The Status of Soil Survey in Albania and some of its Major Environmental Findings

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Introduction

Over the last thirty years, a valuable experience has been accumulated in Albania, regarding soil survey and its applications. Initially it was the Soil Science Department of the Agricultural University of Tirana who carried out soil activities, and then the Soil Science Institute (SSI) of Tirana, created in 1971 took the lead in all related activities. The latter is under the Ministry of Agriculture and Food and it is the only one in the country specialised in soil science.

Until the early 90s the Soil Science Institute, was very well organised, operating throughout the country, by carrying out pedological surveys and fertility tests all over the agricultural land of Albania. Other activities included drainage and irrigation research, soil microbiology, erosion control, and topographic survey. There were 26 districts at the time in the country, each of them having their own soil laboratory and a specialised staff, among them one pedologist and one soil chemist. The Institute provided only scientific and technical guidelines for the "district soil offices", since their management was handled by local administration.

In twenty years period, detailed soil maps from 1: 10,000 to 1:50,000 scale, along with soil reports were prepared for each former agriculture co-

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operative, state farm and district. This indicates that soils have long been considered to be an important part of agricultural development. At national level is available a soil map at scale 1:200,000, which was compiled in 1958 Veshi and Spaho, (1988). The National Soil Classification System was adapted from the Russian System.

With the dawn of political changes and privatisation commencing at the beginning of this decade, the scientific institutions of the country went through drastic changes and setbacks. The Soil Science Institute in 1990 had a total staff of 194 people. Among them, 46 were scientists (11 having Ph.D.) and the remaining were laboratory technicians, field experiment labour force, drivers, supporting staff and administration. In 1999 the staff of the Institute shrunk to 15 scientists and 50 supporting staff. The district soil offices are non-existent anymore and very few soil analyses are being made in the country.

To overcome this situation an effort was made to rehabilitate the National Soil Laboratory at the SSI offices in Tirana. This was fully supported by a grant of the United States Agency for International Development (USAID) in 1998. At present this Laboratory is operational and makes soil, water, plant and fertiliser analyses for major required characteristics.

The most striking process that happened in the last decade in the Albanian agriculture was the change in land ownership. Until 1990, there were 550 agricultural co-operatives and state farms managing all the agricultural land (about 700,000 ha) of the country. Data from 1999 show that most of the agricultural land is distributed to about 500,000 farm families averaging less then 1,5 hectares per farm. This is the greatest "agrarian revolution" of the modern times in Albania regarding private land ownership. The process has gone (and is still going) through controversies on the way this privatisation is done, however, the will of the past Governments and of the existing one is to continue applying the existing law of land privatisation.

From the soils prospective the change in land ownership has brought to difficult times in keeping the link with the thousands of newly created farmers and SSI. Even though many farmers recognise the importance of soil fertility and conservation, there are no signs that anyone of them would consider paying for a soil survey investigation any time soon.

Therefore, even in the conditions of private farming, the opinion of the Ministry of Agriculture and Food (MAF) and of the SSI is that public funding or international donor funds should sponsor soil survey programmes. This becomes a priority especially in the pace of rapid increment of land degradation and environmental damage of Albania's natural resources.

Accelerated soil erosion, deforestation, overgrazing, soil pollution, re-salinization, acidification, waterlogging, flooding, urbanisation, nutrient mining, and loss of soil fertility are perhaps the most alarming environmental problems in Albania (Zdruli 1994). There is an urgent need that these negative effects are being quantitatively estimated and steps are taken to reduce their effects. To achieve this, detailed soil maps and soil investigations are needed, supported by modern techniques like remote sensing and Geographic Information Systems (GIS).

Further soil surveys are planned in co-operation with the European Commission's European Soil Bureau, the Region of Apulia in Italy and the Soil Science Institute of Tirana, under the Interreg II Italy-Albania Project. A mixed team of Italian and Albanian soil scientists will perform soil surveys both in Apulia and Albania.

The study foresees the surveying of all the coastal area and inland valleys of Albania at 1:50,000 and a new soil map of the country at 1:250,000. The latter will be completed following the European Soil Bureau Manual for the creation of a Georeferenced Soil Database for Europe (1998) and will be compatible with other soil maps and databases created throughout the continent.

Following this context, the Albanian delegation welcomes the idea of creating a network of soil information throughout the Mediterranean basin and offers all its commitment for making this network operational and successful. It is in this way that the contacts between the countries of the region will be strengthened for the purpose of making the area more productive and prosperous.

General Features of Albanian Pedological Landscapes

The Republic of Albania is located in the Balkan Peninsula, between 39° 38' and 42° 39' N latitude, and 19° 16' and 21° 40’ E longitude. The country has a total area of 28,748 square km, but only 16.2 percent are below 100m above sea level. It is a very mountainous country, with many varied landscapes, including bare rock. Agriculture is well distributed, but it is most intensive in the western coastal lowland. Albania has a total agricultural land area of about 700,000 hectares, which is about a quarter of total land area of the country. Because of the differences in climate, natural vegetation, elevation, slope, and parent rocks, soils are highly diverse (Zdruli 1997).

The National Soil Classification System

According to the National Soil Classification System the soils of Albania are divided into four belts, which constitute the zonal soils as shown below. The main criteria in their subdivision are elevation and natural vegetation.

Table 1 shows the Legend used to develop the first Soil Map of Albania at scale 1:200,000, which is presented at Map. 1.

Table 1. Generalised table of Albanian soils and their surface areas versus total agriculture land of the country

	Belts	Type	Explanation	%	Area[3] x 1.000 Ha
Zonal soils					
I	Subalpine pasture	LM	Mountain meadow	0.5	3.2
II	Beech and pine forest	MP	Dark mountain forest	3.0	20.2
		LMP	Dark meadow forest	0.6	3.4
III	Oak forest belt	KM	Cinnamon mountain	17.7	121.3
		KL	Cinnamon meadow	5.4	37.0
		LK	Meadow cinnamon	7.5	51.3
IV	Mediterranean shrubs	HK	Grey cinnamon	25.7	176.2
		HKL	Grey cinnamon meadow	6.4	50.7
		LHK	Meadow grey cinnamon	18.5	127.1
Azonal soils					
	Alluvial	AL	Fluviatile soils	11.8	80.9
	Peat	LT	Boggy soils	1.4	10.0
	Saline	LKr	Solonchak, solonetz	1.4	9.7
	Primitive mountain soils	PM	Undeveloped soils	0.1	0.4
	Sand beaches	PL	Undeveloped soils		0.2
TOTAL				100.0	691.6

Distribution of soils

I. Subalpine pasture belt at 1600-2700 m high.

[3] Area refers to total agricultural land of the country.

II. Beech and pine forest belt at 1000-1600 m high.

III. Oak forest belt at 600-1000 m high.

IV. Mediterranean shrubs belt at 0-600 m high.

The above belts show the distribution of soils that follow a sequential rule dominated by elevation and vegetation. These soils are called zonal soils. Their relevant characteristics are related to the fact that their formation occurred under specific biological, geological, topographic, and climatic conditions and their location is well defined according to the elevation. Soils within each belt do not occur in any other belts.

Map. 1 1958 SOIL MAP OF ALBANIA

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In areas where soil formation is not related merely to natural vegetation and elevation, soils are considered as azonal and include alluvial, peat, saline, and undeveloped or primitive soils. They can occur in all of the above mentioned soil belts.

The National Soil Classification System and methods of soil resource inventory, in Albania, were developed locally with minimal inputs from the outside world. Due to the size of the country and particularly, the extent of arable land, the Albanian system served its purpose by providing the first assessments for the land resources of the country and helped to make decisions on fertiliser use and land reclamation projects. However, modern concepts were not used and translation to other systems, such as Soil Taxonomy (Soil Survey Staff 1998) and the FAO Legend of the Soil Map of the World (FAO-UNESCO, 1988), proved cumbersome.

Classification of soils according to the US Soil Taxonomy

For a long time the Soil Science Institute and the Ministry of Agriculture has acknowledged the need for incorporating the country with international structures and institutions of soil science. However, although the need was appreciated, due to the general economic conditions prevailing in the country, no concerted effort was made.

During the period 1994-1997, the United States Department of Agriculture (USDA) Natural Resource Conservation Service) in collaboration with the International Fertilizer Development Center (IFDC) of Muscle Shoals, Alabama (USA), and the Soil Science Institute of Albania (SSI), undertook a project to document the soil resources of Albania. A joint team of Albanian and American soil scientists visited the country and sampled many sites. The earlier soil map the country prepared in 1958 and discussed at the above chapter was used as the base map.

At the end of this study a very detailed monograph was published (Zdruli, 1997), which compiled old and modern soil information into one source and provided the first soil map of Albania developed by international standards and methodologies. The map was prepared using the US system of soil classification otherwise known as Soil Taxonomy (Soil Survey Staff 1998) and is presented in Map 2.

Resource base assessments

The existing national soil map at 1:200,000 scale was first digitised using a PC ARC/INFO software, and then this coverage was used for the conversion process into Soil Taxonomy. Climatic information was also compiled and the soil moisture and soil temperature regimes (SMR and STR) were computed using a model developed by USDA/NRCS for each of the 208 climatic stations available in the country. The SMR and STR information is necessary for classifying the soils using the Soil Taxonomy system.

This preliminary information was then used for the field assessment of the soils. Thirty benchmark profiles were characterised and sampled for analyses at the NRCS laboratories in Lincoln, Nebraska. Hundreds of random observations using auger sampling or road-cuts were also made throughout the country. These were used to collect information on landform, land use and soil classification. The exact location of each observation point was determined using a Global Positioning System (GPS).

Map 2. SOIL RESOURCES OF ALBANIA

INSTITUTI I STUDIMIT TE TOKAVE SOIL SCIENCE INSTITUTE TIRANA, ALBANIA	USDA/NATURAL RESOURCES CONSERVATION SERVICE WASHINGTON D.C., USA	INTERNATIONAL FERTILIZER DEVELOPMENT CENTER MUSCLE SHOALS ALABAMA, USA	U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT WASHINGTON D.C., USA

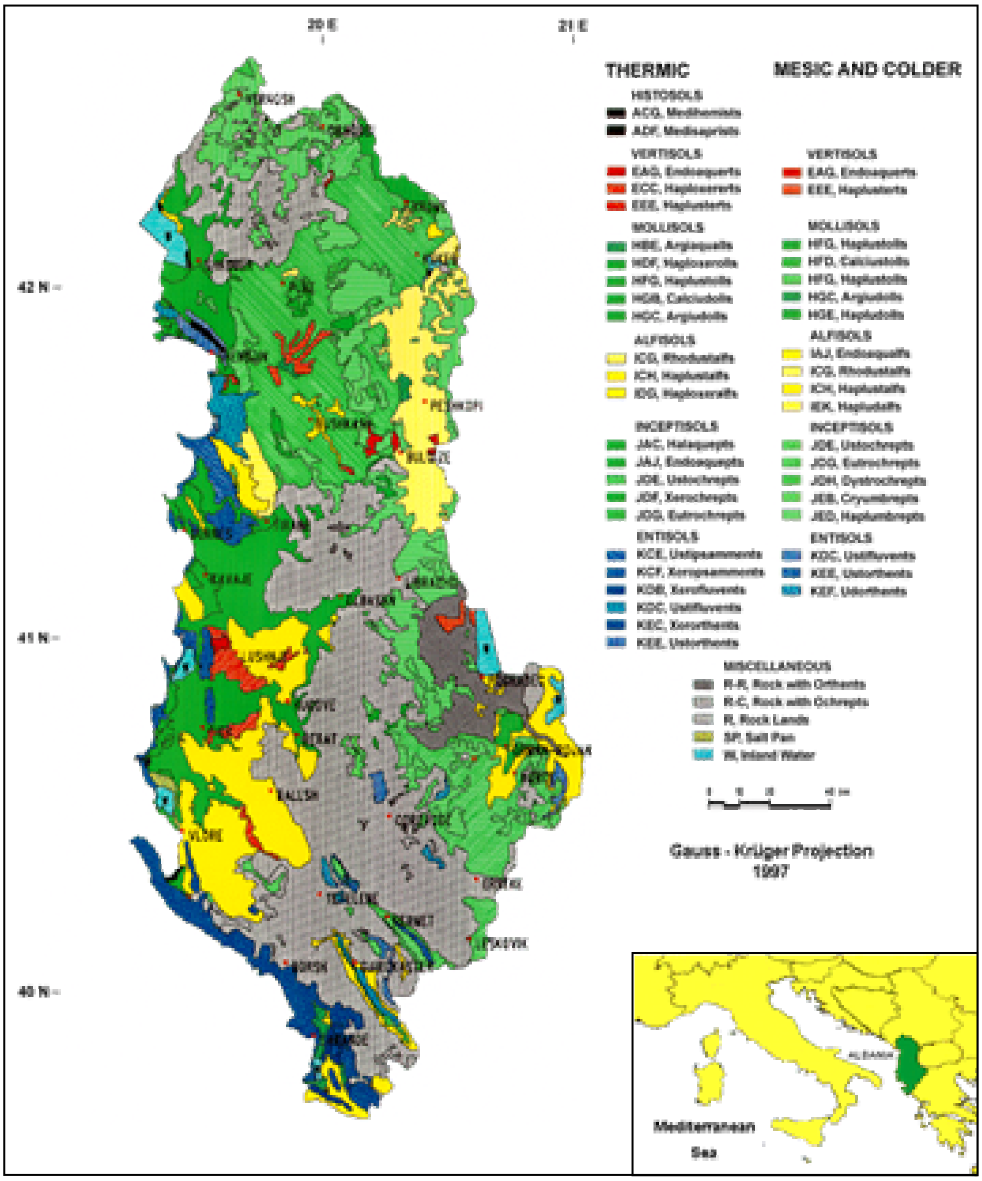

Table 2 shows the correlation between the Albanian systems of soil classification and Soil Taxonomy (Soil Survey Staff 1998).

Table 2. Albanian legend and Soil Taxonomy equivalents

Albanian Legend	Soil Taxonomy equivalents
Zonal soils	
Type *Description*	
LM Mountain meadow	Dystrocryepts
MP Dark mountain forest	Dystrocryepts, Eutrocryepts
LMP Dark meadow forest	Hapludolls, Haplustepts
KM Cinnamon mountain	Haplustepts, Haplustepts
	Haploxererts, Rhodustalfs Haplusterts
KL Cinnamon meadow,	Haplustalfs, Endoaqualfs, Haplustolls, Calciustolls
LK Meadow cinnamon	Hapludolls, Argiudolls
HK Gray cinnamon	Haploxeralfs, Haploxerepts, Rhodoxeralfs
HKL Gray cinnamon meadow	Haploxeralfs, Haploxerepts
	Calcixerolls
LHK Meadow gray cinnamon	Haploxererts, Halaquepts
	Argiaquolls
Azonal soils	
AL Alluvium soils	Ustifluvents, Xerofluvents Haplustepts, Haploxerepts Haplustolls, Haplustalfs
LT Boggy soils	Medihemists, Medisaprists Calciustolls, Endoaquerts
LKr Saline soils	Halaquepts
PM and PL Undeveloped soils	Udorthents, Xerorthents
	Ustorthents, Xeropsamments, Ustipsamments

Description of soil orders

The following is a brief overview of the soil Orders (Soil Survey Staff 1998) occurring in the country. For each Order, the range of properties, including land form and land use, is given. Six soil Orders are recognised in Albania: Histosols, Vertisols, Mollisols, Alfisols, Inceptisols, and Entisols. Table 3, which was generated using a Geographic Information System (GIS) lists the area extent in hectares for all soil at the great group level.

