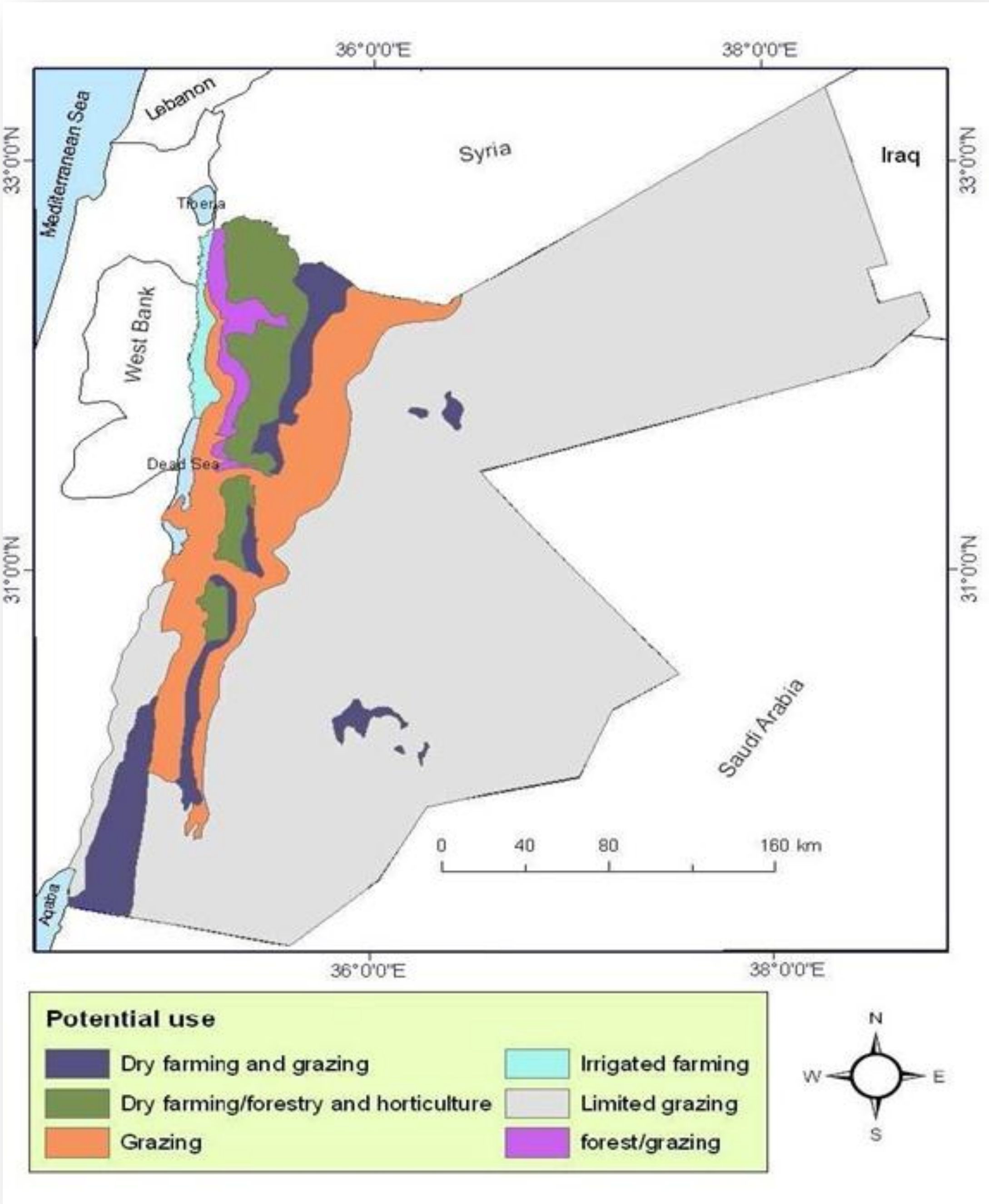

Figure 3. Potential Land Use Map in Jordan

The apparent trend towards a dry climate, which prevails at the present time with frequent droughts, together with the misuse of land resources is considered to be primary causes for the development of the unfavorable soil properties, and the degradation of the vegetative cover. The

misuse of land resources comprises overgrazing in the steppe and desert zones, as well as in the forest land of the Highland. Overstocking with grazing animals has led to either destruction or severe cutting of the plant cover, with subsequent exposure of the soil to erosion effects of rainfall and runoff. Generation of dust storms by plowing practices in the steppe zone is an additional factor in increasing soil loss by deflation.
There has been a rapid rate of population growth in Jordan since the 1940s. Cultivation of marginal lands, and unsound practices such as plowing down slopes, and use of heavy farm machinery have accelerated the rate of degradation of soils and lowered the productivity of the land. Urbanization is also steadily encroaching onto good quality agricultural land in the higher rainfall areas of the Jordanian highlands, reducing the traditional production areas of food crops such as wheat and barley. At the same time, there has been an expansion of arable farming onto the more marginal farming areas of the steppe. In these later areas, this is accompanied by destruction of the natural vegetation cover and, too often, by crop failure.

Pumping of aquifer waters for irrigation has been increasing, without serious attempts to improve recharge into these aquifers such as by water harvesting methods similar to those apparently successful in the past.

Whilst irrigation has made crop production possible in many areas, the long term effects of fertilizers and pesticides on water quality, as well as the state of the aquifer, have been given only limited attention. Any deterioration of the water quality could have marked effects on degradation of the land. However, studies are now commencing in Southern Jordan, which will look closely into the whole issue of water supply.

Certain desert irrigation schemes are continuing to experience fairly serious salinity and sodicity problems, due to a combination of unfavorable soil and drainage conditions. Desertification and abandonment of these lands is slowly increasing.

Agroecological zones of Jordan

Jordan can be divided into four main agro- climatic zones. The pattern of these zones goes with similar patterns as physiography and climate. These zones are as follows:

i. Jordan Valley

Extends from Lake Tiberia in the North to the Gulf of Aqaba in the South. Elevation ranges from 197m below sea level to 392m below sea level near the Dead Sea. The rainfall average is less than 200mm. It is warm in winter and dry hot in summer. The soils that occur in this zone are associations of Vertisols/ Aridisols/ Entisols. This area covers about 0.1 million hectares, 1.1% of the total area. Irrigated agriculture (270,000 ha.) is concentrated in this zone.

ii. Semi Arid zone, Semi-humid zone of Highland Jordan

In Jordan this area is congruent with rainfed agriculture and covers the mountain ridges and dissected plateau East of the Jordan Valley. Elevation varies from 700 to 1500m above sea level. The average annual rainfall exceeds 350mm. Most potentially productive land occurs within this zone and it covers about 2.4 million dunums, or 2.5% of the total area. The dominant soils are Alfisols, Vertisols, and Lithic Entisols.

iii. Steppe Zone

This lies in the east and south of the Highland zone. The elevation descends gradually towards the East and with an average altitude of 600- 800m above sea level.
The average annual rainfall is 150- 250mm. This zone covers about 6.3% of the total area, which is about 5.6 million dunums. The dominant soils are Vertisols, Lithic entisols intergrades into Aridisols. It is considered to be the outside front separating the areas with good agricultural land from those occurring under dry climate.

iv. The Arid Zone (Badia)

Includes the dissected peneplain with granite and sandstone mountains of the Eastern and North Eastern and Southern deserts. The average annual rainfall is less than 200mm. This area covers about 90% of the total area, which is about 81.1 million dunums. The dominant soils are Aridisols and Entisols. The most important characteristics of this zone are high variability of the limited rain, low plant cover, and high rate of wind and water erosion.

Soil of Jordan

Introduction
The soils of Jordan have been classified according to the criteria and definitions of the USDA's Soil Taxonomy (1975) and the 1990 keys to Soil Taxonomy, contained in SMSS Technical Monograph Nol9. In this report there follows a brief description of the great groups which have been recognized during the course of this study.

4-1 Andisols
Only very limited areas of soils of this order have been recognized on the basis of their observed characteristics; they are associated with cindery parent materials of volcanic cones, mainly in Regions 15 and 16. But also in a few sites in Region Jordan Highlands Plateau. Two great groups have been recognized : Vitritorrands in the arid Region North-east Jordan Basalt Plateau and Haploxerands in the northern parts of Region **–** North Jordan Basalt Plateau
and the more moist parts of Region **–** Jordan Highlands Plateau. Both groups are very stony with a loamy textured matrix, and are often shallow to basalt rock.

4-2 Aridisols

4-2-1 Calciorthids
Calciorthids have widespread occurrence in Jordan within the aridic moisture regime, and are an important constituent of Regions Wadi Arabah**,** Wadi Arabah Escarpment**,** Arabah Hills Dissected Basement Plateau**,** - Disi-Ram Highlands**,** South Jordan Dissected Sandstone Plateau the eastern part of Region – Jordan Highlands Plateau**,** Jafr Basin**,** East Jordan Limestone Plateau
, Hafira-Jinz Depressions**,** - North-east Jordan Basalt Plateau and – North-east Jordan Limestone Plateau. They occur on a wide range of parent materials except in coarse textured, sandstone derived soils and in recent and sub-recent
alluvia where there has been insufficient leaching to segregate the calcium carbonate into concretions.In the very stony and/or gravelly fans derived from Basement Complex, Calciorthids have been recognized on the basis of hard $CaC0_3$ pendants on the underside of stones; these pendants are likely to be old and may represent a previous partial leaching cycle. Calciorthids occur in association with Camborthids and Gypsiorthids and to a lesser extent with Torriorthents especially in Regions Arabah Hills Dissected Basement Plateau
and **–** Disi-Ram Highlands, and Torrifluvents in wadis. Coarse textured Calciorthids occur in Region Arabah Hills Dissected Basement Plateau

in colluvial and alluvial fans, but are dominantly fine –loamy and fine – silty in texture in the other Regions, with a varied content of stones and gravel depending on the parent material and slope position.

4-2-2 Camborthids

This great group occurs in association with Calciorthids, Gypsiorthids, Torriorthents and Torrifluvents, in the same Regions. Like the Calciorthids, the Camborthids occur in a wide range of parent materials, but are a minor component of the soils in Regions Arabah Hills Dissected Basement Plateau and Disi-Ram Highlands. The predominant textures are fine – loamy, fine-silty and, more rarely, clayey. The Camborthids are highly calcareous, and contain calcuim carbonate concretions which are insufficient to constitute a calcic horizon. Camborthids can occupy the same landscape position as calciorthids, but are more commonly found in lower slope positions, in valley fills,. In part, their presence reflects younger parent materials, but may also indicate reduced leaching in finer textured valley fills and in filled depressions. Camborthids are the dominant Great Group in Regions East Jordan Limestone Plateau and Hafira-Jinz Depressionsand North-east Jordan Limestone Plateau where the topography is gently dissected limestone plateaux.

4-2-3 Gypsiorthids

These occur in association with Calciorthids and Camborthids. They occur usually as a subordinate Great Group except where the parent material contains large amounts of gypsum, e.g in the Quaternary alluvium around the Azraq Basin, and in limited areas of the lisan marls. Otherwise, their occurrence is sporadic, and does not seem to relate clearly to particular landscape facets. One shallow group is associated with partially weathered chalky limestone on hill crests especially in the eastern portion of Region Jordan Highlands Plateau and parts of Region **–** Jafr Basin. Another more specific occurrence has been noted in limited parts of Regions – East Jordan Limestone Plateauand – North-east Jordan Limestone Plateau Where pockets of gypsum occur at the junction between red clay material and underlying partially weathered limestone; these soils are often relatively shallow

4-2-4 Paleorthids

This great group with its cemented calcic horizon occurs sporadically associated with a wide range of parent materials, including Pleistocene fans and terraces, limestone rocks and basalt.

The most widespread occurrence of Paleorthids is, usually laminar layer overlying basalt. They are the major great group in some mapping units in Region 15, where most are in the xeric subgroup. Their common occurrence may reflect a mode of formation relating to the permeability of the weathered basalt allowing the rapid coating of the basalt boulders, and the presence of calcium rich waters flowing over the basalt plateaux. Abraded reminants of petrocalcic horizons have been noted in soils on the escarpment to the Jordan Valley, suggesting a wider occurrence which has been removed by erosion by the highly erosive rivers and wadis of the escarpment.

4-2-5 Salorthids

Most of the soils of the arid regions are saline except in wadi beds and channels, and evaporites occur on the surface of some basins as flood water evaporates. However, the Salorthid great group with its requirement of a water table within two meters is of very limited occurrence. They are found in limited areas near the much reduced Azraq pools, around the Dead Sea, especially in the Ghor Safi area and in limited spring fed sabkhas in Wadi Arabah; limited sandy Salorthids occur behind the Aqaba beach.

5- Entisols

5-1 Hydraquents

This great group recognized only along the margins of the Dead Sea where the lowering water level has exposed very young, clayey, sea bed alluvium with a very varied, but generally high organic matter content. The soils have a high water table which is not strongly saline possibly because of the seaward flow of fresh groundwater from the fans of the escarpment.

The soils has a high *n* – value of more than 0.7, except in a shallow, often more sandy surface horizon, where the soil has had the opportunity to dry out sufficiently to form weak structure.

5-2 Torrifluvents

These are generally layered soils with a very mixed particle size class. They occur in recent alluvia of wadi channels, usually in areas where dissection is severe, and occasional run-off is very rapid. Most contain numerous gravel layers. The soils of this great group are calcareous, but do not contain visible calcium carbonate. Virtually all the Torrifluvents are non-saline, reflecting their youth, coarse texture, and occasional leaching by flash floods. This great group occurs in most of the arid Regions including Regions Wadi Arabah, Arabah Hills Dissected Basement Plateau, - Jafr Basin, East Jordan Limestone Plateau, Hafira-Jinz Depressions, North Jordan Basalt Plateau**,** North-east Jordan Basalt Plateau and **–** North-east Jordan Limestone Plateau. They occupy significant proportions of between 5 and 10 percent in Regions Wadi Arabah, Jafr Basin, East Jordan Limestone Plateau, Hafira-Jinz Depressions and North-east Jordan Limestone Plateau**.**

5-3 Ustifluvents

This great group is limited to a few wadi channels in the Jordan Valley, Region 1 which flow off the escarpment and in parts of the Zor. They are non-saline and coarse textured, often with numerous bands and lenses of gravels. They also occur in recent alluvium of the lower reaches of the Zarqa River and other major, deeply incised wadis.

5-4 Xerofluvents

These soils are of very limited extent and occupy narrow wadis in the more highly dissected areas of Regions Northern Highland Dissected Limestone Plateau, Central Highlands Dissected Limestone Plateau, Southern Highlands Dissected Limestone and Jordan Highlands Plateau; in Region Jordan Highlands Plateau their xeric moisture regime is maintained by occasional wadi flow. The soils are generally coarse textured, and are non-saline and have no visible secondary carbonate. The soils support important grazing and browze species and are occasionally cropped for barley in the drier areas. In the higher rainfall areas they are often prone to severe flooding and are usually uncultivated.

5-5 Torriorthents

These are important soils in most of the arid Regions. They form a high proportion of the soils in Regions Wadi Arabah, Wadi Arabah Escarpment Mestone, Arabah Hills Dissected Basement Plateau, Disi-Ram Highlands, South Jordan Dissected Sandstone Plateau and North-east Jordan Basalt Plateau, where slopes are steep or the parent material is too coarse and stony to show the effects of weathering. This is especially well seen in Region Arabah Hills Dissected Basement Plateau with its preponderance of very stony and gravelly alluvial and colluvial fans. In this latter region the Torriorthents are most commonly on reworked fans where an older calcic horizon has been destroyed.

They are also associated with hill and ridge crests and steep slopes where the rate of erosion is faster than soil renewal and significant areas of soils less than 30cm deep to bedrock occur.

5-6 Ustorthent

This great group is associated with Ustochrepts mainly in a narrow zone in the middle and lower part of the escarpment to the Jordan Valley. They are associated with young colluvium on steep slopes, or are very shallow to rock: a few occur on extremely gravelly terraces within the ustic moisture regime. Most have a loamy – skeleted particle size class. The soils are calcareous and non-saline and carry grasses and browze few are cultivated.

5-7 Xerorthent

This great group is composed predominantly of very shallow soils on hill crests, ridges and steep slopes in Regions Northern Highland Dissected Limestone Plateau, Central Highlands Dissected Limestone Plateau, Southern Highlands Dissected Limestone and Ajlun Highlands Dissected Limestone Plateau. A very few deep Xerorthents are associated with landslip zones where weathering is very limited. The predominant texture is a stony silty clay loam. These shallow soils carry grazing and browze, very few are cultivated. They are moderately calcareous and non-saline.

5-8 Torripsamments

These are sandy soils largely of aeolian deposits, but a few are found in very sandy alluvia. This great group occurs in Regions Wadi Arabah,, Arabah Hills Dissected Basement Plateau and South Jordan Dissected Sandstone Plateau, but most widspread associated with the sandstones of Region 6 where it comprises 35 percent of the soil observation sites. The great group occurs on recent dunes, on older sand sheets, and less frequently on sand sheets overlying rock and in some wadi alluvia. The soils are weakly calcareous and show visible carbonates in older sand sheets; most are only weakly saline.

5-9 Xeropsamments

This great group is found in one small area where sand from the sandstones of Region Disi-Ram Highlands has been blown up onto the high level edge of the Ras en Naqb – Jebel Petra escarpment. They occur at the very limits of the xeric moisture regime.

6- Inceptisols

6-1 Ustochrepts

This great group occupies limited areas in the northern two thirds of the Region, Jordan Valley, and a narrow strip along the mid section of the escarpment to the Jordan Valley and the Wadi Arabah in Regions Wadi Arabah Escarpment and Jordan Valley Escarpment. These soils occur where rainfall exceeds 300mm and annual average soil temperature exceeds 22°C i.e. lie within the hyperthermic temperature regime. In places their moisture content is increased by run-on from surrounding areas and some may receive additional moisture from slow seepage from small, weak springs. In the south they occur at high altitudes of between 800-1000m, but in the north they are found at ever decreasing altitudes, about 400-600m near Karak, 150-300m around Wadi Shuheib and below sea-level in the north of the valley. In the Jordan Valley, they occur in the alluvial fans of the Ghor, and are usually deep and medium to fine textured; stone contents are low except near the apex of the fans. Many have been cultivated and irrigated for a long period, and the Ustochrepts have a dark surface horizon with a moderately high organic matter content resulting from their cultivation : these surface horizons are anthropic in nature. On the escarpment, the Ustochrepts have developed on stony colluvium derived mainly from limestone, but with some sandstone admixture in places. Their depth varies greatly over short distances and they carry natural grazing and browze, and are seldom cultivated. The Ustochrepts are moderately to very calcareous and non-saline.

6-2 Xerochrepts

Soils of this great group occupy extensive areas of Jordan where rainfall exceeds 200mm, or where additional moisture is received from run-on in depressions, wadi channels etc in more arid areas.

The great group is dominant in Regions Northern Highland Dissected Limestone Plateau, Central Highlands Dissected Limestone Plateau, Southern Highlands Dissected Limestone, Ajlun Highlands Dissected Limestone Plateau and in limited parts of **Region** Jordan Highlands Plateau where soil moisture content is enhanced by run-on. The soils of this great group have developed in alluvial and colluvial mantles derived from calcareous rocks, directly on limestone, and in Quaternary fluviatile and aeolain deposits of the plateaux and high level depositional basins. The Xerochrepts occur in a wide range of topographic positions, from the long steep colluviated slopes of the valleys and the eroded upper part of the escarpment to the Graben, to the nearly level plains of Irbid. Madaba, Karak, and Tafila. The texture varies from fine-loamy to clayey, and the Xerochrepts on the steep colluvial mantles normally contain a high stone content especially when associated with the Amman Silicified Chert. Shallow Xerochrepts occur on hill crests and ridges and on the steeper slopes of valleys and the upper escarpment, but the majority are generally deep soils.

The Xerochrepts vary from strongly to non- calcareous; the level of free $CaC0_3$ depends partly on rainfall with weakly or non-calcareous soils occurring in areas where rainfall exceeds 500-550mm, but partly on parent material. The Amman Silicified Chert is weakly calcareous and gives rise to weakly or non- calcareous soils where rainfall is greater than about 400mm. Many Xerochrepts do have free calcium carbonate which is segregated into concretions in the drier xeric areas, and often occurs as one or more well defined calcic horizons occurring at depths of 60 to 200cm Calcic horizons are absent in the wetter north and along the edge of the escarpment, but become more prevalent to the east and south as rainfall declines. Calcic horizons within 90cm are verycommon in Regions ^{0} and 10 and in the south and east of Region 8; they rarely occur in Region 18.

The Xerochrepts are associated with Vertisols in the higher clay areas of Regions 8 and 9, organic rich Haploxerolls in high rainfall areas in Regions 8 and 18, and Xerorthents on hill crests, steep slopes and in relatively young, very stony colluvium. To the east they grade towards the Camborthids and Calciorthids of the more arid Regions. The Xerochrepts are the most important soils agriculturally, supporting rainfed cereal and summer cropping, tree crops, grazing and browse and, increasingly, irrigated horticulture. They are also the soils most at risk from the rapid spread of urbanization especially in Region 8.

This great group is of very limited extent and is found on the escarpment to the Jordan Valley and Jordan Valley Escarpment in association with soils of the Ustochrept great group, i.e. in the narrow zone where rainfall exceeds 30"?mm and annual soil temperature exceeds 22°C, and in individual sites within the valley where the high surface organic matter has been deemed not to be anthropic in nature.

The limited area of Haplustolls on the escarpment is associated with the head reaches of small wadis, small flatter areas within the generally steeply sloping terrain, and other sites where moisture seepage encourages a relatively dense vegetation of grasses and shrubs. These soils are moderately to strongly calcareous and non-saline. They often contain a few calcium carbonate concretions which, in places, are of sufficient volume to form a calcic horizon: these soils are included in the Calciustoll great group, but only a few sites have been so defined.The Haplustolls and Calciustolls have the same textural range as the Ustochrepts.

7- Mollisols

7- 2 Haploxerolls

These soils occur in Regions Northern Highland Dissected Limestone Plateau and Ajlun Highlands Dissected Limestone Plateau where rainfall is high, and can sustain a vigorous vegetation growth. They occur most commonly under tree, dense scrub, and grass vegetation, but are also found in

cultivated soils. It seems likely that under Jordanian conditions the mineraliztion of organic matter is rapid when the natural vegetation is removed and the soil cultivated. The return of organic matter to the soil under rainfed cropping and subsequent grazing or removal of residues is limited and insufficient to maintain a high level of organic matter. However, under perennial cropping, especially when the crop is not clean weeded, organic matter build up is more rapid and conditions more closely approximate those under natural woodland.
The Haploxerolls are largely confined to the steeper slopes which they are either uncultivated or under tree crops. Thus, there is a high proportion of shallow and moderately deep soils (25-80cm). The soils are mainly fine-loamy in texture, with a few clayey examples. They normally have a high stone content. Mycelia of calcium carbonate commonly occur in the Haploxerolls, but they are usually only weakly to moderately calcareous; a few are non-calcareous.

8- Vertisols

8-1 Chromusterts
These cracking clay soils are confined to a limited area in the northern part of the Jordan Valley where they have developed in gently sloping alluvial deposits. Their profile characteristics are in all ways similar to the more extensive Chromoxererts of the plateaux which are described below.
Chromoxererts are important soils of Regions **–** Northern Highland Dissected Limestone Plateau and Central Highlands Dissected Limestone Plateau, and have very limited occurrence in Regions 10 and 18. The largest area and best developed of the Chromoxererts occur in the Irbid plains and Yarmuk basalt plateaux. The parent material appears originally to have been fluviatile and aeolian deposits laid down on limestone and basalt. An alkaline environment and limited leaching has favoured the formation and persistence of smectite which provides the typical swelling and shrinking characteristic of this great group. In the summer, the soil cracks very widely, especially in the Irbid region, with surface cracks of between 5cm and 10cm common, and extend downwards for up to 100cm. The great group also shows well developed wedge shaped aggregates and extensive slickensides. Again, these features are best developed in the north of Region 8 and are less conspicuous in Regions Central Highlands Dissected Limestone Plateau **and** Southern Highlands Dissected Limestone**.**
The Chromoxererts are confined either to shallow basin areas or to flat or very gently sloping land. This kind of topography ensures the very limited drainage which restricts leaching of calcium carbonate and maintains alkalinity in these clay soils. The clay content of the Chromoxererts is usually in excess of 45 percent.
The Chromoxererts are associated with, and grade into, the Xerochrepts. This gradation includes an important area of Xerochrepts with some of the vertisolic characteristics of the Chromoxererts. There are the clayey Xerochrepts which occur in association with the true Chromoxererts. In many places these Vertic Xerochrepts occupy the moderately sloping, low interfluves while the Chromoxererts are found on the flat basins between the low interfluves. It is possible that on the more sloping areas, drainage and leaching are too rapid to maintain the conditions for high smectite content which encourages well developed Vertisol characteristics. Vertisols are generally calcareous and a few have calcic horizons.Chromoxererts occupy relatively small areas in relation to Xerochrepts, but are important for cereal production and, locally, for tree crops.

5- Land degradation in Jordan

5-1 Vegetative Cover Degradation
Degradation of the vegetative cover is the most important cause and factor that contributed to exposure of the soil to the various erosion factors, whether it was the wind or water. The vegetative cover deterioration is the result of inappropriate farming practices adopted by man in Jordan, especially cultivation of natural low-rainfall rangelands for production of

cereals which succeeds only once in every 5-7 years. This practice led to removal of the vegetation that protects the soil, especially after the 200m.m isohyets) was cultivated, in addition to cultivation of areas where the average annual wide- spread use of the mechanical plow, which enabled plowing of very large areas of natural rangelands in very short periods of time. It is estimated that about 90% of the area of rangelands that can be plowed (between 100 and rainfall is below 100m.m. This kind of cultivation has damaged the natural vegetation and exposed the soil to water and air erosion. And the shift in land use from ranges to arable lands has altered the ecosystem over large areas which, in turn, led to a continuously decreasing productivity. This was exacerbated even more by immature grazing and overgrazing (placing animals on rangelands in numbers that largely outnumber the range carrying capacity, and use of ranges at an early stage of the season and during a period that is critical to the plant growth). As despite the continuous reduction of the area of natural rangelands in Jordan (due to other competing land uses), the numbers of animals has increased substantially, which led to the exceeding of the range carrying capacity and to overgrazing. This, in turn, led to degradation of the vegetative cover and erosion of the soil. Also, grazing of goats in the mountainous areas damages the natural vegetation, as goats tear the trees and plants' covering and eat the seeds, stems and even the roots of the plants, which prevents natural regeneration of many of these trees and plants. The reduced area of the mountainous rangelands due to urbanization and sift to other land uses has led to increased pressures on the remaining rangelands and to the use of natural and man-made forests for grazing. In addition, the increased numbers of animals, the changed breeding and nutrition methods/ techniques, lack of movement tom other areas through the year, failure to utilize the field crop by-products, in addition to the reduced production of fodder by the cultivated lands, have expedited the vegetative cover degradation. For example, the non-organized overgrazing at the forests in 1991 has damaged over one million of forest trees and bushes. The continued great pressures on the mountainous rangelands would lead to their degradation, reduce their productivity and change them into areas of un-palatable and thin vegetation, and ultimately they would lose their important role.

As regards forests in this region, the major problems they face are forest fires. They annually experience 20-100 fires that damage about 20-30 thousand trees. Moreover, there is the permitted and un-permitted cutting of trees and bushes. Trees that are cut every year are estimated at about 10-20 thousand. Meanwhile, encroaching grazing is responsible for damaging about 5-10 thousand seedlings every year.

Furthermore, there are the problems of smoke pollution, diseases and insects that affect the forests. All these factors together have led in one way or another to a deteriorated vegetative cover, which in turn caused soil degradation and erosion, and ultimately to desertification.

Soil Erosion

The soils in this region have been suffering from natural erosion since a long period of the past due to variable climate conditions (from dry weather to moist), and the quantity and severity of rainfalls have had great impact on erosion in the region. It is estimated that 20% of the total annual rainfall become surface runoff and lead to erosion. Official records indicate that several meteorological stations in the highlands have recorded a total rainfall that exceeded 100 m.m in one day; i. e. average rainfall in one day was 158 and 115 m.m at Naur and (Irbid and Karak) respectively. The extent of soil erosion by rainfall varies according to slope grade and length, as its ability to erode increases with increased grade and length of slope.

Due to weak texture of shallow and steep lands, and its decomposition into its original components upon the first rainfall showers, the fine materials tend to block the voids in the surface layer, which increases surface runoff and, consequently, erosion. And the water of the surface runoff, together with the water-born fine particles, which are estimated to be about 1.9% of the water volume, block the voids and reduce permeability of the soil. And when the severity of rainfall increases, the surface layer, with its various size materials, is eroded. Meanwhile, it was noticed that medium size surface stones tend substantially to hinder erosion.

Results of studies indicate that sheet erosion at Zarqa River basin reaches 90%; and the rill erosion may reach 20%. Land slides prevail in the Semi-ghor regions of the basin at slopes exceeding 35%. And due to increasing populations and misuse of lands, expedite erosion has increased, which reduces the soil fertility and potential productivity. The main wrong farming practices in this region are the vertical plowing on the contours, use of improper plowing tools and excessive number of plowing operations. Preparation of land with minimum intervention by man and leaving remnants of plants on the soil surface minimizes erosion, as compared with other preparation methods contour cultivation, also, reduces erosion as compared with plowing along the slope. Moreover, the kind of plows used affects the volume of erosion; it was found that the use of the chisel plow is more suitable to Jordanian lands than the mold and other plows.

Another study (Batik & Arabiat, 1980) indicated that the highlands are dominated by water erosion, which was about 10-50 tons/ha in level regions (i. e. Irbid and Madaba) and about 200 tons/ha at steep regions. In addition, removal of forests, overgrazing and urbanization have increased soil erosion. A study of Wadi Ziglab basin indicated that average loss from bare surface soil was about 6-300 times more than it was from lands that are covered with trees and grasses.

Property and its Fragmentation

Lands in Jordan face several problems; on top of which are the property fragmentation, publicity and dispersion. In addition, the large geographic distance between these lands and the owners' living places reduces their economic returns in some cases. These problems can be attributed to the increased population pressure on agricultural lands, the laws pertaining to land holding and ownership (property, handling, use rights … etc.), and expanded urbanization. In spite of this, the government has succeeded in solving the property fragmentation at certain regions, and is endeavoring to solve it at the others.

Fragmentation of property, the scattering of the farming units and their declining area are considered crucial problems and constitute a significant obstacle to mechanization of agriculture and use of modern technological techniques, which has reduced agricultural production and abstinence of farmers from land utilization. In addition, the lands scattering and dispersion do not allow efficient management of these lands. And above all is the problem of encroachment onto the State lands, as the problem of encroachments onto forests, ranges, vegetation and water basins has not been tackled in a way that prevents their re-occurrence. Negligence to implement the laws, too, has led
to an increase in the size of these encroachments, with the subsequent environmental problems.

5-4 Urbanization Encroachment onto the Agricultural Lands

During the past three decades, the building and construction sector witnessed a large horizontal expansion at the expense of agricultural lands due to lack of an Optimum Land Use Law that is based on the degree of suitability of land to the various land uses. Construction has expanded, the local (village and city) councils' borders extended, and land sale prospered, which threatened the agriculture sector, 882 Thousand donums has been lost to be used as urban area. Records of the Department of Land and Survey indicate that the area of lands that has been allocated for urban centers as cities and villages (and which was solicited from the agricultural landuse) reached 169 thousand ha. That is in addition to the area already occupied by about 115 urban centers, which is estimated at about 23.3 thousand ha. All these lands are located within the best agricultural regions that receive an annual average exceeding 350m.m of rainfall. Moreover, major, secondary and village roads extend over 1606, 2396 and 1525km respectively. The total length of roads in the Kingdom is about 5527km.

If Amman is taken as an example for urban expansion, its total area in 1956 was 550 ha and reached 18 thousand ha in 1981. And in 1992, the total area of Greater Amman had become 63 thousand ha.

Furthermore, the urban expansion has led to abandonment of agriculture and shifting towards trading and sale of lands. Arbitrary urban expansion has also led to establishment of communities that lack proper sanitary conditions, such as improper water uses and inappropriate waste methods that polluted the surface and underground water sources and negatively affected the environment as a whole.

5-5 Rangeland in jordan

Rangelands have been classified as marginal lands, those receiving 200mm or less of rainfall annually. They comprise more than 80% of Jordan’s land area and constitute a resource with a potential greater than is recognized. It is estimated that the present annual production of range resources amounts to 262 million Scandinavian feed units (SFU) which cover not more than 30% of the present livestock requirement. In 1970, the production of feed from range was estimated up to 340 million SFU. It should be noted that 63% of this production is in relatively high potential regions, which cover no more than 12.5% of the total land area. The high potential regions are exposed to severe degradation by human activity more than the other regions. It should be understood that the proper management of the natural resources – soil, water, rangelands, forests and wildlife – cannot be successful without the support of the beneficiaries and their participation during the planning and execution of any program.

On most of the areas inspected, two processes appear to be going on simultaneously. One of the processes is over-grazing and the other is over-rest. Over-grazing long thought to be the result of too many animals grazing, is now known to be the result of timing. The real cause of over-grazing is the result of a high number of animals returning to re-graze an already grazed plant before it has time to recover from the first grazing. When this happens, root energy used for re-growth is not replaced before the plant is re-grazed. Continued grazing of plants in this manner creates a drain on root reserves until the plant dies. Ranges are over-grazed one plant at a time.

Over-rest, long considered beneficial on ranges actually can be a major factor in range degradation. In brittle environments, such as in Jordan’s, plants do not decay they oxidize. As animals in an un-controlled grazing pattern selectively graze they tend to pass up plants with old growth and over-graze plants with new growth. Plant material builds up in non-grazed grasses shading out growth points, enventually, causing the plant to die.

Un-grazed shrubs tend to get old, woody and un-palatable until they are completely neglected. The shrubs when un-pruned tend to die out. Shrubs pruned by grazing respond with new growth. Even over-grazed shrubs tend to be more vigorous than completely un–grazed shrubs. On ranges where few animals graze in loose bands, the tendency is for some plants to be over-grazed while others over-rest. The need then is for biological planned grazing where animals are densely grazed for short periods of time and are then moved to stimulate the movement of large herds of grazers, as was done in the past. This will rehabilitate the resource.

Planned grazing of this type can produce another beneficial effect. That of animal impact where densely herded and grazed animals will knock down old plant material with their feet putting oxidating organic material on the ground water. In this manner, the plant material can easily decay.

The hooves also break up soil capping, plant seeds and compact soil into prepared seed beds. The physical effect coupled with the nutrient benefit of dung and urine actually renovates the soil in a natural way. Animal impact in a properly planned grazing scheme will produce the tendency to move succession upward quite rapidly if monitoring and replanning are part of the action steps. Even low rainfall areas such as Badia will respond favourably to biologically planned grazing.

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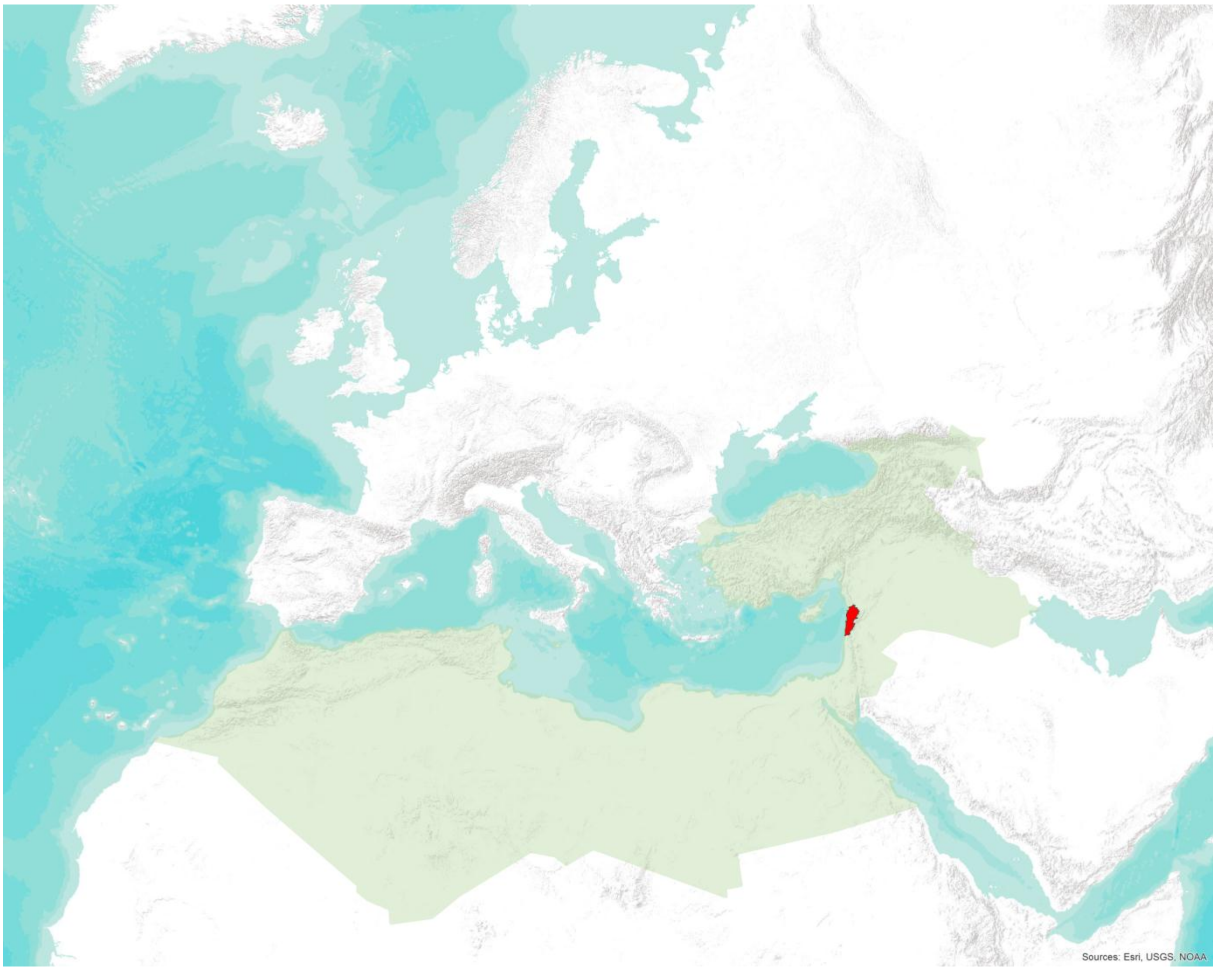
Chapter IX.
SOIL RESOURCES of LEBANON



SOIL RESOURCES of LEBANON

Talal Darwish[1]

ABSTRACT

Fragmented soil studies in Lebanon over the past fifty years focused primarily on soil genesis, classification and mapping. Earlier studies on the reconnaissance soil mapping at 1:200000 scale used the old French soil classification. Consequent studies in the sixties and seventies addressed soil genesis and suitability for irrigation, and mapped soil mineralogy using the American Taxonomy. Recent studies focused on soil fertility and management of major nutrients in calcareous soils. Special attention was paid to intensive agricultural practices on the coastal area and the resulting land degradation by salinity buildup in the soil-ground water system. In addition to the production of the soil map of Lebanon at 1:50000 scale, studies supported by the Lebanese National Council for Scientific Research (CNRS) and executed at the Centre Remote for (CRS) focused on soil erosion, soil contamination with heavy metals and nitrates, soil desertification causes and effects of soil salinity. Updating of soil information was done by the CNRS-CRS staff and the first soil map of Lebanon at 1:1 million scale was produced using the Georeferenced Soil Database of Euro Mediterranean Version 4 Countries in 2000. The further development of soil studies and capacities make the updating of soil database for Lebanon a feasible task for better integration into the regional soil database. Based on the progress made in national soil mapping since 2000 and the creation of the new Soil Geographical Database of the Euro-Mediterranean Countries, Version 6.0, the new soil map of Lebanon will be used using the level I (soil class) for the identification of major soil mapping unit. The detailed soil database will be mobilized to produce a more workable structure which can be harmonized and integrated with nested and regional soil maps and databases.

Keywords: Soil map, database, land degradation, soil pollution, erosion, sealing, east Mediterranean

INTRODUCTION

General Situation

Lebanon is a mountainous east Mediterranean country with old civilization, steep slopes and torrential seasonal rainfall. Since Phoenician times, land management was faced with soil erosion. The abundance of rocky lands with soil patches points to ancient process of soil erosion. For this reason, local population implemented terracing on sloping and steep lands to alleviate the impact of soil erosion and sedimentation. Recently, land degradation expanded and intensified to cover also soil salinity, soil and water contamination, soil sealing, drought and recurrent forest fires. The main driving forces of land degradation in Lebanon are; human pressure, poverty, mismanagement, deforestation, uncontrolled quarrying, overgrazing, chaotic urban expansion and weakness of policies and outdated legislation. Despite the promulgation of recent laws and elaboration of landuse planning project in 2003, the limited natural resources in the country are still subject to increased threats.

Geography

The Republic of Lebanon is located on the eastern coast of the Mediterranean Sea with a total area of 10,452 km² and population exceeding 4 Million. Slopping and steep lands with rugged mountainous characterize the country. Lebanon is characterized by the presence of two mountain chains positioned parallel to the coast, “Mount Lebanon” with the highest peaks reaching 3,088 m amsl to the west and “Anti-Lebanon” to the east at the Syrian border slightly exceeding 2,800 m amsl, separated by the Bekaa plain (Figure 1).

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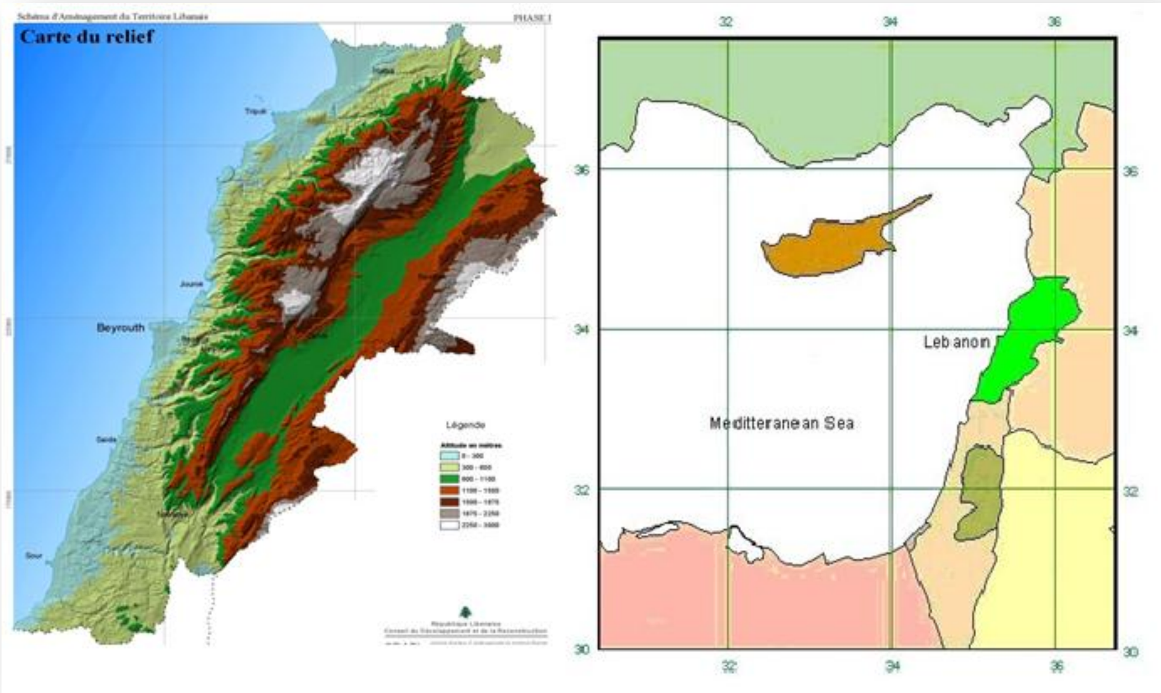


Figure 1. Digital Elevation Model (DEM) extracted from Stereoscopic Russian Image shows the complex topography of the country (Source: SDATL, 2004).

The change in elevation above sea level is abrupt. The coastal line stretches over 225 km from north to south representing relatively large plain in the north and narrow plains in the rest of the country.

Demography

The population of Lebanon is estimated at 4.0 million with an estimated growth rate of 1.2 percent between 2000 and 2015. Population is unevenly distributed across the country with more than 90% living in urban areas; 60% of the population is squeezed onto 8% of the land in the narrow coastal zone (CDR, 2004). The spatial distribution of the population has major implications for the environment, in terms of demand for land and water resources, the use of land, and for the environmental services it provides (ECODIT, 2009). Beirut with more than 1 million people is the administrative capital of Lebanon. Tripoli, located 90 km north of Beirut, represent the second capital with about 268 thousands inhabitants. Saida (Sidon) – 196 thousands and Zahlé – 148 thousands inhabitants are located 41 km south of Beirut and 47 km east of Beirut respectively are followed by Tyr (Sour), with 205 thousands inhabitants, located 79 km south of Beirut (SDATL, 2004).

Climate

Lebanon has a typical Mediterranean climate with long, dry summer and mild winter with torrential rain and relatively short spring and autumn seasons (Figure 2). The complex orography and vicinity to the Mediterranean Sea predetermine Lebanon’s climatic conditions. Local topographic features and the Arabic Peninsula in the east create a variety of micro-climates within the country with contrasting temperatures, rainfall amount and distribution. Conditions vary from typical Mediterranean climate along the coastal plain to subhumid in the middle mountain range and sub-alpine or mountain Mediterranean climate on the highest slopes, which are covered by snow during at least six months per year

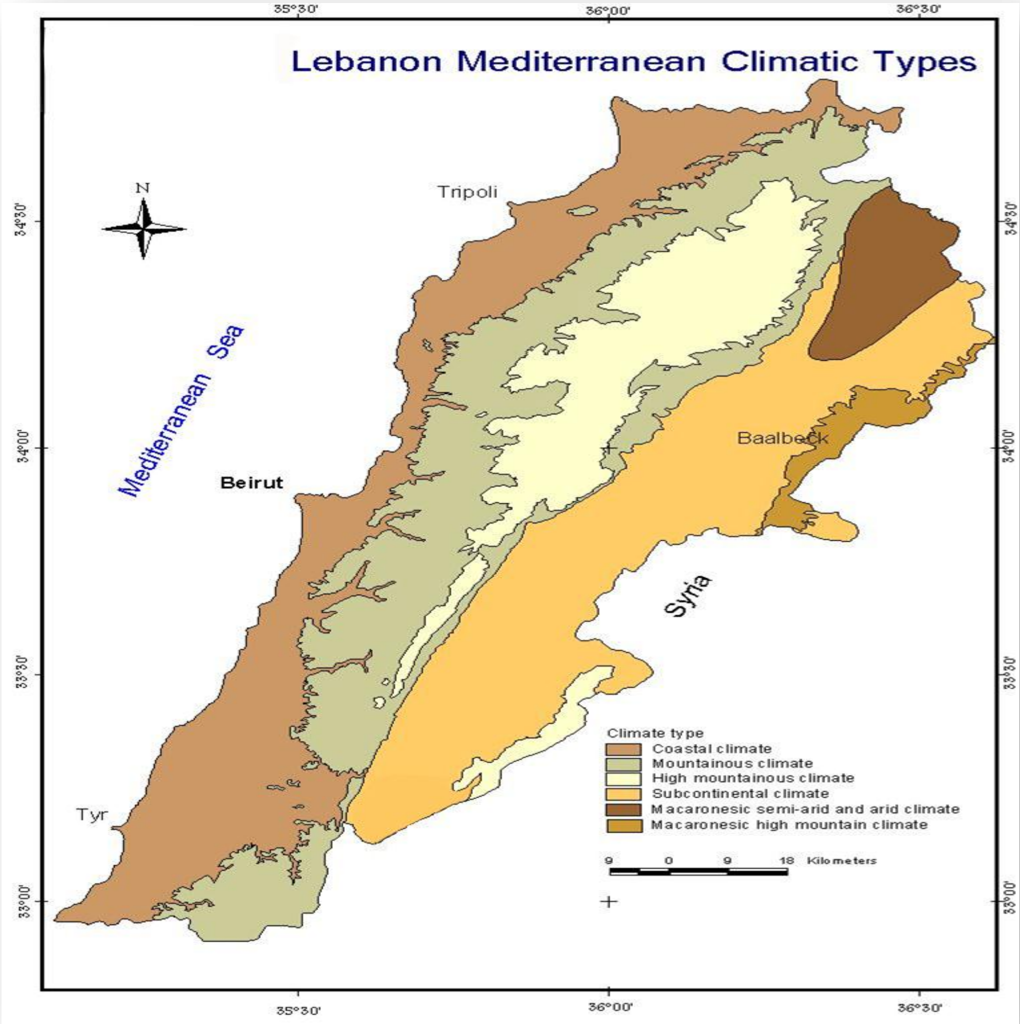


Figure 2. Main climatic types of the Lebanese Republic classified according to the Soil Geographic Database of Euro-Mediterranean countries (Source: Darwish, CNRS).

Geology

The geology of Lebanon was grouped into seven major associations. Based on porosity four groups (quaternary alluvial and colluvial sediments, fluvial and tertiary sediments-marl, shale and clay) have different, relatively low, permeability. The non clastic Mesozoic sedimentary carbonates (mainly limestone and dolomite) expose secondary porosity and present elongated fractures with large spacing; thus, they have high permeability. The clastic Mesozoic sedimentary rocks (sandstone), defined as low permeable, since they include chaotic inclusion of clay either laterally or vertically. The volcanic rocks (basalt) are locally permeable except when they include soft tuff material. This classification is important for the assessment of the soil formation and evolution, regional and local drainage, land capability and land management in Lebanon and for the estimation of soil erosion risks, soil hydrologic regime, water retention capacity and fertility potential and irrigation scheduling.

Natural resources

Lebanon consists of the coastal plains where precipitation is close to 800 mm and the climate allows the development of vegetable, fruit crops and greenhouse production. This area stretches from Abdé in the North to Nakoura in the South and can be divided into relatively large northern plain of Aakkar with about 14, 000 ha mainly irrigated lands with field crops and 5000 large livestock units. The coastal band includes several narrow coastal plains with useful agricultural area of 15 000 ha. The Mount-Lebanon includes shelf of Aakkar in the North to Shuf-Naher el Awali in the South. It is characterized by high precipitation, altitudes ranging between 250 m and 2000 m, a development of irrigated arboriculture and non-irrigated olive trees, apple, vineyards and almond trees. The dimension of surfaces to forest nature and pastures allow a livestock development, and particularly goats. Forests covered 139,376 ha while Other Wooded Lands (OWLs) covered 108,378 ha, 13.3 percent and 10.37 percent of the surface area of the country respectively. Other lands with trees (including fruit and olive trees) covered a surface of 116,210 ha (11.1%) of the surface of the country (MoA/FAO, 2005).

The Bekaa plain is divided into two distinct parts: the Orontes Valley, which is characterized by a low level of precipitation (between 200 and 400 mm), and large tracts of pastures. The useful agricultural area is in the order of 20,000 ha of which 53% is irrigated and the livestock, mostly cattle and goats, is of the order of 21,000 large livestock unit. The Central and South Bekaa is the most fertile region of the Lebanon and characterized by a precipitation ranging between 500 and 800 mm. The useful agricultural area is estimated at about 64,000 ha of which 61% are irrigated and a developed livestock. This region is a consistent part of Lebanese agriculture with 25% of the large livestock unit, 25% of useful agricultural area and 30% of the irrigated useful agricultural area of the country.

The Anti-Lebanon is a mountainous area that has a low level of precipitation and useful agricultural area in the order of 7,000 ha of which 13% is irrigated. The Hermon Mountain in the South East represents a useful agricultural area is the order of 13,000 ha of which 16% is irrigated. The southern Plateau is characterized by an altitude ranging from 250 to 800 m and a relatively high level of precipitation ranging between 600 and 800 mm. The useful agricultural area is the order of 35,000 ha of which 16% are irrigated and the numbers of livestock, mostly sheep and goats, is estimated to be 24,000 small ruminant units.

There are fourteen permanent watercourses (rivers) in Lebanon, which are considered of the small-scale type, in terms of spatial area and discharge (Table 1). The majority of feeding to these rivers is from the melting snow and the issuing springs. Three of these rivers (El-Kabir, Orontes and Wazzani) are shared with the neighboring regions. Whilst, the coastal rivers (Litani, Ibrahim, Abou Ali…) are almost with short length (i.e. <60km) and characterized by steep sloping terrain, which accelerates run-off velocity (5-10 km/hr), thus resulting in uncontrolled discharge of water to the sea.

Table 1. Rivers of Lebanon

No*	River	Average annual discharge (Mm^3/year)	Watershed Area (km^2)
1	El-Kabir	213	195 (within Lebanon)
2	Al-Bared	168	284
3	Abou-Ali	369	482
4	El-Jauz	82	196
5	Ibrahim	498	326
6	El-Kalb	251	237
7	Beirut	101	216
8	El-Damour	256	333
9	El-Awali	284	291
10	Siniq	111	102
11	El-Zahrani	202	140
12	Litani	387	210
13	Orontes	470	1980 (within Lebanon)
14	Hasbani-Wazzani	190	625 (within Lebanon)

Land use systems

The land use map of Lebanon published by CDR (SDATL, 2004) showed that the major agricultural areas are located in the Bekaa followed by the Akkar plain and South Lebanon. These are occupied by rainfed and irrigated field crops, irrigated vegetables, grape and fruit trees production. The mountainous areas of Lebanon including the Anti-Lebanon mountains represent valuable source of terraced fruit trees (apple, cherry, peach and others).The olive orchards map produced by CNRS (2010), based on IKONOS 2005, indicated the area of olive to slightly exceed 45000 ha while MoA estimates for 2000 were of estimations 58000 ha.

COUNTRY SOIL INFORMATION and DATA

Legacy Soil Information and Digital Soil Resources,

In Lebanon, the first soil studies and maps were produced during the 1960s and 1970s by the Lebanese Agronomic Research Institute (LARI). The 1975-1990 civil war, however, greatly curtailed its abilities to engage in similar studies. There has not been any new recruitment drives, and funding has not been adequate. LARI is currently focusing on the study of climatic data, introduction of new crop varieties, controlling crop and animal diseases and testing of virus free seedlings. The produced maps before 1975 targeting suitability for irrigation, soil amendments and fertility aspects covered dispersed areas at different scales ranging from 1:50,000 to 1:20,000 (Table 2). The unique full-coverage soil map that covers the whole country, at a scale of 1:200,000 dates from 1952 and was compiled by Bernard Geze. This map represented a coherent work, which was based on aerial photos and limited field sampling and analytical data. In 2000, it was converted into digital format at the National Council for Scientific Research-National Center for Remote Sensing (CNRS-NCRS).

In 1997, the establishment of the CNRS-NCRS signaled a new page in soil related activities by embarking on a number of new projects. One such major effort was the mapping of soil resources with the use of remote sensing and integrated information systems for the creation of a new soil map for Lebanon at 1:50,000 scale accompanied by a soil terrain database (Darwish, 2001). This work was carried out in parallel with the updating of the soil map of Geze at 1:200,000 and production of a digital version implementing the FAO-UNESCO Legend and the World Reference Base for Soil Resources (WRB, 1998).

Table 2. Available soil information in Lebanon

Author	Theme	Scale	Date	Type of spatial object	Owner/ Provider
Bernard Geze	General soil map of Lebanon	1:200,000	1956	Polygons and report	MoA
UNDP, FAO	Suitability for irrigation	1:20,000; 1:50,000	1969	Polygons and report	LARI
A. Sayegh et al.	Mineralogy	1:200,000	End of 70'ˢ published in 1990	Polygons and report	CNSR
W. Verheye	Classification, South Lebanon	1:50,000	1973	Polygons and report	CNRS
T. Darwish et al.	Detailed soil map	1:50,000	2006	Polygons Database	CNRS
T. Darwish et al.	Erosion	1:200,000	2002	Polygons Database	CNRS
T. Darwish et al.	Soil desertification index	1:200,000	2002	Polygons Database	CNRS
T. Darwish et al.	Heavy metal pollution, Central Bekaa and North	1:50,000	1999-2004	Polygons Database	CNRS
T. Darwish et al.	Nitrate contamination, Central Bekaa	1:50,000	2007-2009	Polygons Database	CNRS

The CNRS-NCRS team also created the Soil Geographical Database at 1:1,000,000 scale for Lebanon based on the Euro-Mediterranean methodology, as part of European Soil Bureau project covering the whole Mediterranean basin. Soil information available at NCRS was largely used for the production of different vulnerability and hazard maps including the National Action Program to Combat Desertification and “Schema Directeur d’Amenagement des Territoires” of Lebanon (SDATL). Further soil studies by the NCRS team produced the maps on heavy metal content in the soils of central Bekaa as part of the Arab-German project: Protection of the Soil Ground Water System from Contamination with Heavy Metals. The project evaluated land quality using Eikman Klocke concept for the agricultural and non agricultural use of lands based on the levels of contaminants. Similar studies were carried out by the NCRS team in North Lebanon within the framework of a project supported by the Lebanese French program: L'Accord de Coopération pour l'Evaluation et le Développement de la Recherche - CEDRE.

Soil Classification, Soil Surveys and Current Soil Mapping Efforts

With the increasing human pressure on limited land resources, the analysis of land system management and soil degradation gain exclusive interest. An important place is allocated to the impact of land degradation both on local and regional levels. Because the consequences of land degradation are not limited within national borders, response to land management counts across countries. In view of the Euro-Mediterranean partnership, integrating the soil information into the Soil Geographical database of Euro-Mediterranean Countries (Jamagne *et al.,* 2001; Lambert *et al.*, 2003) seems crucial for the harmonization of efforts to combat desertification and reverse land degradation. The work program is facilitated by the availability of several databases addressing soil mapping and management e.g. the Global and National Soil and Terrain Database (SOTER, 1995), the

FAO database (Krone and Utermann, 1998), the Georeferenced Soil Database for Europe (Finke *et al*., 1998).

These procedures are workable at different scales starting from the 1:5 M. until 1:100,000 scale for the SOTER and from 1:1 M. till 1:250,000 scale for the other databases. The FAO-dbase is a soil profile and laboratory frame representing a tool for the organization of field and laboratory investigation. It allows the laboratory data storage and thematic tabular retrieval. The remaining methodologies are not strictly a cartographic tool but conceptual models with computerized structure of the data. Mapping is allowed through the use of traditional soil maps and description of the spatial relationship among objects involving the landform and geology. Building a digital soil database facilitates its application for major classes, environmental functions, and sensitivity to degrading influxes and land capability classification (Montanarella and Nègre, 2001).

But, while SOTER traditionally uses the available soil maps as support to build the database, with the related eventual loss of some information, the European methodologies aim at preparing a geographic database by relegating the problem of the cartographic representation of data to a secondary position (King *et al*., 1994). The transformation of the European soil map at 1:1 M. scale into database required additional archiving work to make the base operationally usable in European programs (Burrill and King, 1993). Thematic mapping is usually based on the agro-hydrologic model (soil and water assessment tool-SWAT), universal soil loss equation (USLE) and German concept on soil protection effectiveness (1994). Analyzing the soil vulnerability to contamination, impact of the environment and landuse change on water quality, predictive erosion and desertification hazards necessitate the retrieval of spatial data from the database, which allowed, for instance, predicting nitrates fluxes in the soil-groundwater system and elaborating mitigation scenarios (Laurent and Rossignol, 2004).

Recent soil mapping addressed the production of the new soil map of Lebanon and derived first soil database in the country using the Euro-Mediterranean methodology at 1:1 M. scale (Darwish et al., 2000). In this work, the available soil data starting from the 1950ies were used and enriched with more recent soil mapping and characterization (Lamouroux, 1971; Osman, 1980; Verheye, 1973; Darwish et al., 1999a). Despite the small scale, the resulting soil map and database maintained the small non mappable units to reflect the soil geomorphologic diversity and the need for a differential approach in land suitability and soil management at the national and regional levels. Thus, the database evaluates the possibility of using the proposed new geometric and attribute information to estimate the overall land capability, sensitivity of the ecosystems to erosion and desertification. The derived maps assisted the elaboration and integration of national policies addressing the decision making on soil management and protection issues that can serve land use planning.

According to this map and classification, the relatively deep Inceptisols and shallow Entisols (Keys to Soil Taxonomy, 2006) named also Cambisols and Leptosols (WRB, 2006) are occupying the Lebanese mountain landscape in association with rocky lands, Regosols and other very shallow soils (Lithic leptosols, Lithic Luvisols) (Figure 3). This landscape is hilly to mountainous with limestone as the dominant rock type (Darwish and Zurayk, 1997). Terraced land (Terric Anthrosols) is mainly used for fruit trees production. These soils are distributed among the marginal lands with eroded Lithic Leptosols, which are used for grazing. With historical deforestation, urban encroachment and animal pressure, erosion is normally enhanced, notably along the slopping lands of both east and west mountain chains. For this reason, these soils are truncated, young and not developed. On moderately sloping and rolling lands, Xeralfs (Luvisols) are the classical mature red Mediterranean soils formed on limestone or other basic rocks. They occupy about 52% of the zones with xeric Soil Moisture Regime. On level lands (Plaines, valley floors, footslopes) Fluvisols and Vertisols develop from quaternary alluvial and colluvial sediments. The vertic soil types are prone to swelling shrinking upon drying-wetting which can cause problem to plant root system due to soil physical properties.

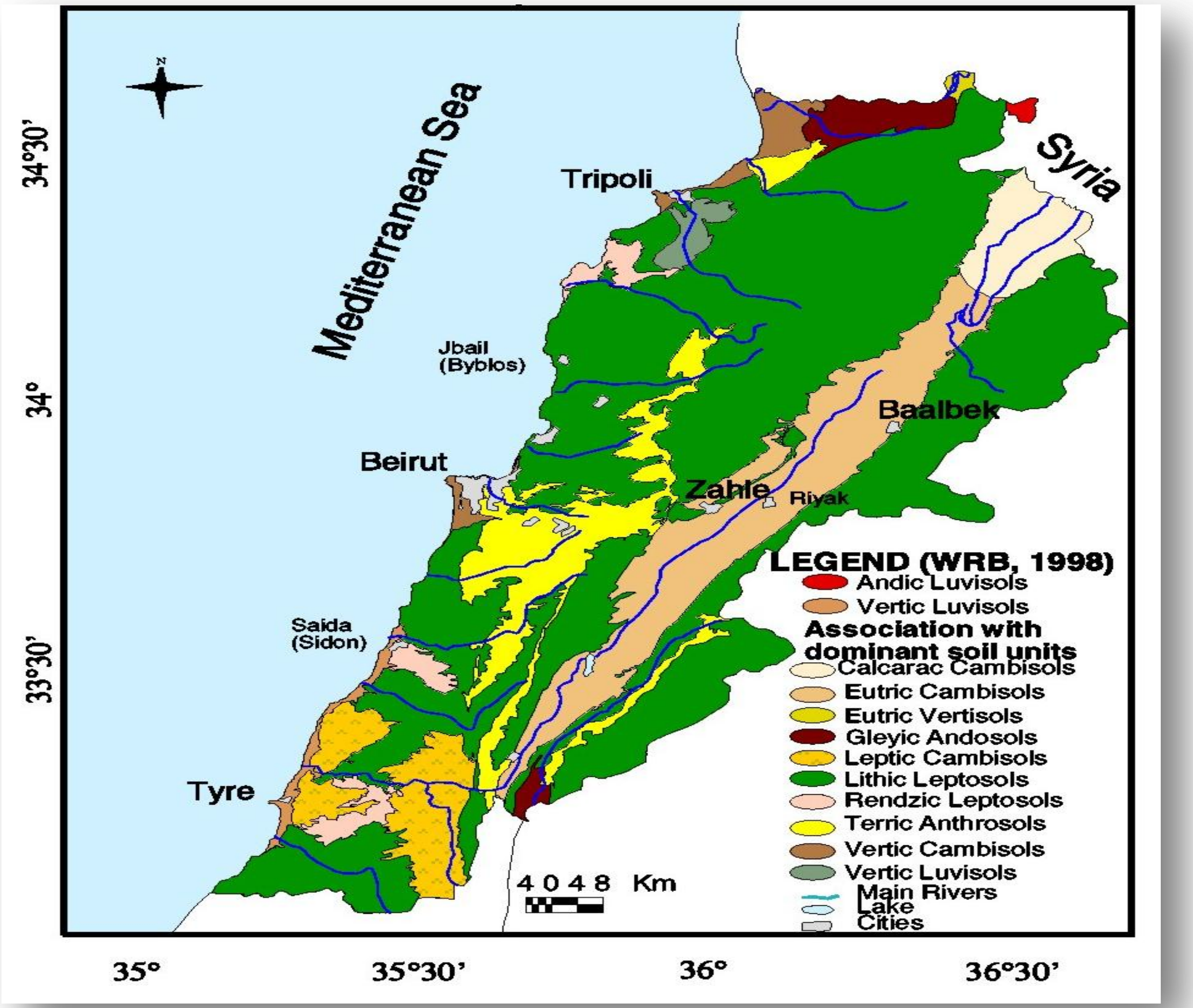


Figure 3. Soil map of Lebanon at 1:1,000.000 scale (Darwish et al., 2000)

The first complete soil map of Lebanon at a scale of 1:200,000 appeared in the early fifties of the last century (Geze, 1956) the names were updated and the map was converted into digital format (Figure 4) in 2000 (Darwish et al., 2002a). The original hard copy soil map was the result of a French-Lebanese co-operation with the Lebanese Ministry of Agriculture. In early fifties the mission established the Lebano-French station at Rayak-Tal Amara. The map was based on fieldwork and on the earlier produced geological maps of Lebanon at 1:50,000 and 1:200,000 scales (Dubertret, 1941-1955), as well as on aerial photos. Geze used the topographic maps of the country at 1:50,000 scale for geographical location, field validation, description and sampling. The results were presented in the "*notice explicative*" published in the mid fifties (Geze, 1956). The "*notice*" contained detailed additional information on Lebanon's geomorphology, climate and soil characteristics.

Soil names were largely based upon the soil nomenclature reflecting early attempts of soil studies and classification in the Middle East region. In a sense it anticipated the old French classification of Aubert and Duchaufour proposed in 1956 at the VIth International Congress of Soil Science held in

Paris. Geze's soil categorization was also based on the works of other French soil scientists who worked in ORSTOM (Segalen, 1977). The main criteria for soil identification and therefore soil names used by Geze in the Soil Map of Lebanon were: soil color, lithology and texture. The map and its legend, however, were up to most recently the only complete soil map for the country, and thus could be considered as an initial national soil classification system. This is true despite the non-uniform basis for soil type identification and nomenclature used which characterizes the early attempts of soil classification.

The striking diversity of Lebanese topography, geology, climate, hydrology. vegetation and human impact results in a remarkable mosaic of soil types that rarely can be found in comparable areas. This is why Geze's approach relied on applied pedology in a way to facilitate availing practical knowledge for soil management. Geze rightly considered the map a reconnaissance soil map of Lebanon and frame for future research on more detailed soil cartography. However, the progress made in soil studies and classification world-wide was not reflected in the production of new and updated Lebanese soil maps.

This was partially due also to the civil war in the country (1975-1990). Obviously, the need to upgrade Geze's map arose, and the opportunity came through the support of the European Commission's Soil Bureau (ESB). Funding was provided within the framework of the EC's ResManMad project (ERBIC18CT970151; 1998-2000). Thus, a new digital soil map of Lebanon at a scale of 1:250,000 appeared as updating of existing old soil information which kept the geometric dataset while converting the soil names into FAO and WRB nomenclature (Darwish et al., 2002b). The original attribute data were enriched from modern soil studies to produce thematic maps related to the national land use planning project (SDATL) and national action program to combat desertification (NAP).