Table 3. Areas in hectares according to Soil Taxonomy Great Groups. (Soil Survey Staff 1996)

Soil Taxonomy classes	**Total Ha**	Soil Temperature Regime	
		Thermic	Mesic and colder
A HISTOSOLS	**3,978**	**3,978**	**-**
ACG Medihemists	3,037	3,037	-
ADF Medisaprists	941	941	-
E VERTISOLS	**58,542**	**37,756**	**20,786**
EAG Endoaquerts	6, 825	2,014	4,811
ECC Haploxererts	34,193	34,193	-
EEE Haplusterts	17,524	1,549	15,975
H MOLLISOLS	**208,402**	**154,894**	**53,508**
HBE Argiaquolls	7,284	7,284	-
HDF Haploxerolls	97,517	94,111	3,406
HFD Calciustolls	4,341	-	4,341
HFG Haplustolls	41,043	18,361	22,682
HGC Argiudolls	29,904	25,421	4,483
HGE Hapludolls	28,313	9,717	18,596
I ALFISOLS	**498,670**	**293,833**	**204,837**
IAJ Endoaqualfs	3,592	-	3,592
ICG Rhodustalfs	146,761	-	146,761
ICH Haplustalfs	90,491	37,557	52,934
IDG Haploxeralfs	256,276	256,276	-
IEK Hapludalfs	1,550	-	1,550
J INCEPTISOLS	**1,015,951**	**145,073**	**870,878**
JAC Halaquepts	11,261	11,261	-
JAJ Endoaquepts	33,348	33,348	-
JDE Ustochrepts	135,223	5,283	129,940
JDF Xerochrepts	95,181	95,181	-
JDG Eutrochrepts	320,767	-	320,767
JEB Cryumbrepts	121,559	-	121,559
JED Haplumbrepts	298,612	-	298,612
K ENTISOLS	**164,613**	**149,902**	**14,711**
KCE Ustipsamments	825	825	-
KCF Xeropsamments	15,843	15,843	-
KDB Xerofluvents	7,518	7,518	-
KDC Ustifluvents	30,902	26,635	4,267
KEC Xerorthents	89,900	89,900	-
KEE Ustorthents	11,774	9,181	2,593
KEF Udorthents	7,851	-	7,851
MISCELLANEOUS	**924,640**	**639,216**	**285,424**
R-C Rock with Ochrepts	726,838	613,747	113,091
R-R Rock with	99,219	-	99,219

Orthents			
R Rocky lands	52,991	-	52,991
SP Salt pan	4,056	4,056	-
W Inland water	41,536	21,413	20,123
TOTAL LAND & WATER AREA	2,874,796	1,424,652	1,450,146

Histosols

According to the Soil Resources map (Map 2), Histosols make up to 3,978 ha or 0.56 percent of the total agricultural land. The actual Histosol area has decreased compared with that of more than 40 years ago, since many of them were found to be Mollisols, Vertisols and/or Histosols. The difference appears to be because of the changes that have taken place in almost all the swampy areas of the country. After reclamation, these lands were put under intensive farming, which caused important changes in the properties of these soils. The most notable change was the reduction of organic carbon content.

Histosols in Albania are very productive soils. By using advanced technologies and high inputs, yields would probably double and the income could increase notably. The main tasks for the future remain the maintenance of the drainage systems and improvement of irrigation techniques.

Vertisols

Within the National Soil Classification System Vertisols were not identified as a separate type at the highest level and without regard to their typical physical properties, were included along with other types of soil in the same soil mapping unit. Recent studies, however, revealed that Vertisols are well present in Albania and occupy about 58,000 ha, or about 2 percent of the country's total area. The most extensive areas are found in low-lying terrain of the western coastal zone and have Thermic Soil Temperature Regime. All the magnesium-rich (smonitsa) soils having been formed on basic or ultrabasic rocks, or on their derivatives, classify as Vertisols, specifically as Usterts and Aquerts.

Vertisols are potentially good agricultural soils, but they need appropriate land management and especially excellent drainage system. Their major problems are related to physical soil characteristics such as plowing difficulties and water management. They offer considerable potential for the intensification of agriculture, subject to the application of technologies that are designed to meet the specific Vertisol management requirements.

Mollisols

Mollisols make up 7.25 percent or about 208,000 ha of the whole territory of the country. They are located both in thermic areas (154,894 ha) and mesic and colder temperature regimes (53,508 ha). Mollisols formed on strongly weathered alluvium from limestone, sandstone and shale formations, as in some areas of the coastal plains are very productive and fertile.

Generally, Mollisols are young soils. Radiocarbon dating shows that these soils can form in a period of 550 years to 1,000 years. This is sign of their “fragility” that can be altered by mismanagement. Intensive cultivation may lead to a drastic reduction of the organic matter content and lower their natural fertility.

Mollisols are very productive soil, where some of Albania's best yields in wheat, corn, sugar beet, potatoes, forage and vegetable crops are achieved. Investments in these areas are justified because a good return is guaranteed.

Other Mollisols classified within lithic or ruptic lithic subgroups are usually shallow soils equivalent to Rendzinas (FAO-UNESCO 1974), which are potentially suitable for forestry. Therefore, erosion control and reforestation should be the main focus for these areas in the future.

Alfisols

Alfisols cover approximately 498,670 ha or about 17.3 percent of the total land area of the country. They occupy the second largest area among the six orders of Soil Taxonomy found in Albania. The most essential pedological feature is the presence of the argillic horizon (Bt), which qualifies these soils as Alfisols. Almost 60 percent of them, which include Ustalfs and Xeralfs, occur in thermic areas. Other Alfisols are Aqualfs and Udalfs found only in mesic areas.

Typical Alfisols are the Rhodustalfs, which occupy areas from Kukës to Peshkopi in the north-east of the country and south towards Librazhd. They have a typical reddish colour very similar to the Mediterranean terra rosa, except they do not have a xeric SMR. The geology of the area where Rhodustalfs occur is made entirely of limestones.

Alfisols are well-developed soils and from the oldest ones identified in Albania. Data from Radiocarbon examinations show an age up to 8,500 years BP for an Alfisol sampled in the upper part of the valley of Korça, in south-eastern part of the country.

Alfisols have high potentials for agriculture. In particular the Haplustalfs of Korça are considered among the best soils of the country, especially for wheat, sugar beet and potato cultivation. Xeralfs are very good for olive groves, vineyards and fruit trees. A major constraint limiting higher yields is the dry season associated with the xeric and ustic SMR. Therefore, an adequate irrigation system is an important investment for the future.

Inceptisols

Inceptisols occupy the largest areas of the whole country. Their total surface area of 1,015,951 ha or 35.3 percent of Albania's territory, is divided into thermic, mesic and colder temperature regimes, but the major extent occurs in mesic zones. The main suborders according to Soil Taxonomy (1996) that had been identified are Aquepts, Ochrepts and Umbrepts.

Aquepts occupy entire areas in the northwest of the country. They are influenced by fresh alluvial depositions from the Drini and Buna rivers, which create the conditions for a aquic moisture regime. Other Aquepts are found in the western coastal plain at low depressions.

Saline areas are classified as Haplic or Vertic Halaquepts. It is important to emphasise that the area of these soils is increasing recently. Some other areas within the saline zone as in Akërni in Vlorë classify as Vertic Natraqualfs.

Xerochrepts are found only in the thermic areas, in the coastal plains, while Ustochrepts have a distribution in both thermic and mesic STRs. The Xerochrepts of the alluvial areas are very fertile, have a silty nature and good physical properties. Most Ustochrepts in mesic areas are relatively shallow, with a lithic contact within 50 cm of the soil's surface and are formed on ultrabasics rocks and limestones.

With such a large extent, Inceptisols have a great variety of potential uses and are found on some of the most fertile lands of the country. Endoaquepts, Xerochrepts and Ustochrepts of thermic areas in the flat zones can be used for intensive agricultural production, including cash crops under irrigation. Other Ustochrepts and Eutrochrepts occur mostly in mountainous areas and are best suited for forestry and grazing. Reforestation and grazing limits are necessary to control erosion in these areas.

Entisols

Entisols make up 5.7 percent of the total surface area of the country. They are spread throughout Albania, however they’re major extension, occur in the thermic area. Only the suborders of Psamments, Fluvents and Orthents have been recognised.

Psamments are found only in thermic areas occupying the beaches of Adriatic and Ionian Seas. Fluvents occur in both thermic and mesic areas and are the equivalents of alluvial soils. They can have a xeric, ustic, or udic SMR. Orthents are located in thermic and mesic and colder STRs as well and cover much of rocky areas of the numerous mountains of

Albania. Wherever they occur, Orthents have a lithic contact within 50 cm or less and usually have little evidence of pedogenetic development. In the Albanian system of soil classification, they are equivalent to "primitive" or undeveloped soils.

Depending on their classification, Entisols in Albania have a variety of uses. Fluvents are very good soils, with high potentials for intensive farming. Their location is excellent for cotton, rice, corn and vegetable cultivation, but is dependent on irrigation capability. Orthents have limited potential for agriculture, but are naturally suited to forestry and grazing as long as erosion is controlled.

Miscellaneous soil units

The miscellaneous grouping includes a variety of soils, rock and inland water. This special category is introduced to better describe the Albanian landscape. Except for the Western coastal plain, the most visible feature of the country, is the presence of mountains and inland valleys. Generally at lower elevations within the inland valleys the soils are deep, fertile and suitable for agriculture.

Midslope soils are shallow with a lithic contact and are mostly covered by shrubs and forests. The highest elevations are mostly bare rock or a mixture of rock and some soil. It is this category that is represented under the miscellaneous groupings of Rock with Orthents, Rock with Ochrepts and Rock land. In the first two groupings, the ratio between soil and rock is about 1:4, while the last group is just bare rock. These subdivisions are found throughout Albania, mostly in mesic and colder areas. Together they make up to about 32 percent of the country's territory. That is quite a large area, which could be used for different purposes, including mining, forestry, and grazing or as protected natural areas.

Albanian Soil Data for the Soil Geographical Database of Europe at scale 1:1,000,000

The integration of Albanian soil information into the Soil Geographic Database of Europe was a timely event and for the first time included soil data for the country at the European level. This was done according to the Users Guide methodology that was developed for the elaboration of the European soil database version 3.1 (INRA, 1995).

Because the soils have been generalised from the original 1:200,000 scale soil map, it is impossible to show the full diversity of the soils at the scale 1:1,000,000. Included in this new soil map are 65 Soil Mapping Units (SMU), 57 presenting soil units and 8 of them non-soil SMUs (inland water). There are a total of 139 Soil Typological Units (STU), which are not shown individually on the map, but their details are included in the database. Twelve Major Soil Groups have been recognised at the first level of the FAO Legend (1974), and 25 soil types at Unit level.

The majority of Albanian soils are classified as Regosols, because much of the country is mountainous with shallow soils. Cambisols, Lithosols, and Luvisols are the next most important groups. A small area of Kastanozems has been identified in the north-eastern valleys as well.

Typical soils in the western coastal area are the Fluvisols, Luvisols, Phaeozems, and Vertisols. These are soils of alluvial origin of Quaternary deposits and are under the influence of Mediterranean climate. Bush and macchia mediterranea on the hills and grass type on the flat lands represent the natural vegetation. Arenosols occur on sand beaches and on the surrounding sand dune hills. Solonchaks are found in the low lying areas of the Adriatic Sea and pockets of Histosols occur in low depressions.

Included in the database for each SMU are twenty four attributes compiled in semantic tables showing major soil characteristics, like soil name according to FAO Legend of 1974 and the Revised Legend (FAO-Unesco, ISRIC 1990), dominant and secondary textural class, dominant limitation to agriculture use, parent material, maximum and minimum altitude, dominant and secondary land use, depth class to textural change, depth class of an obstacle to roots, impermeable layers within the soil profile, soil water regime, water management system in the agricultural land, and purpose and type of water management system. Since much of the information is based on expert judgement, a separate column indicates the confidence level of the Soil Typological Units attributes.

The database creates the possibilities for estimating other missing soil characteristics through the use of pedotransfer functions and rules (Bruand, et.al 1996). In this way, important information can be derived for the second and third level of the soil classification (FAO 1974, modified EC-ISSS 1985) and on the properties of parent material.

Along with the soil map, an analytical soil profile database was created for some representative soils of Albania. These data were entered in the database according to the guidelines described by Madsen and Jones (1995).

As soil patterns do not normally follow political borders, problems arose with the soil patterns in the border areas between Albania, Greece and Former Yugoslav Republics. These problems were resolved in collaboration with all of these countries.

The conclusions from the above study are summarised below:

- More detailed information at large scales of 1:10,000 to 1:50,000 is required to show the true picture of the soils in Albania;
- Agricultural land in the country is a finite resource and there is not much land left that is suitable for conversion to cropland;
- Sustainable land use has still to be developed;

- Land degradation is seriously threatening the soil resources;
- Extensive areas covered by shallow soils are best suited to forestry or managed grazing. At present, most of these are either mismanaged or have been abandoned, leading to accelerated soil erosion;
- The flat lands are intensively cultivated, but they are effectively under a nutrient mining regime because inputs do not match the outputs;
- Where management practices are inappropriate, waterlogging and re-salinization occur;
- Addressing these problems will require the adoption of a national soil policy, which takes into account sustainable land use practices and appropriate management strategies.

Land Resource Stresses and Environmental Degradation of the Natural Resources

Most of the internal resources and the energies of the Albanian people and the Government Institutions have been focused recently on making Albania a viable nation. Developing a democracy from a turbulent past is a difficult and slow process.

The time has come for the country to develop strategies and policies that address both production and environmental implications. Economic progress in the absence of environmental integrity is a formula for further discord between the natural ecosystem and the socio-economic indicators.

Description of land resource stresses

Degradation of natural resources deals with two interlocking complex systems: the natural system and the human-induced system. The interaction between the two systems determines the success or failure of resource management programs. Land degradation is increasingly threatening the quality of natural resources with direct impacts on sustainability of agriculture and eventually, the quality of life

(UNDP, 1995). The degradation processes in Albania include the human-induced land stresses like chemical pollution, salinization, nutrient mining of agricultural land, deforestation, over-grazing and accelerated soil erosion and natural processes or conditions, which include acidification, flooding, stony and shallows soils, and areas of low temperatures and poor accessibility.

The processes that are natural have a much lesser extent than the human-induced, which result from mismanagement and require both mitigating technology and also a societal commitment through stewardship and awareness. It is estimated that about 85 percent of the country's territory is under human-induced degradation stresses. Map 3 shows the spatial distribution of all the land resource stresses nationwide and Table 4 gives their respective surface areas.

Map 3. Land Resources Stresses

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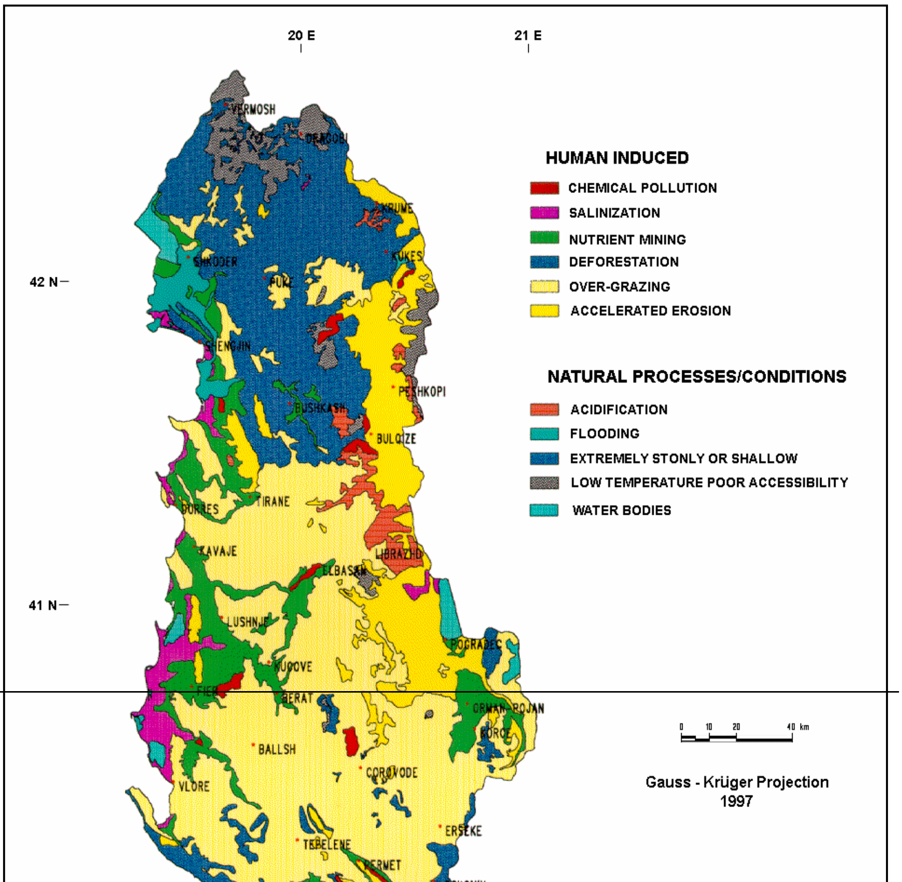

Table 4. Land Resource Stresses of Albania. Surface area in km^2 and in percent.

LAND RESOURCE STRESSES	Area	%
Human induced		
Chemical pollution	165	0.6
Salinization	654	2.3
Nutrient mining	2,936	10.2
Deforestation	5,005	17.4
Over-grazing	12,201	42.4
Accelerated erosion	3,585	12.5
Natural processes and conditions		
Acidification	624	2.0
Flooding	461	1.6
Extremely stony or shallow	1,614	5.6
Low temperatures/poor accessibility	1,182	4.1
Water	320	1.1
TOTAL	28,747	100

Soil erosion, deforestation and over-grazing are perhaps the most serious environmental problems in Albania today. Estimates for soil erosion show values from 32 tons per hectare up to 185 tons per hectare (The World Bank, 1993), however final scientific data are yet to be published. There are several factors contributing to accelerate soil erosion, which include natural ones (i.e. irregular rainfall pattern, shallow soils, high slopes, fragility of soil material) and human factors such as abandonment of sloping land, deforestation, over-grazing and misuse or mismanagement. Another form of degradation are the landslides, found in many areas throughout country, greatly reducing not only to the sustainability of agriculture but also the long term security of rural housing.

Eroded areas are spread all over, but most typically they occur in the northeastern part of Albania, where the degradation of natural resources is more intense (Zdruli 1998). The estimated area where erosion is the most constraining factor of sustainable development is about 350,000 ha.

A side effect of erosion is also the siltation of the reservoirs. There are more than 650 reservoirs spread all over the country used for irrigation and larger ones used for both power production and irrigation. At the existing rates of erosion and denudation of the sloping lands within the catchment area, life expectancy of the reservoirs will be greatly shortened.

Albania's deforestation had started more than five hundred years ago, when most of the oak forests of the country's southern part were cut to build the merchant ships of old Venice, and later because of the burning of wood for fuel, and the expansion of villages onto hillsides. The deforestation problem will particularly be intractable, unless some mechanism is found to increase alternative affordable heating and cooking supplies. Illegal cutting for commercial purposes had drastically increased over the last decade and the governmental structures are proving to be inefficient in halting the damage.

Recent data show an increasing number of livestock herds, which compete for food, therefore it is expected that the pressure on Albania's pasturelands will increase. At the moment, ***overgrazing*** seems to be the most important factor affecting land degradation. Fires on natural pastures, such as in the southern part of the country, are causing considerable damages not only to pastures themselves, but also to forest, fruit trees, olives groves and biodiversity.

Both forest and pasture-lands make up 50 percent of the Albania's natural resources, representing an extremely large area with high potentials for the development of the country, if managed properly.

Saline soils of Albania are located on the Western lowland coastal plain and are under the influence of Mediterranean climate, which accelerates evaporation in summer and causes salts to concentrate on the surface. The reverse phenomenon occurs in winter, when, because of heavy rainfalls, salts are leached down into deeper layers.

Typically salty soils occupy flat areas, often below sea level where saline conditions may also occur within the swamp and marsh soils. In recent years there is evidence of increasing salinization in those areas and unfortunately the trend is still continuing to be negative. Overall saline areas occupy about 30,000 hectares.

Flooding is increasingly becoming a problem especially in the northwestern part of the country. The same scenario is realistic for the many other lower part areas. Total estimated area under the threat of flooding is more than 40,000 ha of land. There is a chain reaction from overgrazing, deforestation and erosion culminating in the flooding, which is also accelerated by the poor maintenance of drainage canals and pumping stations. Waterlogging is reducing yields in those areas and the reverse phenomena of swamp and marsh formation is becoming evident.

Acid soils are mainly located in the north-eastern part of Albania and to a limited extent in the south-east. Acidity plays an important role in reducing crop yields. Since acidification is a natural process influenced by the parent materials and the climate of the area, there is concern that the acid soils may expand, even in those lands that were considered ameliorated by using lime a few years ago. The estimated area of acid soils is about 60,000 ha, but that may reach values as high as 90,000 ha, according to some surveys of the Soil Science Institute.

Albania has a relatively short history in fertiliser use and very long tradition in agriculture that dates back more than 2,000 years. Soils have been exploited systematically and have received little inputs from other sources, other than some manure. Even during peak years, the country had used fertilisers less than almost any other nation in Eastern Europe. Still the rates of fertiliser use are far below the needs, mainly because of low purchasing capacity. It is believed that most of the best agricultural lands in the country today are under ***nutrient mining*** conditions leading to a continuous reduction of soil fertility. Overall affected area is about 200,000 ha located in the flat zones.

Site-specific stresses

Certain areas within the country are affected by several kinds of typical stresses. They can be summarised as: urbanisation of high quality farmland, point-source contamination from mining activities, factory wastes and effluents, uncontrolled and random disposal of urban waste on agricultural land, heavy metal contamination from natural and human activities, and loss of biodiversity.

There are no available data on the surface areas effected by each of the site-specific elements. Some estimates (UNDP 1995) for the urbanisation of the surrounding areas of the capital city of Tirana show that the land lost to unplanned construction is one and a half times larger for the same number of inhabitants, than if the home-construction would have been planned. Agriculture land contaminated by the oil and gas industry, factory wastes and effluents is roughly 50,000 ha.

Albania has the highest population growth rate in Europe. In less than 50 years its population has tripled, and this trend is expected to continue, at least over the medium term. This is the main reason why the food policy for the country must promote the sustainable management of soil resources in harmony with the environment.

The present picture is not very promising, since much of the land is mismanaged. Sloping lands are either abandoned or under the increasing threat of erosion and overgrazing. Flat lands are being explored continuously without little inputs added to the soil, however, the biggest threat is the alarming urbanisation by home construction, building highways and business, which are invading enormous areas of very fertile land. Those lands are the most productive in the country from the agricultural prospective. They should be protected for the next generations.

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Soils of Tunisia

Amor Mtimet[1]

Introduction

Pedological studies based on soil survey, photo-interpretation, laboratory analysis, and remote sensing, were implemented in Tunisia since more than half-century. The magnitude of these surveys is so high that they practically cover the whole territory of the country. They were aimed mainly at acquiring better knowledge of country's soil resources in order to use them in land reclamation and agricultural development projects. Therefore, Tunisia is among the few African countries where abundant soil data and studies are available. They include:

- 636 Pedological studies;
- 310 Specialised pedological studies;
- 2,085 Preliminary survey studies; and
- 18 Bulletins published by the Soils Directorate.

Thus totalling 3,049 classified documents.

About 65% of the total surface area of the country is covered by pedological surveys, which equals to about 10,669,000 ha. Nevertheless some of those concerned with agriculture development, often ignore this large mass of valuable soil data. It is becoming evident that the decision-makers are more prone to consider crop and animal production, hydraulic works and management plans rather than the sustainable use of land resources.

In order to benefit from the funds of a new agriculture policy, the use of soil information has become a must, and those who are in charge of the national development should start addressing also the

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sustainable management of soil services. Extension services to farmers are now evolving which would allow them to an easier access to soil information.

Description of the soils

General background

Since Tunisia is at the same time a Mediterranean and a Saharan country the soils show all the sings of this climatic, morphological and geological diversity. According to the French system of soil classification the soils of Tunisia are classified as podzols, vertisoils, red Mediterranean soils, calcic-magnesic soils (dominant soils), brown and isohumic soils, saline and hydromorphic soils and also poorly evolved soils. Their distribution is based on the catena system.

The structural and geo-morphological framework of pedogenesis in Tunisia

The set of the geological data of the Tunisian environment leads to distinguish nine large natural zones from the north to the south of the country (Mtimet 1999):

1. The flysch Oligocene zone of Numidia (Mogods-Kroumirie);
2. The marly calcareous zone of Béjà;
3. The Mejerda valley;
4. The Atlas that subdivides into:
   - Deeper zones, and
   - Transversal ditch zone
5. The Ridge;
6. The Sahel zone subdivided into:
   - Kasserine island or High Steppe;
   - Eastern Plain or Low Steppe, including:
   - Sahel of Sousse and Plateau of Sfax;
7. The domain of the southern Atlas depressions;

8. The Dahar Dome and the Sahara platform; and
9. The coastal plain of Jeffara.

All the above, comprise a high diversity of soils. They include the arid soils of the Northwest as well as soils showing characteristics inherited from Quaternary paleo-climates (ancient, middle, recent). The later cover the slopes and *glacis* – of large valleys and crusts. Among the typical elements of soil formation in Tunisia should be mentioned the harsh climatic conditions, heavy winter showers, variable plant cover, and predominantly calcareous and marly lithology.

The soil cover

The total surface area of the country of about 16,4 million hectares has a length of 900 km and a width of 542 km. It is evident therefore for Tunisia to show from the north to the south a rather strong bio-climatic variability. The distribution of land use and land cover is given below, however those data do not cover the whole territory of the country.

- 1,300,000 ha are used for annual crops (average), which can reach as high as 1,667,000 (1992,1993 data);
- 2,000,000 ha of shrub crops;
- 1,000,000 ha for *maquis* and forest rangeland, of which 680,000 are forests;
- 6,000,000 ha rangeland (this areas are on the decrease);
- 600,000 ha for alfalfa steppe (resources on the decrease);
- Another 5,015,000 ha (or about 30% of the total surface area of the country) consist of inadequate land for agriculture use, made of raw mineral soils and saline soils as found in Erg- Regs- Sebkhas- Chotts- salty lakes (Garaât).

The North

The North includes three bio-climatic areas (humid, sub-humid and semi-arid) and at least 5 natural regions. The major soil groups are:

- ♦ Forest soils: leached brunified soils of extreme Northwest and the mull soils;
- ♦ Topomorphic and lithomorphic vertisoils are present in depressions and inland plains and are characterised by the presence of swelling clays of dark colour (soils are higher in organic matter content, and show cracking during the dry season);
- ♦ Mediterranean red soils or the local Béjà soils, found also in Bou Kornine and Jebel Zaghouan have developed on Jurassic limestone or on *glacis* of the Quaternary. They have fine texture, a well-developed polyhedral structure and calcareous accumulations.
- ♦ Carbonate soils (calcic-magnesic) regularly cover calcareous parent materials. Their thickness is variable following the general ground morphology. They exhibit crusted horizons or contain coarse calcareous elements.
- ♦ Alluvial soils (poorly evolved) sometimes have a thickness of more than 2 m. They cover large valleys of extended watersheds of Mellegue, Mejerda, and Tassaa. These alluvial soils undergo salinisation processes downstream and in the low valley areas of Mejerda (Mornaguia, Kalaat Landalous) or along the Beni-Khiar, Kélibia (Cap Bon) plain.

The Centre

South of the ridge, the semi-arid domain and part of the arid domain extend southward to Sfax, Gafsa. The Centre includes 4 great natural regions: the High Steppe, the Low Steppe, le Saheland, and the Kairouan region. They present the following soils (prevailing soils are given in decreasing order):

1. iso-humic soils;

2. carbonate soils (calcic-magnesic);
3. saline-sodic soils;
4. poorly evolved soils;
5. mineral soils resulting from erosion.

♦ Iso-humic soils are brown soils with dominantly coarse texture. They are rather deep with an organic matter content ranging from 0,5% to 1,5%. On the plateaux of Sidi M'hedeb and Sfax, they have calcareous crusting, which allows them to be associated to calcic-magnesic soils. These soils develop over large surfaces, mainly in the low steppes, in the Sahel and in the Sfax region (Centre, Centre East).