Soil information was further updated with the production of the new soil map of Lebanon at 1:50,000 scale (Darwish, 1999; Darwish et al., 2006a) using the FAO-UNESCO, WRB legends and USDA soil taxonomy (Figure 5 and 6). Information derived from this map has been used for the national land use planning project, national action program to combat desertification and production of different thematic maps related to flood and forest fires risk mapping.

Other soil studies addressed rangeland degradation by overgrazing (Darwish and Faour, 2008), soil salinity on the southern coastal strip (Solh et al., 1987), the causes and impact of soil salinity on the Lebanese coast (Atallah et al., 2000; Atallah et al., 2009) and inland north east Bekaa (El Khatib et al., 1998; Darwish et al., 2005a) and the evaluation of hydrodynamic features of alluvial soil from Bekaa (Chalhoub et al., 2009). Soil erosion has been treated from the vulnerability point of view involving erosion factors in different GIS models (Bou Kheir et al., 2001) with a few studies on descriptive soil erosion within two Lebanese watersheds (COLD, 2004).

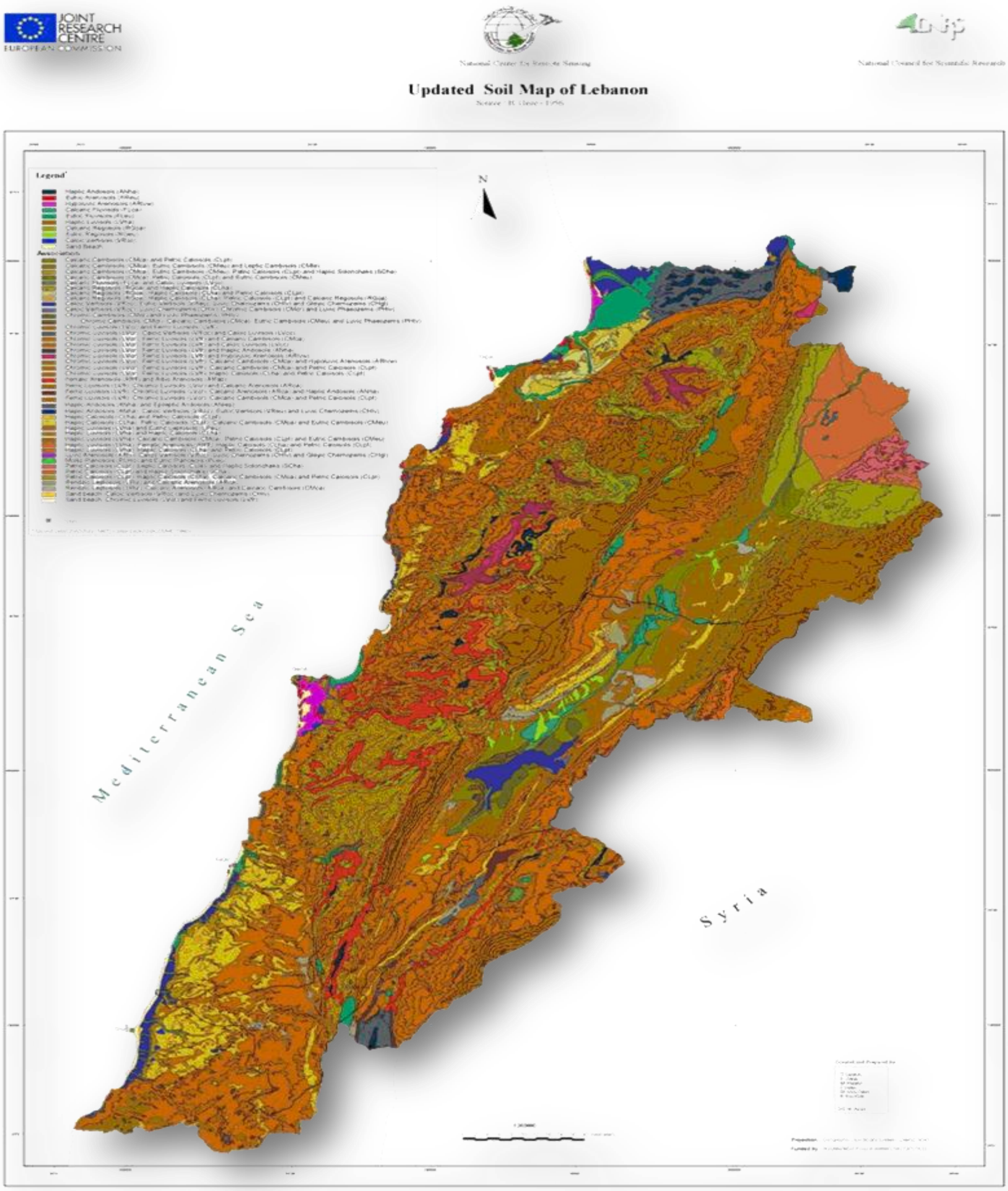
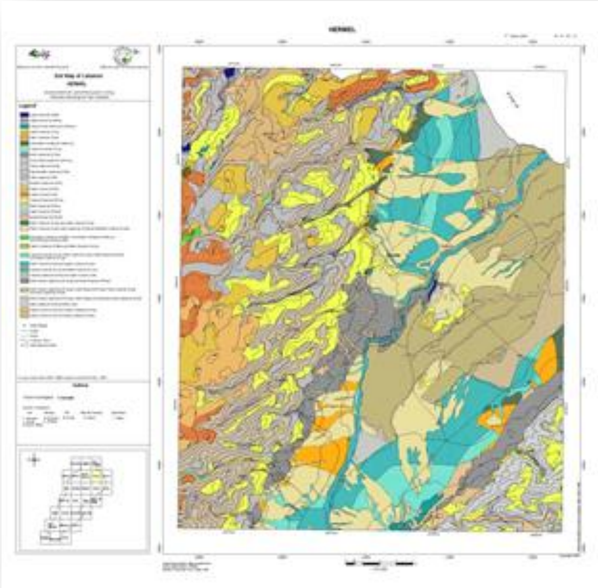


Figure 4. Updated soil map of Lebanon at 1:200,000 scale (Darwish et al., 2002a)

Land degradation as perceived by local population (Zurayk et al., 2001) and loss of productive soils as a result of urban expansion (Darwish et al., 2004) and land abandonment (Youssef et al., 2009) and pressure on marginal lands by overgrazing (Darwish and Faour, 2008) were assessed using GIS and RS. Soil vulnerability to desertification based on soil chemical and physico-chemical properties was assessed for the National Action Program (NAP, 2003) to combat desertification in Lebanon (Darwish, 2003). Pilot area studies on soil pollution assessed nitrate and heavy metal risk (Moeller et al., 2003), heavy metal background values (Nsouli et al., 2004), the risk of pollutant transfer to groundwater (Darwish et al., 2008) and pesticide adsorption and degradation on soil particles (Thomas et al., 2005). More recently, soil resilience and the adaptation of the agricultural sector to climate change

(Hamzé et al., 2010) and the impacts of abandoned quarries on soil and water resources were assessed by Darwish et al. (2010).



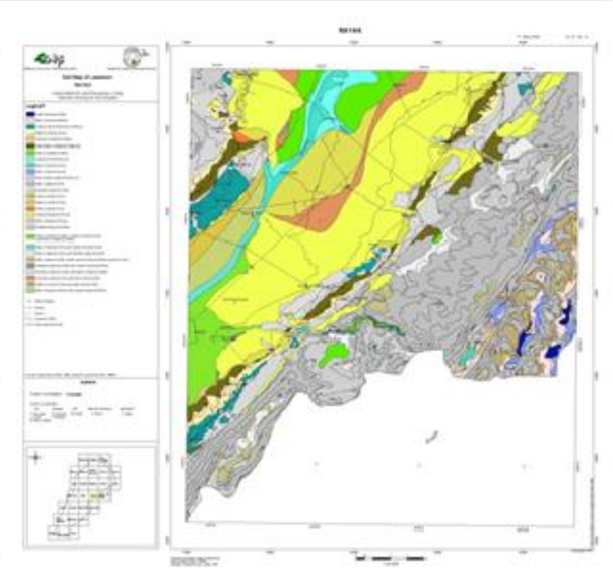


Figure 5. Soil map of Hermel, north-east Lebanon **Figure 6.** Soil map of Ryak, Central Bekaa, Lebanon
Source: Darwish et al., 2006a

SOIL THREATS

Land resources in Lebanon have been continuously under pressures from the abundance of bare and deteriorated lands and shallow soils pointing to severe erosion and land degradation. Several natural and human-induced factors contributed to land degradation in the country. Lebanon is distinguished by a rugged topography with 64% of territory having complex landform with sloping and steep slopes, enhancing water-erosion. Torrential rainfall causes flash floods and erosion sometimes leading to mass movements due to poor drainage and weak lithology.

Deforestation and degradation of vegetative cover in the mountains are among the most direct and oldest human-induced factors of land degradation. Unfortunately, such negative impacts keep piling up: forest fires and chaotic urban sprawl amplifying the negative impact of deforestation. Inappropriate irrigation practices and fertilizer application causing secondary soil salinization not only in the arid inner dry areas but also in the more humid Mediterranean coast with protected agriculture. Improper practices also lead to deterioration of groundwater quality and soil contamination hazards. The integrated approach reviewing natural and human factors of soil degradation in Lebanon facilitates the monitoring of land degradation, extraction of indicators and the elaboration of measures to prevent and reverse land degradation.

Urban Encroachment on Arable Lands

Rapid and chaotic urban growth is one of the principal causes of desertification in the Mediterranean area (Eswaran and Reich, 1997). This is particularly true in Lebanon where the total urbanized land covers a cumulative area of 646 km^2, or 6.3% of the Lebanese territory. The area between 0 and 400 meters above sea level represents 19.3% of the country. The most important urban agglomerations are concentrated on the coastal zone, which comprises 47% of the total urbanized area (Dar-Iaurif, 2002). The improvement in the traffic circulation network between the capital Beirut and other coastal cities will intensify the urban stress along the coastal region. The integration of RS and GIS provides an efficient way to monitor changes, thus contributing to environmental assessment of land degradation. This is reflected in the comparison of urban sprawl over Lebanon (Figure 7) with the soil aptitude for agriculture (Figure 8).

Comparing land capability/suitability for agriculture with the observed chaotic urban expansion on the country level revealed that the total urbanized area in Lebanon detected from Landsat in 2005 cover 1348 km^2, or 13.2% of the Lebanese territory (Figure 7). Among these, an area 650 km^2 was located on prime lands consuming the highest proportion (31%) of these lands. On the other hand, the urbanized area in and around Beirut has increased from 254 km^2 in 1963 to 599 km^2 in 1998, i.e., more than two fold. Urban sprawl encroached on agricultural land near the coastal cities Tripoli, Byblos, Sidon, Tyr and invaded the forested mountain slopes overlooking the coastal plains, i.e., Jounieh bay.

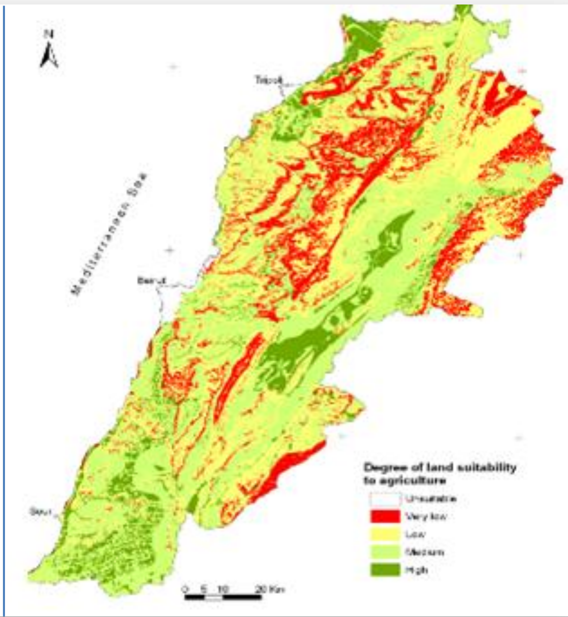


Figure 7. Urban sprawl into different lands in Lebanon (Landsat 2005) **Figure 8.** Soil aptitude to agriculture based on measured morphological and soil data
Source: CNRS, Lebanon

According to the Ministry of Transport, encroachment on the maritime public domain is at around 1,532,704 m^2, with the highest percentage in North Lebanon, followed by Central Lebanon (ECODIT-IAURIF, 1996). Moreover, more than 24% of the terrain stretching over the coastal zone of Lebanon (225 km in length and 8 km in width), is urbanized (Huybrechts, 1997). Large scale multi temporal image analysis of land use change in the second largest coastal city Tripoli (North Lebanon) and its surroundings, revealed a large expansion of urban areas between 1964 and 2000 at the expense of natural habitats (Figures 9 and 10) (Darwish et al*.,* 1999b). This was about 208% fold increase in urban expansion, with a simultaneous loss of 2702 ha of prime land and reduction of arable land by 60% (Table 1). The intersection of land use and soil capability maps of Tripoli area showed a mean loss of 67.5% and 19.2% of class 1 and 2 soils respectively. This loss of natural resources implies a clear threat to productivity, quality of life and the sustainability of agriculture for coming generations.

Soil erosion

Several studies in the CNRS-NCRS combined remotely sensed data and GIS technique to produce soil erosion vulnerability maps. For example, the assessment of erosion in the central Lebanese mountains showed more than 90% of the area having moderate and high erosion rates (Faour et al., 1999; Bou kheir et al., 2001). One of the essential dynamic factors in this context is related to the human impact on soil development and sedimentation. Erosion importance is amplified by the abundance of steep slopes and barren lands notably in the mountain areas. Excavation processes such as quarrying, construction practices, wrong agricultural operations and deforestation represent the main cause of soil erosion.

The analysis of potential soil erosion as a function of soil characteristics (soil depth, structure, texture, organic matter content, structural stability), geomorphology and climatic conditions (Figure 11) showed the frequent occurrence of medium, high and very high erosion on the escarpments of the western and eastern mountain chains in Lebanon (Darwish et al., 2002b). Recent studies used RS and GIS techniques to assess soil erosion in Mediterranean karst landscapes (Bou Kheir et al., 2008) and derive the risk of gully formation and diagnosis (Abdallah and Bou Kheir, 2009). However, despite the abundant number of models and studies on soil erosion in Lebanon, these studies are purely qualitative assessments of potential soil erosion. A semi-quantitative assessment of soil erosion was tested by the NCRS team in two watersheds of Lebanon (Khawlie and Darwish, 2005). Results showed the spatial distribution of single or multiple processes of erosion (splash, sheet, rills, gully, and mass movement), their combination, intensity and percent of area affected.

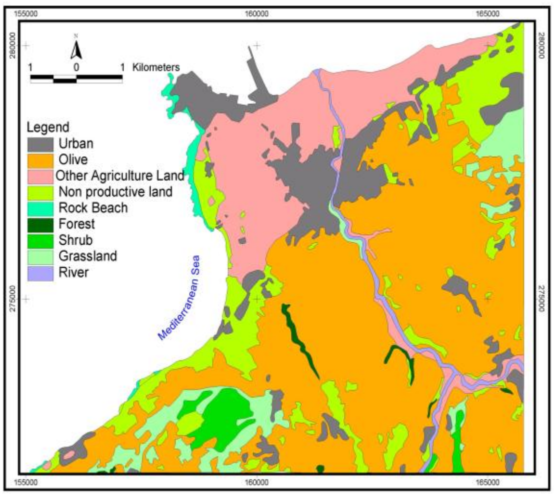


Figure 9. Land use of Tripoli in 1964

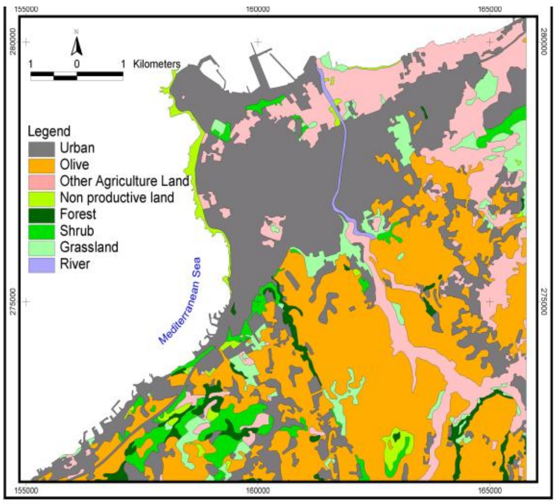


Figure 10. Land use in Tripoli in 2000

Source: Darwish et al., 2004.

Soil salinity

More than two thirds of the soil resources in Lebanon are facing additional stresses like alkalinity, moisture deficit, mismanagement of irrigation, fertilizer input and salinity (Darwish, 2001). In Hermel area, north east Lebanon, more than 52% of monitored sites at open fields, showed soil salinity (ECe) to be from slightly saline to saline (El Khatib et al., 1998; Darwish et al., 2002c). Recent monitoring of ECe of the saturated-paste extract of 75 samples in Qaa indicated an increasing proportion of salt-affected soils in comparison with the previous field sampling undertaken in 1997 in the same area (Table 2). However, the statistical analysis showed no direct correlation between secondary soil salinization and the amount of added manure. It is rather the combination of high evaporation rate and the use of manure with high salinity index mineral fertilizers coupled with mismanaged irrigation and restricted drainage that probably enhanced the salinity buildup in the soil.

Similar cases on seawater intrusion into coastal aquifers and secondary soil salinization were reported on the coastal strip by other workers (Atallah et al., 2000; Darwish et al., 2005a; El Moujabber et al., 2006). Results showed a steady increase in the soil electrical conductivity (ECe) from 0.4 dS/m to 15 dS/m (Solh et al., 1987) and explained by poor soil leveling. However, soil salinity rose up to tenfold inside the greenhouse compared to outside soil. This was associated with excessive input of fertilizers (Atallah et al., 2000) and use of saline water in irrigation and chlorine accumulation in the soil (Atallah et al., 2009).Improving fertilizer use and the efficiency of water application was possible through fertigation of protected and open field crops based on soil conditions and crop demands.

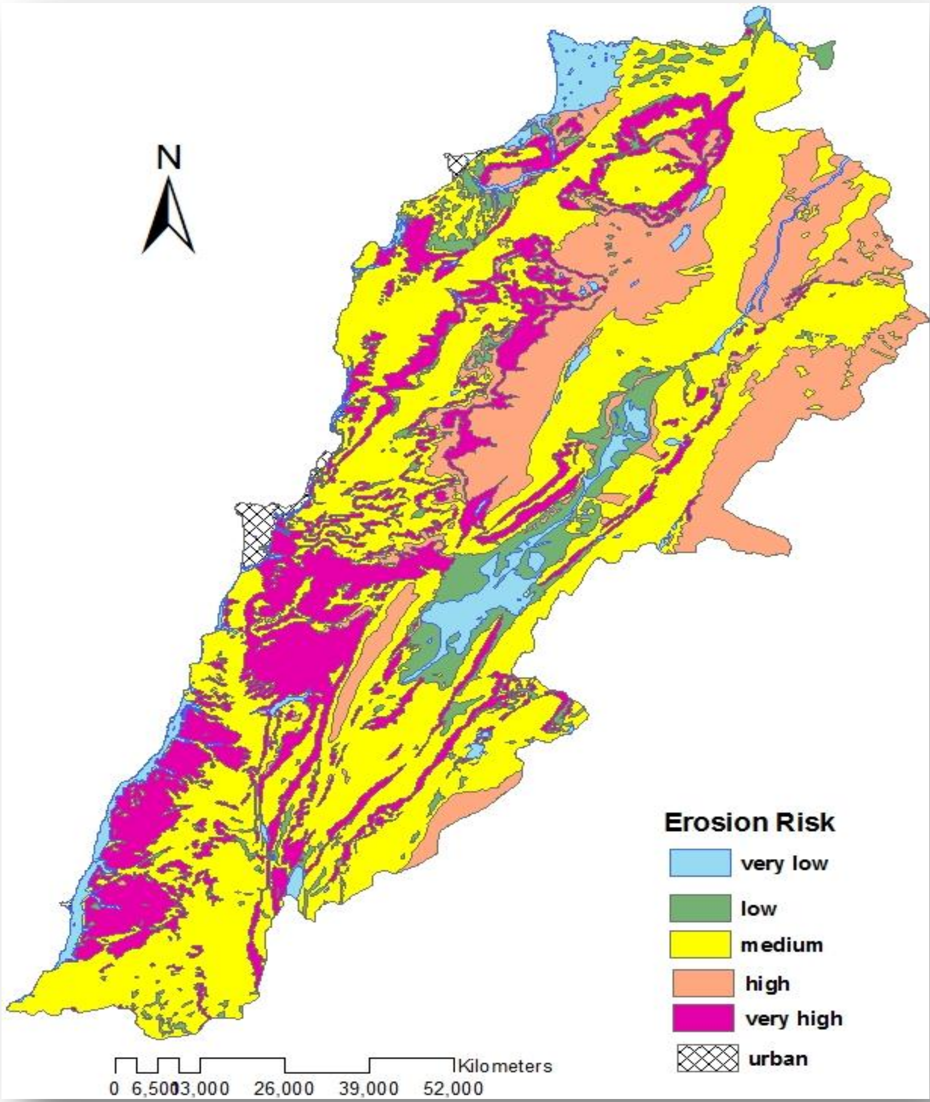


Figure 11. Potential soil erosion map of Lebanon at 1:200,000 scale

Soil pollution
Human activities, industry, manufacturing and agriculture resulted in a slight accumulation of certain heavy metals in the soil with possible contamination of high water table with Ni, Cr and nitrates (Darwish et al., 1999c). The cooperative project between CNRS-NCRS, ACSAD and BGR on soil-groundwater protection from pollution in a pilot area of Central Bekaa plain confirmed that in addition to the geogenic origin, excess fertilizer input, possibly carrying heavy metals as by product, and the use of low quality irrigation water are major causes of heavy metal input to the soil-groundwater system (Moeller et al., 2002; Mueller and Darwish, 2004).

Monitoring of soil radioactivity twelve years after Chernobyl accident showed a relatively high 137 Cs activity per surface area contamination, up to 6545 Bq/m2 in the top soil layer 0-3 cm of some Lebanese areas, associated with an exponential decrease in levels with depth (El Samad et al., 2007). On the other hand, the level of residual DDT in Lebanese soil samples were within the permissible limits for agricultural soils except in two surface soil samples collected from urban areas with high human activities (Dagher et al., 2004). The assessment of pollution from phosphate fertilizer industry showed significant enrichment in the soil of surrounding areas of toxic, bio-available trace elements (Cd, Zn) (2.5-6.9, 295-506 mg/kg) and radionuclide (U, 20-98.69 mg/kg) leading to soil, plant, and groundwater contamination (Kassir et al., 2011a). Similarly, soil amendment by phosphogypsum application to a Mediterranean red soil was assessed (Kassir et al., 2011b). Results showed toxic metal transfer from the soil surface to a soil depth between 20 cm and 55 cm with decreasing mobility in the order Zn>Cd>Pb>Cu pointing to the risk of Cd accumulation in crops.

Poor rotation, low water and fertilizer use efficiency resulted in increased nitrate content in the soil and groundwater (Darwish et al., 2009; Darwish et al., 2011). Fortunately, soil protection effectiveness is still significant via the possible heavy metal transfer to deep aquifer. But, indications for a higher leaching potential of soluble pollutants within the soil are the constantly high concentrations of nitrate down to 5 m depth at the permanent vegetable production and fruit trees cultivation sites of Central Bekaa area (Figure 12).

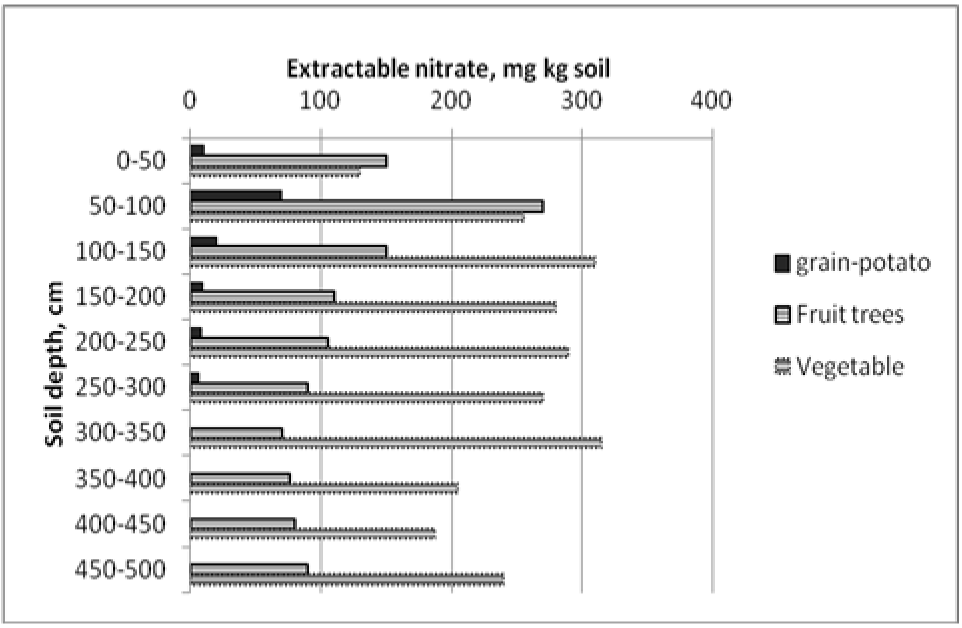


Figure 12. Depth distribution of soil nitrate (Nmin) as a function of different landuse (Darwish et al., 2009)

Nitrate accumulation in the soil can pose problems not only to the soil-groundwater system but also to public health. Given over irrigation practices and the pattern of rainfall in the country, a clear positive water balance is created during winter resulting in nitrates leaching to groundwater (Figure 12). Following lower precipitation rates and a decline in water quality in Lebanon (Khawlie, 1999), the groundwater quality on the coastal area has been deteriorating especially with excessive pumping causing seawater intrusion (El Moujabber and Bou Samra, 2002; El Moujabber et al., 2006).

FUTURE PROSPECTS and INTEGRATION STUDIES

Future Plans on Soil Resources

Lebanon's limited territory has a striking diversity of natural conditions and soil resources. Intensive agricultural practices in the greenhouses along the coastal area resulted in the salinization of the soil while excessive pumping from coastal wells contributed to seawater intrusion and accumulation of salts in the soils. Salt removal from the soil was tried using a sequence of crops from the more tolerant to the less tolerant to salts (El Moujabber et al., 2006). Although Lebanese soils are naturally not saline, increasing signs of salt buildup are noticed notably in greenhouses along the coast and in North East Bekaa. Increased salinity levels in Jieh (Southern coast) now threaten the sustainability of agriculture in the area. Coupled with the weakness of extension services, poor farming practices exacerbate the prevailing situation. Dissemination of good agricultural practices is a national priority in order to protect soil and groundwater from the ravages of increased salinity.

Revitalizing the Lebanese agricultural sector requires a clear national policy aiming at the conservation of Lebanese productive lands and the promotion of rural development and agricultural activities. Research aimed at a well structured method to estimate future farmland requirements in densely populated areas must be promoted. Due to institutional weakness and the absence policy implementation, most Lebanese quarries have not been as yet exploited following environmental concepts and in preparation for post operation reclamation or restoration. In a country having shortage of fertile arable lands and witnessing increased forest fires with recession of vegetation cover, the current policy and legislation licensing the new quarries in Lebanon needs reconsideration.

Almost all mentioned studies on soil erosion addressed land vulnerability to soil erosion. A semi-quantitative assessment of soil erosion was done only in two watersheds (Damour and Zahrani) and in a pilot area within Nahr Ibrahim watershed using the Participatory Action Program/Regional Activity Center PAP/RAC methodology. The work combined field description of different forms of soil erosion-deposition, erosion intensity, extend, assessment of physical and biological factors like topography, geology and vegetation and socio economic factors like human activities, land tenure, market conditions, value of land use and alternative uses to map erosion and priority intervention areas (COLD, 2004). Therefore, physical factors were combined with the socio-economic driving forces to elaborate draft management programs with the participation of involved stakeholders. Thus, the need to continue this work in remaining watersheds becomes imperative (Darwish, 2012). This in turn is expected to lead to the elaboration of response management plan and set a series of indicators helping the elaboration of curative and protective measures to monitor the progress made by the defined stakeholders both at national (government) and local (municipalities, NGOs) levels.

Currently only about 700 km^2 of land located in North Lebanon and central Bekaa plain is characterized in terms of heavy metal content and land quality and suitability for specific agricultural and non agricultural uses. Although heavy metal and nitrate dietary uptake was assessed (Nasreddine et al., 2006; Darwish et al., 2009), cropping of vegetables on low quality lands is a general practice. For this purpose, it is recommended to assess soil quality nationwide to control crop cultivation on suitable land. Soil analysis for the determination of total heavy metal content used in Eickman Clocke concept could be carried out at the CNRS-Atomic Energy Commission where the non destructive methods-particle induced X-ray emission (PIXE) and particle induced gamma ray emission (PIGE) methods were successfully applied to the soils of North Lebanon (Nsouli et al., 2004).

The effectiveness of soil protection against the transfer of soluble pollutants based on the German concept for a limited Lebanese area showed different degree of groundwater protection secured by the soil cover; with significant areas having moderate and low soil protection effectiveness. The residence time of soluble pollutants transfer from the soil surface to groundwater table spatially varied between several weeks and three years. Available data does not allow extrapolation in the soil mass. For this reason, it is necessary to distinguish between a soil and a surface deposit. The fractured system (karstic limestone, faults) of the surrounding mountain area implies the necessity to undertake geophysical studies on the depth of ground water, water table and nature of deposits overlying the aquifer in the whole country, particularly in the Bekaa Valley.

The major challenge in sustainable management of natural resources in Lebanon is the absence of clear policies and regulations to protect soil resources. An example of human pressure on soil resources is the chaotic urban expansion and observed mismanagement of fertilizer and water inputs leading to soil salinity and contamination. To overcome the problem of land degradation in Lebanon it is necessary to implement national and regional land use planning to define arable lands, assess land capability and suitability and set policies and incentives to agricultural land use systems. The first step of such an approach should be a proper understating of interfering socio-economic issues, the dissemination of good agricultural practices and the promotion of participatory approaches to land management issues.

There is a need to control the quality of imported fertilizers regarding their heavy metal content and to establish collective irrigation schemes notably along the coastal areas and to disseminate the research results and promote know how transfer to farmers. Local stakeholders must learn how to manage fertilizer application and irrigation through the use of saline water to save fresh water and reduce the impact on the coastal soil-groundwater system. For this reason research and technical soil expertise should be prepared and taught at technical schools for farmers that need to be established. The pivotal role of research establishments like the CNRS in promoting and funding research and in creating an atmosphere conducive to good research and the role of the MoA in promoting applied research and know how dissemination could not be overemphasized.

A series of measures must be undertaken to address soil information in Lebanon like the establishment of a soil agency that is able to avail and provide efficiently soil information at national and local level. There is a need to keep *updating the available soil maps and associated database.* Establishing the national soil database must be completed by more detailed soil mapping. All these efforts remain incomplete unless the government enacts appropriate legislation for soil conservation and increase people awareness on the fragility of the soil ecosystems through appropriate public and scientific channels. This will lead to apply land use planning based on land use requirements for actual and future needs. Establishing an effective extension service linked to the research institutions and the sector of agricultural production is the second most important measure to improve soil and water management serving sustainable agriculture and protecting the land from degradation.

Data Integration with the European Soil Database

The national legend used in Lebanon for soil classification was based on the French taxonomy introduced by Bernard Geze in 1956. Lamouroux and other French pedologists (1968a, b, 1971), as well as Lebanese soil scientists like Ahmad Osman (1974) who worked in Lebanon for a long time in the sixties and early seventies maintained this tradition. The Belgian soil scientist Verheye (1973) used the American Soil Taxonomy in his studies for soil mapping of the Southern Lebanon areas. In the eighties, Ryan and Ayubi (1981) contributed to the studies of phosphorus retention and dynamics in Lebanese calcareous soils and used again the US Soil Taxonomy. However, the more complete research was published by FAO in 1969 on soil irrigability and soil fertility.

The Lebanese multilingual experts use either of these soil classification systems. The less used until now is FAO-UNESCO and WRB Legend. The first attempts to use the FAO-UNESCO revised Legend commenced with the project on soil and ground water pollution by CNRS in co-operation with ACSAD and German BGR. But, it seems that identifying more clear boundaries between major soil units in the FAO-UNESCO Legend was not very appropriate and Soil Taxonomy could be useful regarding the diagnostic power and implementation facilities of a soil map. At the end of the nineties and in cooperation with the European Soil Bureau (ESB) of the European Commission, (EC), the soil map of Geze at 1:200,000 was digitized and updated with the implementation of the FAO-UNESCO Legend and the World Reference Base for Soil Resources (WRB) (Darwish et al., 2002a). Later on, with the support of the ESB and CIHEAM/IAM-B, the Euro-Mediterranean Soil Geographical Database at 1:1,000,000 scale covering Lebanon was created as a first step to cover the rest of the Mediterranean basin. This project was supposed to establish the Euro-Mediterranean network for soil information and could open the way for coordinated actions in order to improve soil management and address issues like cross-boundary soil degradation and regional land use planning (Darwish et al., 2005b). The new detailed soil map of Lebanon used all three mentioned above classifications (Darwish et al., 2006b). Meanwhile, farmers use their own taxonomy and unfortunately little attention has been paid to the indigenous soil knowledge, a common problem for many countries.

With the absence of updated soil map of Lebanon, the elaboration of the soil-geographical database for the country used the published data and was mostly based upon extensive recent soil classification project that allowed the enrichment of the database with a detailed attribute data. During 1997-2001, soil mapping based on modern techniques (remote sensing, GIS) and large fieldwork was completed. It allowed the excavation of more than 400 profiles, which were described according to the FAO guide (1990) and sampled horizon wise. Samples were analyzed for their main physical and chemical characteristics according to Ryan *et al.,* (1996). Soil types were classified following the Keys to Soil Taxonomy (1996), FAO-Unesco revised Legend (1997) and WRB (1998).

The new soil map of Lebanon at 1: 1 Million scale was produced keeping the non-mappable areas notably those complementing nested areas across national borders like the alluvial plain and basaltic plateau of northeast Lebanon and Marj-khiam plain of South Lebanon. As separation criteria for entities the lithology-landform association was used to identify the soil typological and major mapping units. The associated database was built according to the Soil Geographical Database of the Euro-Mediterranean Countries, Version 4.0 (2000). Attribute data contained information on soil location, slope, minimal and maximal altitude, parent material, land use, fluctuation of ground water depth, limitation for agricultural use, texture and textural change with depth, spatial change of texture, structure, rootable depth, depth of impermeable layer, water regime, water management practices and other soil fertility parameters. A total of 13 Soil Mapping Units (SMU) were identified in Lebanon (Table 2). Two of them consisted of one, pure, Soil Typological Units (STU), three SMU were formed from association of two STU, three SMU represented association of 3 STU, and five SMU consisted of more than 3 STU. The soils of the plains, except the semi-arid northeastern part of Lebanon, represent mainly deep Cambisols (35-45% of the area), Fluvisols (20-25%), Luvisols and Vertisols (15-20%), and Arenosols (10-15%). Eroded Luvisols, Leptosols and terraced Anthrasols dominate in the mountains. In areas with annual precipitation less than 250 mm Calcaric soil units and Calcisols dominate revealing the direct impact of climate on soil formation and evolution (Dudal and Pecrot, 1980).

Based on the progress made in national soil mapping since 2000 and the creation of the new Soil Geographical Database of the Euro-Mediterranean Countries, Version 6.0, the new soil map of Lebanon (Darwish et al., 2006a) will be used based on the agglomeration of the detailed soil map at 1:50.000 scale using the level I (soil class) for the identification of major soil mapping unit. The detailed soil database will be mobilized to produce a more workable structure which can be harmonized and integrated with nested and regional soil maps and databases.

CONCLUSION

Based on multiple natural and human-made factors affecting land resources i.e. the highly fragile Lebanese ecosystem land degradation and desertification are largely observed in Lebanon. Pressure is noted through soil erosion, salinity, soil sealing and pollution, forest fires and chaotic quarrying. The tremendous loss of soil resources is intriguing immediate measures and responses, at the technical, socio-economic and legislative levels. Preparing updated basic and thematic soil maps and databases can affect decision making and raise public awareness about the limited natural and notably soil resources in the region. It must be made clear that the wellbeing of the society is directly related to the management of water and soil resources. The deterioration of soil cover, recession of agricultural production and loss of indigenous knowledge leads to complex socio-economic problems triggered by poverty and exacerbated by land abandonment and emigration. Therefore, building national soil database and integrating it with the Euro-Mediterranean soil geographical database is beneficial both at national and international levels. It must complete the regional efforts to combat desertification and improve the living conditions of Euro-Mediterranean countries.

ACKNOWLEDGMENTS

This report is based on the publication and outputs of research activities and projects supported by CNRS Lebanon and other national and International organizations e.g. MoA, CDR, ECODIT, IAURIF FAO, UNEP and EU.

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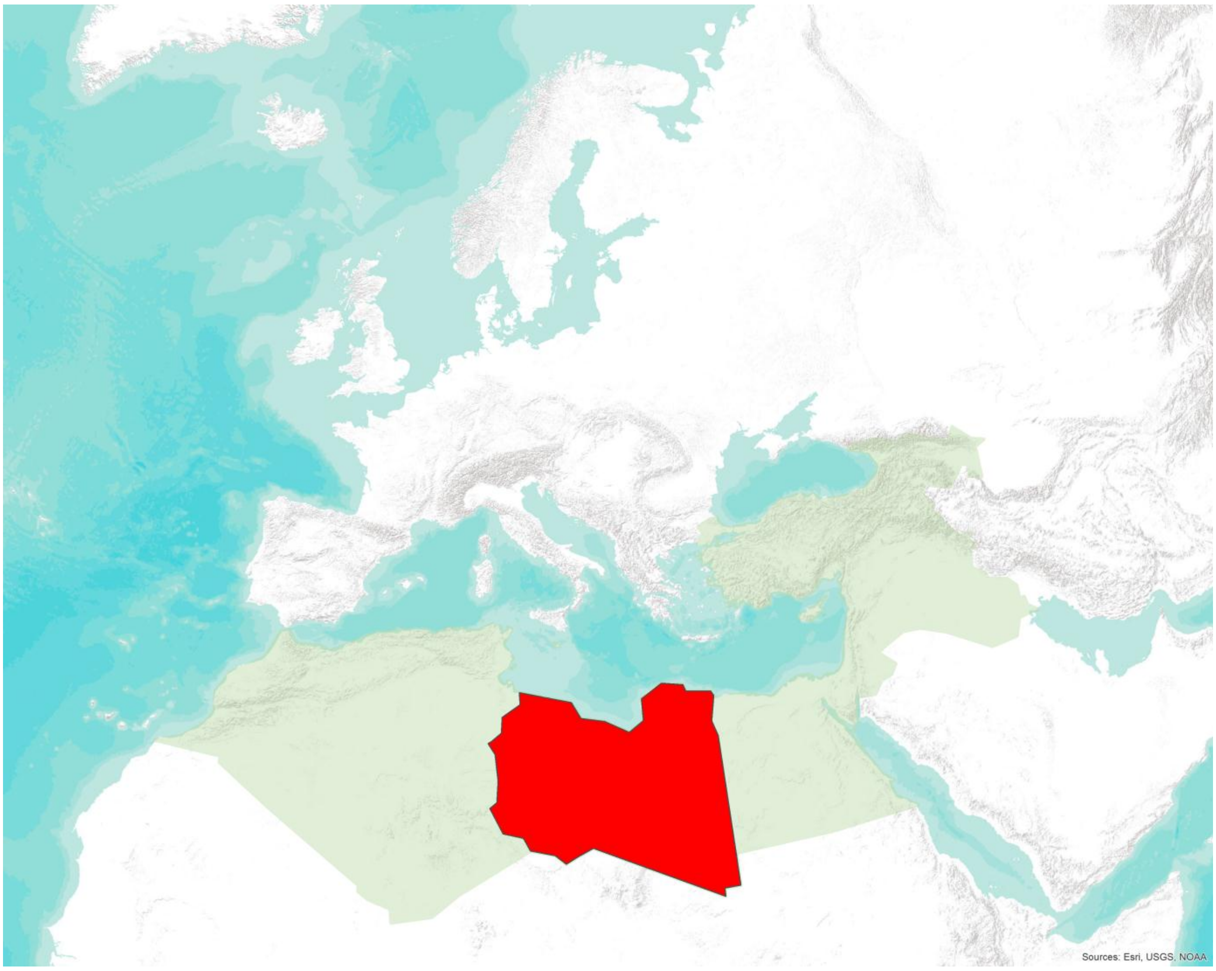
CHAPTER X
SOIL RESOURCES IN LIBYA



SOIL RESOURCES IN LIBYA
(National Report)

DR .BASHIR NWER [1]

ABSTRACT

Libya is situated in the north of African continent and covers more than 1.7 M Km^2 .The Mediterranean coast and Sharah Desert are the main natural features. The desert covers more than 95 % of the county. The cultivated area is slightly over 2 %. The suitable land for cultivation is concentrated in the north of the country and s. As a result, most of the agricultural projects are in the north and few projects developed on the south. Therefore, emphasis was given for soil survey and studies in the northern part of the country and scattered areas on the south. Different soil classification systems were used. Libyan soils are influenced to great extent by aridity and most of these soils are undeveloped or partly developed and may include one diagnostic horizon or a number of diagnostic horizons which characterise the arid areas. Land degradation and desertification are the main soil threats face agricultural development. There were substantial efforts to develop land inventory in Libya to aid land use planning and combat the environmental hazards. However, the variety of soil classification were used make limit the use of soil data. Therefore, careful analysis and assessment of the data in these soil survey studies is crucial process so that soil information can be used effectively in land use planning and decision making. Otherwise, some data can mislead decision making process and have severe consequences on the country agricultural future. Libyan authority recognised the need for land information system and has commenced a project which executed by FAO to addresses ecological and socio-economic problems by introducing adequate and modern technologies to improve the management and use of natural resources in Libya through cross-sectoral planning policies. A key components of this project is The Land Resources Information Management System (LRIMS) which aims to model land suitability at the sub-national level in the first phase. Techniques of land evaluation provide a means of integrating soils data with real world decision making in land use planning. The aim of this paper is to review soil resources in Libya and explore the possibilities to integrate soil data into Soil Geographical Database of Eurasia.

Keywords: Libya, Soil, Soil Survey, Soil data, Soil information, soil resources, Land information.

1. INTRODUCTION

Libya is located in the north of Africa and covers 1,759,540 million Km^2 (Figure 1). It forms part of North African plateau extending from the Atlantic Ocean to the Red Sea. The Mediterranean coast and the Sahara Desert are the country’s main natural features. There are several highlands but no true mountain ranges except in the largely empty southern desert near the Chaidian border, where the Tibesti Massif rises to over 2200 meters. Only 4 per cent of the country is arable land, with the rest comprising rocky outcrops and loose surface materials. In addition, there is a shortage of land receiving sufficient rainfall for agriculture. The highest rainfall occurs in the northern Tripoli region (Jabal Nafusah and Jifarah Plain) and in the northern Benghazi region (Jabal al Akhdar). These two areas are the only regions where the average yearly rainfall exceeds the minimum (250-300 mm) considered necessary to sustain rain-fed agriculture. Only 2% of total land area of Libya is arable and 4% is suitable for grazing livestock. Most of the agricultural areas are located in Al-Jabal al Akhdar in the North East and Jifarah Plains near Tripoli. Annual rainfall in these areas ranges between 200 and 500mm and irrigation using groundwater resources is common.

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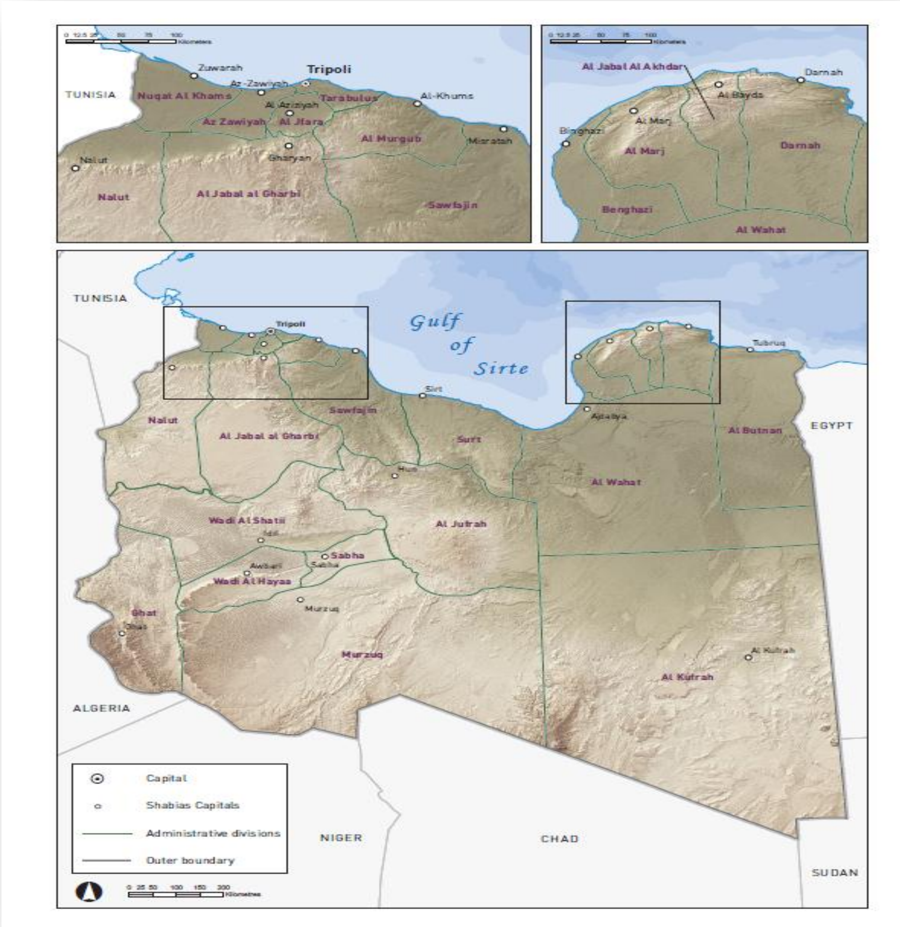

Figure3. Map of Libya (Source: Minstery of Agriculture 2012)

Agriculture activities represent an important constituent of Libyan economy where it employs about 5 % of the labour force and provides less than 9 % of the gross domestic product (GDP). Animal husbandray is still a significant activity but relies heavily on imported feed. The unsustainable use of these resources poses a severe long-term ecological and socio-economic threat to Libya's agricultural lands.

The climate in Libya is influenced by the Mediterranean Sea to the north and the Sahara desert to the south, resulting in an abrupt transition from one kind of weather system to another. Three broad climatic divisions can be observed:

- The Mediterranean coastal strip, with dry summers and relatively wet winters; The Jabal Nafusah and Jabal Akhdar highlands, experiencing a plateau climate with higher rainfall and low winter temperatures including snow on the hills;
- Moving south to the interior, pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal amplitudes. Rain is rare and irregular and diminishes progressively towards zero in the south.

Rainfall is the main feature of precipitation in Libya; nonetheless it is very erratic and limited. Precipitation levels vary substantially across Libya. The mean annual precipitation varies from zero millimeters in Southern Libya, to 600 mm at the Coastal belt. In El-Kufra, Jalo, Jaghboub, Sebha and Gadamis precipitation is zero (El-Tantawi, 2005). Tripoli, Zwara, Misrata, Derna, Benina and Shahbat which are located along the Mediterranean coast experiences precipitation of up to 250 mm. Overall, Libya does not receive enough precipitation for rainfed agriculture – only two percent of Libya receives enough precipitation for rainfed agriculture. The average monthly rainfall received in 2008 was only 13.3mm (estimated from data monthly rainfall data presented in Libya Statistics Book 2008) – only in December, January and February when the amount of rainfall received (40.5mm, 51.9mm and 26.0mm, respectively) exceeded 25mm (Libya Statistics Book 2008). Only rain stations in Shahat (38.8mm), Yefren (35.1mm), Alkhoms (34.0) and Misrata (30.2) received average monthly rainfall exceeding 30 mm (Libya Statistics Book 2008). Across the country rainfall is particularly limited in the months of June, July and August. Given this sporadic rainfall pattern, agriculture production in Libya is highly reliant on irrigation.

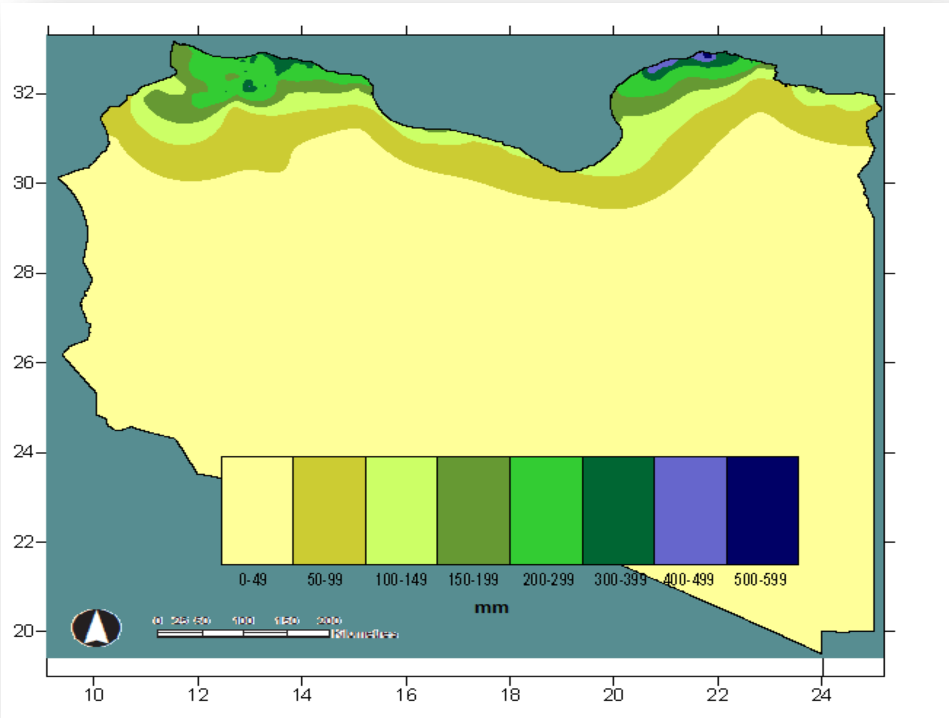

Figure 4. Map of precipitation in Libya (Source: NAP, 2009)

The temperature is lowest in January and starts to increase gradually from February until July and August when the highest temperatures are reached. The temperature also varies from region to region. In the coastal region, the monthly average temperature is between 23 °C – 25 °C. In the semi-desert regions the monthly average temperature is between 25 °C - 28 °C, whereas, the maximum temperature in the desert regions may exceed 30 °C (Benina Meteorological Report, 2002). Prevailing winds are north-easterly in north west Libya and north-westerly in the rest of the country. In the spring and autumn, strong southerly winds known locally as “Ghibli” blow from the desert, filling the air with sand and dust raising the temperature to approximately 50° C. These strong winds are a major erosion factor in the desert, transporting sand from one place to another. The high temperatures experienced in the coastal area reduce with altitude in the hills. In summer coastal temperatures near sea level can exceed 43°C, but in the winter these can fall to freezing point (Pallas, 1980; Salem, 1992; Alghraiani, 1993).

Humidity is another climatic condition which constraint agriculture production. Humidity does not only affect crop farming but also animal rearing. Humidity potentially has immense effect particularly on irrigated farming. High humidity potentially causes heat exhaustion in animals which leads to respiration problems, increased rectal temperature, water consumption, decreased feed intake, weight gain and inactivity (Epperson and Zalesky 1995). Although humidity is in general low in Libya (El-Tantawi, 2005), there exist substantial variations between the regions of the country (Statistics Book, 2008). The annual relative humidity recorded in 2008 ranges from 22% in Yefren to 72% in Jalow (Statistics Book, 2008). In Derna, Hoon, Jalow and Tazerbo the annual relative humidity recorded in 2008 was in excess of 70%, while the annual relative humidity recorded in Nalut, Zwara, Yefren and Tripoli were below 35%.

Substantial variations in relative humidity also exist between the different seasons of the year. Analysing humidity data Libya from 1946 to 2000, El-Tantawi, 2005 reported summer (June – August) and winter (December to February) relative humidity levels for the coastal and desert regions of Libya. Generally, humidity levels in the Coastal belt are higher than that of the Desert belt. For example, in the coastal regions of Agedabia, Benina and Derna the mean annual winter humidity levels were 69.1%, 73.3% and 71.0% respectively and that of the summer season were 59.5%, 61.6% and 74.9% respectively. In the desert regions of El-Kufra, Jalo and Sebha the mean annual winter humidity levels were 41.6%, 56.2% and 46.7% respectively and that of the summer season were 21.7%, 37.7.6% and 25.0% respectively (El-Tantawi, 2005).

Population growth is a primary factor driving increases in the demand for food and agricultural products. The total population of Libya has dramatically increased over the last three decades. It was only 1.986 million in 1970 while in 2003 it had rise to 5.551 million. Compared with 1970, the total population had doubled by 1980 and trebled by 2003 (FAOSTAT, 2004). The needs and demands of a rapidly increasing population have been the principal driving force in the allocation of land resources to various kinds of uses, with food security as the primary aim. Population pressure and increased competition among different land users have emphasized the need for more effective land-use planning and policies. Rational and sustainable land use is an issue of great concern to the Libyan government and to land users interested in preserving the land resources for the benefit of present and future populations. An integrated approach to planning and management of land resources is a key factor to implementing solutions which will ensure that land is allocated to uses providing the greatest benefit for the country.

2. COUNTRY SOIL INFORMATION AND DATA

Legacy Soil Information and Soil Surveys

A large number of soil surveys and studies have been conducted in Libya. However, the emphasis of these studies were given to the northern part of the country and to small scattered areas in the southern desert. In the past, there was no unified technical specifications for soil survey in Libya. Therefore, many different classification systems used in soil classification, methods of soil analysis, and the criteria on which the interpretation of data is based . The major soil classification systems used in these reports are USA Soil Taxonomy, modern soil classification of Russia, French soil classification, and FAO/UNESCO system (Nwer, 2005). The major available interpretive soil and land maps are land capability, soil salinity, soil erosion, soil depth, and soil and land suitability (FAO, 1998).Table (1) shows an example of soil surveys in Libya. Most of available maps are not in digital format except some that has been digitised in recent years in different technical centres. The main problem faces the use of soil information (soil surveys outputs) is not how to convert the taxonomic units in one soil classification system to another, but how the results of the soil properties can be compared. Therefore, careful analysis and assessment of the data in these soil survey studies is vital for future development.

Table1. Examples of Soil Survey Types in Libya (North Western Zone)

No.	Location	Type of Survey	Scale	Area (ha)	Year	Soil Map Class	Class. System	Interactive maps
1	Zoara	Semi-Detailed	1:50000	400,000	1994	×	USA	2
2	Kraret Eshtaf	Detailed	1:20000	1144	1993	×	USA	4
3	Tarhunah-Weshtath	Detailed	1:20000	4232	1992	×	USA	4
4	Wadi Kado	Detailed	1:20000	9556	1992	×	USA	4

(Source : Modified from Ben-Mahmoud, 2001)

Many soil surveys in recent years were dedicated to Great Manmade River Project (GMMRP) which was initiated to transport water from south the north of the country to fulfil the domestic and agricultural needs of the nation. Soil classification systems used in these reports are USA Soil Taxonomy.

Topographic maps available covers most of northern zones and these maps have been achieved in 1973 at scale of 1:50 000 and 1:250000.In addition, there is a topographic map of Libya at a scale of 1: 1 M and physiographic map of Libya at a scale 1:1.5 M. Additionally, a large number of aerial photographs and mosaics are also available at different scales (aerial photographs 1:25000 to 1:60000- mosaics 1:50000).

As mentioned in the introduction, the assessment of Libyan natural resources evidently revealed limited natural resources, especially of water and suitable land, and on the hazards and negative repercussions on agricultural development and food security associated with their misuse. A sound strategy, policy and action programmes oriented towards the conservation, sound management and efficient utilisation of natural resources and towards addressing the environmental sustainability dimensions constitutes a high national priority. Therefore, the government with the aid of FAO in 2000 established Libyan Soil Database and Land Resource Information Management System. The Libyan authority recognises the importance of providing comprehensive data required for development planning of agriculture sector and for further strengthening its capacity to formulate, implement and monitor various policy measures at national and regional levels.

To achieve these goals, a project entitled *" **Mapping of Natural Resources for Agricultural Use and planning in Libya** ".* The output of the project is a systematic methodology for classification and mapping of agricultural land resources information using remote techniques in place. A methodology for establishment, operation and manipulation of a digitised geographic information database defined. A firm foundation is established for the national relevant institution to use RS/GIS and IS technology in the gathering of agricultural land resources information for the planning of national development (FAO, 2008).

The project activities included:

- generation, processing, integration and archiving of data using latest technology;
- establishing appropriate policy and legal frameworks;
- developing strategies and mechanisms to facilitate information management processes;
- creating a National Spatial Data Infrastructure (NSDI) to promote cooperation among agencies, and

- promoting and strengthening technical and scientific collaboration with other countries in the region.

Despite difficulties faced the project in terms of finical resources, phase one of the project was accomplished. There is a proposed phase two which aims to use these data and information in monitoring programmes and issues related to combating desertification and climate change. The government is putting phase two in their highest priorities and working to mobilise the necessary finical resources for the programme.

Soil Classification

Soils and their characteristics in Libya are effected to great extent by the nature and conditions in which these soils were formed in different areas of the country. Generally, aridity is the main characterises of such soils. Most of these soils are undeveloped or partly developed and may include one diagnostic horizon or a number of diagnostic horizons which characterise the arid areas. Almost all Libyan soils require a comprehensive fertilization programme for acceptable rates of yield. The main characteriscics of Libyan soil are low organic matter, low nutrients and high levels of calcium carbonates.

Soils in Libya are classificed in accordance with US Soil Taxonomy as shown in Table (2) (Ben Mahmoud, 1995). According to FAO Soil Classification System the major soil classes can be identified in Table (3) (FAO, 2002). Figure (3) and show how the geographic distribution of these soils in Libya.

Table 2. Soil Classification in Libya in accordance with US Taxonomy

No.	Soil Order	Sub order	Sub Groups
1	Entisols	Psamments	Torripsamments - Xeropsamments-
		Fluvents	Torrifluvents - Xerofluvents
		Orthents	Torriorthents – Xerorthents
2	Aridisols	Argids	Paleargids - Haploargids
		Salids	Haplosalids - Aguisalids
		Calcids	Haplocalcids
		Gypsids	Haplogypsids - Petrogypsids
		Cambids	Haplocambids
3	Alfisols	Xeralfs	Rhodxeralfs– Natrixeralfs- Haploxeralfs
4	Mollisols	Rendolls	Haplorendolls
5	Inceptisols	Xerepts	Haploxerpts
6	Vertisols	Xerets	Haploxerets

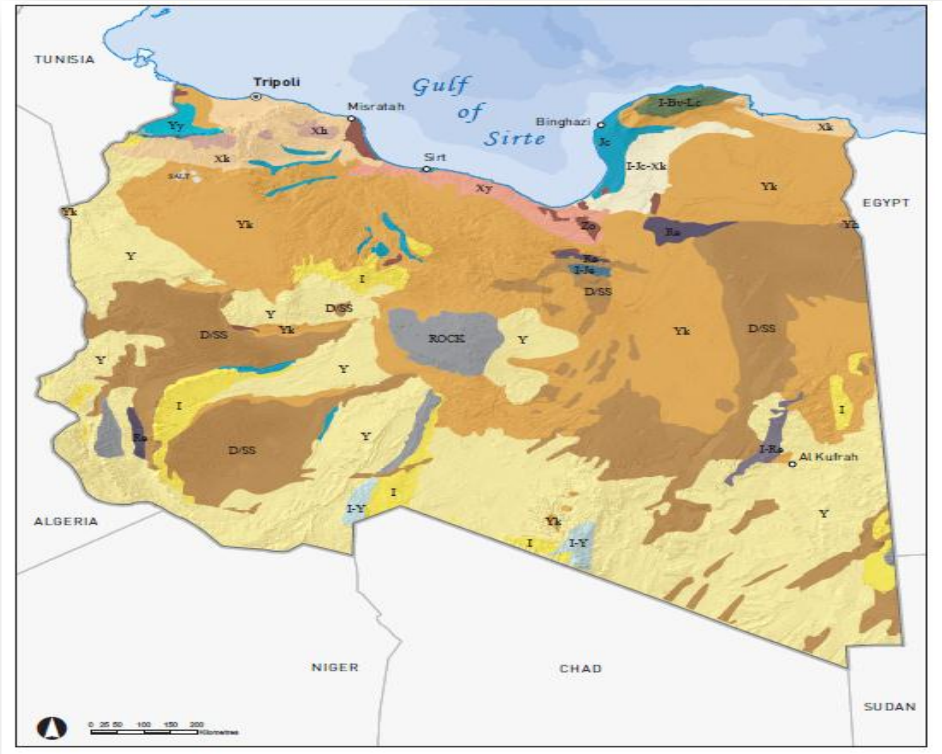

Figure 5. **Soil Map of Libya (Source: FAO, 2002)**

Table 3. Major Soil Classes in Libya according to FAO (2002)

No	Soil Classes	Sub Classes
1	Regosols (R)	Gelic Regosols (Rx) - Calcaric Regosols (Rc) Dystric Regosols (Rd) - Eutric Regosols (Re).
2	Luvisols (L)	Plinthic Luvisols (Lp)- Gleyic Luvisols (Lg)- Albic Luvisols (La) Vertic Luvisols (Lv)- Calcic Luvisols (Lk)- Ferric Luvisols (Lf) Chromic Luvisols (Lc) - Orthic Luvisols (Lo)
3	Lithosols (I)	
4	Fluvisols (J)	Thionic Fluvisols (Jt) - Calcaric Fluvisols (Jc)- Dystric Fluvisols (Jd) Eutric Fluvisols (Je)
5	Yermosols (Y)	Takyric Yermosols (Yt) - Luvic Yermosols (Yl)- Gypsic Yermosols (Yk) - Calcic Yermosols (Yc) - Haptic Yermosols (Yh).
6	Xerosols (X)	Luvic Xerosols (Xl) - Gypsic Xerosols (Xy) - Calcic Xerosols (Xk) Haplic Xerosols (Xh).
7	Solonchaks (Z)	Gleyic Solonchaks (Zg)- Takyric Solonchaks (Zt)- Mollic Solonchaks (Zm)- Orthic Solonchaks (Zo).
8	Cambisols (B)	Gelic Cambisols (Bx)- Gleyic Cambisols (Bg)- Vertic Cambisols (Bv)- Calcic Cambisols (Bk)- Humic Cambisols (Bh)- Ferralic Cambisols (Bf) Dystric Cambisols (Bd)- Chromic Cambisols (Bc)- Eutric Cambisols (Be)
9	Salt	Salt Flats
10	Rock	Rock debris or desert detritus-
11	D/SS	Dunes or Shifting Sand

Current Soil Mapping Efforts

Soil mapping in Libya has progressed to enter the digital era. As mentioned there were a huge data collected in the form of soil survey reports and maps (hard copy). Land evaluation is an integrated part of soil survey reports and maps. Likewise there were different land evaluation technique were used. Land capability classification was used in the Russian soils survey. Mahmud (1995) applied a modified productivity rating index in Libya. Eleven soil properties were taken into account to produce an overall rating. Most of the recent survey which have been conducted by GMMAR include suitability rating as integrated part of the soil survey.

Nwer (2005) developed Land suitability classification using GIS to produce land suitability classification for certain crops. The study was conducted on the north east of the country. The land evaluation in this research based upon FAO methodology for land evaluation. The most important developments for land evaluation applications in Libya have been the use of knowledge-based expert systems and the associated application of Geographical Information Systems. This combination has enabled the production of specific information relevant to land evaluation studies.

The project "Mapping of Natural Resources for Agricultural Use and Planning" (LIB/00/004) - funded by the Libyan Government and executed by FAO – addresses ecological and socio-economic problems by introducing adequate and modern technologies to improve the management and use of natural resources in Libya through cross-sectoral planning policies. The project intends to further support the planning and development of the agricultural sector and strengthen the conservation efforts, and sound-use of the land. The outputs and key component developed of phase one are as follows:

- Land mapping cover was produced as visual interpretation of LandSat7 ETM images, using LCCS and GeoVIS (National and regional). 1:50,000 for agriculture aeras.
- Natural resources databases (soil, water, and climate).
- Topographic maps 1: 50,000 (digital layers: admin border, roads, drainage, contours, height points, settlements) covering North of the country.
- Topographic maps 1: 250,000 (digital layers: admin, roads, drainage, contours, height points, settlements) covering North of the country.
- Soil maps 1: 50,000, Russian studies 1980 (Northeast, Northwest) and Telecart (West) 1994 are available in digital format.
- Land Resources Information Management System (LRIMS). LRIMS is project aimed to strengthen capacity in agricultural production through land resource management at national and sub-national level. The main objective of the project is to model land suitability at the sub-national level based on six main models – climate, land cover, vegetation, water, Land Utilization Type (LUT) and socioeconomic.

3. SOIL THREATS

Erosion

The effect of erosion on agriculture has been regconised and studied for many years. Soil erosion leads to a reduction in soil quality and productivity and hence crop yield. Erosion often results in a decrease of the soil supply functions in three several ways, by (1) the removal of organic matter; (2) the change in depth to a possible root-barrier; and (3) the loss of structure and increased compaction (Bakker et al, 2004).The conditions in Libya where the environment is vulnerable, the variability of rainfall and the occurrence of occasional relatively heavy showers characterised by high intensity the land surface is the main factors that accelerate soil erosion. The combination of these factors in addition to the topography has increased the rate of soil erosion by water in some areas of the country. In addition, the Mediterranean climates do not favour the development of a dense vegetation cover on most slopes, which are poorly stabilised at ground level. As a result, areas with Mediterranean type climates are traditionally classified as areas with high potential erosion rates (Saunders and Young, 1983; Brown, 1990).

There have been some studies dealing with the influence of soil on agriculture potential in Libya, but the problem of soil erosion is mentioned only briefly in some pilot studies. The soil erosion maps can be found as brief part of these reports and studies. However, there have been two major studies in Libya.The first was a report by FAO (1959) made by a team of experts using the available information on water resources to advise on measures for development of water resources and water conservation in northern Cyrenaica (north-east of Libya). The second study was conducted by Selkhozpromexport (1980). It concluded that the north-east of Libya is subject to severe erosion. The most affected are represents 70.7 % of the north-east. Selkhozpromexport (1980) distinguished two types of accelerated erosion: water erosion and wind erosion. Water erosion is common in the form of sheet washing, occurring mainly within the Jabal Akhdar Upland while wind erosion is found in the form of deflation within the littoral plain (Selkhozpromexport, 1980; Mahmoud, 1995). Table (4) shows the size of the problem in Libya and especially in the study area. Figure (4) shows how severe the erosion hazard in Tripoli area as example of the country.