♦ The other types of soil, i.e. calcic-magnesic, alluvial, saline and those resulting from erosion activity, cover almost half of the south-western part of the Ridge and the High Steppe of Kasserine region. The valleys and the slopes are generally covered with calcareous or gypsum nodule-soils. Some areas of the latter were used for fruit trees irrigated by sprinklers after decrusting and subsoiling the hardened pans.

♦ Saline-sodic soils are found in depressions and in the main Sebkhas like El Kelbia, Sidi El Hani, Monastir, El Gharra and Charita (region of Souassi). They develop on alluvial materials and on quaternary soils mostly consisting of marls, gypsiferous clays and sands. The supply of saline water and the rather fine sedimentation are the main processes that cause salinisation of these areas.

♦ Saline soils of Sebkahs are slightly saline thanks to the high content of sand and silt. Chloro-sodic groundwater, having various levels of salt concentration depending on the seasons is also present. The piezometric level generally ranges between 0,8 m and 1,40 m. Waterlogging is observed at the base of the soils as well as gley or pseudo-gley spots.

The South

The southern domain of Tunisia extends from the low plains situated south of Gafsa Mountains up to the Sahara boundaries. It includes huge morpho-pedological sets where the parent rock and maritime types of climate of Sahara influence and determines the variety of soils. These soils are:

1. calcic-magnesic soils (calcareous soils containing gypsum and limestone);
2. iso-humic soils (subdesertic called sierozems);
3. saline sodic soils (sebkha - chott);
4. poorly evolved alluvial soils (irrigated oasis soils and soils used for dry farming);
5. raw mineral soils (on hard rocks, coarse colluvium or calcareous and gypsum crusts).

- ♦ South West is characterised by large spaces of poorly fertile soils:
  1. wind borne sandy soils; (Erg);
  2. salt-affected or saline-sodic soils (Sebkha - chott);
  3. pebble soils (Regs, Hamadas du Dahar);
  4. loess soils (crusted sierozems, poorly evolved soils developed on old iso-humic soils but truncated and evolved at the surface of 0 to 50 cm;
  5. poorly evolved soils of the watershed formed on alluvial or wind borne parent material

- ♦ SouthEast has a rather uniform unit: the Jeffara plain, which stretches from Oued el Akarit, in the North, up to the Libyan boundary in the Southeast. From West to East, three compartments are distinguished: the Upper Jeffara, Low Jeffara sub-set, and the sub-set of the El Ouara plain in the south. The surface area of this region is crossed by *oueds* that drain the streams of Matmata Mountains. Its main soils are calcic-magnesic soils (located largely on footslopes), poorly evolved alluvial soils (low plains and oued valleys) and saline sodic soils of Sebkhas and Garâats.

- Poorly evolved soils, either wind borne or fluvial, form the best agricultural lands of south west (oasis or Ségui soils). In fact, they are deep (>1,50 m) and have silty-loam to sandy texture. Organic matter can barely exceed 0,5%. Gypsum accumulations could be present at medium depths of 40 - 60 cm and a gypsum borne crust is therefore present almost everywhere at the boundaries of *garaâts* and *chotts*. Of course, salinity appears from bottom to upper layers. Its content varies according to the cultivation patterns. In most cases, these soils show spots of waterlogging and salinity as found in Nefzaoua, Gherib, Jerid, Gafsa regions.

- Sandy soils of the plateaux and eastern Erg. The sandy soils of this last unit are characterised by their particle size distribution (ferruginous coarse sand) and the magnitude and morphology of their sand dunes (Barkhanes, Dunes, Shan interdunes). They are used as desert pasture. Sandy soils of plateaux (Dahar, boundary of chotts) have a finer white and ochre yellow material (fine sand), and are poorly structured. They result from the mechanical and chemical degradation of gypsum or loess material (Sahara loess with calcareous nodules). They surmount by a shallow layer and consolidated layers of gypsum or calcareous crust. These soils thus constitute parts of the rangeland, which are very sensitive to overgrazing or episodic cereal growing during the rainy periods.

- Salt-affected soils (solonchak, solonetz) develop over large depressions: Chott Jerid, Chott Gharsa and the numerous *sebkhas* and *garaats* act as outlets of the major watersheds. They cover large surfaces with saline crust during the dry season or swampy areas with the presence of a sub-surface layer during the cold seasons. Gypsum concentrations can appear at 40-60 cm depth. The boundary of these units (200 to 500 m) is occupied by wind borne sands (*nebkhas*) with halophyte vegetation used by camels for grazing.

- Pebble soils are also called raw mineral soils. They are made of coarse elements, which largely exceed 70% of their volume from the bottom of the valley colluvium to the upper coarse alluvium. These could be Lithosols or Regosols either, if their soil matrix includes finer elements. They cover the Dahar and the slopes of the mountains Chareb and Matmata.

- Iso-humic loess soils (sierozems, poorly evolved soils and Regosols, Mtimet 1983) of Matmata mountains and their edges as well as those of Segui of Gafsa, have developed over wind-originated parent materials. They have undergone through a pronounced pedogenesis (calcareous accumulations as nodules and crusting) during middle and recent Quaternary age.

- These deep soils cover the slopes, the valleys, the large marly depressions of Tamezret, Techine, Beni Kheddache, Beni Zeltene, as well as the plains near Jeffara eastward. Their morpho-analytical characteristics show the relevance of fine sands, coarse silts and a poor structural stability that initiate rill and gully erosion in the form of *jessours*. Rehabilitation works of soil and water conservation are an old practice (e.g. Jebalias) and they are consolidated at present by recent works. The lands are used for tree crops, olive trees and legumes.

The relevance of saline soils and secondary salinisation

Sodium chloride is the salt that, due to its high solubility, influences more the saline environment of south Sahara, however a large part of salt-affected soils also exhibit relevant gypsum spots related to the presence of calcium sulphate in ground water. In the zone of fluctuation of water table or the capillary fringe explored by roots, sulphates can precipitate giving rise to various forms of gypsum accumulation. They occur as nodules, crusts and incrustations of gypsum flower and micro-crystals, as found in Terch, Deb-deb, and Ras-Kelb. These forms are spectacular, particularly in the downstream portion of badly drained old oases and on the boundaries of the *chotts*.

Generally, these soils are not arable except those that, through irrigation, can be leached and drained (oases), as well as some fringes of land that, on the occasion of rainy years, can sustain, due to temporary drainage, episodic cereal growing (barley).

Salinised landscapes

The estimated areas actually affected by ground water rise, are evaluated to be about 10,000 ha in the Low Valley of Mejerda, 1,000 ha in the Middle Valley and about 5,000 ha in the upper Valley. For the oasis, the affected surface areas are about 500 ha in the oasis of Gafsa, 2,500 ha in the oasis of Tozeur, 5,000 ha in the oasis of Kébili and about 2,000 ha in the oases of Gabès. In addition, should be considered other 4,000 ha subdivided into several small perimeters in depressions of the Centre and in Sahel. Many efforts are being made at present (setting up of new drainage systems, reclamation) to remedy such constraints.

Agronomic suitability and soil sensitivity: their efficiency in dry and irrigated farming

The agronomic suitability of the soils is the result of a match between the morphological factors and the physical-chemical properties of the soil in a given climate. Climate remains a decisive factor not only for the different agricultural uses of land (rainfed or irrigated system) but also for the degradation processes of the soil as well. Methods and agricultural practices are associated with the management of agricultural lands in the search for better yields. Following are some considerations for different regions of the country.

The North

- The North West with its natural regions of Kroumirie-Mogod (sub-humid zone) is devoted mainly to silviculture and animal husbandry. Forest rangelands are covered with fodder crops. Supplemental water is needed at the footslopes of the mountains and terraces to allow the cultivation of tree crops.

The Upper Tell plateaux and internal plains that extend towards Northeast, are the domains of Vertisols and red soils (Chromic Luvisols). They form the cereal-growing zone where the best yields of the country are achieved. (Jendouba - Béja - Le Kef - Siliana). In fact, field crops (durum wheat, soft wheat, barley, and oat, associated with fodder rotations) are mostly suited to these soils.

- The North East which include the sub-humid to semi-arid regions of Bizerte, Ariana, Zaghouan and Nabeul have various type of lands, suitable for field crops, olive trees, fruit trees and vineyards.

The Centre

- Central and Western regions include Central Tunisia and southern slope of the Ridge. The western mountains (Djebels Chemama, and Chambi) are covered with forests (Aleppo pine), rangeland and alfalfa steppe. Below this belt, occur the olive trees and fruit trees associated with cereals (oat), which cover the footslopes of the mountains. The plateaux of centre west, and alfalfa steppe, are used as rangeland up to the plain of Sidi-Bouzid, towards the East. In the plain of Kairouan and Enfida, olive trees, vegetable crops and irrigated cereals cover large surfaces.

- In the Centre and Eastern regions are included the coastal sector of Sahel of Sousse and Sfax, which are covered with olive groves and almond trees as the major agricultural crops. Rangeland is found in the lithological crusted zones: gypsum plateau of Sidi-M'hedeb and the region of Skhira where protected agriculture around shallow wells is now extending on ameliorated soils (subsoiling, and addition of organic matter supply).

The South

The areas of southern Tunisia are located south of the 200-mm rainfall/year line and thus are included within the arid Sahara bio-climate. Along the edge of Gabes Gulf included are 6 governorates.

- The South West includes the large areas of Chott Jérid, Rharsa and Erg. The only arable lands are found in the traditional (Nefzaoua, Jerid, and Gafsa) or modern oases (new irrigated schemes: Ibn Chabbat, Hazoua, and Régim Mâatoug, el Faouar). The remaining area represents rangelands for semi-nomads around the Chotts or towards Dahar (reverse of Matmata).

- The South East region is mainly cultivated with tree crops, such as olives, figs, and almond trees, which dominate in the plain of Jeffara that benefit from runoff waters. Coastal oases of Gabes, Medenine, Jerba are situated on alluvial soils and are irrigated from deep wells with salty waters (> 3g/l). Episodic cereal crops or some irrigated schemes (Sidi Maklouf, Ben Gardane) are scattered in the region. Saline rangeland soils are found along the edges of *sebkhas* (El Melah, El Adibet) and in El Ouara plain.

Soil suitability and constraints in agricultural production

Tunisian soils are subjected to quite contrasting climatic factors like drought (over 3/4 of the surface of the country), short duration torrential rainfall, and increasingly important anthropogenic factors along the coast (urbanisation, inadequate cultural practices, and land tenure problems). All these factors make the soils fragile and increase their sensitivity to the degradation of their surface and their profile, either mechanical or chemical. To summarise the main processes of land degradation, the importance of the following factors has to be examined:

- water erosion;
- wind erosion;
- urbanisation; and
- salinization and waterlogging.

On average per year, these processes affect about 23,000 ha, most of which is related to water erosion, i.e. 10,000 ha. The present strategy for water and soil conservation to a large extent consists, in decreasing such rates as for example in the region of Kef, Siliana and Kirouan. Several observatories and experimental stations monitor these processes.

The following soil constraints or factors are considered important for agricultural development: slope, thickness, texture, permeability, limestone, salinity and drainage.

Nation-wide, 29% of lands are occupied by agriculture, 36% by rangeland and 35% by lands, which are inadequate for agricultural production. Fertile agricultural lands represent about 21,5% of the total area of the country.

♦ Depending on the bio-climatic regions and their sensitivity, the different types of land cover can be classified in the following order:

  - Cereal-growing lands;
  - Tree croplands;
  - Low plains and oasis irrigated lands;
  - Forest lands of the North and the Centre;
  - Rangeland of the Centre and the South.

Cereal lands

These lands mainly consist of vertic soils or brown red and brown iso-humic soils. Two physiographic and physiological constraints have to be considered for better exploiting these soils. The former relates to the percentage of slope when it exceeds 8% in marly soils, because as result of mechanisation gully erosion and landslides occur. . The latter appears when the slope is too small and lateral drainage is absent. It forms then swampy areas (*marjà*) where waterlogging is considerable. Such areas are quite evident in the regions of Jendouba and Kef. Of major importance for better farming is also the monitoring of water quality and fertility status of the soil.

Tree-crop lands

They include deep brown or alluvial soils with a well-balanced texture. These soils are found into many bio-climatic areas. The lands could be not suitable to young plantations if the following characteristics are observed:

- soil depth is smaller than < 80 cm;
- slope is too high;
- texture is fine (clay to silty clay); and
- a crust layer or gypsum crusting is present close to the surface (< 40 cm).

Tree-crop lands have to be protected from runoff through hydraulic works (terraces, cordons, *tabias*, *meskat* system, and *jessours*) and thus benefiting from additional water in the rainy periods of the central and southern regions of Tunisia.. Tree-crop lands represent more than two thirds of the cultivated land (3,5 million ha). Olive trees extend over 1,5 million ha of the Tunisian land.

Irrigated lands

Irrigated lands continue to increase in Tunisia as development projects for the efficient use of underground and runoff waters are on the increase. At present irrigated lands equal about 350,000 ha.

The forecasts for the next five-year plans estimate that these surfaces will reach 400,000 ha. Such important projects will contribute to intensify land productivity and to increase agricultural production in the country.

The development of these areas requires huge credits in order to prevent loss in productivity. Secondary soil salinisation is one of the causes in the lowering productivity of these soils in the irrigated schemes. Its origins are many and diversified and its prevention necessarily needs appropriate land-use policies and efficient irrigation water management.

Control checks for secondary soil salinisation in the irrigated schemes, are officially established as an ordinary activity within the Soil Directorate. They are aimed at localising, in the space, the salinised surfaces, determining the origins of salinisation, its position along the soil profile and formulating possible solutions to reclaim the soils and correct this constraint. Such measures are indispensable, since the diagnosis and precise localisation are useful data that allow precise methods of intervention in order to improve soil productivity.

The irrigated surface area in Tunisia is estimated to be about 350,000 ha. The Northeast includes 32% of this area, the Centre and the West 31%, the Northwest 22%, the South 9% and the Centre and East 6 %. Vegetable crops, field crops (cereals, legumes, fodder and industrial crops) and fruit trees are increasingly extending in the proximity of dams and wells. Compared to other regions, the South and the Centre-West of the country are potentially better suited for extension of irrigated areas.

However, the use of salty water for irrigation in the areas of the Centre West and the South, especially on those soils having fine texture (silty to silty-clay) could result in increasing salinity and therefore reduction of productivity. To avoid this more attention should be paid when drafting irrigation and drainage development schemes.

Salinisation does appear in the dry periods and/or when the well discharge decreases (i.e. year 1993/94). Other causes of salinisation are found when abundant irrigation water is applied resulting thus in groundwater rise as found in the low plains (Mejerda, Kairouan), in the periphery of Sebkha or of Chott (oasis), where drainage is almost non-existent and waterlogging occur.