Cambisols, Calcisols and Letpsols of Jabal Nafusa and the Luvisols, Cambislos and Leptsols of Jabal Al-Akhdar are the soils which are exposed to water erosion. There are some measures and practices have been used in the coastal area to combat erosion hazard. For example, store water diversion drain, hydrological constructions, strip cropping and contour cultivation practices.

Wind erosion is widespread in all areas of Libya. The main factors contribute to wind erosion hazard are: arid climate, the absence of adequate vegetation cover, soil texture, wind regimes and the human factor (mismanagement practices). Wind erosion can remove several centimeters of surface material per year in area that have sand soils. For the last three decades Libya has taken measures to control wind erosion. Afforestation, sand dunes fixation with (dry materials, petroleum emulsion and synthetic rubber) (NAP, 2006).

Table 4. Water Erosion in Libya

Erosion Type	Area (1000 ha)	
	North West Region	North East Region
Sheet Erosion		
Slight	155.5	241.7
Moderate	154.5	41.7
Severe	54.5	1.7
Gully Erosion		
Slight	85.3	0.8
Moderate	57.0	0.0
Total Erosion	511	285.7

Source : (Selkhozpromexport, 1980; Ben Mahmoud, 1995)

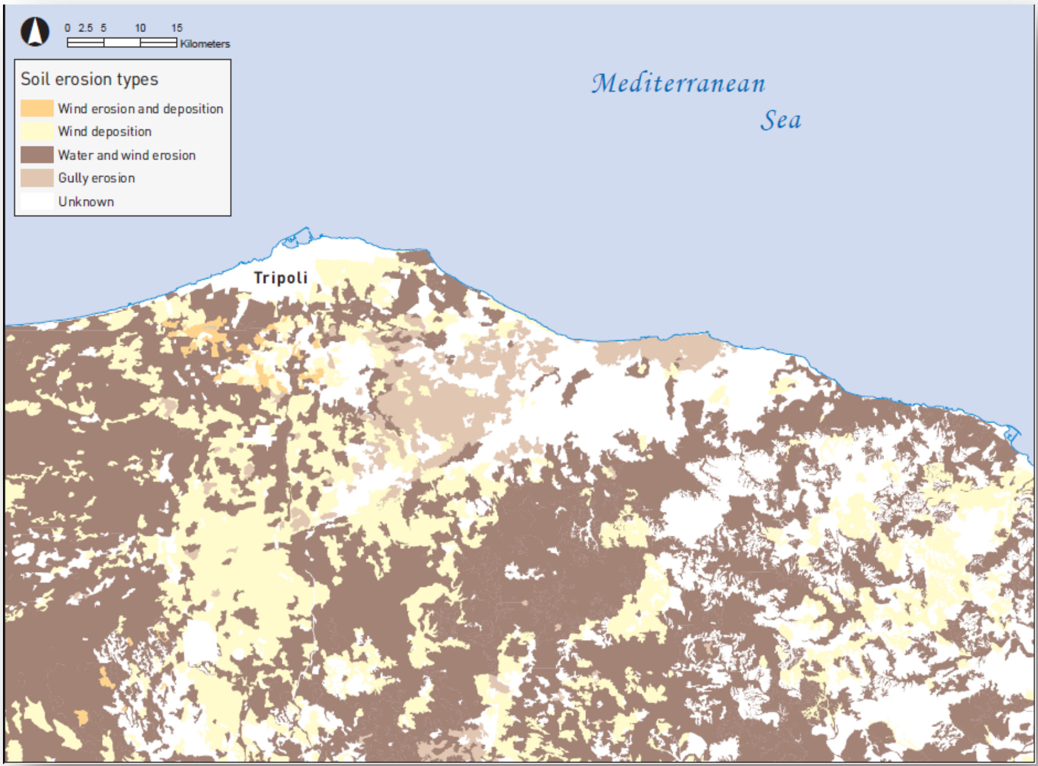

Figure 6. **Soil Erosion Types in Tripoli (Source: Minstery of Agriculture 2012)**

Salinisation

Soil salinity is a serious problem in arid and semi-arid zones of the world where poor quality water is often the only source available for irrigation. Salts tend to accumulate in the upper soil profile, especially when intense evapotranspiration is associated with insufficient leaching. The addition of salts to the soil alters its physical and chemical properties, including soil structure and hydraulic conductivity (Mass, 1996; Tanji, 1996).

Libya is potentially at risk of soil salinity. As study of the coastal region for the area receives more than 200 mm of rainfall per year indicated that 12 % of northwestern areas and 23 % of northeastern areas are salt affected soils (sebkhas) in Libya. In addition, considerable areas of cultivated soils is being converted to saline soils due to saline water irrigation in Jefara plain where there is sea water intrusion occurs.

Table 5. The degree of Salinity of Libyan Soils

No.	Degree of Soil salinity	Soil Classification
1	Strongly Saline soils	Salids (Solonchaks) , Natriargids (Solonetz), Gypsids
2	Slightly to Moderately Saline soils	Xerofluvents, Torrifluvents (Fluvisols), Xerorthents and Torriorthents (Regosols).
3	Slightly Saline Soils	
4	Soils are not Saline	Reodoxeralfs, Haploxeralfs, Pelloxerets, Xerochrepts and Rendolls.

Decline in Soil Biodiversity

Libya faces serious challenges in natural resource management despite the enactment of environmental protection laws in the 1990s and the ratification of numerous conventions.
A major concern is the depletion of underground water resources as a result of overuse in agricultural developments, causing salinity and sea-water penetration into coastal aquifers. Recent coastal development is leading to uncontrolled depletion of these coastal aquifers, exceeding their annual replenishment capacity, which allows seawater encroachment. As a result of high salinity levels, some aquifers are now almost unusable.

In addition, there is a danger of genetic erosion of all wild species because of the heavy grazing, human use and frequent occurrence of drought hazards in the country.

The low priority given to biodiversity, habitat protection and air pollution will have long-term effects on the country’s ecosystem. The main challenges lie in the absence of appropriate policy instruments and weak institutional capacity to address environmental issues and implement effective policies and strategies. Hostilities prevented any major progress in the last 12 months and it is likely that given the other problems the country must deal with, environmental concerns will not be a priority.

Decline in Organic Matter

Soil organic matter increases the amount of water a soil can hold and the proportion of water available for plant growth. In addition, it is a major source of the plant nutrients phosphorus and sulphur, and the primary source of nitrogen for most the plants. Soil organic matter greatly influences the biology of the soil, because it provides most of the food for the community of heterotrophic soil organisms (Brady and Weil, 1999).
Libyan soils have low soil organic matter content. The soil survey and research revealed that in most of the country soils SOM is less than 1 % except Jabal Ahkdar highlands soils which exceed 1 % in Vertisols, Mollisols and Alfisols.
There is no routine analysis of SOM in the country and the measurements of SOM is limited to the pervious soil surveys and studies and it is one of measurements.

4. FUTURE PROSPECTS AND INTEGRATION STUDIES

Future Plans on Soil Resources

The Land Resources Information Management System (LRIMS) is a project initiated by the Libyan Government, Food and Agricultural Organization (FAO) of the United Nations and the United Nations Development Programme (UNDP). The project is aimed to strengthen capacity in agricultural production through land resource management at national and sub-national level. The main objective of the project is to model land suitability at the sub-national level based on six main models – climate, land cover, vegetation, water, Land Utilization Type (LUT) and socioeconomic.

The future plans are to accomplish phase two of LRIMS. The key components and important outputs can be summarized as follow:

- Improve soil data (soil dataset with all existing soil data; finalise the soil map for all the irrigated or potentially irrigated agricultural areas, and undertake a preliminary soil survey in potentially suitable agricultural areas (undertaken at 1:50 000 scale).
- High resolution for soil map
- High resolution land cover/land cover change data
- Socio-economic data collection
- Usage of LRIM to aid the implantations of environmental convections (UNCCD, UNFCC and UNCBD)
- Climate Change Module
- Decentralization of LIRMS

The continuity of mapping natural resources project is a crucial for future agricultural development. In addition, there is a pressing need to develop the institutional arrangement. The reforms of the institutions dealing with natural resource information management are vital in order to organize and effectively plan for sustainable development in Libya.

Data Integration with the European Soil Database

The extension of the European soil Information System (EUSIS) to the European Union neighboring countries in the form of Soil Geographical Database of Eurasia at scale of 1:1,000,000 is an important step forward to achieve co-operation and technology transfer. Information and experience exchange can be a platform for further co-operation in soil monitoring, and other environmental concerns. This includes combating desertification and land degradation, biodiversity and climate change.

The integration between Libyan soil data and European soil data can be achieved through the co-operation between Libyan Agricultural Minstery and EU. As mentioned there are sufficient digital soil data for such small scale. However, verification and validation has be considered for soil data in Libya. FAO soil map of Libya can be the starting point to integrate soil data and maps to the Eurasia. The soil data available with different soil classification systems can be used for verification where uncertainty exists.

5. CONCLUSIONS

Libya in the last two decades has adapted expansion policies with the view to increase agricultural production, protecting soil and water resources and combating land degradation. Therefore, attention has been paid to land inventory, reclamation and development. Huge areas throughout Libya were subject to soil survey, reclamation and development. A number of problems have arisen associated with agricultural development. These problem related to overgrazing, misuse of water and soil resource, and poor management practice. These problems require assessment ,long term planning and responsive action plans. There were many attempt to tackle the problems of salinity and erosion. A number of other actions should be undertaken and become a priorities in near future such as land degradation and decline biodiversity and climate change. It is essential that Libya evaluate and assesses these practices and management in order to develop a prospective for future agricultural. Soil information management should be an integrated part of this process of evaluation, planning and development.

The soil survey focused in the northern region and scattered areas of the south region. Different soil classification systems were used (Russian, American and FAO). Many soil survey firms contributed to these studies in Libya.The main problem faces the use of soil information not how to convert the taxonomic units in one soil classification system to another, but how the results of the soil properties can be compared. Therefore, careful analysis and assessment of the data in these soil survey studies is vital. Techniques of land evaluation (both land capability and land suitability) provide a means of integrating soils data with real world decision making in land use planning. Only then the best use will be made of Libya's soil resources.

Libyan authority have realised the limitations to use soil information efficiently and effectively. Accordingly, an ambitious project (Mapping of Natural Resources for Agricultural Use and Planning) has been funded by Libyan government and executed by FAO to improve the management and use of natural resources in Libya through cross-sectoral planning policies. One of the most important component to the mentioned project is LRIM. LRIM aimed at deriving agricultural-specific indicators through the analysis of the multi-disciplinary database information. It is planned to implement this system on national and regional levels. It is planned that the project will be a tool to integrate soil, climate, and water information. In addition, through the project data gaps can identified, data quality can be assessed. As a result data will be improved which will be of huge impact on policy formulation and decision making process to achieve sustainable agricultural development.
The lack of reliable and usable data in some regions of the country can be tackled through dedicate some funds for limited soil surveys. This can be achieved through decentralisation.

Institutional reforms should be a priority to form a national body for geographical information systems, which can accommodate tasks such as providing resource inventories. For example, this includes managing and retrieving soil or geological information, maintaining cartographic and statistical coverage, and predicting land productivity in biological and economic terms under a variety of scenarios. If this can be achieved, then land evaluation studies will be effective, accurate and responsive to the country’s needs. In addition, funding needs to be provided and sustained for research institutions, in addition to training a labour force which will carry out this development.
It is very important that Libya co-operate with international body’s and organization for experiences exchange and knowledge transfer. It goes without saying that EU top the list of such co-operation for the obvious geographical and historical reasons.

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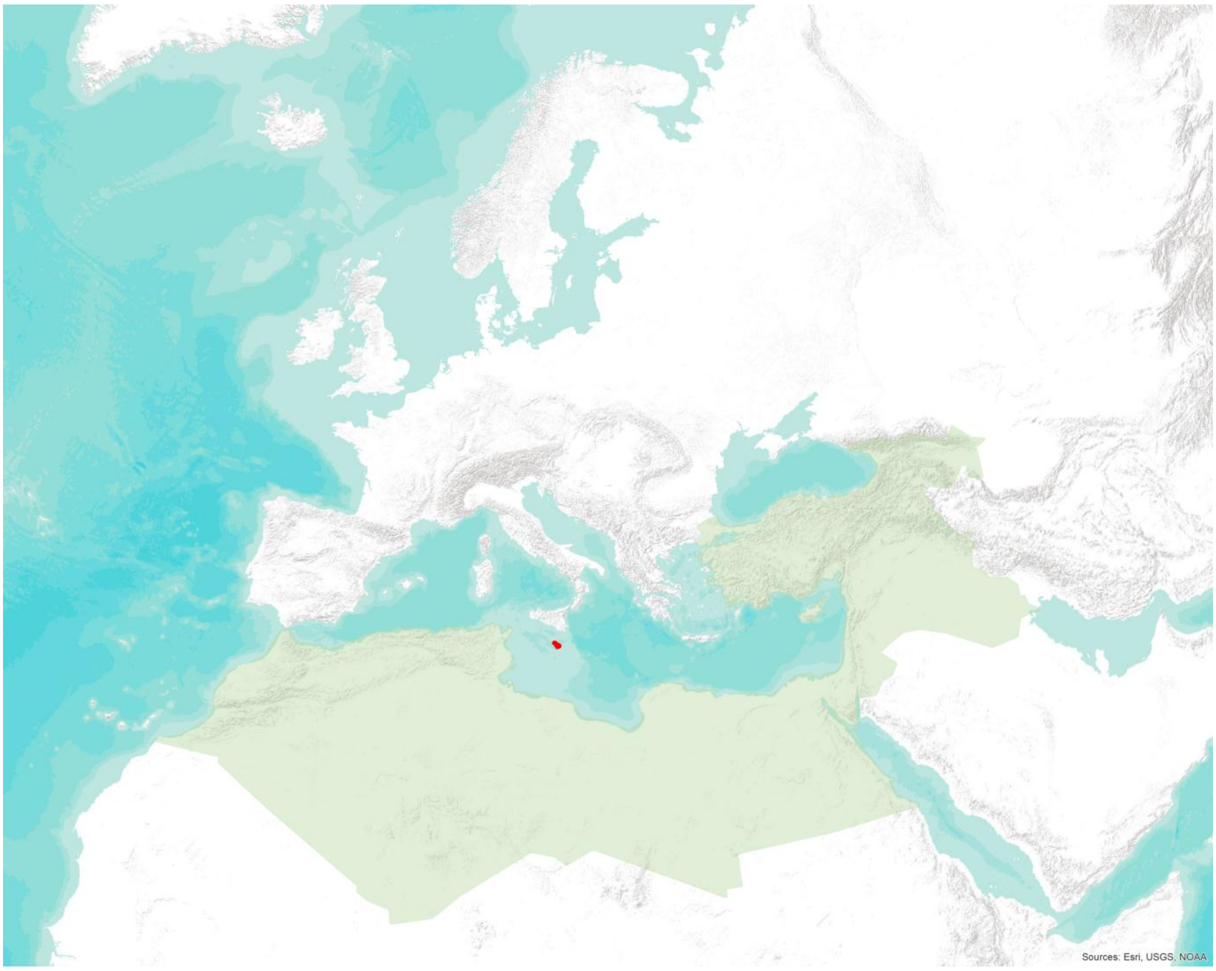
Chapter XI.
Soil Resources of Malta



Soil in Malta
Malta Environment and Planning Authority[1]

Soil is a primary resource for agriculture, which in the Maltese Islands is a highly sensitive industry, as well as being a fundamental element of natural ecosystems. Various mechanisms have been adopted to protect and enhance soil in the Maltese Islands. Legal means such as the Fertile Soil (Preservation) Act, and the legal notice on the conservation and preservation of rubble walls and rural structures, through the assessment of soil quality, are also in place.

Moreover, efforts to address various aspects of soil protection is also reflected within the following Maltese legislation (legal instruments and/or similar initiatives):

- 2012 National Environment Strategy (NEP);
- 2013 Draft Strategic Plan for the Environment and Development (SPED);
- 2003 Code of Good Agricultural Practice (CoGAP) & GAEC-SMR/ Cross-compliance (CAP): *Cross-Compliance related to EU Aid Applications in terms of the Paying Agency Regulations, 2005 (LN 346 of 2005 as amended by LN 207 of 2009);*
- 2007 Policy and Design Guidance for Agriculture, Farm Diversification & Stables (regulating Outside Development Zone planning permits);
- Various Waste Management regulations transposed into local action: *e.g. Waste Management (Landfill) Regulations, 2002 (LN 168 of 2002 as amended by LN 289 of 2002, LN 70 of 2007, LN 146 of 2007);*
- Plant health protection regulations which address risks resulting from actual use of pesticides (incl. biocides) and their impact upon soil contamination and biodiversity (due to soils being an important source of the gene pool);
- Bird and Habitat/ Natura 2000 regulations (which include amongst other compensation payments to protect habitats by avoiding deterioration of agricultural soils).

There is however no legal instrument for regulating non-agricultural soils or for remediating contaminated industrial soils and no consolidated law preventing soils from becoming degraded due to one or a combination of threats identified in the European Thematic Strategy addressing this non-renewable resource.

Principal threats to soil in Malta

Soil is threatened by a range of human activities that undermine its long-term availability and viability. As previously mentioned, the European Thematic Strategy for Soil Protection identifies nine key threats to soils: erosion; decline in organic matter; soil contamination (local and diffuse); soil sealing; soil compaction; decline in soil biodiversity; salinisation, flood and landslides and desertification. Increasing urbanisation and development in Malta, together with the intensification of agricultural practices, have accentuated the pressures on land, and thus on soil and its natural distribution. Although data on the extent and severity of soil threats, and on the economic and environmental implications of soil degradation, are lacking, the principal threats to soils in Malta may be described as erosion, decline in organic matter, soil contamination, and salinisation, arising out of contamination, soil sealing and land abandonment. The latter has an

[1] Background information
Source: State of the Environment Report 2008; Land Sub-report; Published March 2011 by the Malta Environment and Planning Authority,
ERDF Project 156 – Environmental Monitoring (project financed with EU Cohesion funds under the Operational Programme 1 (2007-2013) – Investing in Competitiveness for a Better Quality of Life; Technical Reports for Activities 1 to 4.

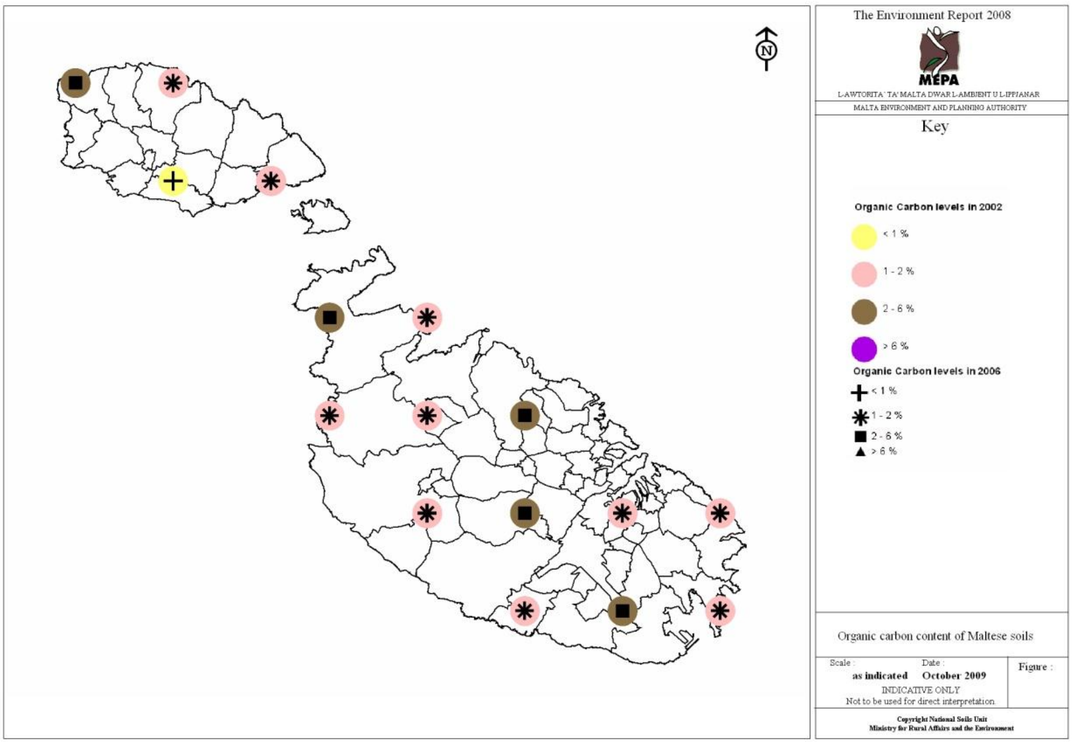
impact on desertification pressures in the Mediterranean region with Malta already declaring itself as an affected country to this growing global environmental challenge.

The then-National Soils Unit of the Agriculture Department within the former Ministry for Rural Affairs and the Environment (MRAE), now the Ministry for Sustainable Development, Environment and Climate Change (MSDEC) carried out sample monitoring of key soil quality indicators during 2004-2006, the results of which are presented below.

Soil organic matter decline

Soil organic carbon content is one of the primary indicators of soil quality. Organic material in the soil is derived from residual plant and animal matter synthesised by microbes, and decomposed under external influences such as temperature, humidity, moisture and ambient soil conditions. Soil organic matter plays a major role in maintaining soil quality, because of its influence on the exchange of nutrients, water retention, soil structure and its stability, soil ecology and overground and soil profile biodiversity, but also as a source of plant nutrients. Generally, topsoil organic carbon content gives an indication of the evolution in organic matter volumes, since changes in organic matter status are usually greater in the surface layers.

Organic content in the soil is influenced by: natural factors (climate, soil parent material, land cover and/or vegetation and topography), and human-induced factors (land use, management of farming practices and degradation). One of the main causes of the decline in soil organic matter in Malta is human activity, principally intensive cultivation. It is widely believed that a major threshold is two percent soil organic carbon, below which potentially serious decline in soil quality will occur. In 2006 the average organic matter in sampled topsoil was 2.1 percent, 0.2 percent more than the average in 2002, with the highest percentage (4 percent) recorded at Mellieha.

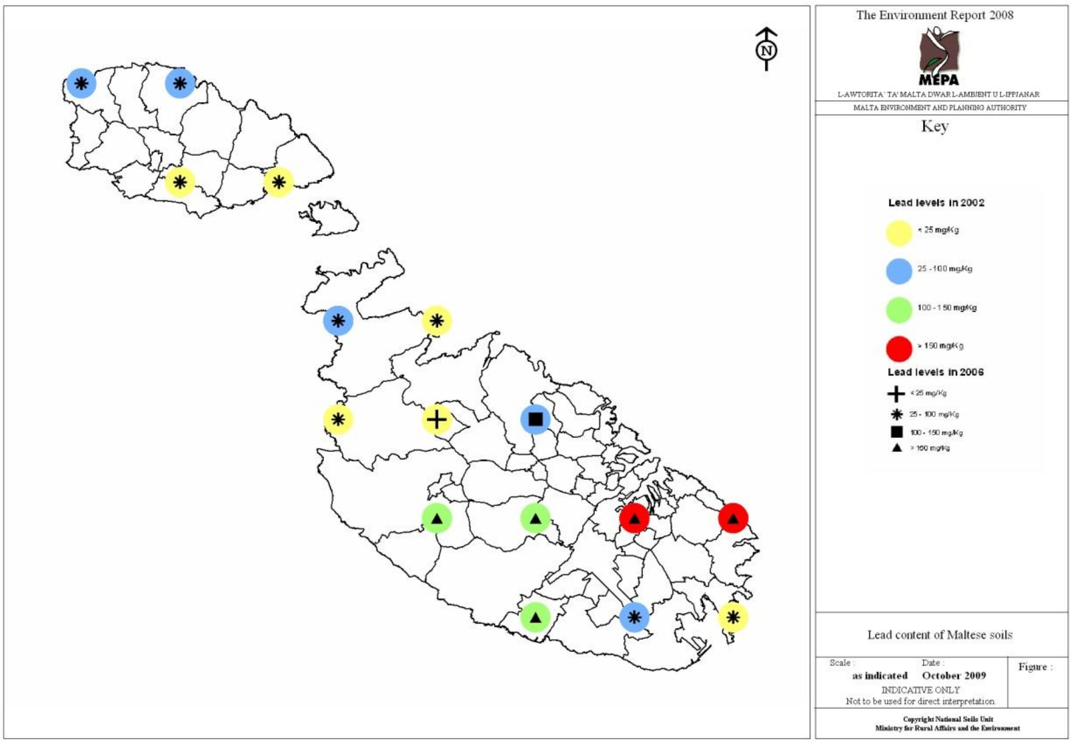


Map 4.5. Organic carbon content of Maltese soils (2006)
Source: National Soils Unit (MRAE) 2006

Soil contamination

Soil contamination is still an emerging issue for Malta, and data in this area remains scanty. Specific waste streams, some industrial activities, historic military activities, the storage of certain substances, agricultural activities, and some recreational activities (e.g. shooting ranges) may contribute to the contamination of land and soil. This contamination can pose immediate or long term risks to human health in terms of behavioural problems and learning disabilities, as well as soil function, and the wider environment. Contaminants may escape from the sites, resulting in further land and soil contamination, but also in air and water contamination.

Contaminants may also be indirectly the cause of damage to buildings and underground services, or the cause of the contamination of the food chain. Information on lead concentrations in Maltese sampled topsoils provides insights into soil contamination in the Islands. The Maltese population is known to have high mean lead blood levels. Whilst soil lead levels is not considered as one of the main reasons behind high lead blood levels in Malta, its monitoring is useful since there is a noted correlation between soil lead levels and distance of the field from the road. The monitoring of lead levels in soils is thus important in terms of understanding and controlling potential health risks from contaminated food and water sources.



Map 4.6. Lead content of Maltese soils (2006)
Source: National Soils Unit (MRAE) 2006

The average content of lead in monitored sites was found to have increased from 78 milligrams per kilogram (mg/kg) in 2002 to125mg/kg in 2006. The site monitored in Paola recorded the highest concentration, that of 451mg/kg, up from 266mg/kg in 2002. Lead concentrations generally exceed 100mg/kg in South and central Malta (Map 4.6), the part of the island that is more densely populated.

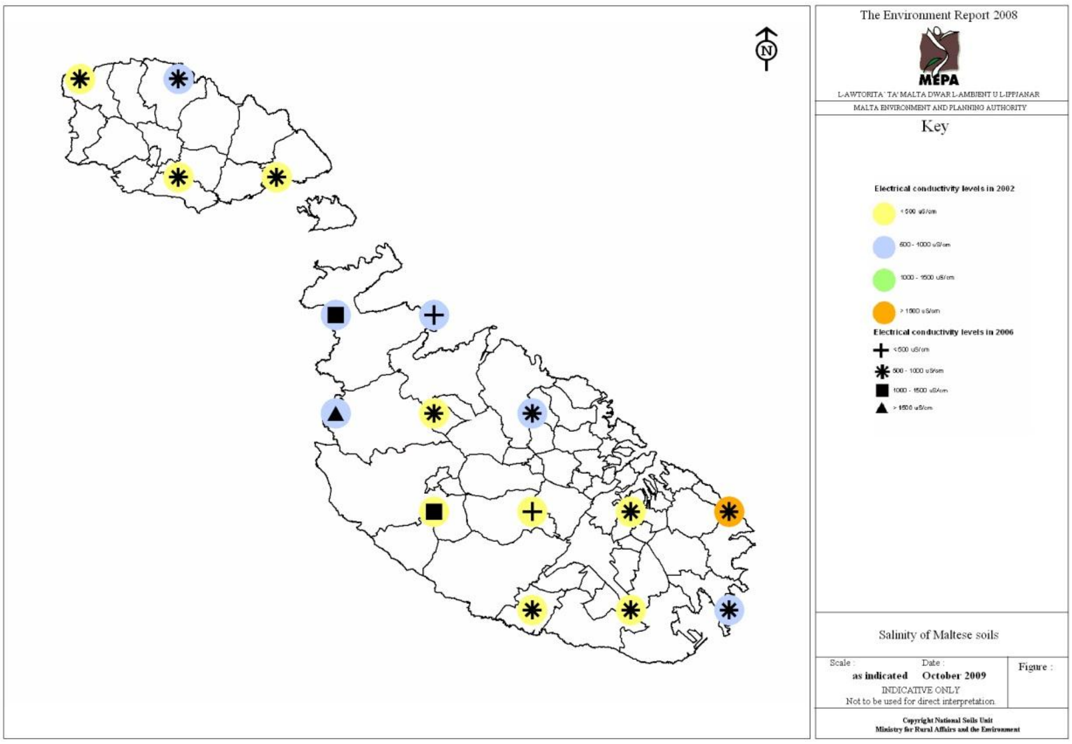
Soil contamination can be from either from diffuse or local sources. Diffuse contamination is caused by one or more point sources, however emission, transformation and dilution make the relationship between the pollution source and the soil contamination difficult to trace. This type of contamination is usually associated with atmospheric deposition, certain farming practices and inadequate waste and wastewater recycling and treatment. Local soil contamination is originally caused by point sources and usually affects high-density urban areas, those with a long tradition of heavy industry, or those in the vicinity of former military installations and waste dumps. In the Maltese context, possible causes of lead in soil may be remnants from car exhaust, paint, used pellets from hunting or emissions from industrial activities. Let off sites for firework displays, associated with local religious feasts or other activities when this practice is adopted, are another potential source of soil contamination.

Other than the above, there is little data on soil contamination in Malta. Recent information, mostly related to industrial permitting process, is compiled on a case-by-case basis.. Meanwhile, the information provided below is based on estimates of the potential sources of land contamination. Malta has identified the main sources of soil contamination as agriculture (both the animal husbandry and the arable sectors), sites used for waste disposal, storage facilities for oil and other fuels, scrap metal yards, and sites subject to illegal dumping of wastes. Sites that have a degree of inevitable contamination in view of the nature of the activity practiced on these sites include: fuel station and deposits; the two power stations at Marsa and Delimara; the former Maghtab dump site; the 16 IPPC sites; designated industrial areas, as well as a number of illegal scrap yards.

The monitoring of contaminated sites is also important in the light of groundwater protection, and the identification of potential contaminants, and the application of the necessary means to control them, is essential. The future disassembling of these sites, and their reuse for other purposes, requires the sensitive surveying of the site in order to propose suitable alternative uses, and ensure their appropriate rehabilitation, as has been carried out with respect to the Maghtab and Wied Fulija former waste dump sites. Guidance needs to be prepared and legislation enforced in this regard.

Soil salinity

Soil salinisation, or the excessive increase of soluble salts in the soil, is among the most important and widespread of soil degradation processes. The salinisation of soil, and thus the accumulation of salts on or near the soil surface, may result in unproductive soils. The soils of Malta are vulnerable to soil salinisation by natural processes, due to its small geographical scale. The main cause of salinisation according to the State of the Environment Report (SOER) is the use, for irrigation, of groundwater that is rich in salts (mainly sodium chloride). Between 2002 and 2006, average soil conductivity (indicating salinity in soil) increased by 30 percent, from 581 micro Siemens per centimetre (µS/cm) to 756µS/cm at the sites monitored. Highest values were recorded in coastal areas where salt from sea spray is deposited, such as in Mgarr in the north of Malta, where in 2006 there was a concentration of 1,580µS/cm.



Map 4.7. Soil salinity levels in Malta (2006)
Source: National Soils Unit (MRAE) 2006

Soil sealing

The increase of sealed soil areas translates into loss of uses such as agriculture and afforestion. Sealed soils result in the impairment of a soil system, affecting ecological soil functions and thus disrupting the potential of the soil working as a buffer and filter system, as an important resource for water capture and biodiversity or as a carbon sink. Sealing of soils also influences the change of water flow patterns, whilst potentially contributing to the fragmentation of habitats. Current studies suggest that soil sealing may be irreversible although this condition may be mitigated if not reversed if the right de-sealing incentives and related monitoring measures are in place. One of the main mechanisms contributing to soil sealing is that of urbanization, and rate of land development has been identified as an indicator of soil sealing. However other activities also contribute to soil sealing, these include: trapping, recreation, creation of informal car parks, off-roading, and the creation of new roads and/or road widening.

This review of the pressures on and status of Malta's soil resources indicates that they are important for the maintenance of ecosystem health, agriculture and water management. However soils are threatened by a range of factors including contamination, soil sealing and land abandonment. There is a need for Malta to update national legislation, and build capacity in this area for monitoring and enforcement.

Other degradation threats

Local research about topsoil and subsoil compaction using the pre-compression stress (PC) concept or mapping susceptibility rates of compaction is not available at the time of writing.

Furthermore, no comprehensive and systemic monitoring studies, addressing the presence, abundance concentration and general conditions of micro, meso and macro fauna diversity (which characterize the classical trophic levels of the soil horizon) have been carried out in Malta.

A local knowledge gap is also experienced in relation to addressing issues associated soil landslides and/or flooding although flooding is known to occur in built-up areas, particularly remnants of valley sides which have also been stripped of soil due to intense urban development and land use competition taking place there.

Information related to Policy
(Source: National Environment Policy 2012, published February 2012 by the Ministry of Tourism Culture and the Environment)

Soil is one of Malta's most important natural resources, with socio-economic and ecological importance. Malta's soil resources are important for the maintenance of ecosystem health, agriculture and water management, as well as for supporting tourism and recreation-related activities in the countryside. However soils are threatened by a number of pressures such as the loss of organic matter and related biodiversity decline, contamination, soil sealing and erosion. Malta's high rate of urbanisation, together with the intensification of agricultural practices in certain sites, has accentuated the pressures on soil, particularly on those that are more vulnerable, such as clay soils. Due to the expected impacts of climate change on soils and water availability to plants, and the need to address adaptation to climate change, further soil protection measures have become increasingly necessary.

Policy: Protect, manage and enhance Malta's soil resources in a sustainable manner
National legislation for the prevention of loss of soil and obligatory maintenance of soil-retaining structures already provides a framework under which further soil protection measures may be put in place.