Forest lands of the North and the Centre

Forest lands of the North and the Centre include the major Tunisian forests, covering 675,000 ha, and consisting of cork oak, holm oak, Aleppo pine, etc. Cropped soils extend in the chain of Kroumire, High Tell and the Tunisian Ridge. They occur in the mountains, hills, and *glacis* as brown calcareous Mediterranean soils, and/or rendzina soils.

Beyond the forest domain, which is still rather protected, cropland areas are increasingly expanding threatening thus the natural woods and causing erosion by runoff. According to recent studies, the decrease of forest cover in Kassarine region is estimated to be equal to 1% per year (Jebel Chemmama) while since the independence of the country, more than 1,000,000 ha nation-wide have been converted from forests to cropland. Estimated surfaces converted to cropland in the Centre cover about 379,000 ha and 2,800,000 ha of rangeland steppes in the south of the country.

During the last years, the Government has started considerable reforestation programmes for the areas of Northwest, the Centre and the West. The results of these efforts are already visible and remarkable.

Rangeland areas of the Centre and the South – Desertification hazards

In the past years these lands were covered with perennial crops, like alfalfa (especially in the upper parts) and other steppe species (*arthrophyton, rantherium*), but since the 60s they have been subjected to tillage and overgrazing. Meantime, the increasing number of cattle herds has contributed to further degrading the plant cover and indirectly the soil.

After the70s, the old nomad pastures of southern regions of Tunisia (Sidi Toui, el Ouara), have been replaced by mechanised cereal growing thanks also to some rainy years. This practice has favoured the desertification of many areas of these regions.

From the ecological point of view and in order to highlight the fragile nature of our land resources, it should be reminded that the arid zones (Sahara zone not included) cover over 6,290,000 ha, which are estimated as:

- 12% very degraded areas;
- 40% medium degraded areas;
- 17% marginally degraded areas; and
- 31% not degraded areas.

The structure of Soil Directorate

The Soil Directorate is a technical institution operating under the supervision of the Ministry of Agriculture. The major references presently used by technical services go back to the pedological service set up in 1942 that was restructured with the services of agricultural hydraulic engineering to establish in 1977 the Directorate of Water and Soil Resources (Direction des Ressources en Eaux en Sols - DRES). Finally, the present structure of the Soil Directorate was acquired by decree n° 83-1244 of 22 December 1983 that states its main attributions as follows:

- Soil inventory and mapping;
- Pedological expertise;
- Protection and safeguard of agricultural lands and natural resources;
- Studies on land management;
- Studies for soil recovery and reclamation;

- Analyses for pedological, agro-pedological and environmental purposes;
- Soil information database management, development and updating.

The Soil Directorate includes three sub-directorates and two shared services.

Responsibilities of the Sub-Directorate of Soil Inventory and Mapping

- Soil inventory through the establishment of basic soil maps and of databases in order to improve and update soil classification, and assist in land management and land use planning;
- The drafting and execution of projects aiming at the preparation of different types of maps, including land classification maps for irrigation and also providing assistance to the farmers for the optimal use of soils.

Responsibilities of the Sub-Directorate of Research and Experimentation

- To carry out basic research in the field of soil science in order to increase and deepen knowledge on the different soil types of the country;
- To carry out applied research on soil fertility and to provide guidance for better land use in agriculture through experimentation;
- To control the irrigated schemes and follow up their evolution, especially referring to salinisation.

The Sub-Directorate of Soil Analysis

Is in charge of the following:

- Analytical determination of the physical, chemical and biological characteristics of soils and waters and promotion of new analytical techniques most appropriate for the different soils of the country ;

- Co-ordination and supervision of the regional soil and water analysis laboratories in the country.

Other specialised scientific institutions

Since 22 December 1983 the Soil Directorate of the Ministry of Agriculture is the national responsible agency to study and monitor the soil resources in Tunisia. Nevertheless, there are also other research and teaching centres that may initiate and conduct soil-related actions and programmes. They include:

- L'INRAT (Institut National de la Recherche Agronomique de Tunisie).
- L'INRGREF (Institut National de Génie Rural, des Eaux et des Forêts).
- L'IRA (Institut des Régions Arides).

These actions consist in research studies related not only to soils but also to other components of the environment including water, plant, and human activities.

The presence of international institutions like IRD (former ORSTOM) and GTZ in mission in Tunisia contribute to the development of some research projects. They aim at addressing environmental problems such as soil erosion, salinisation, desertification process, and allow, to a large extent, to benefit from the technological transfer and scientific training.

The List of soil analyses made at the central laboratory

Classical physical and chemical analyses

Particle size distribution, pH (water, K Cl), total carbon, total nitrogen, pF (4.2 – 3 – 2.7), Moisture and saturation, Cation exchange capacity, Exchangeable potassium, Exchangeable sodium, -

Exchangeable magnesium, Exchangeable calcium, Total and active $CaCO_3$.

Specific analyses

Total and free iron, C.p.i. (Chlorosing capacity index), B.d. (bulk density), R.d. (real density), Structural installation index, Leaf analysis (nitrogen, Ca, Na, K).

Future analyses (scheduled)

Heavy metals: Cu, Zn, Fe, Mn, Trace elements (for mineral nutrition).

Location of Soil Laboratories in Tunisia

Tunis, Ariana, Bizerta, Beni Khalled (Nabeul), Jendouba, le Kef, Kairouan, Kasserine, Sidi Bouzid, Monastir, Mahdia et Gabès.

Suggestions

The medium and long-term objectives of the Soil Directorate include the investigation and assessment of the state of soil resources in Tunisia through:

- Sustainable soil development and management in the context of the Mediterranean and pre-Sahara regions;
- Surveying soils and soil ecosystems in different agro-ecological environments;
- Investigating soil distribution within the different landscapes;
- Assess the impact of human-induced activities on soils and environment in both dry and irrigated farming.
- Use of Geographic Information Systems (GIS) for database creation and for making environmental impact assessments;
- Active participation in the Euro-Mediterranean Network of Soil Information.

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- Carte bioclimatique de la Tunisie - Ech. 1:1,000,000.

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Soils of the Syrian Arab Republic

Mohammad Ilaiwi[1]

Status of soil surveys in the country

Soil mapping at the national level

At this level one could mention three major soil survey projects covering the total area of the country:

1. General soil map of Syria, prepared by FAO: The map was produced in 1965 at a scale of 1:500,000. The report of the map includes 151 pages (Van Liere, 1995)

2. Soil map of Syria at a scale of 1:500,000 prepared as a technical assistance project of USAID to Syria. The project was terminated in 1982 (Yuksel, 1982). The legend of the soil map was built up with association of subgroups of the U.S.D.A. Soil Taxonomy (1975).

   The soils of Syria were grouped in 999 associations. The report of the map is entitled "Land Classification/Soil Survey Project of the Syrian Arab Republic" comprising 567 pages (Yuksel, 1982). For each soil association on the legend, the report includes the following information:

   - General characteristics;
   - Location and extent;
   - Geomorphology;
   - Climate;
   - Geology;
   - General land use;

[1] Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), Damascus, Syria.

- Soils;
- Surface stoniness; and
- Crop recommendations.

The report also includes interpretation of limitation and potential for each soil association. The work was based on investigating 93 soil profiles and about 600 soil observations, which were performed by the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD).

3. Soil map of Syria, prepared by ACSAD at a scale of 1:1,000,000 in 1983.

   The legend of the soil map includes 55 groups of soil associations at the subgroup level (USDA, Soil Taxonomy, 1975) with some modifications, especially in the associations of the gypsiferous soils. In addition to soil associations, the legend includes information on slope and texture of the surface layer (0-30 cm).

The description of each group include (Ilaiwi, 1983):

- Location, landscape and parent material;
- Rainfall;
- Land Use;
- Composition and soil occurrence; and
- Range in soil characteristics.

The work was based on a systematic soil survey covering the whole country. About 700 soil profiles were described, of which about 100 profiles were analysed. Mineralogical and micromorphological investigations were carried out for a large number of samples.

The map legend was recently converted according to the 2nd edition of USDA, Soil Taxonomy, 1999. In this map as well as the U.S.AID map, the mapping units were delineated on satellite data of the same map scale.

Information from both maps, as well as additional data from local soil surveys, was used to prepare the "Soil and Terrain Digital Database-SOTER). About 190 profile descriptions and analyses were used to represent soils of the 90 SOTER units of Syria. In addition to SOTER map, both USAID and ACSAD map are also digitised.

Soil mapping at the local level

Soil mapping at this level has been done either by foreigner consulting companies or by the staff of the Ministry of Agriculture and Agrarian Reform. In the first example the surveys usually covered areas chosen for agricultural development (mainly irrigation projects) with mapping scales of 1:25,000 or larger. Irrigation and drainage designs are usually included in such surveys.

Most of these studies were carried out within the Euphrates irrigation projects and to a lesser extent to the Khabour and the Al-Ghab irrigation projects. Classification systems used are dependent on the nationality of executing agencies. Examples of these studies are listed in Table 1

Soil surveys carried out by the staff of Soil Directorate within the Ministry of Agriculture cover about 40% of the country. Examples are given in Table 2. Since the beginning of the eighties, work was started in surveying areas with the highest agricultural potential.

A local methodology was followed to describe soil profiles according to the following items: Depth, Colour, Texture, Structure, Roots, Consistency, Oxides and stains, Permeability, Drainage, Cemented layers or rocks, Carbonates and Moisture.

Laboratory analyses performed in the country include the following:

ECe, pH Calcium Carbonate, Organic Matter, Gypsum, CEC, Exchangeable K, Available Phosphorous, Mechanical analyses and soluble salts.

The mapping scale was 1: 25,000. In general, where topographic maps at the same scale are not available, the mapping scale becomes 1:50,000. About 20,000 profiles were described and analysed.

Land capability of soil mapping units was evaluated according to the USDA handbook no: 210.

Major soil constraints for agricultural production and for sustainable use of land resources

Soil constrains for agricultural production in Syria could be listed as follows:

1. Shallow soil depth over bedrock: These soils are usually found in mountainous areas and commonly associated with steep slopes. Removal of the natural forest cover, in historical as well as in recent times is believed to be the main reason for soil shallowness. Rock outcrops are found in summits, and upper parts of slopes followed by Lithosols (Lithic Torri/Xerorthents).

2. Presence of cemented crust very close to the soil surface: These are the petrocalcic and petrogypsic horizons. Petrocalcic horizons prevail in three mapping units in Syria. They are mostly related to mountainous fronts and colluvial fans. Their climate is typically transitional between the arid and Mediterranean climates, with rainfall ranging from 200÷350 mm.

Table 1. Examples of soil surveys carried out by foreign consulting companies

Area	Implementing party	Submission date	Scale	Total area (ha)	Remarks
Left bank of southern Khabour and Euphrates	Techno-prom export	1963	1:25,000	38,000	Pedology, geology, hydrology, irrigation & sewage net design
Euphrate basin	Nidico	1963	1:100,000	1,759,000	Pedology, geology, hydrology
Low Euphrates	Ghisarsit	1976	1:50,000 – 1:25,000	164,800	Pedology, geology, hydrology, topography
Low Euphrates, area one	Ghisarsit	1978	1:25,000	65,450	Irrigation & sewage net design
Low Euphrates, area 1&2	Ghisarsit	1981	1:25,000	78,500	Pedology, geology, hydrology, irrigation & sewage net design, topography
Middle Euphrates	Roma ghrimex	1978	1:25,000 – 1:5,000	30,817	Pedology, geology, hydrology, irrigation & sewage net design, topography
Baliekh basin	Aleksander jeep	1966 – 1967	1:25,000	502,000	Pedology, geology, hydrology, irrigation & sewage net design, topography
Baliekh basin, sections:3,4,5,6	Soghria	1974	1:25,000	163,460	Pedology, geology, hydrology, irrigation & sewage net design, pilot project topography
Baliekh basin, sections:3,4,5,6	Roma ghrimex	1980	-	71,590	Pedology, geology, hydrology, irrigation & sewage net design, topography
Baliekh basin, sections:1,2	Techno Export strowy	1975	1:25,000	50,000	Pedology, geology, hydrology, irrigation & sewage net design, topography
Baliekh basin, Pilot Project	Aleksander jeep	1967	1:25,000	24,500	Pedology, geology, hydrology, irrigation & sewage net design, topography
Baliekh basin	General establishment for investment, Alexander jeep company	1966-1967	1:20,000	9,500	Maps are annexed
Al-Rassafa basin	Techno Export strowy	1974	1:25,000	62,000	Pedology, geology, hydrology, irrigation & sewage net design, topography
Mskanah Sharek	Nipon Koy	1977	1:25,000	56,000	Pedology, geology, hydrology,

					irrigation & sewage net design, topography
Typical Farm	Solkhoz brom Export	1974	1:25,000	4,049	Pedology, geology, hydrology, irrigation & sewage net design, topography
Maskanah Ghareb Project	Solkhoz brom Export	1975	1:25,000	24,343	Pedology, geology, hydrology, irrigation & sewage net design, topography
Maskanah Ghareb Project	Solkhoz brom Export	1977	1:100,000 - 1:25,000	174,500	Pedology, geology, hydrology, irrigation & sewage net design, topography
Aleppo plateau	Solkhoz brom Export	1980	1:100,000	385,196	Pedology, geology, hydrology, irrigation & sewage net design, topography

Table 2. Examples of local soil surveys carried out by the soil directorate of the Syrian Ministry of Agriculture

Area	**Implementing party**	**Submission date**	**Scale**	**Total area (ha)**	**Remarks**
Al Ghab	Soil Directorate, FAO	1973	1:50,000		Map annex
Taar Al-ulla Alasharina	Soil Directorate	1975	1:20,000	54,027	Soil annex (lab analyses results, soil groups diagram, soil grades diagram
Al-sen river	Soil Directorate	1974	1:20,000		Maps are annexed (pH and $CaCO_3$ data are in soil groups)
Jablah	Soil Directorate	1974	1:20,000	35	Maps are annexed
Al-Faid valley (Raqqa)	Soil Directorte, Dr. M. Shaliha	1973		4,000	
Daraa and Sowaidaa	Soil Drectorate, Soil	1980	1:25,000		Maps are annexed

	classfication and Pedological Research Section				
Al-Assi basin	Soil Directorate, Soil classification and Pedological Research Section	1980	1:25,000	60,000	Annex (lab analyses results, soil groups diagram L2L, geological diagram of the area)
Lower Euphrates, two banks	Ministry of Agriculture and Agrarian Reform	1974	1:25,000	164,000	Pedology, geology, hydrology, irrigation, & sewage net design, topography
Pilot project	Soil Directorate	1974-1978	1:5,000 - 1:25,000	24,000	Pedology
South of Rassafah	Soil Directorate	1978	1:25,000 - 100,000	20,000	Pedology
Babiri area	Soil Directorate	1976	1:25,000	5,000	Pedology
Al-Bosaira-Saadoni	Soil Directorate	1979	1:25,000	7,000	Pedology, geology, hydrology, irrigation, & sewage net design, topography
Ishbilia farm & cow station	Soil Directorate	1974	1:5,000	1,000	Pedology

3. High concentrations of gypsum and calcium carbonates: The Calcids and Gypsids are almost equally represented in the Aridisols of Syria. Together they cover about 40% of the country. The Gypsids (Gypsisols) are mainly characterised by horizons with a very high amount of gypsum, ranging between 70 and 90% and in extreme cases the percentage may reach as high as 95%. Practically such horizons form a depth-limiting layer especially when the crust caps them. Hy-

per calcic horizon is usually found in association with soils having petrocalcic horizons.

4. Both hyper calcic and petrocalcic horizons are mostly found in the Mediterranean climate, forming a white layer occurring at various depths below the red normal soils. Surface crust is usually found on the top of the lime layer.

5. To represent these particular soils, the concept of hypergypsic and hypercalcic horizons were proposed to the "World Reference Base for Soil Resources" (WRB) and already are included in the system. Another proposal was also made for their inclusion to the US Soil Taxonomy.

6. High concentrations of soluble salts: Soils with high salinity are usually found in some natural depressions that have a shallow saline ground water level. These types of soils have a limited extension in Syria.

7. Low organic matter content: This is common property for soils with arid and Mediterranean type of climate where the organic matter content seldom exceed 1%.

8. Surface crust formation: This process occurs locally in soils with high silt content and in volcanic ash soils near Raqqa.

Major environmental problems related to soils

The main agricultural practices in Syria and their environmental consequences will be discussed in the following section. Special emphasis will be given to land degradation processes in relation to the major agricultural land use types.

Major soil degradation processes in Syria are salinisation in irrigated areas, water erosion in mountain regions and wind erosion in the steppe area. These processes are discussed below.

Salinisation

In 1997 the irrigated agriculture has been practised in about 1,167,000 ha. This area forms only 6% of the total surface of the country and about 21% of the total cultivable lands. However, it plays an important role as a major key factor for agricultural development in Syria. While all summer crops, such as cotton, are produced under irrigation, production of irrigated winter crops is much higher compared to them of rainfed agriculture. Salinisation is the major land degradation process in the irrigated agriculture. Evaluation of the salinity status however, is not always the case, since this requires systematic soil surveys and sampling.

Surface water irrigation**:** The Euphrates river is the biggest source of irrigation water in Syria. Following are two examples showing the salinity status in areas irrigated by the Euphrates river water.

The Euphrates valley (lower terrace)**:** The fertile alluvial soils (Fluvents) are the prevailing soils in the valley. The Euphrates valley is the largest irrigated area in Syria. Some of the earliest human agricultural activities were started in this valley. As early as 6,000 BC, the region was inhabited by grain farmers. Irrigation became extensive between 4,000 and 3,000 BC. Evidences of historical salinisation are almost absent within the Syrian part of the valley.

Recent soil salinisation processes in the valley have started as early as the late 1940s, when large scale irrigated agriculture became possible by using diesel irrigation pumps. The process has remarkably accelerated at the beginning of the 1950s when cotton was introduced into the area as a summer cash crop. Misuse of irrigation water accompanied with the absence of any kind of drainage systems and improper management led to the upraise of the ground water level and consequently salt accumulation within the root layers by evapotranspiration.

In the middle of the 1960s, a quite large area became out of agricultural use due to extreme salinisation. The first semi-detailed soil survey for 123,000 ha of the lower Euphrates valley carried out in the late 1970s, proved that the electrical conductivity of the soil saturated paste extract was over 8 dS/m for 50% and over 16 dS/m in about 30% of the area (Abd Al-Karem *et. al*. 1984).

The Euphrates valley (higher terraces): Near Raqqa about 10,000 ha mainly located within the second Euphrates terrace were brought under irrigation in 1970. The land was prepared for a modern irrigation project therefore, a soil survey has been carried out in the year 1980. Severe salinisation with more than 16 dS/m of the soil paste extract took place in about 24% of the project area (Abd Al-Karem et al., 1984), as a result of insufficient and improper drainage system.

The salinisation processes have been remarkably accelerated due to the introduction of rice cultivation for the first time in the area. It has been estimated that in Syria about 3,000 to 5,000 ha of the irrigated lands became unsuitable for agricultural use every year, due to extreme salinisation (THF, 1994).

Ground water irrigation: In 1997 about 701,634 ha have been irrigated by ground water. This area represents 60% of the total irrigated land in Syria and it has been gradually increasing from 30 % during 1970 to 44 % in 1980 and 49 % in 1990. However drastic increase of 10 % took place in only two years (Soumi 1993).

Considering that, the total renewable ground water in Syria represents only less than 7% of the total available water resources one may notice the irrational and unbalanced policy of using water resources in the country.

According to the FAO guidelines (Ayeres and Westcot 1985) on water quality for irrigation severe restrictions for irrigation are indicated when the electrical conductivity of the water exceeds 3 dS/m.

To check on the quality of irrigation water, samples from three wells north of Deir el-zor within the steppe area have been analysed (Al-Beshi, 1995). The ECe values were ranging between 7 and 10dS/m.

Furthermore the guidelines also indicate limits for specific ion toxicity. In the analysed samples, sodium and chloride are found to be the dominant cations and anions respectively. A severe restriction degree is given in the guidelines, when the concentration exceeds 9 meq/l for sodium and 10 meq/l for chloride.

These concentrations where ranging in the Syrian samples between 35-45 meq/l for sodium and 37-52 meq/l for chloride. It is obvious that when both the total soluble salt concentration and the composition of these salts are considered, the analysed samples and similar waters are not suitable for irrigation.

Water erosion

Mountainous regions under humid Mediterranean climate are, probably the most accessible regions to water erosion due to its natural conditions, such as steep and long slopes, shallow soil cover, high rainfall average (800-1,500mm) and frequent rain storms. Rather dense forests cover much of the area. Forest fires, intentional or not, are the worse human intervention in the area. About 8,000 ha have been subjected to fire during the period 1985-1993.

Another human activity leading to water erosion is farming. About 2,440 ha of the natural forest has been converted to agricultural lands during the period 1985-1992 (MAAR-SAR, 1994).

It is obvious that in this region, the removal of the vegetative cover by any means will lead to tragic consequences as far as soil degradation is concerned.

Recent investigations within the Lattaquia province have shown that, the maximum annual soil loss under natural forest conditions ranges between 10 to 60 kg/ha per year, and from 200 to 2,550 kg/ha per year, while under burned forest converted to agriculture land the values reaching 960 to 3,280 kg/ha per year (Kebebo and Jaloul, 1993).

Wind Erosion

About 50% of the soils in Syria are Aridisols. These soils are characterised by an aridic soil moisture regime. By definition, without irrigation Aridisols are not suitable to grow small grain crops (e.g. wheat and barley) in most years. Under the prevailing climatic conditions in Syria, Aridisols occur when the annual average of the rainfall drops below 250 mm.

Water requirement for barley as the major rainfed crop in the steppe area has been computed under the conditions of the Syrian steppe. A minimum of 250 mm is needed to grow barley.

In the middle of 1980's rainfed agriculture has been seriously expanded in the country to include large areas within the steppe, where Aridisols prevail. Agricultural statistics indicate that rainfed agriculture in the Syrian steppe has been increased from 36,000 ha in 1982 to 218,000 ha in 1985 and reaching 552,000 ha in 1990.

At Deir El-Zor City, which is located within the steppe the annual average of the rainfall is about 160 mm. The climate data for 20 consecutive years show that in 2/3 of the years the actual annual rainfall was below the average, and in some years it was even below 1/3 of the average.

As a result of the expansion of the rainfed agriculture in the Syrian steppe, severe environmental consequences have been observed. These consequences are mainly related to the nature of the soils.

The soils of the steppe are mainly characterised by weak structural stability and light texture. Based on the percentage of the soil aggregates larger than 1 mm in the surface layer, it has been estimated that more than 50% of the soils of Syria are extremely accessible to erosion. A map of soil susceptibility to wind erosion has been prepared for the major part of the steppe area (MAAR-SAR, 1985). It shows that most of the area is also extremely accessible to wind erosion.

The natural vegetation cover has probably the major role in protecting the soil over the years. When rainfed agriculture was expanded in the steppe, the shrubby cover has firstly been eliminated leaving the soil particles to the action of the wind. The maximum wind speed at Der el-Zor ranges from 16 to 27 m/sec. during the year. Assuming that a minimum wind speed required to transport soil particles is 5 m/sec, it may be a considerable soil movement by wind throughout the year when the dry soil particles are subjected to the wind action.

Dust, dust storms, sand accumulation on roads, railroads, formation of sand sheets, sand hummocks and sand dunes are the main environmental consequences resulting from the introduction and expansion of rainfed agriculture in the Syrian steppe. Dust frequency and intensity have been remarkably increased during the last few years in the eastern part of the country. It is worth mentioning that rainfed agriculture was prohibited in the steppe land since 1995.

The human-induced soil degradation map of Syria has been prepared following the GLASOD guidelines and the Explanatory Note of the world map of human - induced soil degradation (Ilaiwi*, et al.* 1992).

To prepare the present soil degradation map and due to scale limitation, the 201 mapping units of the soil map of Syria, where grouped into 68 physiographic units. The units are characterised by a great degree of homogeneity of topography, geology soil, climate, vegetation and land use. All elements of the human-induced soil degradation status were evaluated for each mapping unit. The legend of the map has been prepared following the procedures of the world GLASOD map.

For each mapping unit the following elements have been indicated:

- Degradation type;
- Degradation severity;
- Affected percentage;
- Causative factors;
- Recent and past rate.

These elements are clearly shown on the map legend and the mapping units.

Results

Table 3 summarises the results of the evaluation of the human-induced soil degradation in Syria. It shows that soils affected by different degrees cover about 18% of the total area of the country. Wind erosion is the most serious degradation type. If the steppe area alone is considered, about 25% of the total area is affected by wind erosion.

Salinisation has lesser extension, however when the irrigated area is considered we could conclude that about 45% of this area is affected by different degrees of soil salinisation. Water erosion degrades about 6 % of the country.

Table 3. Relative extend of human-induced soil degradation in Syria (x 1,000 ha.)

Type	**Degree**		
	Slight	***Moderate***	***Se-vere***
Water erosion -Loss of top soil	902	127	29
`Wind erosion -Loss of topsoil	1,210	380	30
-Over blowing	11	267	130
Salinisation	15	20	90
Total	**2,138**	**794**	**297**

Specialised scientific institutions or research centres on soils

Specialised centres on soil studies and research in Syria can be listed as follows:

♦ Soil Directorate

It is one of the main directorates of the Ministry of Agriculture and Agrarian Reform. The directorate was established in 1970. The headquarters are located in Damascus, while several field offices are established in the Syrian provinces. It consists of different technical sections such as, laboratories, soil survey, soil fertility, environment, land use and GIS. It carries out also studies and research in relation to soil and land, and also participates in most projects for soil mapping in the country. Other areas of expertise are field experiments aiming at conserving land productivity and increasing production through an efficient extension service.

♦ General Organisation of Remote Sensing (GORS)

GORS is a governmental institution linked to the office of the Prime Minister, which main goal is to apply remote sensing techniques for monitoring natural resources. It was established in 1986, and it consists of four main technical directorates, which are: data processing applications, projects fulfilling, photography and photogrametry, and field studies.

GORS conducts and takes parts in soil studies and research projects in co-operation with the related national institutions. In co-operation with the Agriculture Faculty of Damascus University it has carried out studies, such as soil and forests study in the coastal area.

Other projects include preliminary study of soil water erosion in co-operation with Agriculture Faculty of Techreen University, land degradation monitoring in north east Syria in co-operation with the International Centre for Agricultural Research in the Dry Areas (ICARDA) and land use mapping of west Syria. All the GORS soil studies and mapping are fulfilled using different remotely sensed data and satellites images.

♦ Agriculture faculties

There are five agriculture faculties in the Syrian Universities:

- Damascus University in South Syria;
- Aleppo University in Aleppo (2 faculties, one in Aleppo city in the north and the other in Deir Ezzor in the Eastern part of Syria);
- Techreen University in West Syria; and
- Baath University in central Syria.

All the faculties teach soil science and related subjects, such as soil chemistry, soil physics, soil formation and genesis, soil conservation, land reclamation, soil survey and classification, soil mapping, soil fertility and plant nutrition. The main awarded degree is B.Sc.; however, post-graduate degrees (M.Sc. Ph.D.) are awarded as well for scientific research related to soil and land resources.

Soil maps available in the country

At the Soil Directorate of the Ministry of Agriculture are available the following maps:

1. Semi detailed soil survey for Syria according to the US Soil Taxonomy at scale of 1:500,000;
2. Soil survey for first, second and third level stabilisation zones at scale of 1:50,000;
3. Soil survey for irrigated areas in the steppe;

4. Land use maps of extension centres, at scale of 1:25,000; a total of 640 maps are available;
5. Soil survey and classification of Euphrates basin;
6. Soil information system database of Syria at scale of 1:500,000 (SOTER).

Map projections used in the country

The only two map projections used in Syria are:

- UTM zone 37.
- Lambert Conformal Conic/Spheroid Clarke 1880.

Conversion of national soil legends into the international systems

Due to non-uniformity it is difficult to provide a clear and sharp opinion. However it seems that in most cases, using profile descriptions and laboratory analyses, one could classify soils according to the FAO legend (1988) or at the subgroup level of USDA, Soil Taxonomy.

Laboratory methods used for soil analysis

Soil physical and chemical routine analysis are described below:

❑ Particle size analysis

The methods usually used are either hydrometer or pipette; the latter is preferable because of accuracy.

❑ pH

pH or soil reaction, is determined on soil water suspension 1:2.5 and KCl 1N 1:2.5. The more common one is the determination on saturated paste, but it is more difficult to conduct.

- Organic matter

The common method is the oxidation of organic carbon by potassium dichromate and titration by iron sulphate.

- Cation exchange capacity and exchangeable cations

These two analyses are carried out by using CH_3 COO NH_4 1N. The exchangeable cations are determined either by A.A.S or by titration for Ca and Mg, and flame photometer for K and Na.

- $CaCO_3$

Is determined usually by calcimeter or back titration, both methods are good, but the former one is faster.

- Gypsum

There are many methods or (extraction solutions), however, the most commonly used and preferable is the acetone one.

- Water extractable ions

The most common ions analysed are K, Na, Ca, Mg, SO_4, CL, HCO_3, CO_3, and NO_3. These ions are determined on water extract. K, Na, Ca, Mg are determined by A.A.S. or flame photometer for the first two elements, SO_4, by turbidity, Cl, HCO_3 by titration.