One of the National Environmental Policy pledges refers to undertaking of a legislative review to address lacunae related to threats to soil quality, such as erosion and contamination. Other NEP objectives are described below:

- Continue to promote soil conservation measures through future agricultural programmes;
- Put in place a soil quality monitoring system;
- Strengthen capacity to monitor soil movements and enforce legislation on soil conservation;
- Protect agricultural land and gardens of conservation value to avoid further soil loss by sealing and erosion through spatial planning system;
- Investigate the sources of significant risk factors in terms of soil contamination, leading to the identification of potential contaminated sites, and formulate action plan to address them.

A number of soil protection measures have already been implemented through rural development programmes, such as the maintenance of rubble walls, the establishment and maintenance of conservation buffer strips, and support for organic farming and low-input farming. In addition, within the group of baseline conditions that farmers need to comply with, are a number of conditions relating to soil conservation.

Such measures will be enhanced in future agricultural programmes. The Code of Good Agricultural Practice will continue to be used to promote soil protection through soil conservation guidelines that are to be adopted by farmers on a voluntary basis.

Through the Maltese Soil Information System (MALSIS) project, geo-referenced data on soil types, soil landscapes and key soil properties was produced for a number of soil bodies and also for certain 'hot spot' areas. We will continue to carry out the necessary studies to monitor soil quality through a monitoring project funded by the European Regional Development Fund (ERDF). We will also strengthen capacity to monitor soil movements and enforce legislation on soil conservation. In addition, the spatial planning system will be used as a tool to protect agricultural land and gardens of conservation value, and to avoid further soil loss through sealing and erosion. The environmental permitting process will be used to control pollution from industrial activities (including waste management facilities) in order to avoid soil contamination in line with EU standards. Significant risk factors in terms of soil contamination will also be investigated, leading to the identification of potential contaminated sites and an action plan formulated to address them.

Soil management in Malta

The Malta Environment and Planning Authority (MEPA) is presently undergoing preparation aimed towards soil monitoring for the presence of radiation to partly address the proposed obligations under the Proposal for a Framework Directive on soil protection. This baseline monitoring is funded through an EU funded project to fulfill monitoring obligations emerging from Articles 35 of the EURATOM Treaty and to implement the first National Environment Radioactivity Surveillance Plan (NERSP) for Malta as per Article 36 obligations of the same Treaty. Monitoring results and associated reports will be available by mid-2013 and will indicate, through sample testing of around 60 sites, topsoil conditions in terms of radiation parameters and a number of indicators.

In parallel to the above, a short term monitoring/investigation plan of all major threats to soil quality (desertification issues are also included in this analysis) is being developed which, together with the availability of existing data, will enable project consultants to optimize the location of survey points.

The latter assessment will include the collection of primary data from around 36 monitoring points which were determined through a multicriterial model of MALSIS data described in past SOER editions. The final product would include the objective of producing a short-term Maltese Soil Model containing thematic risk maps for each indicator tested and classified under one or a combination of degradation threats to soil quality.

Eventually, this information would be uploaded on a dedicated Shared Environment Information System (SEIS) to be administered by MEPA.

Subsequently, a long-term monitoring programme will be designed on the basis of these results and on further assessment of additional indicators addressing a wider range of issues associated with assessment of threats to soil quality. A number of tools are planned to be established in accordance to standard modern professional and research practices:

- a revised and updatable distributed scheme for the monitoring and control of soil erosion;
- a revised and updatable distributed scheme for the monitoring and control of soil organic content and compaction based on periodic grid control at key locations. A similar distributed scheme for the monitoring and control of soil salinization will be supported by a periodic analysis of soil salt content. A similar periodically modified landslide inventory map

will also be included in this monitoring system (the latter technique being particularly useful for Malta due to the island's high degree of urbanization);

- a large-scale distributed dynamic map for the prediction of landslide triggering due to rainfall, based on the definition of a specific deterministic or statistical model;
- preparation of guidelines for real-time identification of potential contamination sites, supported by a National Registry of Contaminated Sites;
- a revised and updatable distributed model for the monitoring and control of desertification.

The long-term strategy will be defined further once data on preliminary indicators is acquired.

In parallel to the above, the Directorate for Agriculture currently administers (in part) regulations aimed at protecting soil quality in terms of erosion, compaction and contamination. This activity is done through the monitoring of GAEC measures, SMR standards and funding for LFAs on agricultural land registered for this purpose.

Concurrently, soil samples provided by farmers are regularly tested by the soil and irrigation water laboratory within the Plant Health Directorate (MRRA). Sample testing includes measuring soil salinity (pH, electrical conductivity, soluble sodium and chloride), fertility (potassium, nitrate-nitrogen), physical properties (particle size distribution, organic matter content) and presence of pollutants/heavy metals (lead, chromium, nickel, zinc, copper and iron).

Furthermore, a recent EU project on information gathering on the presence of nitrates within local agricultural soils[1] is also being managed by Agriculture Directorate within the Ministry for Sustainable Development, Environment and Climate Change (MSDEC). This nation-wide initiative entitled *Information and communications campaign for the proper use and management of nitrates in agriculture and livestock breeding* launched earlier this year (with project's completion date being set for December 2013), is being managed by the Plant Health Directorate under the auspices of the PS [2] within the same Ministry.

Aforementioned campaign is designed to provide farmers and livestock breeders with information and training to act in accordance with the 1991 European Nitrates Directive and subsequently with recommendations included within the associated 2011 Nitrates Action Plan for Malta.

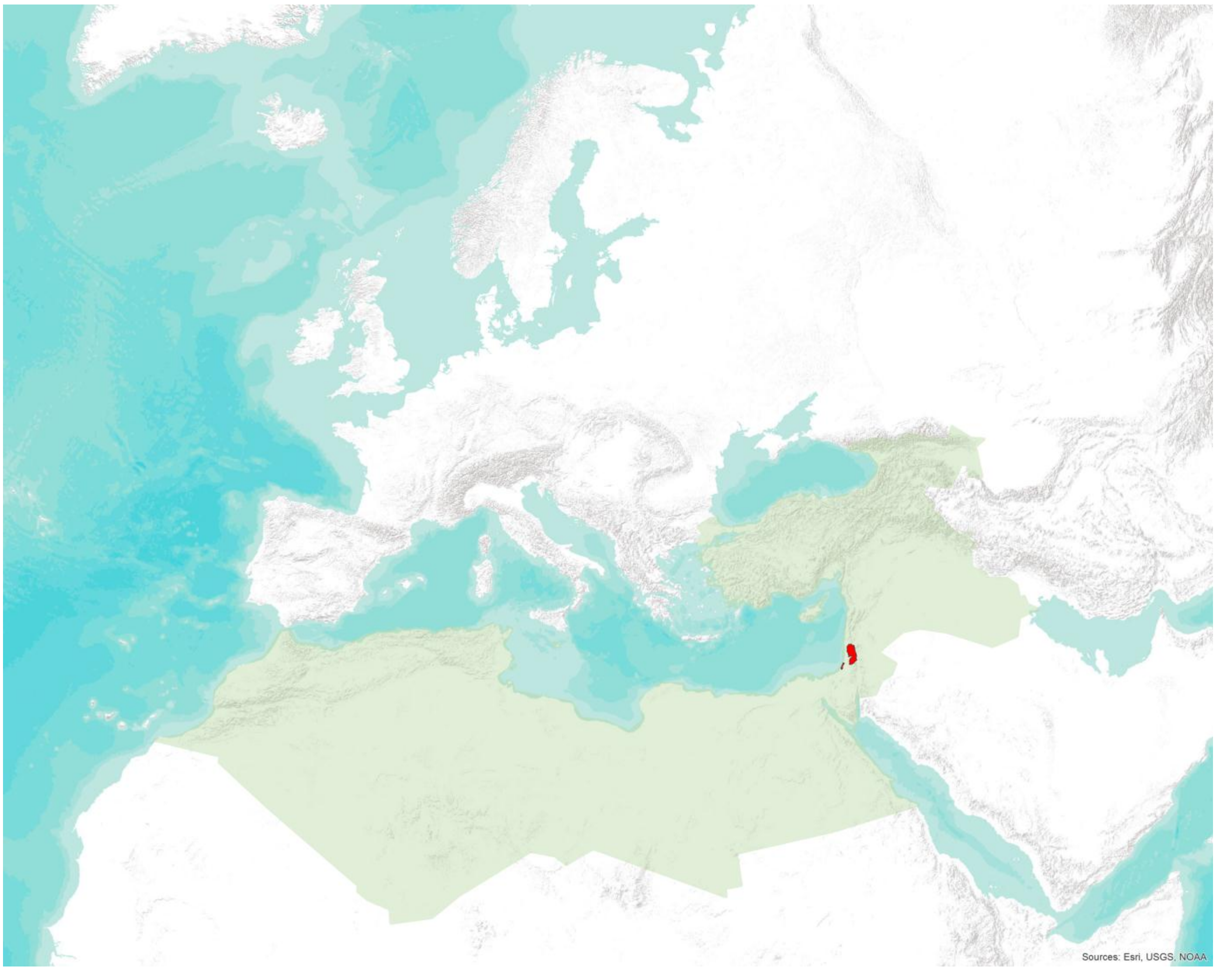
Publications

A list of publications about Maltese soils, including the National Soil Information System (MALSIS) project can be found in: http://www.mepa.org.mt/soil-publications

[1] LIFE10INF/MT/000092

[2] Parliamentary Secretariat for Agriculture, Fisheries and Animal Rights,

Chapter XII.
Soil Resources of Palestine



Soil Resources of Palestine

Basim Dudeen, Wael Abu Rmailah, Mohamed AlSalimiya , Mohammed AlAmleh[1]

Abstract
The importance of addressing the proper management of soil resources in the West Bank and Gaza Strip (W&G) is highlighted in this paper. It is introduced by displaying basic information about the target area in terms of its location, population and some socioeconomic indicators. Physical features represented in climate, land use/cover, agro-ecological zones and geology. The history with relevance to soil mapping and surveying indicating that this area deserves special attention to its soil resources for several reasons. The current situation of soil management in the W&G is progressing at the technical level as a result of the efforts exerted by the governmental sector represented in the Ministry of Agriculture and the non-governmental sector represented in the Land Research Center. This progress is displayed in this paper in the volume of soil surveying and establishment of National Soil Information System. However, the absence of control on the land and natural resources due to Israeli occupation is restricting the proper management of soils in the W&G. In addition to that, human and natural induced pressures are exacerbation the situation. These pressures are represented in soil erosion, soil salinization, soil contamination, soil sealing, reduction of vegetation cover and decline of organic matter. Impacts and responses were also addressed followed by some conclusions and recommendations for the sake of proper soil management and well being of Palestinians.

Keywords: West Bank and Gaza Strip, soil resources, soil degradation, soil surveying, soil erosion, rangeland, soil management.

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Figure 1. West Bank and Gaza Strip - Palestine

Introduction

Palestine, represented currently in the West Bank and Gaza Strip (Figure 1), has a unique geographic location at the intersection between three continents, Africa, Asia and Europe and between very different ecological zones (Irano-Turanian, Mediterranean, Saharo Arabian and Sudanian). This situation leads to a remarkable variety of ecosystems and biodiversity as well.

The West Bank and Gaza Strip (W&G) are located east to the Mediterranean Sea between 29° and 33° North Latitude and between 35° and 39° Longitude. The total area of the W&G (including the Palestinian part of the Dead Sea) is about 6245 km^2 (365 km^2 in Gaza Strip). It is populated by more than 4.2 million Palestinians, according to the projection of Palestinian Central Bureau of Statistics survey in 1997, 2.6 millions in the West Bank and 1.6 millions in the Gaza Strip. . The Gross Domestic Product was estimated at around 6,257 million dollars, and the income per capita is estimated at 1,737 $ per person.

The absence of the proper management for Palestinian natural resources for the last 45 years due to the Israeli Occupation, in addition to the high population growth rate (3.5-5.0%), centralization of peoples in smaller spots of land, Israeli colonizing activities like colonies construction, bypass roads and military bases, all these factors increased the pressure on soil in particular, and natural resources in general. The accumulation of these pressures resulted in a comparatively high rate of soil degradation.

The geographic, political and socioeconomic uniqueness of this area imposes additional pressure on these resources. Although there is a deep understanding and appreciation of the extent of soil degradation in Palestine, there are hardly any available records or rates of soil degradation, nor are significant parameters systematically monitored. The few existing published work is unconnected and mainly descriptive and qualitative.

This paper concentrates only on the evaluation of physical, geographic and national human impacts on soil degradation.

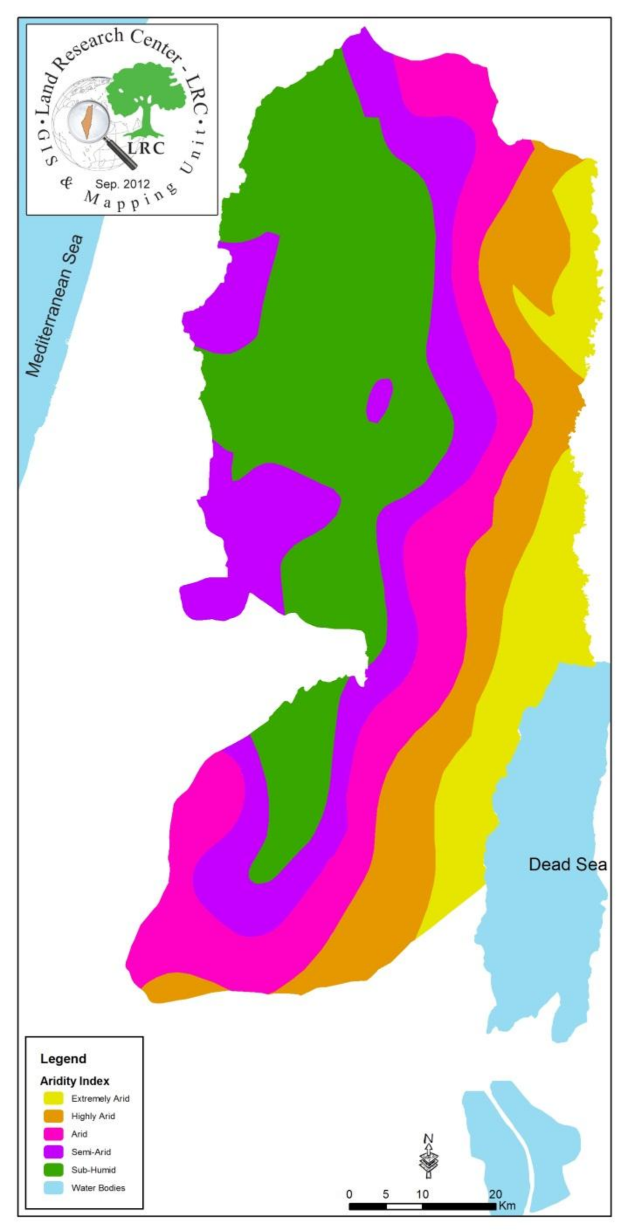

Figure 2. **West Bank Climate Map**

Climate

Palestine belongs to the sub-tropical zone. On the coast (Gaza Strip) and on the highlands (West Bank), the climate (Figure 2) is of Mediterranean type with a long hot and dry summer, short cool and rainy winter. Accordingly, the climate of Palestine is classified as an eastern Mediterranean one. The temperature increases toward the south and towards the Jordan Valley (east). The rainfall is ranging from 100 to 700 mm annually depending on the location. In the southern part of the West Bank, the area of Jerusalem Desert and Jordan Valley, arid conditions prevail.

Other classifications for the climate of Palestine were addressed as well. In 1953, Meige classified Palestine into three climatic regions: arid, semi-arid and Mediterranean. Arid climate has comparatively low amount of precipitation (<200mm) with temperate winter and very hot summer. Semi-arid has medium amount of precipitation (200-500 mm) with temperate winter and hot summer. Mediterranean climate has the highest amount of precipitation (>500) with cool winters and hot summer.

Rosenan, in 1970, prepared a rainfall map and climatic zone map of Israel and Palestinian territories. He divided the previous classifications defined as arid zone, into extremely arid (including the southern part of the Jordan Valley); arid and semi-desert (including part of the eastern heights represented mainly in Jerusalem desert); mildly arid (including a strip adjacent to the eastern heights); semi-arid (including the central heights); and humid and sub-humid (including the western heights and the semi-coastal area).

Land Use / Cover

The following information represents the percentage (%) of types of land cover/use (Figure 3) in the W&G:

Palestinian built up areas (3.67), Israeli colonies (1.34), closed military areas (20.23), Military bases (0.28), state land (24.23), nature reserves (5.68), forests (1.1), Palestinian cultivated areas (28.90), Israeli cultivated area (1.09), Dead Sea (3.05), and others (i.e. dumping sites, industrialized zones, etc) cover about 10.43 percent.

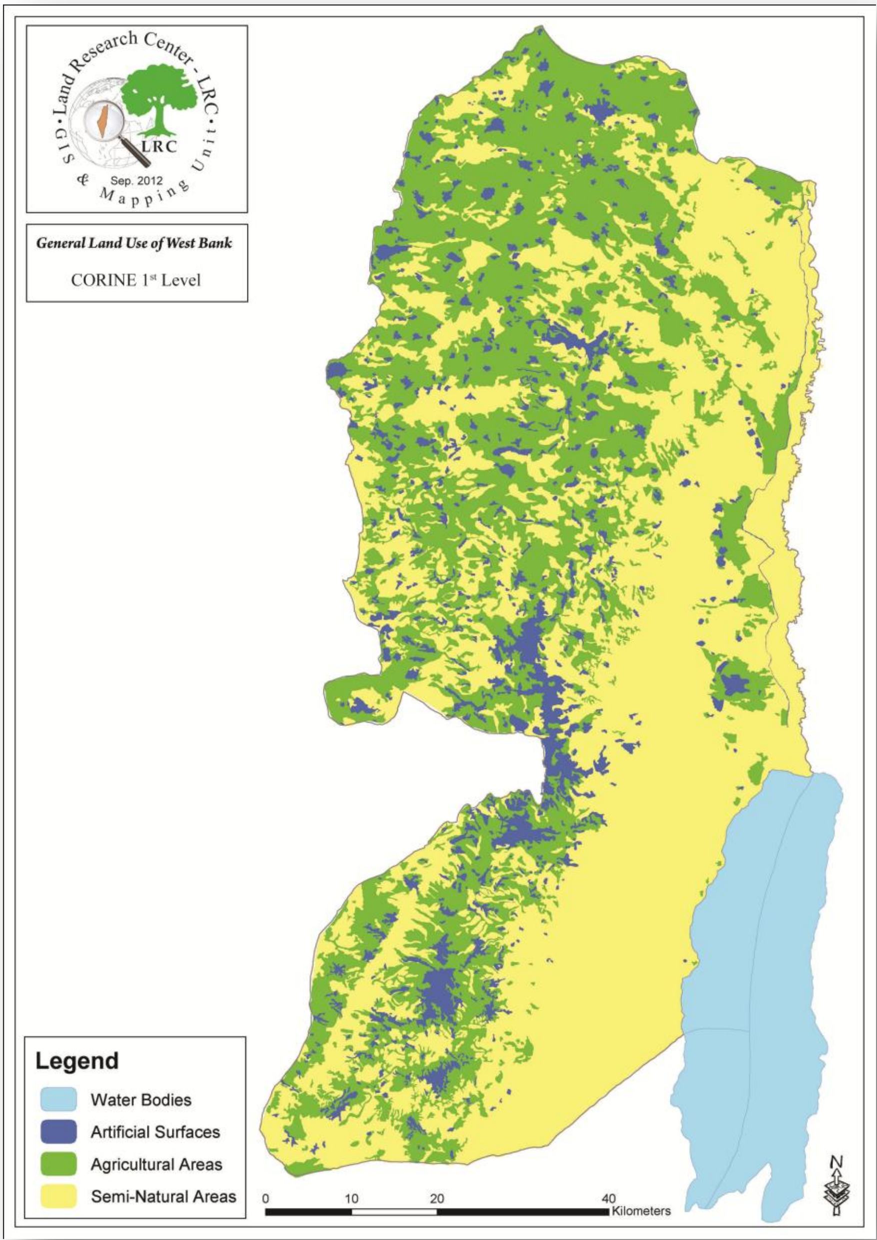

Figure 3. West Bank General Land Use

The Land Research Center, within the land system classification study, presented estimations for the agricultural and urban areas at the first level of CORINE land cover system. The estimations were as follows: cultivated hills (46%), uncultivated hills (34%), arable plains (12%) and the rest are made of other minor forms of land use. These data are approximate and depending on the general use of the land unit in each land system.

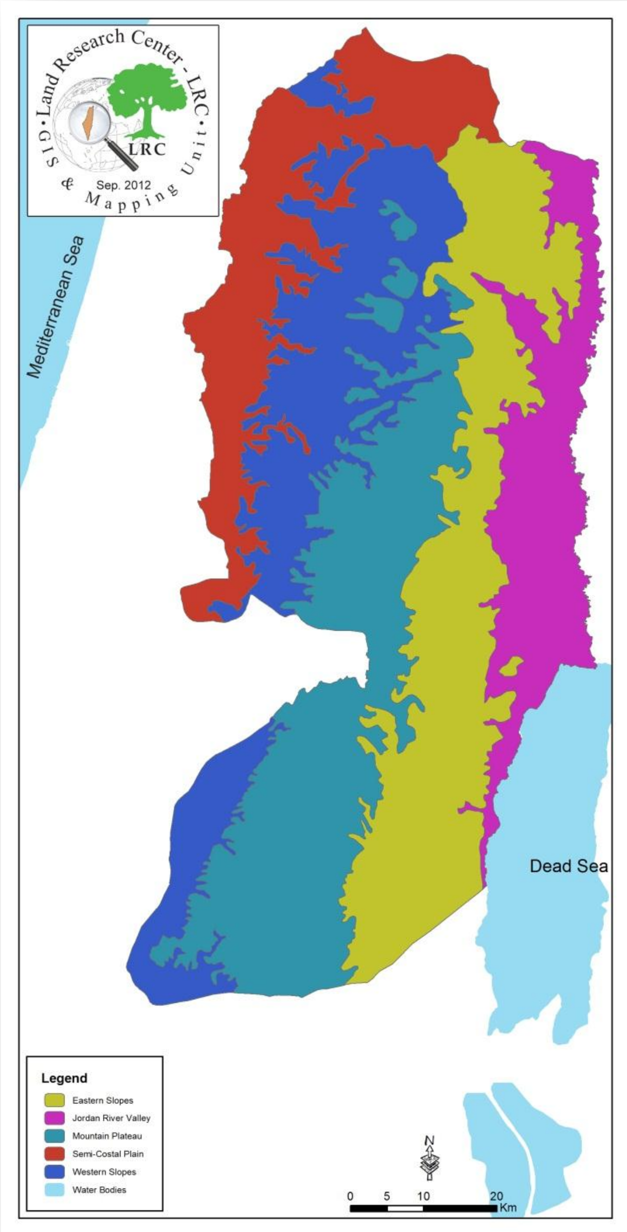

Figure 4. West Bank Geomorphological Map

In the context of the land cover/use study conducted by the Land Research Center for Gaza Strip, the following are estimations for the land use: periodically irrigated land (17%), discontinuous urban fabrics (15%), non-irrigated land (42%), citrus plantations (9%), continuous urban fabric (9%), Sclerophyllous vegetation (8%). The Land Research Center is working at present on a land use map at the third level of CORINE classification methodology (Land Research Center, 2000).

Agro-ecological zones

W&G has five agro-ecological zones determined by location, rainfall and altitude. They include Central Highlands, Semi Coastal Region, Eastern Slopes, Jordan Valley and the Coastal Zone (the Gaza Strip) (Figure 4).

The Central Highlands:

These include the area from Jenin to Hebron. The zone is mountainous rising up to 1,000 m above sea level. It is mostly hilly and rocky, and soils are often shallow. Average annual rainfall ranges from 350 to 700 mm. Out of the total cultivated area, 95% is rain-fed 60% under olives, grapes, almonds, and fruit trees, and 35% under field crops, mainly winter ce-reals and grain legumes. The remaining 5% of the cultivated land is irrigated and mainly utilized to produce vegetables.

The Semi-coastal zone:

This is a narrow strip comprising parts of the Jenin and Tulkarm districts with altitudes of 100 - 300 m above sea level and has an average annual rainfall of 600 mm. Much of the soils are medium textured of alluvial origin and consist of silt and loam derived from a variety of parent materials.

Less than half of the cultivated area depends on rain only. More than half is irrigated or receives some supplementary irrigation water. The rainfed crops are cereals and grain legumes; however, fruit trees are also grown under rainfed conditions. Irrigated crops include a wide variety of vegetables, potatoes, citrus and other fruit trees.

The Eastern Slopes zone:

This is a transitional zone between the Central High-land and the desert areas of the Jordan Valley. It extends from the eastern parts of Jenin to the Dead Sea in the south. The steep mountains with little rainfall that predominate in this region make it an almost semi-arid to desert zone. Agricultural production is of marginal importance and is limited to rainfed cereals such as wheat and barley. Olives are cultivated as well in sporadic small spots. Average annual rainfall is 250-300 mm. Some parts of the zone are used for spring grazing. The total area of this zone is approximately 1,500,000 dunums, with altitudes varying from 800 meters above sea level until 200 m below sea level.

The Jordan Valley zone:

Jordan Valley is a narrow strip between the Eastern Slopes and the Jordan River. It is 70 km long and drops to about 400 m below sea level near the Dead Sea. Rainfall is low (100 -200 mm), winters are mild and summers are hot. Soils are sandy and calcareous.

This zone is the most important irrigated area in the West Bank. Hot summers and warm winters characterize the climate of this region. The availability of both springs and ground water makes this area most suitable for off-season vegetables and for semi-tropical tree plantations, including bananas and citrus. All strains and varieties of dates palm trees are still in existence. Citrus orchards with special taste and early ripping season are remarkable in the Jordan Valley. Recently, early grape strains began to take place as an economical cash crop.

The Coastal zone (Gaza Strip):

This zone is located along the eastern coastal plain of the Mediterranean Sea. Sinai desert to its south. It has a semi-arid Mediterranean climate of long, hot summers and mild winters with fluctuating rainfall. Rainfall is relatively moderate in the north reaching 300 mm and is below 200 mm in the south.

There are many other attempts to classify the land of Palestine, some of them are very old. There is a recent classification work done by the Land Research Centere, dividing the West Bank into twelve land systems based on geology and climate of the system level, and land use and topography at the subsystem (land unit) level.

Geology

Regarding the geology of the West Bank and Gaza Strip, there has been a lot of research work since the beginning of this century. Following are some explanations regarding different areas of the country.

The Jordan Valley which comprises one of the lowest depressions of the earth has been formed as a result of an "earth fissure", its most part is covered by diluvial marls which frequently display a dissected topography. Tertiary limestone also occurs in some localities.

Eastern Heights, Central Highlands and the Semi-coastal region consists of Cenomanian, Eocene, Turonian and Senonian limestones. Whilst the Cenomanian and Turonian limestones are mostly very hard and resemble marble, the Senonian and Eocene limestones are generally of soft and chalky nature.

Gaza Strip region has a substratum of Tertiary limestones, calcareous sandstone marls, clay and marine diluvium. Partially fossilised dune sand deposits cover wide stretches of land. These dune sands are often cemented by calcareous sediments and cemented infiltration, and form therefore compact masses of hard rocks.

Several geological maps at different scales are available. A general geologic map for Israel at a scale of 1:250,000 displays the geology of the West Bank and Gaza Strip.

Soil surveying and mapping

West Bank and Gaza Strip is relatively a small geographic area; however, the soils are remarkably diverse in their properties. This diversity is due to the variation in climatic, origin (parent material) and topographic features. The soils of Palestine have been the subject of many studies since the beginning of this century. Several attempts were made to classify, identify and even map the soils.

The first soil survey of the country was made in 1927-28 by Strahorn from the American Bureau of Soils on behalf of the World Zionist Organization. He surveyed almost 4.9 million dunums of the low-lands of Palestine. Maps at a scale of 1:40,000 and 1:63,000 were used in the field, and the data were then assembled on a 1:250,000 map. Strahorn used the American system of soil series as the primary unit for soil classification and for mapping purposes. Twenty-six soil series were defined and given the geographical names of the first place where they were identified.

Reifenberg and Whittles (1947) studied in details the chemical properties of most soil types identified in Palestine, he compared their composition to that of subjacent rocks. He published a schematic soil map at a scale of 1:1,6 million, which relies heavily on the geological map. He classified the soils according to the identified climatic regions. In combination with the parent material, he considered climate as the dominant factor in the differentiation of the soils, and they were; therefore, grouped into 4 climatic zones, which are differentiated by specific rainfall conditions.

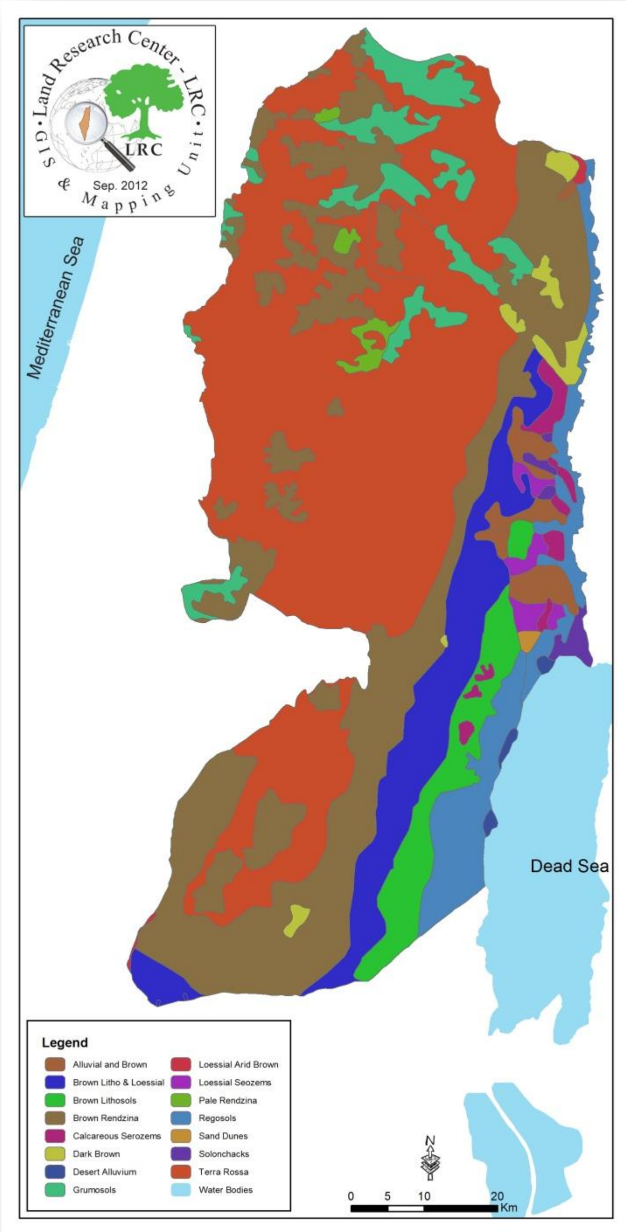

Figure 5. Soil Map of West Bank

Aridic region comprises desert soils, Lisan Marl soils, and the loess areas. Semi-arid region comprises Mediterranean Steppe soils and dune sands. Semi-humid region comprises *kurkar* soils, (sand-stone cemented with calcium carbonate), red sandy soils, and *nazzaz* soils (red sandy soils, which have a compact, impermeable pan layer). The latest are concretionary in character and often are found at a slight depth below the surface**.** These soils are classified as black earth and alluvial soils. Humid region comprises the "terra rossa", red soils on volcanic rocks, and mountain marl soils. It is worth mentioning that not all these soils are identified in the West Bank and Gaza Strip. The soils in the following regions were classified according to the rain factor (Figure 5).

In the Jordan Valley, the main soil type according to Reifenberg, is Lisan marls. They are deposits of a former inland lake and consist of loose diluvial marls. The Lisan Marl soils are generally of a rather light nature, their clay content varies from approximately 10 to 20%. High concentration of lime content is present, which varies between 25 and 50%. Where there is no possibility for irrigation, the Lisan marls are covered with a very sparse growth of halophytic plants.

In the Eastern Slopes region, the main soil types are the semi-desert soils, the secondary soil types are the “terra rossa” and the mountain marls. For the semi-desert soils, the formation of sand and gravel is characteristic of desert weathering. As a result of the lack of rain, agriculture is only possible in those quite isolated places where scanty spring showers occur.

In the Central Highlands region, the main soil type is “terra rossa”. This is the most typical soil of the mountains in the West Bank and Gaza Strip and is the product of the Mediterranean climate and soil formation on hard limestone. Its soil reaction is generally neutral to moderately alkaline and it has a high content of soluble salts. Both the high iron content and the low organic matter are responsible for the red color. They are mainly of loamy texture.

In addition to the “terra rossa” soils, mountain marl soils and alluvial soils are also present in considerable areas. Mountain marl soils are formed from the chalky marls of Senonian and Eocene age. These soils are well distinguished from the “terra rossa” as far as the vegetative cover is concerned. They are not very fertile because of their poor water holding capacity and the high lime content.

In the semi-coastal region, the main soil types are alluvial, “terra rossa” and mountain marls. Alluvial soils are distributed all over the region, but most typically occur in the vicinity of the agro-ecological sites. These soils are not considered as climatic or zonal soil types. In the West Bank, they are mainly found in the mountain-enclosed basins and in the Plain of Jenin. The soils are formed by the deposition of alluviums transported by water. They are generally very deep and of clayey nature. The reddish or brownish alluvial soils brought down from the mountains have at many places been leached out of their lime content.

In the Gaza Strip, the main soil type originates from the dune sands. Dune sands are overlying alluvial soils in a shallow layer creating ideal conditions for fruit plantations. Citrus plantations dominate the area. These dune sands have exceedingly low water holding capacity and very high water permeability. In addition to the sandy soils, loess soils are also occurring in the Gaza Strip. These soils owe their origin mainly to the dust storms of the desert.
To a great extent, included in the are also locally weathered soils. They are rich in calcium but poor in iron and aluminum, have a high percentage of fine particles, which belong mainly to the fine sand fraction. They are easily permeable by water and air, therefore their texture is most suitable for cultivation of root crops.

Zohary (1942) studied the relations between vegetation and the various soil formations, and based upon field reconnaissance observations he published a generalized soil map at a scale of 1:600,000. He defined 11 soil types and introduced the Rendzina group into the local nomenclature. They are sub-groups of three sub-geographic zones. Within each zone, mainly the petro-graphical and topographical features are responsible for the soil formation and its diversity.

Rosensaft and Gil (1955) through the USDA Soil Conservation Service published a soil type map at scale of 1:500,000 on which 13 soil types are distinguished. The map is not accompanied by any explanatory text, and it is thus not known what criteria were used for establishing boundaries between soil types**.**

Dan et al. (1962) described the soils of Israel and mapped them on the basis of soil associations. The West Bank and Gaza Strip soils were included in this study and a map having a scale of 1:250,000 was prepared. The soil associations on the map were defined as geographical associations of the listed soil units. They are distributed in a landscape segment according to a definite pattern related to the physiographic, lithologic and micro-climatic conditions.

There are 17 soil associations included in the above map. They are divided into two major groups: those of subdued mountains and high plateaux, all of which have a high proportion of Lithosols or bare rock and rock outcrops, and those of the low plateaux and plains, which include all the major agricultural areas. According to this study, the soil associations which are existing in the West Bank and Gaza are: “terra rossa”, brown and pale rendzinas, bare rock and desert Lithosols, Grumosols, dark brown, sandy Regosols and arid brown, sand dunes, and calcareous serozem soils, which are loess and/or loess like soils.

A. Amiel (1965) described the soils in the south-western heights of the West Bank (southern Shfela) and those of the coastal plain, which include also the Gaza Strip. He concentrated on the genesis and then properties of these soils, particularly studying the type and the source of parent material, means of transportation and processes of soil formation.

A. Banin and Amiel (1969) established a correlation between chemical and physical properties of several groups of soils of Palestine. Samples were taken from various locations representing the main soil groups in the country. A set of chemical analyses was made and important conclusions on soil proper-ties were found.

Dan et al. (1976) re-classified and mapped again the soils of Palestine. They used the physical properties as a basis for their classification. And divided the soils into 34 units accompanied in 20 soil associations. In 1976 they published a soil map at scale of 1:500,000. This map could be considered as an expansion of the map of 1962 and 1972 with significant modifications. In addition to the adopted local classification the USDA Soil Taxonomy and FAO classification was introduced in the descriptions.

A soil map at a scale of 1:250,000 for Israel was recently published by Dan et al. in 1992. The West Bank and Gaza Strip is included in this map. A division has been made between the soils of the Mediterranean zone and the soils of the desert zone. Within each zone several soil types have been de-fined and described. The effects of climatic conditions, types of parent material, topography and erosion on the character of the soil forming processes and on the nature and properties of soil pro-files are investigated with respect to each zone. The classification and nomenclature used in this publication follow the soil map of Israel published previously in 1976. A 1:500,000 map showing the distribution of salt affected soils and another one at scale 1:250,000 showing trace elements were also published.

The soils are compared and evaluated on the basis of the nutrient elements they contain. The data presented show significant differences in nutrient elements levels between soils of the Mediterranean zone and soils of the desert zone.

Generally, there is very little local literature regarding the soils of the West Bank and Gaza strip. Recently, Land Research Center, implemented soil surveys in different sites in the West Bank and Gaza Strip. This is the first time that Palestinians are doing such a work by themselves.

The main achievements being realized are the pedagogical characterization of the Eastern Heights Land System by classifying the soils according to "Soil Taxonomy" (USDA, 1998) and the FAO - ISRIC World Reference Base for Soil Resources (WRB 1998).

Other achievements were the preparation of soil maps at detailed scale such as:

- Jericho District: 1,300 ha at the scale of 1:10,000; the area is located Southward and Eastward the city of Jericho up to the bypass road.
- Hebron District: 1,800 ha at the scale of 1:25,000: the area is located Eastward of the city of Hebron and includes the villages of Sa`er, Al Jalajil, Ash Shuyukh up to Bani Na`im.
- Gaza District: 400 ha at the scale of 1:10,000: the area is located Southeast of Beit Hanun.

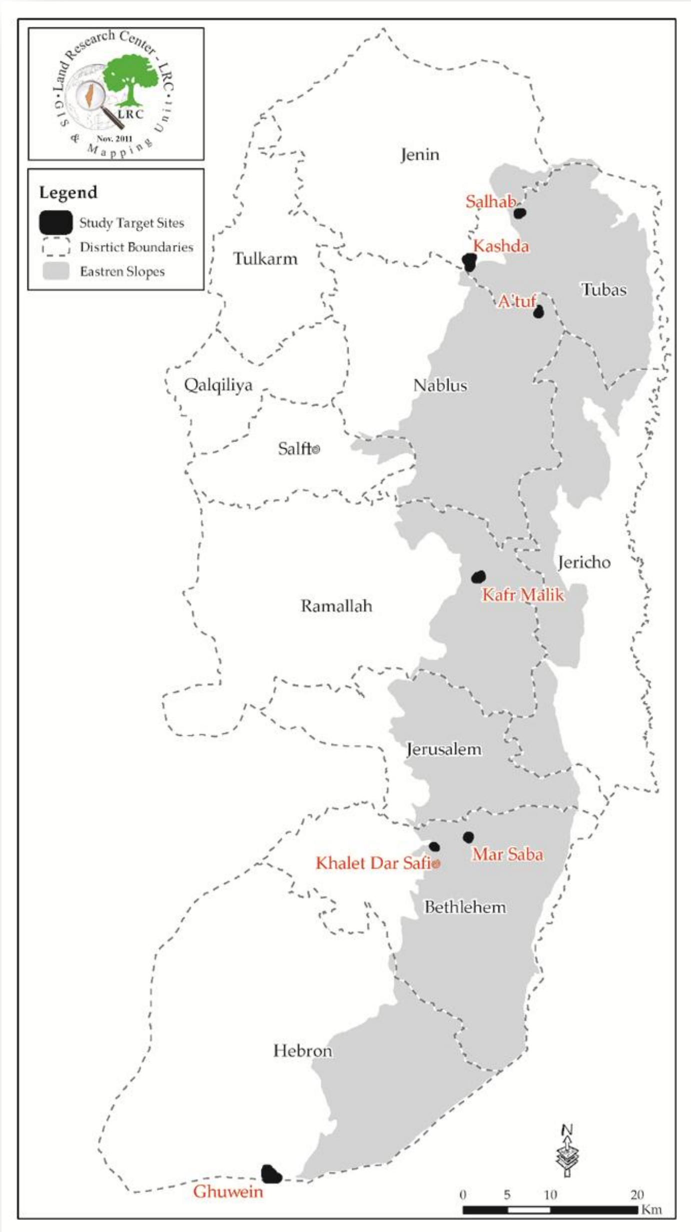

Figure 6. Study Sites Map

Soil Survey and Classification of the Communal Rangeland in the West Bank – 2011

In the context of Sustainable Rangeland Management in Communal Land Project in West Bank, seven sites were selected as target areas representing plots of eastern slopes rangeland (Figure 6). To understand the implications of soil classification in the seven target sites, soil mapping at an appropriate scale (1/10,000 in this study) was undertaken.

Aerial photographs with resolution of 75 cm / pixel were utilized to delineate the landform elements component in each of the target sites. Ancillary data combined with field checking during the survey helped in modifying the borders of the landform elements.

Totally 37 profiles and 250 augers were done and 103 soil samples were collected and analysis. The total observations in the seven study sites is composed of 250 augers and 37 profiles distributed in a representative way among the seven sites. For each profile all the morphological, physical and chemical data were identified either in the field or in the laboratory. These properties are either essential for soil classification according to the FAO - World Reference Base for Soil Resources (2006) or helping in evaluating the soil quality and obstacle of soil management.

There are five main reference soil group defined in these sites according to the FAO - World Reference Base for Soil Resources (2006) classification system. At the lower level, there are 9 prefix qualifiers and 23 suffix qualifiers as shown in Table 1.

Table 1: Soil Classification of the Communal Rangeland in the West Bank

Soil Type		
Reference soil group	Prefix qualifiers	Suffix qualifiers
CAMBISOLS	Endoleptic	Colluvic, Calcaric, Humic, Epiclayic
	Epileptic	Calcaric
	Endoleptic	Calcaric, Humic, Skeletic, Clayic, Chromic
	Epileptic	Colluvic, Calcaric, Epiclayic
	Epileptic	Calcaric, Episkeletic, Epiclayic, Chromic
	Haplic	Calcaric, Humic, Endoskeletic, Endoclayic, Chromic
	Epileptic	Calcaric, Epiclayic
	Epileptic	Calcaric, Episkeletic, Epiclayic
	Endoleptic	Colluvic, Calcaric, Sodic
VERTISOLS	Sodic Calcic	Hyposodic, Eutric
	Sodic Calcic	Calcaric, Hyposodic
CALCISOLS	Petric	Endoclayic
	Endoleptic	Sodic
	Haplic	Sodic
LUVISOLS	Endoleptic Calcic	Humic, Episkeletic, Epiclayic
	Endoleptic Calcic	Humic, Sodic, Epiclayic
	Endoleptic	Humic, Epiclayic, Rhodic
	Endoleptic Vertic	Sodic, Endoclayic
	Calcic	Sodic, Hypereutric, Endoskeletic, Clayic
	Epileptic	Hypereutric
LEPTOSOLS	Haplic	Calcaric, Humic, Sodic
	Haplic	Eutric
	Haplic	Calcaric
	Cambic	Calcaric
	Haplic	Calcaric, Episkeletic
	Haplic	Calcaric, Sodic, Episkeletic

The Present situation

It is evident that the national soil information system in Palestine has just started with the soil surveys implemented by the Land Research Center. The soil information system should be used for the protection of soils against degradation and pollution and should be utilized by the decision-makers at all levels.

The following soils lcategories should be considered for soil conservation:

- Soils of zones exploited for non-irrigated agriculture;
- Agriculturally high productive soils;
- Low productive agricultural soils;
- Soils endangered by water erosion;
- Soils contaminated by persistent contaminants;
- Urban soils and soils likely to be affected by industrial use; and
- New formed anthropogenic soils of mining areas.

This categorization would hardly succeed without a well structured Geographic Information System (GIS). The current structure of the soil GIS at the Palestinian Soil Office include the following:

1. Digitized information from the land system publications, which include information data from DTM as slope, aspect and elevation. The scale of the land system map is 1:50,000. The main aim of this work is to build up a national digital geo-referenced database of the soil and terrain resources in Palestine. It is based on the unanimously accepted concept that soil and terrain represent a single entity that incorporates processes and systems of interrelated physical, chemical, bio-logical, geo-morphological and even soil phenomena.
2. Digitized land use/cover up to the CORINE fourth level at a scale of 1:50,000.
3. Detailed soil characteristics from profile surveying data and literature data. Attached are the sheets prepared for the field survey and laboratory data.
4. General soil data like soil exploitation, production, degradation, contamination, and other soil constraints.
5. Attributes of heterogeneity of the soil cover.
6. Criteria for data evaluation.
7. Extrinsic environmental characteristics.
8. Pedo-transfer functions.
9. Models of pollutant transformation between soil and the hydrosphere, the biosphere and the atmosphere.
10. Information about the natural and anthropogenic factors and environmental loads.

The Design of Soil Geographic Information System

Field teams of experienced surveyors examined a number of soil profiles distributed as follows:

- Eastern Heights: 30 profiles; (to be updated after implementing the recent soil surveying)
- Jericho Area: 30 profiles;
- Hebron Area: 12 profiles;
- Gaza Strip: 12 profiles.

The morphological characteristics of each profile are examined for classification purposes according to the attached field sheet. The boundaries of each mapping unit were drawn on aerial photographs at a scale of 1:10,000 for Jericho and Gaza areas and at a scale of 1:25,000 for Hebron area. The soils are further examined by borings to 1.5-m depth, made with a hard soil auger. The distance between the borings ranges from 50 to 200 m, depending on the uniformity of the soils. In the Palestinian Soil Survey System, symbols used for profile description are done according to the Soil Survey Manual, Agriculture Handbook no. 18, and the FAO-ISRIC guide-lines for soil profile description, 1993.

The prospected future of Palestinian Soil Information System (PSIS)

The current utilization and future potential of the Palestinian Soil Information System would be deter-mined and influenced by the following:

- The developments in the political situation. The sovereignty on land is a decisive factor to utilize and encourages upgrading the PSIS. It has a strong impact on environmental legislation, process monitoring and control systems of soils.
- Developments on the socio-economic conditions as a result of the prospected new political era.

The PSIS will be urgently needed in the prospected new born Palestinian State for the following:

- **Soil rating**: a soil appraisal system for assessing soil value should be prepared for the purposes of taxation and agricultural soil sub-sides.
- **Environmental Protection** for district administration in the form of soil maps, land evaluation maps, soil contamination maps. Some of these were already started within the context of various projects.
- **Urban Planning**: PSIS should be used for urban planning on the national level and regional and municipal levels.
- **Agricultural needs** in the form of information about soil nutrients, pH status and soil contamination.
- **Education, Research and Publicity**: data from PSIS serve for education, environmental and agricultural research projects and also for public information.
- **Accessibility** to scientific information about agricultural utilization, rational fertilization and profitable land management.

The Palestinian Soil Office establishment

Palestinian Soil Office (PSO) was established in 1997 under the auspices of the Land Research Center (LRC), which is a branch of the Arab Studies Society. This initiative came in the context of the project entitled “Inventory of the Soil Resources in the West Bank and Gaza Strip- Palestine”. This project is co-financed by the European Commission DG XI under Life-Third Countries Lifetcy 96/GA/59 and is technically sup-ported by the Italian Company TIMESIS & Consortium of Information Systems (CSI).

The general objective for PSO is to establish a comprehensive and well-structured soil database in the West Bank and Gaza Strip. The database would provide planners and policy makers in various fields like agriculture, environment, construction, transportation etc, with the necessary information to set solid and practical policies in the context of the sustainable development processes. In addition to that, this database would supply information of an applied nature to different sectors like engineers, municipalities and agricultural local department. The above mentioned general objectives can be accomplished through:

- Implementing a comprehensive soil survey accompanied by soil classification of the soils in the West Bank and Gaza Strip under a long-term plan. This survey should be exhibited through large-scale maps and should involve detailed in-formation with both scientific and practical aspects.
- Preparing the necessary studies and applied projects to help in soil management and preservation in addition to upgrading soil resources through utilizing the survey results.
- Creating a Geographical Soil Information System to facilitate dealing with data and information and connect with other areas and factors with relevant interest.
- Creating the awareness of people and institutions of the correct ways of managing soils and avoiding any activities that could pollute it and consequently lead to its degradation.
- Co-operating with local and international bodies to set solid policies and plans in various fields like environment, agriculture, efficient water use, etc.
- Working on the establishment of a central soil laboratory to conduct comprehensive soil analyses.

Pressures on Soil

There are various types of pressures on land resulted in the degradation of its quality and quantity. The location and severity of each significant soil degradation process is addressed. The following are the main soil degradation processes that are taking place in the West Bank:

Soil Erosion

Soil erosion is the most destructive degradation process to soils in the West Bank. It is caused by the combination of climate, harsh topography (steep to very steep slopes), thin vegetation cover and poor agricultural practices. Almost all types of soil erosion are taking place in the West Bank and all these types are accelerated by human activities. Water erosion is the most important type taking place in all of its types (sheet, rill, gully and tunnel) depending on the geomorphology and rain intensity. Soil erosion assessment is a prerequisite for sound land use planning; therefore, soil erosion risk map using Wichmeier formula for rainfall erosion losses was prepared utilizing various climatic and topographic factors. Soil erosion is clear in areas with very steep slopes and low vegetation cover as in the case of Eastern Heights. Areas with more than 1 tons/ha of soil loss are comprising more than 50% of the West Bank area.

The soil erosion risk map of the West Bank indicated that brown lithosols, regosols loessial arid brown soils are the most types of soil prone to erosion. These soil types are abundant in the Eastern Slopes and Jerusalem Desert where steep and moderately steep slopes are the determinant factor in addition to the absence or scarcity of vegetation cover. Soil texture also plays an important role in the erodibility, for example, the surface horizon texture of brown lithosols, regosols, loessial arid brown, and loessial serozems is comparatively coarse and thus more readily detached by raindrop splash. In the case of steep slopes with certain aspects, even terra rossa and brown rendzina soils (which are clayey) are exposed to high degree of erosion.

Regarding wind erosion, there is no available data, however, it is certainly taking place in the dry and coarse textured eastern parts of the West Bank and the eastern and southern parts of Gaza Strip.

Soil Erosion Risk Mapping of the Communal Rangeland in the West Bank - 2011

In 2011, LRC conducted a special study entitled "Soil Erosion Risk Mapping of the Communal Rangeland in the West Bank" with the objective of producing an actual soil erosion risks map for the rangelands in 7 representative sites, with a total area of 2,470 dunums, representing the Eastern Slopes area.

The sites are protected rangelands used for the activities of the “Sustainable Rangeland Management in Communal Land” project, supervised by MoA and funded by the Brazilian Government.
GIS was used to generate the required maps; all maps were based on the CORINE model to identify potential soil erosion risks (Figure 7). CORINE relies on: soil depth, soil texture, stoniness, steepness, and climatic indicators.

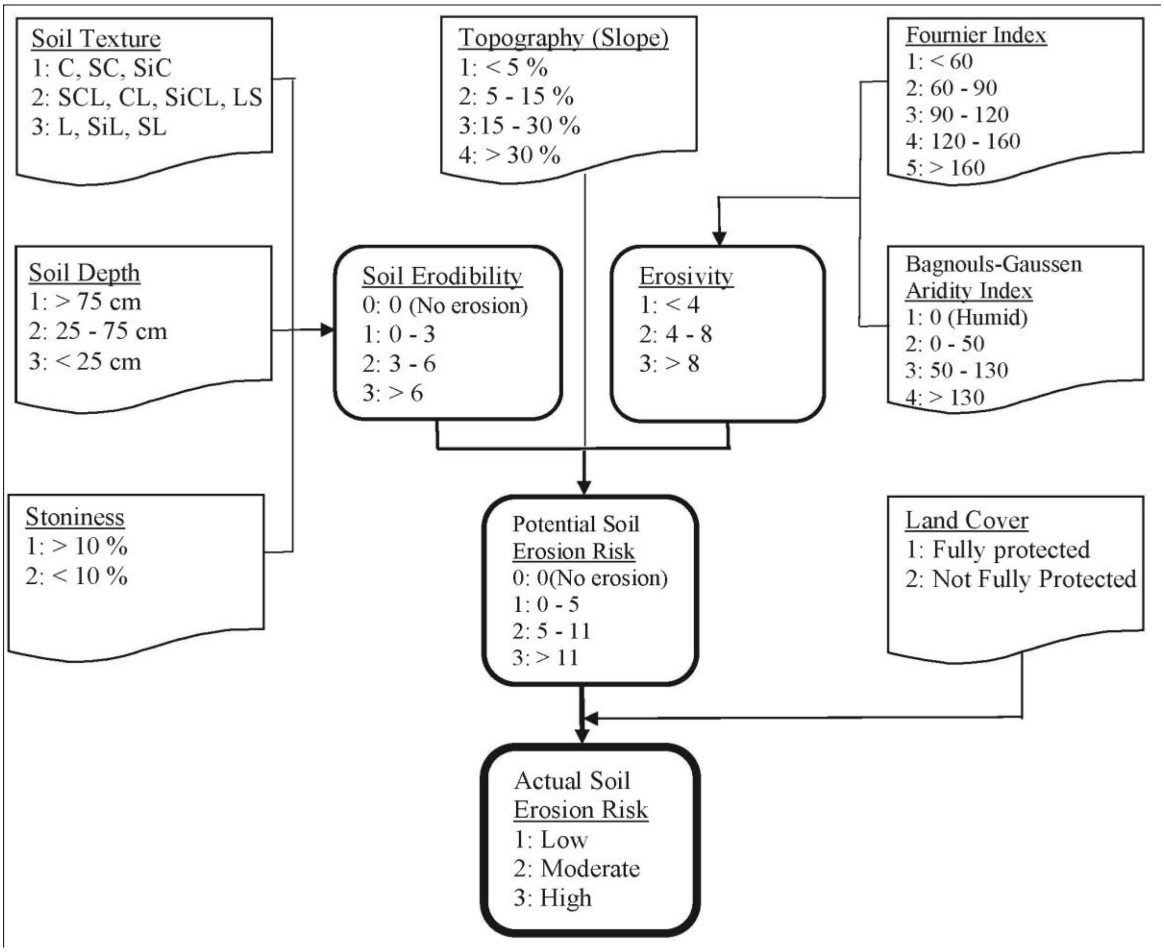

Figure 7: CORINE modified model for soil erosion risk mapping

The study results indicated that 20.6% of the study area highly susceptible to erosion risks; whereas, 42.6 % faced moderate erosion risks; due to topographic characteristics of the site as well as the lack of permanent vegetation cover. 36.8 % of the study area was classified as fairly susceptible to erosion risks.

The study results indicated that; 96% of the site total area of 142.6 dunum is highly exposed to erosion due to the extreme steepness, the lack of vegetation cover, and the soil texture and depth.

Soil Salinization

In general, there is a close relationship between the climate, the moisture regime and the soil salinity. Investigating the climate classification map of the West Bank, it indicates that the soil in vast areas, particularly the eastern part, would be saline. On the other hand, since the soils of the West Bank originate mainly from limestone they have comparatively high percentage of calcium. This fact leads to binding other monovalent ions such as sodium that helps in reducing soil salinity. There are several causes for soil salinity in the West Bank. The main causes are the extremely arid to semi arid climate in most areas; the bad irrigation management and practices and the water quality.

Soils in the Jordan Valley and adjacent slopes (extremely arid and hyper arid climate) exhibit high degree of salinity. Soil associations in this area have variable degree of salinity such as solonchacks, calcareous and loessial serozems, regosols and alluvial brown soils. Irrigation practices in the irrigated arable land of Jordan Valley have magnified the already existing soil salinity.

In areas where the depth of ground water is shallow, soils exhibit and have problems of salinity resulted from the accumulation of salts due to limited leaching capabilities. Even heavy textured soils have this problem such as the grumosols at the plain of Jenin and the southeastern parts of Nablus District.

Other areas of the West Bank are suffering from fluctuating soil salinity due to irrigation practices and soil quality. Salinity in these areas is fortunately reduced by rainfall that led to salt leaching. Also, soil types in these areas (terra rossa, brown and pale rendzina and grumosols) which have a considerable area of irrigated arable land, are not susceptible to soil salinity as those in Jordan Valley due to their heavy texture.

Soil Contamination

One of the degradation processes that have severe impacts on the soil quality is soil pollution with different types of contaminants. One of the dramatic conclusions drawn is that, maybe, there is a strong correlation between soil contamination with the fact that the West Bank and Gaza Strip have one of the highest percentage of cancer in the world according to the World Health Organization reports.

There are several causes for soil contamination in the West Bank. Pesticides and insecticides are the main soil contaminant in irrigated areas. About 200,500 dunums which are used as irrigated land in the West Bank (3.6% of the land area) are intensively exposed to these chemicals. It is estimated that the total quantity of pesticides used in Palestine in 95/96 growing season is 454 tons. Unfortunately some of the used pesticides are internationally forbidden.

The excessive and uncontrolled use of fertilizers is another source of contamination for both soil and groundwater. It is estimated that the total quantity of fertilizers used in 95/96 growing season is 49,420 tons.

Chaotic disposal of industrial and municipal wastes, as well as the Israeli colonies wastewater, is another source of soil contamination in the West Bank. Sewage streams can be easily noticed around major cities and big towns leading to severe soil contamination. There are about 450 dumping sites in the West Bank. Unfortunately, most of the dumping sites are located in wrong places either adjacent to agricultural arable land or urbanized areas. There are several hot spots in terms of the negative effects of the industries waste disposal. For example, many industries are located inside Hebron City and their wastes disposed to the surrounding agricultural land. These industries are leather tanning, shoes making, ceramics and glass, electroplating and metal industries. They represent a serious source for the accumulation of heavy metals in soil.

Limestone waste sludge resulted from cutting stone factories concentrated in Hebron District is another source of soil contamination. Approximately 7500 tons of building stone slag is produced annually in the West Bank, representing thus a waste disposal problem. The accumulated settled heavy particles of limestone slurry and dust would probably change the soil chemical and physical structure of the agricultural land adjacent to the quarry. The dust would increase the calcium carbonate percentage that leads to more alkaline soils that are already alkaline in this region. Also, these particles would change the texture of the topsoil depending on the particle size of the settled dust. Also, the wastewater resulted from the quarries, which is probably drained into the soil with the help of rain, would pollute the surrounding soils. As a matter of fact, studies should be conducted in the area to figure out the impact of the quarries pollutants on soil and the consequent impact on its fertility.

Soil sealing

The rate of soil loss due to surface sealing is relatively high in Palestine. Urbanization and transport infrastructure is rapid either by Palestinians or the expansion and establishment of Israeli colonies and confiscation of land. In the eastern parts of the West Bank, there has been an increase in the animal population resulting in critical ratios of biomass to animals and consequently to overgrazing. During periods of drought, livestock have to be herded for long distances in search of water and suitable pasture, resulting in serious trampling due to the increased traffic by animals. As a result, there is seasonal migration of nomadic communities. These migrations are associated with soil deterioration, particularly around water holes.

Decline of soil fertility

The above four mentioned pressures in addition to other factors as the uncontrolled fertilizers application clearly lead to the decline in organic matter, loss of nutrient elements and an increase in toxicity scale. There are no systematic recording of soil fertility parameters that would help in evaluating the fertility status with time of soils in the West Bank and Gaza Strip. However, agricultural productivity in many areas indicates the degradation in soil fertility.

Reduction of vegetation cover

Although forest area in the West Bank is very small (about 4900 ha - <1%), it is estimated that 23% of the forest area has been destroyed from 1971 to 1999. The majority of this destruction has been caused by the construction of Israeli colonies and military camps.
Rangeland and natural grassland are also negatively affected in the last three decades due to the political situation. The limitation of the access to Palestinian herds resulted in intensive grazing to the remaining small area that is estimated to be about 15% of the former area.

Loss of Biodiversity

The uniqueness of Palestine is also represented in its high degree of biodiversity due to the diversity in soil and climate. At the crossroads of Asia, Africa, and Europe, Palestine region is composed of rich and diverse eco-systems that act as homes to many of rare species. Almost all the distinguished ecosystems in Palestine are under one type or another type of driving forces for biodiversity loss. For example, the Jordan Valley ecosystem comprising the Dead Sea is clearly a threatened ecosystem in terms of biodiversity loss due to land degradation.

Brief Description of the Status in Gaza Strip

Gaza Strip is described separately in terms of the status of soil degradation because it has completely different characteristics from the West Bank and averaging in this case (describing them as one unit) would be misleading.

Gaza Strip has an area of 365 km2 and populated with about 1.26 million Palestinians and about 5,000 Israeli settlers. It is located at the southwestern part of Palestine at the Mediterranean cost on the edge of Sinai Peninsula (map 1). It has one of the highest population densities in the world (3450 people/ km2).

The climate of Gaza Strip is transitional one between arid desert climate of Sinai Peninsula and the temperate semi humid Mediterranean climate along the coast. Average rainfall ranges from 230 mm in the southern part to 400 mm in the north. Average temperature ranges from 13 °C in Winter to 25 °C in Summer.

In Gaza Strip, groundwater exists in the shallow coastal aquifer. The total amount of recharg from this aquifer is estimated at about 50 million cubic meters (MCM). It has a yearly deficit due to over pumping which result in its replenishment from brackish or seawater leading to water quality deterioration. Most of the pumped water is used in irrigation that resulted in soil contamination and an increase in soil salinity. Settlers in the area consume about 6 MCM for all purposes while 1.26 million Palestinians consume 127 MCM. .

The land use figures of Gaza Strip, indicates the degree of pressure on the land in this area. The agricultural areas comprise about 69% of the area; the artificial surfaces occupy about 21%, the forests and semi natural area is about 9% and the water courses represented in Wadi Gaza is less than 1%. Investigating these figures indicates how much pressure is on the agricultural land due to urbanization expansion. If we add to this pressure the fact that the Israeli colonies utilize large agricultural area (more than 7,500 dunums).

There are three types of soil associations in Gaza Strip: sand dunes (106 km2) which is occupying the coastal western area, loessial arid brown soil (190 km2), which is composing the main agricultural land, at the eastern area and sandy regosols (69 km2) at the southeastern part. In the loessial arid brown soil, substratum consists of sandstone cemented by $CaCO_3$ (*kurkar)* and alluvial brown clay represents an impending layer to the root penetration.

Impacts and Response

Having a clear picture about driving forces and pressures of land degradation does not mean that the impacts on the ground are also seen clearly; therefore, the responses as a consequent are not promptitude or ad hoc. As a matter of fact, there are no time referenced quantitative parameters for the state of land degradation several aspects in Palestine to help in assessing the impacts.

The main impacts of these pressures are low agricultural and forage productivity and more abandonment to agricultural practices that collectively lead to more poverty and more fragile ecosystems. The negative impact on human and animal health is indirectly deduced by the comparatively high percentage of cancers in Palestine.

The general characteristics of ecosystems in Palestine at various scales are getting worse when investigated over short period of time. In most agro-climatic zones, soil productivity has already been lowered by erosion or degradation. Direct quantitative parameters are not available but indirect parameters like agricultural productivity, dependency on working in agriculture, forestry and livestock production are all indicating negative impacts.

Responses to the impacts of various pressures on land would be categorized at the national or governmental level and the technical or farm level. Some of these responses are actually taking place, some of them are recommended by the author.

National Level

Although PNA is a newborn authority, the following responses took place at the national level: - Setting the necessary and convenient legislation to protect land resources represented in issuing the Palestinian Environmental Law No. 7 of 1999 and publishing the Palestinian environmental strategy. Ministry of Agriculture (MoA) Strategic and Policies framework also adopted the protection of land resources as a high priority.

- MoA and Ministry of Environment (MoE) formulated in cooperation with specialized Palestinian NGOs the Palestinian National Committee for Combating Desertification (PNCCD).

- The majority of land reclamation projects implemented in Palestine were supervised in cooperation with MoA.
- Organization of tree planting campaigns and annual tree-planting dates. Large number of seedlings distributed free of charge by MoA.

Recommended responses that should be conducted by PNA:
The following are suggested responses that should be conducted by PNA to reduce land degradation:

- Adopting a strategic plan for land use at the country level;
- Activate the PNCCD to take its responsibility of developing strategic framework and policy for combating desertification in Palestine;
- Improve administration, policy and plans of national institutions, human resources research and scientific capabilities;
- Continue and intensify adopting and supervising the activities of land reclamation and soil conservation on new solid bases;
- Prepare and implement national action plans for the establishment, management and conservation of forests and rangeland;
- Setting the convenient plans for the proper management and utilization of water resources;
- Encourage, facilitate and provide capabilities for applied research related to land degradation.

Technical and Farm Level

The responses to land degradation should vary from one ecological zone to another. There is a lot work done by specialized Palestinian NGOs at the farm and technical level to mitigate land degradation. This is represented in land reclamation and water harvesting projects supervised by MoA and funding agencies and conducted in various spots of the country. Unfortunately, there is no available accumulative statistical data of the land area reclaimed or the number of wells constructed or rehabilitated.

Recommended Actions and responses that should be undertaken by NGOs and farmers: In the small humid and sub humid zones traditional agricultural practices ensure that soil degradation is kept to a minimum. The mixed crop canopy protects the soil from physical destruction and keeps organic matter up. However, zones of extremely arid to semi arid climates can be maintained by:

- Soil erosion could be stopped or mitigated in sparsely vegetated areas which represent high percentage of the West Bank area (21%) by the conversion of traditional planting systems from planting field crops to pastures with different and beneficial types of shrubs and grazing plants (introducing agro-forestry approach);
- Maintaining ground cover most of the year by introducing crops with trailing systems;
- Utilization of household organic wastes as fertilizer (composting) for selected crops in the farm or garden.
- In mountainous environments in the West Bank, soil degradation would be traditionally tackled by a combination of crop rotation involving legumes, the application of animal manure and allowing animals to graze harvested fields, as well as fallowing usually for one or two years.
- Palestinian NGOs and research institutions should develop technical solutions to practical problems facing farmers as fluctuating soil salinity, proper soil tillage practices, etc. This should be combined with public awareness campaigns and extension programs for farmers. This means also promoting the involvement of local people in data collection and identifying the technical problems facing them in the field.

- It is desperately needed to survey and collect the available data on land degradation and build specialized database utilizing GIS and remote sensing techniques.

General recommendations and suggestions

It is assumed that the Palestinians will establish their independent state on the lands of the West Bank and Gaza Strip. Therefore, they will have the responsibility to carefully manage their land. The following would be the some resource management goals to maintain the overall quality of life:

1. Maintain continuing access to soil resources and work on the conservation and promotion of these resources while avoiding soil degradation.
2. Consider the sustainable development, which meets the needs of the present situation without risking the ability of future generations to meet their own needs and requirements.
3. Consider all the factors that will aid or obstruct the sustainable development at regional and the national level.
4. Continuing soil classifications and mapping complementary studies.

Considering these suggested strategies the following recommendations are necessary:

- Soil Conservation;
- Soil Quality Promotion;
- Building a Comprehensive Soil Information System in a well defined Euro-Mediterranean network;
- Climatic Aspects;
- Geological Studies;
- Monitoring Changes in Land Use;
- Urbanisation;
- Increasing and preserving the areas of high productivity;
- Social and Educational Programs:
- Strengthening and Upgrading the Capabilities of Palestinian Soil Office;

Conclusion

The deterioration of the natural resources in the West Bank and Gaza Strip is accelerated due to human and natural driving forces. The natural resources proper management in the West Bank and Gaza Strip is technically viable when the Palestinians have the opportunity to control their natural resources. The current situation of having the Palestinian land occupied by the Israel imposes severe restrictions over managing these natural resources. However, Palestinians are exerting a lot of efforts to sustainably use the accessible resources.