- Bulk density by wax method

- Real density by pichnometer

- Electrical conductivity

Using the conductivity meter on soil water extract. The soil water ratio depends on the expected content of salt.

Presence of international institutions doing soil studies

In Syria, there are two main international institutions working on regional levels in the field of soil studies and other related activities. They are ACSAD and ICARDA:

♦ ACSAD

The Arab Centre for the Studies of Arid Zones and Dry Lands was established in 1971 within the framework of the League of Arab States. Its headquarters are based in Damascus, Syria. ACSAD conducts research and studies in the Arab arid and semi arid environments.

ACSAD carried out several activities within the framework of soil studies and other related works such as:

- Preparation of soil maps of some Arab states;
- Preparation of desertification control action plans for some Arab states;
- Participation in the preparation of human-induced soil degradation map of the world;
- Participation in the preparation of the World Atlas of Desertification, which was published by UNEP in 1992; and
- Monitoring and combating desertification through the use of remote sensing and GIS in Al-Bishri mountain (Syrian steppe).

ACSAD has its own soil laboratory and training facilities such as:

- Remote sensing and GIS laboratory;
- Training centre for degraded land rehabilitation; and
- Experimental station for reclaiming salt affected soils.

All soil studies and other related works in ACSAD are carried out by the Soil Studies Section and Desertification project.

♦ ICARDA

The activities of the International Centre for Agriculture Research in Dry Areas (ICARDA), cover a wide range of countries of the Middle East and North Africa. Most of ICARDA's soil activities are conducted under the umbrella of the natural resources management projects, where several related activities are taking place in the field of soil conservation, rangeland management and land resources monitoring. There exist also a close co-operation between ICARDA and ACSAD in the West Asian joint programme for strategic studies, which include research and training to combat desertification.

The other related international institution in Syria are FAO and UNDP, which work in co-operation with the concerned national institutions to strengthen the national capability building in the field of soil studies and other related donor projects.

Suggestions for improving the actual soil information system

- A soil information database is available for Syria at the scale of 1:500,000. We recommend making use of this information and that of about 20,000 soil profiles, studied in the past soil surveys. However, this valuable information needs to be computerised and attributed to the Geographic Information System (GIS) in order to prepare layer scale maps (attribute maps) to be used for agricultural planning and land management;

- Staff training on soil survey and soil classification;

- Staff training on building and updating soil databases;

- Supporting Soil Directorate with related advanced software.

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The Soils of Palestine (The West Bank and Gaza Strip) Current Status and Future Perspectives

Basim Dudeen[1]

Introduction

The Palestinian National Authority (PNA) plans to take care of the natural resources of the country in order to reach to an acceptable level regarding their sustainable use and development. Among many initiatives, which are endorsed by PNA is also the establishment of Palestinian Soil Office. This Office will be placed within the Arab Studies Society, Land Research Centre. This endorsement is extended to the full functioning of the Palestinian Soil Office as a technical reference for soil information and its relevant issues.

This Office started its activities through the implementation of an EU co-funded project entitled:" Inventory of the Soil Resources in the West Bank and Gaza Strip-Palestine". This project is aiming at creating an operational structure that will be able to provide a national framework for conducting soil surveys in Palestine. The project is realised with the help of an Italian expertise in this field represented by the TIMESIS- Organisation and Consortium of Information Systems-Turin. The project is about to be finished in February 2000.

The information presented in this paper is prepared by the Palestinian Soil Office in co-operation with the Palestinian Ministry of Agriculture, Department of Natural Resources. The content of this paper is directed toward satisfying the goals and require-

[1] Arab Studies Society, Land Research Centre, Soil Office, Palestine.

ments of this Conference and to provide some basic information about the situation in this prospected new-born country. Further soil information and data, could be found by contact in the Palestinian Soil Office in Bethany, Jerusalem.

The area of interest

The West Bank and the Gaza Strip are located on the coast of Mediterranean Sea between 29° and 33° North Latitude and between 35° and 39° E Longitude. The West Bank and Gaza Strip (Palestine) are two geographically separated areas, but they are geo-politically an integrated unit. The two territories borders Israel from almost all directions except for the West Bank, which borders Jordan on the east and Gaza Strip borders the Mediterranean Sea on the west. The total land area of Palestine is about 6,245 km^2 (365 km^2 in Gaza Strip), of which, 1,660 $km^2$are under cultivation.

Climate

Palestine belongs to the sub-tropical zone. On the coast (Gaza Strip) and on the highlands (West Bank), the climate is of Mediterranean type with a long hot and dry summer, and 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 south of the West Bank, in the area of Jerusalem Desert and Jordan Valley, prevail arid conditions.

Other classifications for the climate of Palestine were prepared 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 included in here also the 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 subhumid (including the western heights and the semicoastal area).

Population

According to the Palestinian Central Office of Statistics 1997 survey, the population of the country is approximately 2,890 millions, 1,869 millions in the West Bank and 1,020 millions in the Gaza Strip. The Gross Domestic Product was estimated at around 4,173 million dollars, and the income per capita is estimated at 1,200 $ per person.

Land Use and Land Cover

The following represents the percentage of form of land use in the West Bank and Gaza Strip:

Palestinian built up areas (3.67), Israeli colonies (1.34), closed military areas (20.23), Military bases (0.28), left as 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, industrialised zones, etc) cover about 10.43 percent.

The Land Research Centre, 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.

In the context of the land system study for the Gaza Strip, the following is estimation 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 Centre, 2000).

Agroecological zones

Land and water are the two major natural resources that determine the feasibility of agriculture and patterns of agricultural production. In the Palestinian Territories, both they are limited therefore their proper use and efficient management must be accepted as the cornerstone for the development of Palestinian agriculture.

Palestinian lands cover an area of about 6,245 million dunums (one tenth of the hectare) of which the West Bank covers 5,880 million dunums (94.2%) and Gaza Strip 0,365 million dunums (5.8%). Only about one third of the total area, or 1,980 million dunums, is considered cultivable, from which, 1,793 million dunums (90.6%) are in the West Bank and a mere of 0,187 dunums (9.4%) are in the Gaza Strip.

Five agro-ecological zones determined by location, rainfall and altitude can be distinguished in the Palestinian Territories. They include Central Highlands, Semi Coastal Region, Eastern Slopes, Jordan Valley, Sub-total West Bank, and the Coastal Zone (the Gaza Strip).

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 is about 400 mm. Out of the total cultivated area, 95% is rainfed 60% under olives, grapes, almonds, and fruit trees, and 35% under field crops, mainly winter cereals and grain legumes. The remaining 5% of the cultivated land is irrigated and used mainly for vegetables.

The Semi-coastal zone

This is a narrow strip comprising parts of the Jenin and Tulkarem 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 zone transitional between the Central Highland 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. 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 River Jordan. 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 hot. Soils are sandy and calcareous.

This zone is the most important irrigated area in the West Bank. Hot summers and warm winters characterise 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. However, without access to water this region would be a desert.

The Coastal zone (Gaza Strip)

This zone is located along the eastern coastal plain of the Mediterranean Sea. Sinai desert to its south and west determines its semi-arid Mediterranean climate of long, hot summers and mild winters with fluctuating rainfall. Rainfall is relatively moderate in the north reaching 300 mm or more, but 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 Centre, 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 (Dudeen *et al*, 2000).

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 comprise one of the lowest depressions of the earth has been formed as a result of an "earth fissure", and is for the most part of it 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 include also the occupied Palestinian territories.

Literature review on the soils of Palestine

Soil surveying and mapping

Palestine 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, when 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 Organisation. He surveyed almost 4.9 million dunums of the lowlands 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 occurring in Palestine, and 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.

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, (sandstone 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 existing in the West Bank and Gaza Strip. These regions were classified according to the rain factor.

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 type 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 colour. 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 agroecological 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 aluminium, 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 generalised 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 subgroups of three sub-geographic zones. Within each zone, mainly the petrographical 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 microclimatic 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 southwestern 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 properties 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 defined 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 profiles 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. There is very little local literature regarding the soils of the West Bank and Gaza strip. Currently, the Palestinian Soil Office is implementing soil surveys in different sites in the West Bank and Gaza Strip. This is the first time that Palestinians are doing such a work themselves.

The main topics being realised are the pedological characterisation 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 topics of interest are 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 by pass 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.

The final publications will be disseminated in February 2000.

Soil classification systems and their nomenclature

Comparing the different soil maps prepared in the past by several authors and the soil classifications they used, it is interesting to notice that there is rather good match between these systems than the differences they have. The most recent soil maps prepared in Palestine, utilised soil associations and correlated them with their equivalents of the USDA Soil Taxonomy and FAO system. The following table provides this correlation.

Table 1. Correlation between soil associations and the international soil classification systems

Soil Association	FAO Class.	USDA Class.	Parent Material	Natural Vegetation	Agricultural Land Use
Terra rossa (area = 235,210 ha)	Luvisols	Xerochrepts, Rhodoxeralfs	Hard limestones, dolomites with other inclusions of chalk and marl	Mediterranean evergreen sclerophyllous (Quercetea calliprini), Park woods(Pistacia lentiscus)	Fruit trees (grapes, olives, plums, apricots.), grazing and afforestration
Brown Rendzinas and Pale Renzinas (area = 145,698 ha)	Lithosols and rendzina	Xerorthents, Haploxerolls	Soft chalk and marl covered partly Nari crust and hard chalk	Semi-steppe vegetation (Ballotetalia undulatae)	Fruit trees, grazing and afforestration
Pale Rendzinas (area= 762 ha)	Lithosols and rendzinas	Xerorthents	Soft chalk and marl	Spontaneous woods (pinus halepensis)	Non-irrigated orchards, field crops, grazing
Grumusols (area = 28,760)	Vertisols	Xererts	Fine textured alluvial or aeolian sediments	Segetal vegetation of Prosopis farcata, Scolymus maculatus	Annual crops (wheat, corn, barely..).
Brown Lithosols and Loessial Arid Brown Soils (area= 48,391 ha)	Lithosols	Torriorthents	Chalk, marl, limestone or conglomerate, loessial dust	Semi-steppe vegetation(Ballotetalia undulatae), steppe vegetation(Artemisietea herbae-albae)	Grazing, annual crops (wheat, barely…)
Solonchaks (area= 6,608 ha)	Solonchak	Salorthids	Recent alluvial deposits	Halophytic vegetation (Tamarix, Suaeda, Nitraria, Juncus..)	Bare area, some plantations where water is available
Loessial	Yer-	Haplar-	Loes-	Segetal com-	Grazing, an-

Serozems (area= 5,265 ha)	me-sols	gids	sial sedi-ment, sandy sedi-ments and gravel, calca-reous loamy sedi-ments	munities of annual plants	nual crops, some orchards
Sandy Regosols and Arid Brown (area= 418 ha)	Rego sols	Xeror-thents, Torrior-thents	Sand depo-sits, loes-sial depo-sits	Association of Artemisia monosperma, Artemisietum herbae-albae arenarium	Irrigated crops (ci-trus, subtro-pical or-chards, grazing
Sand Du-nes	Aren o-sols	Quartzi-psamment sTorrip-sam-ments	Uncon-solida-ted du-ne sands	Ammophiletum arenarium, Stipagrostis scoparia.	Barren, some fruit trees if irrigated
Regosols (21,220 ha)	Rego sols	Xeror-thents, Torrior-thents	Sand, clay, loess, lisan marls	Mosaic of mi-cro-association of dwar-fshrubs and annual crops	Grazing and afforestra-tion

Some of the names used correspond to international usage, others however are new and local and where not always chosen with equal luck and consistency. It is evident that about 10 genetic soil groups have been generally recognised and widely accepted.

Soils and the type of vegetation

Reifenberg established a relationship between soils and citrus in various places. He noticed the problem of salinity in the Jordan Valley and pointed out that the injuries suffered by the vines are due to the salt content of the soil as to the unsatisfactory drainage conditions. It is well established that in the hilly areas, orchards (apples, plums, pears, etc.) require sufficient soil depth for normal growth, which enables them to develop a root system extending to a sufficient depth. In this respect, figs and olives are quite insensible. Olive groves grow well only on calcareous soils, even when these soils are shallow.

The influence of lithology, relief and exposure on the soil and vegetation of the arid region of Eastern Heights was investigated by Zaidenberg (1981). A close relationship was found between vegetation characteristics and the degree of soil leaching. Vegetation diversity and density decrease with the increase of exchangeable sodium percentage (ESP), sodium absorption ratio (SAR) and salinity values expressed as electrical conductivity. The same is true with respect to the lime content of soils on hard rocks. The reason for this relationship is attributed to the soil moisture regimes.

The factor that is decisive in deciding the type of vegetation is climate and to a certain degree the landform elements. In the Jordan Valley and Gaza Strip irrigated crops are prevailing. In the Central Highlands, the prevailing crops are olive groves and other permanent crops in addition to non-irrigated annual crops. In the Semi-coastal region, a blend of irrigated crops and non-irrigated permanent crops are available where citrus plantations are among the irrigated crops.

Map projections used in Palestine

The following are the specifications of the geodetic systems used in Palestine as obtained from the Palestinian Geographic Center (PALGRIC).

Table 2. Specifications of the geodedic systems used in Palestine

	British Military Survey	PALGRIC	Private Surveyor
Projection	Cassinin Soldner	Cassini, civil grid, Palestine Transverse Mercator	Transverse Mercator, user defined
Datum		Deir Mar Elias, south of Jerusalem	
Ellipsoid:	Clarke 1880 (Palestine)	Clarke 1880 (Palestine)	Clarke 1880
A	8 378 300,782	6 378 300,789	6 378 300,789
B		6 356 566,435	
E^2		0.00680348102	
1/h			293.466
Origin			
Latitude	31 44 02.749		31 44 02.749
Longitude	35 12 43.490	35 12 43.490	35 12 43.490
False Co-ordinates			
False easting	170 251,555	170 251,555	170 251,555
False northing	126 867,909	126 867,909	126 867,909
Scale Factor	1.0	1.0	1.0

Palestinian Geographic Centre through the Palestinian Ministry of Transportation could supply further information for the interested entities.

Development of the Palestinian Soil Information System (PSIS).

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 Centre (LRC). The soil information system should be used for the protection of soils against degradation and pollution and should be utilised by the decision-makers at all levels.

The following land unit categories should be considered for soil conservation:

1. Soils present in each land system as suggested by LRC in the land system classification of Palestine. Each land system has approximately homogeneous geology and climate.

2. Soils present in each unit within the land system. The units are classified based on general land use and landform pattern.

3. Soils present in the landform elements in the land units of the land system.

Each of the above categories would involve subcategories as follows:

- 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 categorisation 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. Digitised 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 georeferenced database of the soil and terrain resources in Palestine. This database is called PALSOTER after the Global Soil and Terrain Data-

base SOTER. 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, biological, geomorphological and even soil phenomena.