There is desperate need to inform the decisions taken by Palestinians when managing the natural resources. This would be achieved through establishing a unified national database for the natural resources in general and for soils in particular. The networking with regional and international organizations addressing soils management would promote this approach.

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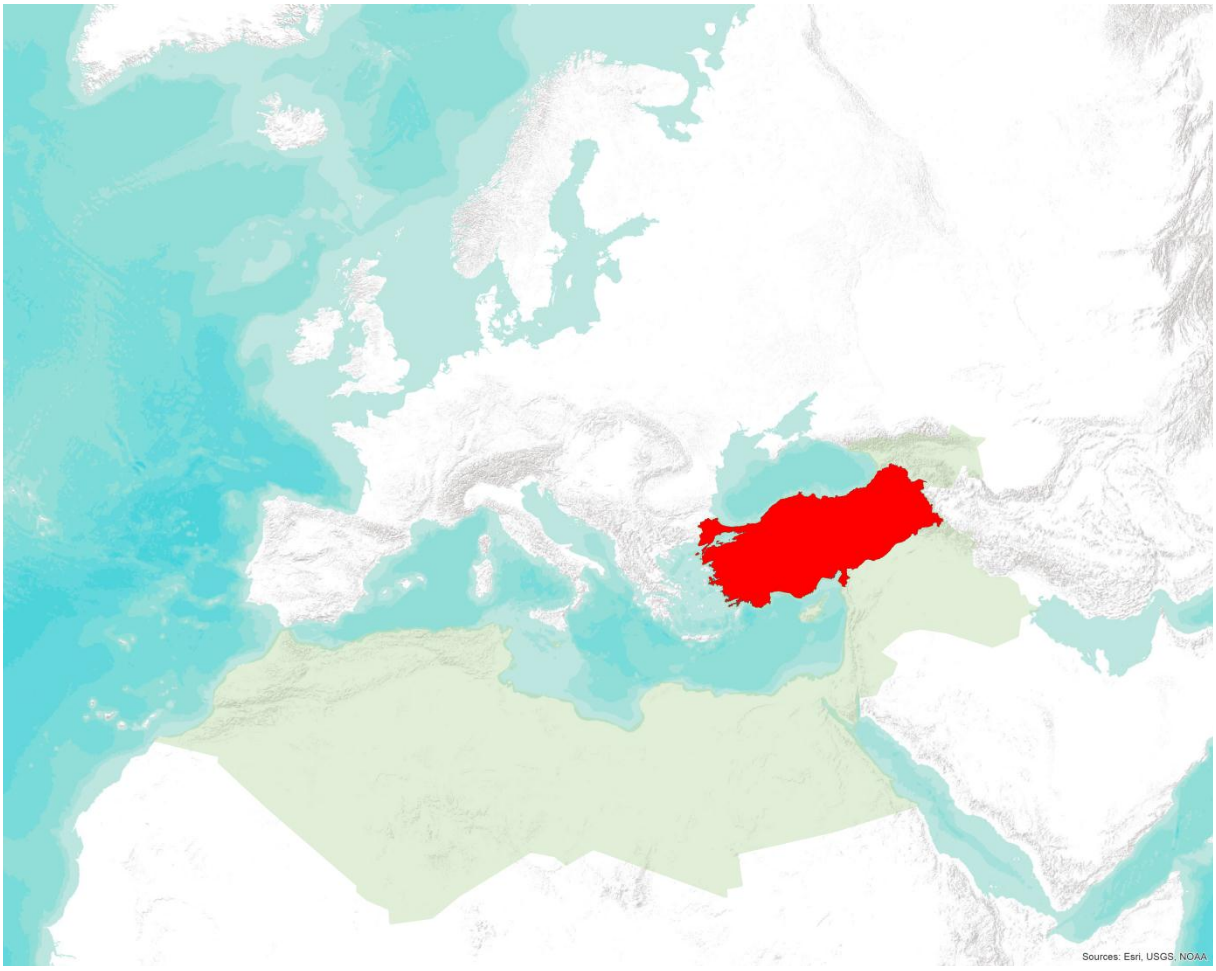
Chapter XIII.
Soil Resources of Turkey



SOIL RESOURCES OF TURKEY

Suat Senol [1] and **Ilhami Bayramin**[2]

ABSTRACT

Due to host numerous variations in the factors of soil formation, all soil units can be found except polar and equatorial belt zone soils in Turkey, located at the junction of Europe, Asia and African continent. Turkey has a total of 770 760 km ^{2} area coverage and annual total precipitation changes between 258.8 mm and 2244.9 mm and mean annual total precipitation is 642.8 mm. Mean weighted altitude is 1132 m and the highest elevation is 5.137 m. Topographically the country is hilly, only 8% of the land has a slope of less than 2%. More than 80% land has higher than 15% slope. Reconnaissance soil survey maps were completed between 1966 and 1971. 1:25,000 scaled topographical maps were used as base maps. Great soil groups were the map units. Classification system was not morphometric, and number of the soil profiles were not sufficient were not sufficient to represent Turkey's soils. Soil map delineations were not checked properly. All of these deficiencies limit these data base for the integration of Turkey Soil Data Base to European Soil Data Base. There are very limited data base (3%) to meet requirements for the European Soil Data Base integration. As a result, in order to have modern soil data base, detailed soil survey studies, at the soil series level, should be started. Institutional arrangements have to be completed. For the short term period small scale soil maps have to be prepared.

Keywords: Soil data bank, general soil map of Turkey, Soil classification

INTRODUCTION

Turkey is located on the Alpine Orogenic Belt with different kinds of igneous, metamorphic and sedimentary rocks. The Collision of the three continents, Asia, Europe and Africa, caused very high and irregular topography. Because of the geologic, climatic and topographic differences and its location at the hub of the Mediterranean civilizations, with different biodiversity zones and favorable land recourses, this feature is reflected in climate and vegetation. Turkey has been exploited for more than 3000 years for its natural wealth (Cangir et al, 2000).

Turkey is a mountainous and hilly country, with an average altitude of 1132 m, and is surrounded by seas from the north (Black Sea), south (Mediterranean Sea) and west Aegean Sea. It is a peninsula that accounts for the great differences in climate, soil and other ecological properties.

Although Turkey is in the subtropical belt having a semi-arid climate with extremes in temperatures, the diverse nature of the landscape, particularly the existence of mountains parallel to the coasts result in great differences in climatic conditions from region to region (Özden et al, 2000a).. There are more than 12 000 plant species and hundreds of different plant community, and the majority of plants, located in areas outside the equatorial and tundra regions, can be seen in Turkey (Dinc, U. et al, 1999).

Mountainous areas of Turkey are composed of Orogenic belts, tectonic and volcanic mountains. North Anatolian Mountains in the north and Taurus Mountains in the south are the major orogenic belts extending east-west direction in Turkey. In general, volcanic mountains have been seen in Central Anatolia and East Anatolia regions. Flood plains, basins, plateaus, high uplands and karst

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topography are other main geomorphological units. There are little or no glacial topography in Turkey. An important part of suitable lands for agriculture is located on the flood plains and plateaus.

Turkey's southern and western coasts are hot and dry in summers and mild and rainy in winters under the influence of a typical Mediterranean climate. Northern part, along the coast of the Black Sea, is rainy all seasons but amount of rainfall is higher than summers. The internal parts of the Anatolian peninsula have cold and rainy winters and dry summers and under the influence of continental climate. Winter precipitation is in the form of snow, and Eastern Anatolia receives highest snowfall values (Figure 1).

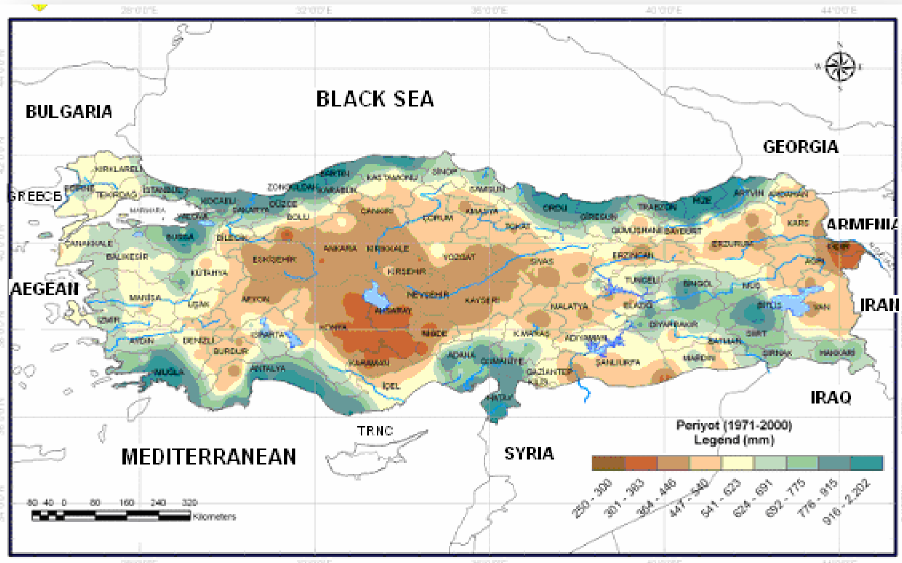

Figure 1. Geographical distribution of mean annual precipitation (Sensoy, S. et al, 2008)

The average annual temperature values are decrease from south to north and from east to west. The hottest places somewhere near the boundary of the Mediterranean coast and south-east Turkey. The coldest places are the Kars plateau in the Eastern Anatolia (Figure 2).

Figure 2. Geographical distribution of mean annual temperature (Sensoy, S. et al, 2008)

Turkey, the average rainfall is around 642 mm annually (Özden et al, 2000a). Turkey’s 642 mm of annual precipitation brings the total amount to 501 km3 water each year. 186 km3 of runoff water occurs each year with a 37% runoff / precipitation rate. The surface and ground water potential is estimated at 104.5 km3 (can be used economically). The water amount per person is 3.600 km3 and this number will decrease to 1.375 km3 by the year 2025. Turkey has 8.5 106 ha of economically irrigable lands. Presently, only 4.5 106 ha are under irrigation. After completing the South East Anatolian Project, 1.6 106 ha of agricultural land will be irrigated (Anonymous, 2001).

"Generalized Soil Map of Turkey" was created between l966 -1970 using 1:25,000 scaled base maps. In this exploratory level study, Turkey’s soils were interpreted in the "Land use capability classification" system based on continuous soil characteristics such as problem risks, production capacities, types and severity factors considering their types and degrees.

COUNTRY SOIL INFORMATION AND DATA

In Turkey, the real understanding of soil survey and mapping began in 1952 with the help of the FAO team and a team composed under the leadership of American soil consultant Harvey Oakes and a Turkish group of consultants. The General Directorate of Soil and Water (today known as the General Directorate of Rural Services, GDRS) completed reconnaissance soil survey maps between 1966 and 1971. The soil survey study was based on using 1:25,000 scaled topographical maps at the reconnaissance level. In this study, map units relating to the 1938 American Soil Classification System of great soil groups with land determiners like the important phases of depth, slope, stoniness, erosion degree and similar characteristics were recorded on the map. After evaluating the data, two maps were published. The first was for every province with a scale of 1:100.000 and called The Soil Resource Inventory Map. The other map shows 17 of Turkey’s 26 Great Watersheds with a scale of 1:200.000 and is called the Watershed Soil Map and Report. Because of the reconnaissance level of the survey, the detail level at a scale of 1:25.000 was not sufficient. The “Turkey Soil Potential Survey and Non Agriculture Aims Land Usage Planning Project” was replaced with the “Turkey Development Soil Map Surveys” by the GDRS between 1982 and 1984. After that, in 1987, maps were prepared (Özden et al, 2000b).

According to the official soil data base, in Turkey, Brown soils are dominant soils with 19,7% area coverage. Other major great soil groups are Brown Forest soils (15,8%), Lithosols (11,7%), Non Calcic Brown Soils (10,2) and Aluvial-Colluvial Soils (10,0%) respectively. The coastal zones and east are highly mountainous except for some large alluvial plains. Central Anatolia is a high, undulating plateau with an average altitude of 1000 m. Southern Anatolia has gentler slopes and an average altitude of 550 m. Thrace is made of slightly undulating land of less than 200 m altitude. In the central, eastern and southeastern regions, Brown and Reddish Brown soils dominate. Some parts of Eastern Anatolia, transition zones and Trace are made of Chestnut and Non Calcic Brown soils. Brown Forest, Non Calcic Brown Forest and Podsolic soils prevail in coastal mountains starting from altitudes of transition zones. Some gently sloping lowlands of the Aegean and Mediterranean regions contain Red Mediterranean soils. Vertisols and Basaltic Vertisols are generally in the Southeastern Anatolia region. The distribution of Great Soil Groups is given in Table 1.

Table 1. The Distribution of Great Soil Groups (1987)

Zone	Great Soil Group	Area (ha)	%
Arid & Grass	Brown	15.298.750	19,7
	Chesnut	4.485.178	5,8
Transition Humid Forest	Non Calcic Brown	6.091.544	7,8
	Brown Forest	12.287.648	15,8
	Non Calcic Brown Forest	7.978.960	10,2
	Podsolic	3.211.260	4,1
	Alpine Meadow	302.094	0,4
Mediterranean	Red Mediterranean	2.239.629	2,9
	Rendzina	602.172	0,8
Azonal & Intrazonal	Vertisols	589.866	0,8
	Basaltic Vertisols	1.061.027	1,4
	Regosols	669.243	0,9
	Lithosols	9.136.719	11,7
	Aluvial & Colluvial	7.776.008	10,0
	Rock Surfaces	2.930.933	3,8
Total		7.4661.031	96,1
Water Surfaces		3.136.096	3,9
TOTAL		**77.797.127**	**100,0**

When we take into consideration Table 2, it is seen that 67,7% of Turkey is less than 50 cm deep. The amount of medium and deep soils is 26.1%. Most of the arable lands are well drained and only 3,6% of the arable lands have drainage problems. The soil depth and drainage distribution of the Turkish soils is given Table 2 and Table 3.

Table 2. Soil depth distribution of the Turkish soils

Depth (cm)	Area (ha)	%
Very Shallow (0 – 20)	28.908.455	37,2
Shallow (20 – 50)	23.696.973	30,5
Medium Deep (50 – 90)	9.299.614	11,9
Deep (> 90)	11.108.114	14,2

Table 3. Soil drainage distribution of the Turkish soils

Drainage Groups	Area (ha)	%
Very Poorly Drained	1.689.358	2,1
Poorly Drained	776.312	1,0
Somewhat Poorly Drained	283.381	0,4
Excessively Drained	26.063	0,1
Total	2.775.115	3,6

Soil erosion is the biggest question for Turkey. The soil erosion distribution of Turkish soils is given in Table 4. It can be seen from Table 9 that 58,7% of lands is exposed to severe and extremely severe soil erosion. In these lands soil fertility is decreased about 50% and they can't be used economically. 15.592.750 ha of land exhibits moderate soil erosion. Only 6,6% of the total lands do not have a soil erosion problem. Urgent precautions should be taken in 63,17% of the land where erosion is a serious problem (Anonymous, 1987).

Table 4. Soil erosion distribution of the Turkish Soils

Soil Erosion	Area (ha)	%
None	5.166.627	6,6
Slight	5.611.892	7,2
Total	10.778.519	13,8
Moderate	15.592.750	20,0
Severe	28.334.933	36,4
Very Severe	17.366.463	22,3
Total	61.294.146	78.7
Rock Surfaces	2.930.933	3,7
Wind Erosion	506.309	0,65

The major salt affected soils are localized in Turkey as follows; Konya-Eregli, the Aksaray and Malya plains of Central Anatolia, and the alluvial plains of lower Seyhan, Igdır, Menemen, Bafra, Söke, Acıpayam and Salihli of all the major river systems. The major problem in these areas is salinity. The latest soil surveys indicate that 1.517.695 ha of land has some degree of salinity and sodicity problems and 2.775.115 ha of land have both salinity and water logging problems. The distribution of the salt-affected arable lands are: 60% slightly saline, 19,6% saline, 0,4% alkali and 8% saline-alkali respectively. Although sodium salts are the main components of the salt-affected soils, magnesium soils in Denizli-Acıpayam, potassium-nitrate-alkali soils in Nigde- Bor, Kayseri, and gypsiferous soils in Central Anatolia are also common in Turkey. Distribution of the salt affected soil is presented in Table 5.

Table 5. Distribution of the salt affected soils

Salinity Degree	LUCC	Area (ha)	%
Slightly Saline	I - IV	558.550	60,0
Saline		176.874	19,6
Alkali		37.236	0,4
Slightly Saline Alkali		111.710	12,0

Saline Alkali		46.548	8,0
Total		930.918	100
Total	VI - VII	586.777	100
Total		1.517.695	100

When we consider the texture of Turkish soils, it is clearly seen that loamy and clay loam soils constitute the main texture classes (Table 6). Loamy soils form 50.49% and clayey soils 41.44% of the Turkish soils respectively. The topographic and climatic conditions associated with the parent material stimulate clay formation in Turkish soils.

Table 6. Regional soil texture distribution of Turkish soils

Regions	Saturation %	Sandy < 30	Loamy 30 – 50	Clay Loam 50 - 70	Clayey 70 - 110	Clay > 110	Total
Central North	Area (ha)	106.019	3025.058	2.718.985	175.272	472	6025.806
	%	1,76	50,20	45,12	2,91	0,01	100,00
Aegean	Area (ha)	76.991	1733.764	1.296.120	157.694	620	3265.190
	%	2,36	53,10	39,7	4,82	0,02	100,00
Marmara	Area (ha)	125.869	1050.226	1.154.409	118.894	1.785	2451.275
	%	5,13	42,84	47,09	4,85	0,09	100
Mediterranean	Area (ha)	29.529	787.559	829.081	107.992	3.147	1757.308
	%	1,68	44,82	47,18	6,15	0,18	100,00
North East	Area (ha)	96.180	924.996	469.024	49.323	1.062	1540.568
	%	6,24	60,04	30,44	3,20	0,08	100,00
South East	Area (ha)	258.974	2389.453	2.316.565	447.340	1.629	5413.962
	%	4,78	44,14	42,79	8,26	0,03	100,00
Black Sea	Area (ha)	32.191	1007.819	1.402.472	224.616	1.569	2668.695
	%	1,21	37,76	52,55	8,42	0,06	100,00
Central East	Area (ha)	47.925	1165.488	1.644.684	163.365	4.738	3026.202
	%	1,58	38,51	54,35	5,40	0,16	100,00
Central South	Area (ha)	300.687	4482.204	1.768.080	112.366	1.180	6664.517
	%	4,51	67,25	26,53	1,69	0,02	100,00
Total	**Area (ha)**	**1074367**	**16566568**	**13599422**	**1556953**	**16229**	**32813541**
	%	**3,27**	**50,49**	**41,44**	**4,74**	**0,05**	**100,00**

The slope distribution of Turkish soils is given in Table 7. When we examine the table, which is prepared according to management groups, it is seen that the rate of lands with high slopes is extremely high and 48.0% of the soils has more than 20% slopes. High slopes are associated with soil erosion, which is one of the major problems in Turkey.

Table 7. Slope distribution of Turkish soils

Slope Groups	Slope %	Area (ha)	%
Very Steep	> 30	23.015.699	30,4
Steep	20 – 30	13.368.866	17,6
Moderate	12 – 20	10.747.597	14,2
Gently Sloping	6 – 12	10.514.253	13,9
Undulating	2 - 6	8.476.067	11,2
Level	0 – 2	9.705.097	12,8

Table 8. The regional soil organic matter content distribution of Turkish soils

Regions	Area %	OM < 1	OM 1 - 2	OM 2 - 3	OM 3 – 4	OM > 4	Total
Central North	(ha)	1567.320	2953.727	1.084.166	286.724	133.869	6025.806
	%	26,01	49,02	17,99	4,76	2,22	100
Aegean	(ha)	1245.020	1400.661	452.196	121.451	45.861	3265.190
	%	38,13	42,90	13,85	3,72	1,4	100
Marmara	(ha)	493.365	1039.453	576.237	218.346	123.872	2451.275
	%	20,13	42,40	23,51	8,91	5,05	100
Mediterranean	(ha)	205.837	710.541	508.627	204.448	127.855	1757.308
	%	11,71	40,43	28,94	11,63	7,29	100
North East	(ha)	155.575	594.218	461.762	209.960	119.069	1540.586
	%	10,10	38,57	29,97	13,63	7,73	100
South East	(ha)	931.217	2332.113	1.481.763	430.788	238.079	5413.962
	%	17,20	43,08	27,36	7,96	4,40	100
Black Sea	(ha)	234.088	698.543	864.709	439.842	431.511	2668.695
	%	8,77	26,18	32,40	16,48	16,17	100
Central East	(ha)	571.963	1584.208	604.497	170.085	95.447	3026.202
	%	18,90	52,35	19,98	5,62	3,15	100
Central South	(ha)	1639.163	3053.195	1.389.635	403.457	179.067	6664.517
	%	24,60	45,81	20,85	6,05	2,69	100
Total	**(ha)**	**7043549**	**1436666**	**7423594**	**2485103**	**1494632**	**32813540**
	%	**21,47**	**43,78**	**22,62**	**7,57**	**4,55**	**100**

One of the main problems in Turkey is the low amount of organic matter content (Table 8). It is seen that the organic matter content of Turkish soils is less than 2% in 65,25% of the soils. Especially, in the Aegean and Central Southern regions, the organic matter contents are lower than the other regions.

High pH is also another limitation in Turkish soils. Since there is a high amount of lime content, parent material and environmental conditions, the pH values in the Turkish soils are generally higher than 6.5 (Table 9). As seen from Table 14, 92.64% of the Turkish soils, the pH values are higher than 6.5.

Table 9. Regional soil pH distribution of the Turkish soils

Regions	Area	pH < 4.5	pH 4,5-5,5	pH 5,5-6,5	pH 6,5-7,5	pH 7,5-8,5	pH > 8,5	Total
Central North	(ha)	2045	15883	79072	946236	4969929	12641	6025806
	%	0,03	0,26	1,31	15,71	82,48	0,21	100
Aegean	(ha)	5663	68618	307724	1314352	1561616	7216	3265190
	%	0,17	2,10	9,42	40,25	47,84	0,22	100
Marmara	(ha)	0	91397	400526	1349514	609634	203	2451275
	%	0	3,72	16,34	55,05	24,87	0,01	100
Mediterranean	(ha)	0	1408	20650	257020	1472660	5570	1757308
	%	0	0,08	1,18	14,63	83,80	0,31	100
North East	(ha)	673	20890	95231	589852	830267	3672	1540586
	%	0,04	1,36	6,18	38,29	53,89	0,24	100
South East	(ha)	0	24371	238152	2660499	2487071	3869	5413962

	%	0	0,45	4,40	49,14	45,94	0,07	100
Black Sea	(ha)	104865	309631	484657	848566	912246	8729	2668695
	%	3,93	11,60	18,16	31,80	34,18	0,33	100
Central East	(ha)	527	4848	79149	873214	2062982	5481	3026202
	%	0,02	0,16	2,62	28,86	68,16	0,18	100
Central South	(ha)	0	3444	54971	957726	5439391	208985	6664517
	%	0	0,05	0,82	14,37	81,62	3,14	100
Total	**(ha)**	**113773**	**540491**	**1760134**	**9796980**	**20345796**	**256366**	**32813541**
	%	**0,35**	**1,65**	**5,36**	**29,86**	**62,00**	**0,78**	**100**

The high amount of lime contents of the Turkish soils is serious problem as well. The lime contents of the Turkish soils are higher than 15% in 33.48% of the soils (Table 10). The Central Southern, Central Eastern and Mediterranean region soils have particularly higher clay contents than other region soils. The depth of the carbonate leaching increases from south to north associated with increasing precipitation from south to north (Eyupoglu, 1999).

In Turkey, only 34.9% (26.374.593 ha) of the soils were suitable for cultivated agricultural practices. In other words approximately 2/3 of the Turkey's soils are not suitable for cultivated agricultural practices. These data shows that Turkey is not a rich country according to the arable land distribution. Soil resources have to be used in accordance with the principles of sustainable use techniques. Percentage portion of land use capability classes of Turkey is presented in Figure 3.

Table 10. Regional lime content distribution of the Turkish soils

Regions	**%**	**$CaCO_3$ < 1**	**$CaCO_3$ 1 - 5**	**$CaCO_3$ 5 - 15**	**$CaCO_3$ 15 – 25**	**$CaCO_3$ > 25**	**Total**
Central North	Area (ha)	644170	934571	2418898	1310890	717277	6025806
	%	10,69	15,51	40,14	21,75	11,91	100
Aegean	Area (ha)	1321505	546128	540017	395600	461939	3265190
	%	40,47	16,73	16,54	12,12	14,14	100
Marmara	Area (ha)	1476299	461822	359163	98371	55618	2451275
	%	60,23	18,84	14,65	4,01	2,27	100
Mediterranean	Area (ha)	275991	125924	307896	446150	601347	1757308
	%	15,71	7,17	17,52	25,39	34,21	100
North East	Area (ha)	701586	388000	300247	83419	67332	1540586
	%	45,54	25,19	19,49	5,41	4,37	100
South East	Area (ha)	895222	1301391	1675570	1068932	472847	5413963
	%	16,54	24,04	30,95	19,74	8,73	100
Black Sea	Area (ha)	1568435	463247	408646	136803	91562	2668695
	%	58,77	17,36	15,31	5,13	3,43	100
Central East	Area (ha)	503978	472087	852560	613329	584246	3026202
	%	16,65	15,60	28,17	20,17	19,31	100
Central South	Area (ha)	187397	1310970	1384812	1310146	2471192	6664517
	%	2,81	19,67	20,78	19,66	37,08	100
Total	**Area (ha)**	**7574583**	**6004142**	**8247811**	**5463641**	**5523361**	**32813541**
	%	**23,08**	**18,30**	**25,14**	**16,65**	**16,83**	**100**

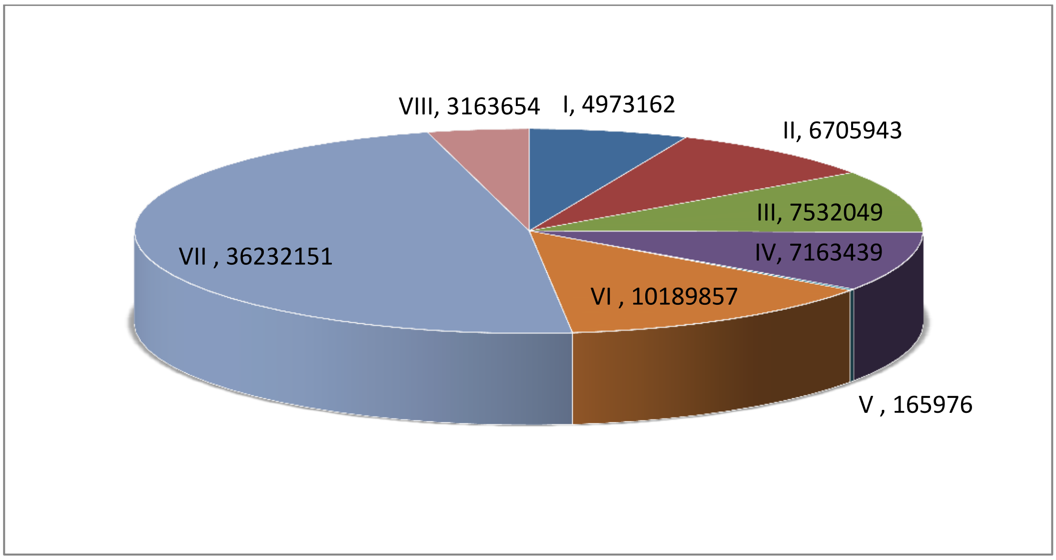

Figure 3. Percentage portion of land use capability classes of Turkey

SOIL THREATS

As mentioned before Turkey has rough topographic properties. Climate is characterized with dry summers and irregular rainfall other seasons. As a result of irregularities of the topography and climate, soil erosion is the one of most important problem in Turkey. Approximately 90% of Turkey's territory is under effect of various intensities of soil erosion. Erosion is greatly effective in the areas of cultivated agricultural areas (http://www.tema.org.tr). Because of the long periods of cultivated agricultural practices Turkey's soils have very low organic matter contents and more than 70% of the lands have less than 2% organic matter content. In parallel with the increase of tractor use between the years of 1950-1960, some pasture and forest areas were converted into cultivated agricultural areas. In these areas, where natural balance was chanced, organic matter contents were dramatically decreased. Continuous surface erosion is also other reason for the low organic matter contents.

Due to chemical fertilizer and pesticides use in the irrigated agricultural areas, both soil and ground water contamination are other problems. Further, non-agricultural industrial waste creates serious pollution. The use of drainage waters for irrigation purposes causes salinity and pollution problems in the areas where irrigation water is insufficient. Salinization is also significant problems in irrigated agricultural areas. For instance, after irrigation was started in the Harran Plain, in South East Anatolian region, 15.000 ha land was exposed to salinization problems (Akış, et al, 2005). On the other hand, salt affected soils were decreased from 85.654 ha to 8.976 ha in the Çukurova plain after drainage system construction and reclamation studies between 1956 and 1984 (Dinc et al, 1991).

Dramatic increases of the non-agricultural uses of the agricultural soils are the most important soil threats during last two decades. In order to create the new industrial, residential and commercial areas in the cities because of the rapidly growing population, many of the agricultural areas have been converted to non-agricultural areas irreversibly. Applications and the area of agricultural lands converted to non agricultural uses during last decade were presented in Table 11.

Table 11. Non-Agricultural Use applications between 2001 – 2010

Years	# Applications	Accepted (ha)	Returned (ha)
2001	1.850	31.843	11.824
2002	5.700	198.817	74.576
2003	3.578	81.116	50.665
2004	2.327	57.020	46.449
2005	2.291	56.198	50.413
TOTAL	**15.746**	**424.994**	**233.927**
2005	1.293	41.998	14.196
2006	3.542	128.311	167.265
2007	3.855	62.224	38.978
2008	4.682	116.331	62.526
2009	3.099	33.848	44.668
2010	1.830	19.301	23.229
TOTAL	**18.301**	**402.013**	**350.862**
GENERAL TOTAL	34.047	827.007	584.789

Soil Protection and Land Use law (SPLU), numbered as 5403, was legislated in 2005. Aims of the law can be summarized as,

- Protection of Soils, Land Use Planning,
- Preventing non-agricultural uses of Agri-soils,
- Determination of Great Plains and their protection,
- Erosion Risk Assessement Maps and Protection,
- Mitigation Measures,
- Monitoring soil pollution and protection,
- Land consolidation and distribution etc.

It can be seen from Table 11 that between 2001 – 2005, total of 424.994 ha agricultural land were converted to non-agricultural lands. During this period there was only regulation to protect soils. However, after SPLU law, 402.013 ha agricultural land was converted to non-agricultural lands. Although legal arrangement was implemented, institutional arrangement was not executed properly. Official numbers showed that legislation of SPLU was not prevented loose of agricultural soils.

FUTURE PROSPECTS AND INTEGRATION STUDIES

Using available soil data base, Turkey was involved integration of European Soil Database (Aksoy, et al, 2010). However, these data have many deficiencies. At the beginning, number of the soil profiles was not enough to represent all Turkey's soils. Quality of the existing data is also questionable and physical, chemical, mineralogical and morphological identification have to be upgraded. For this reason, a nationwide soil survey and mapping work should be initiated immediately. It would be better to divide soil survey studies into two groups as long-term and short-term studies.

During long term studies, institutional arrangements have to be completed. Soil experts have to be educated. Laboratories have to be prepared with adequate equipments. Soil Data Base studies have to be started. In the short term studies, 1:1.000.000 scaled Turkey General Soil Map has be re-prepared. Existing data has to be analyzed, and additional profile inspections have to be used. Digital geological and topographical data have to be analyzed using GIS techniques. These studies have to be carried out by the experts at the universities under one expert coordinator.

All researchers have to analyze representative soil profiles where appropriate in their region. After data examination, SMU "Soil Mapping Units" have to be re-defined and boundaries should be updated.

CONCLUSIONS

Turkey hosts different very diverse soil parent materials, different land forms, climatic conditions and vegetation. As a natural consequence of this diversity of the factors, soil properties show differences, one place to another. Due to the relatively new science of soil across the country, reconnaissance soil maps are the only national soil data base in Turkey. Integration of the Soil Database of Turkey into European Soil Database, 1:1,000,000 scaled soil-map was prepared based on these reconnaissance soil maps by Aksoy et al (2010). Because of the all deficiencies, 1:1.000.000 scaled soil map has to be prepared again.

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European Commission
EUR 25988 – Joint Research Centre – Institute for Environment and Sustainability

Title: Soil Resources of Mediterranean and Caucasus Countries

Editors: Yusuf Yigini, Panos Panagos, Luca Montanarella

Luxembourg: Publications Office of the European Union

2013 – 243 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424

ISBN 978-92-79-30346-3

doi: 10.2788/91322

Abstract

This book is result of the workshop on “Extension of the European Soil Database” held in Izmir/Turkey on 14-15 May 2012. The country reports on the status of soil mapping and the development of national soil information systems were presented briefly and discussed in relation to the objective on extension of the European soil database and information system. The most recent extension studies cover Algeria, Armenia, Azerbaijan Cyprus, Egypt, Georgia, Iraq, Israel, Jordan, Lebanon, Libya, Malta, Morocco, Palestine, Syria, Tunisia, and Turkey this book features country chapters, with contributions from 13 of the above-mentioned countries.

LB-NA-25-988-EN-N

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ISBN 978-92-79-30346-3

9 789279 303463