2. Digitised 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. Pedotransfer 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:

1. Eastern Heights: 30 profiles;
2. Jericho Area: 30 profiles;
3. Hebron Area: 12 profiles;
4. Gaza Strip: 12 profiles.

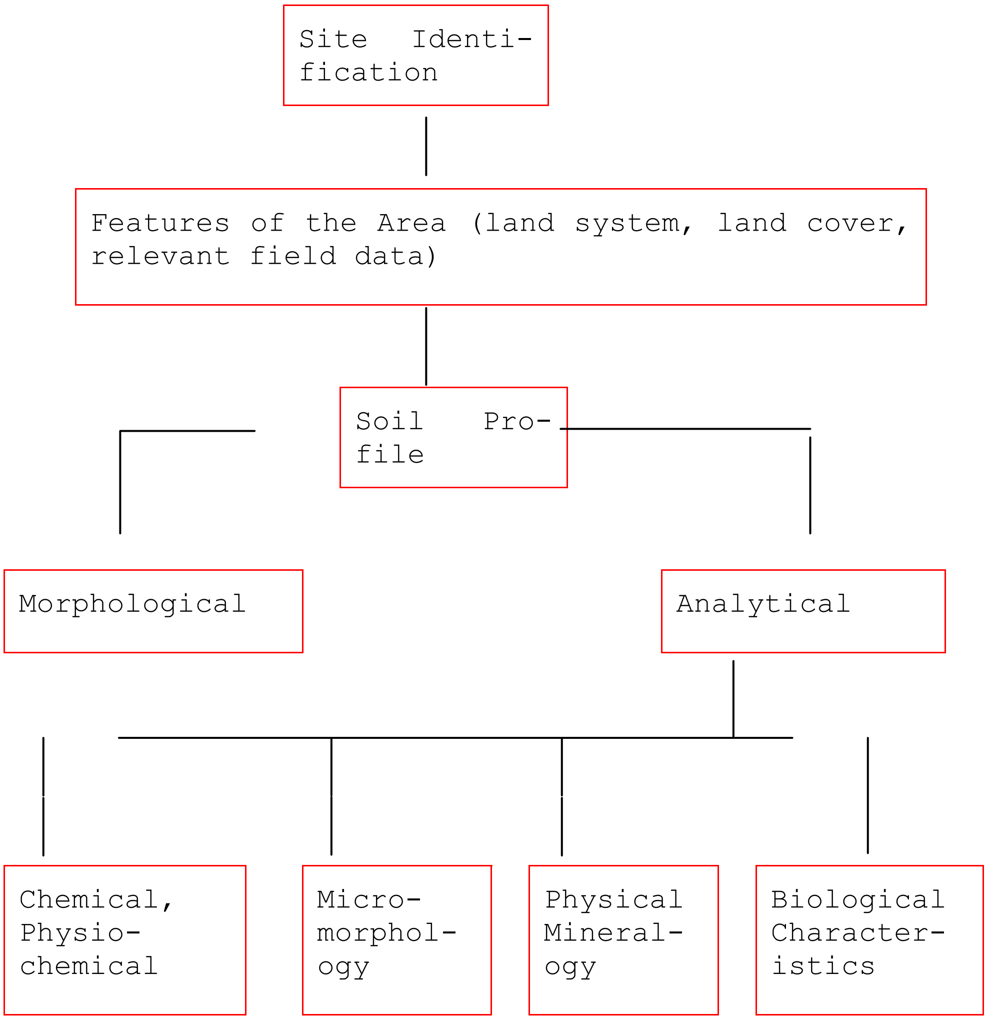
The morphological characteristics of each profile are examined for classification purposes according to the attached field sheet. The boundaries of each mapping unit were drawn on aerial photographs at a scale of 1:10,000 for Jericho and Gaza areas and at a scale of 1:25,000 for Hebron area. The soils 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 guidelines for soil profile description, 1993.

The field data are entered into an MS Access 97-database software. These data were integrated with both remote sensing and GIS structure represented in ArcView. The data acquisition and their organisation were based on the assumption that the data collected will be continuously updated through recent surveys. The data are introduced into the system by a combination of different methods. Both the analytical and topological data are imported into the GIS system. The core of the soil GIS is represented by the profile database represented in the attached sheet.

inserire form 1

inserire form 2

The general structure of this database can be summarised in the following scheme:



The creation of a co-ordinated information system on the state of environment and natural resources is one of the major aims of the PSO. This implied setting up a homogeneous framework for collecting, storage, presentation and interpretation of the environmental data.

The prospected future of Palestinian Soil Information System (PSIS)

The current utilisation and future potential of the Palestinian Soil Information System would be determined and influenced by the following:

- The developments in the political situation. The sovereignty on land is a decisive factor to utilise 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 subsides.

⇨ **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 utilisation, rational fertilisation and profitable land management.

Laboratory methods

For the currently on-going soil survey investigations, laboratory analyses were done at the laboratories of the faculty of Agriculture at Hebron University. Cross checking were done in Israeli

(Hadera) and Italian specialised laboratories. The following analysis were realised: Particle Size Distribution (Texture, Soil Reaction (pH), Electrical Conductivity (EC) mS cm^{-1}, Cation Exchange Capacity (CEC), Exchangeable Cations: Ca, Mg, K, Na, Available Phosphorous, Nitrogen, Organic Carbon, Free Carbonate, Gypsum (in Jordan Valley), Elemental Analysis using ICP.

Standard laboratory analyses were performed as described in the "Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples", Soil Conservation Service, 1972 and Soil Science- methods and applications. Only the laboratory data from standard analyses are entered into the permanent soil survey laboratory database. Standard analyses are documented by method codes that identify the analytical method.

Samples are collected for all horizons of the profile to a depth of 2.0 m or to hard bedrock (lithic contact) if it is at a lesser depth. The results were inserted in the soil database and linked with profile point theme with the GIS. The methods adopted varied depending on the soil type. For example, gypsum is tested for samples taken from Jordan Valley only. For calcareous soils the testing methods in certain cases, like cation exchange capacity are different from those for non-calcareous soils.

The Palestinian Soil Office establishment

Palestinian Soil Office (PSO) was established in 1997 under the auspices of the Land Research Centre (LRC), which is a branch of the Arab Studies Society headed by Mr. Faisel Husaini. 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 supported 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 information 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 utilising 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.

Major soil constraints for agriculture development

The following are some specifications of the kind of constraints and problems encountered in each agroecological zone:

In Jordan Valley, the main soil problem in this area is **soil salinity.** The salinity is increasing with time due to several reasons: the nature of soil parent material and its underlying substratum composed of lacustrine deposits; the climate which motivates large amount of evaporation leaving larger concentrations of salts in the soil.

The irrigation also leads to the creation of more saline soils, in certain cases this lead to the transformation to halomorphic soil type, which is a major setback in the soil quality as what is starting to appear in the Jordan Valley and Gaza Strip. Salinity has a large negative impact on the quantity and quality of vegetation. The increased salinity of irrigation water is also contributing to this problem.

In the Eastern Heights, the soil constrain in this region is **soil erosion.** The lack of vegetation due to the high temperature and low amount of precipitation accelerates the desertification process. This problem is monitored now by some research centres using remote sensing techniques. The Land Research Centre is currently preparing studies for this agroecological zone in particular. Soil pollution from chemical sources is also a constraint for sustainable land use in the area. A lot of dumping sites exists in this zone.

In the Central Highlands, the main soil constraint is **erosion** in uncultivated hills. Terracing the moderately steep hills with considerable amount of soil would be the best possible solution to this problem. Also dumping sites causing soil pollution are another constraint. Pesticides in this region pollute the soils as well.

In the Semi-Coastal region, the same constraints as in the previous zone are prevailing, but with less degree, especially **soil erosion**, due to the large amount of vegetation.

In the Gaza Strip, the main soil constraint is **soil salinity**, which have some different driving forces from those in Jordan Valley. The nature of soil is sometimes imposing a serious restriction for certain type of vegetation.

In general, the most important reason for erosion is the destruction of vegetation. Wars throughout the history of Palestine lead to severe vegetation destruction. **Grazing** and **overgrazing** is also another remarkable reason for this since it leads to the exposure of soils to wind erosion. The change of the type of Palestinian agriculture in addition to the use of vegetation for the manufacture of charcoal and the burning of lime have an adverse effects on the amount of vegetation.

Another important reason for soil erosion is the significant disappearance of terrace culture. Large percentage of mountain slopes in the West Bank is steep and sometimes very steep. On these slopes, the soils are washed away and the rainfall causes deep rills and gullies. In the case of the West Bank and Gaza strip with very limited water resources, it is worth mentioning that we should think of alternative ways to combat desertification utilising the available amount of water.

The increased and cumulative effects of chemical based fertilisers, pesticides, and herbicides on soil are an important land management issue. They require maximum attention.

General recommendations and suggestions

It is postulated 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.

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

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Status of Soil Survey and Soil Information System in Morocco

Mohamed Badraoui and Mohamed Stitou[1]

Introduction

Located in the upper north-western corner of Africa, Morocco is essentially a semi-arid to desertic country (93 % of the total area). It is known as the country of contrasts. Changes in climate, topography, geology, geomorphology, soils, social and economic conditions occur at very short distances.

The total annual water resources of Morocco are evaluated to 150 billions m^3 from which 80 % are evaporated (ANAFID, 1993). From the remaining useful volume of water (30 billions m^3) only 21billions could potentially be mobilised. Up to 1998, 14 Billions m^3 of water were effectively mobilised essentially for irrigation.

The total area which can potentially be irrigated was evaluated to 1.35 millions ha. This area represents 14 % of the total agricultural land of Morocco. One million ha are already irrigated. The rest is cultivated under rain-fed conditions.

The major natural resources inventories, including soils, were performed in the north-western part of the country, which is more suitable for agricultural management. Less effort was devoted to the East and the South regions.

The present report deals with the status of soil survey in Morocco, the major soil constraints with respect to agricultural production, the agro-ecological zones, and the use of Soil and Terrain

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(SOTER) procedures to set a soil database at the scale of 1: 5,000,000.

Status of soil survey

It is well established that soil inventory and mapping at appropriate scale is necessary for any agricultural management. Before the political independence of Morocco in 1956, foreign pedologists performed most of the soil observations and mapping for both scientific purposes and management needs.

The National Office of Irrigation (ONI) did the first real soil surveys for the selection of potentially irrigable land. Large regions, such as Sebou, Oum Er-Rbia, and Moulouya watersheds were first surveyed at the reconnaissance scale (1:500,000 to 1:100,000).

The results of these investigations were used to delineate potential irrigable zones, which should be surveyed later at more detailed scale (1:50,000 to 1:5,000) for intensive cropping under irrigation. The scientific aspects of these studies were presented as regional soil maps at the scale of 1:500 000 in September 1966 during the Mediterranean Congress of pedology.

The direction of agricultural development and the direction of rural equipment continued soil survey. At the same time, the National Institute of Agronomic Research (INRA) of Morocco and The Institute of Agronomy and Veterinary Medicine (IAV Hassan II) of Rabat continued to make reconnaissance soil surveys in different regions where soil data were asked for by land managers. Extensive soil maps were performed for the so-called Integrated Projects of Rural Developments (PIDR).

At present, pedologists of public and semi-public institutions through private companies make soil survey. The following institutions are involved in this process:

- Administration of rural equipment(AGR/DAF/DDGI/DAHA);
- Direction of vegetal production (DPV);

- Administration of forestry and soil conservation (AEFCS);
- INRA;
- IAV Hassan II;
- National school of Meknes;
- Provincial directions of agriculture in non irrigated areas;
- Regional offices of agricultural development in irrigated areas.

The total area covered by soil survey is estimated to 20 Millions ha. It is mostly concentrated in the North and central western part the country, north of the Atlas Mountains. Therefore, at present, only about 28 % of national soil resources are mapped and characterised at different scales. The French soil classification system (CPCS of 1967) is almost the unique legend used. A schematic general soil map of Morocco was prepared at the scale of 1:2,000,000 (MADRPM, 1996).

One can easily recognise that irrigated regions are well characterised and soil maps at detailed scales (> 1:20,000) are available. However, little information is available in the mountainous and desert regions. For agricultural development, soil data are of primary importance at least for two main reasons:

1. Evaluation of soil quality with respect to the management and proposition of appropriate techniques which permit to reduce the limiting factors;

2. Before any agricultural management should be considered Soil maps should be used as a reference base, which can be used to evaluate the impacts of farm management on soil qualities over time. Indicators of soil quality changes are necessary to evaluate the sustainability of the soil system and thus the whole agricultural management.

Considering the importance of soil information for management and the lack of soil data in many regions of Morocco, such as mountainous and arid zones, the use of satellite images (Landsat TM and SPOT) was evaluated in the Settat region. It was concluded that Infra-red satellite data can help making soil survey in arid zones only when the soils are not covered by vegetation (bare soil) and when water content is at the minimum (Merzouk *et al.*, 1989). However, field observations will never be replaced by images.

The major processes, which allow explaining soil distribution in Morocco, are:

- Erosion;
- Calcium carbonate dynamics;
- Vertisolization;
- Iron redistribution;
- Brunification;
- Salinisation;
- Hydromorphy.

The major soil types present in Morocco are presented in table 1.

Table 1. Major soils types encountered in Morocco.

French classification (CPCS, 1967)	Soil Taxonomy	FAO Legend (1989)
Sols minéraux bruts	Entisols	Fluvisols, Regosols, Lithosols
Sols peu évolués d'érosion	Entisols, Aridisols	Regosols, Lithsols, Renkers, Yermosols
Sols peu évolués d'apport	Inceptisols, Mollisols, Aridisols	Fluvisols, Rankers, Greyzems
Sols calcimagnésiques	Inceptisols, Mollisols, Aridisols	Rendzinas, Yermosols, Xerosols
Sols isohumiques	Inceptisols, Mollisols	Xerosols, Kastanozems, Chernozems, Phaeozems
Vertisols	Vertisols	Vertisols
Sols à sesquioxydes de Fer (Fersiallitiques)	Alfisols	Luvisols, Acrisols
Sols brunifiés	Inceptisols, Alfisols	Cambisols, Luvisols
Sols sodiques	Soils with saline phase	Solontchaks, Solonetz
Sols Hydromorphes	Soils with aquic moisture regime	Gleysols, Planosols

Although Soil Taxonomy and FAO classifications are partially known by most pedologists (courses of soil classification), the French soil classification is the only system used for official soil survey in Morocco. Only scientific studies use FAO or Soil Taxonomy conversions for publication requirements.

Major soil constraints affecting sustainable agricultural production and development

Interpretation of soil maps in terms of constraints for irrigation or rain-fed agricultural management is a major concern in all soil survey studies performed in Morocco. The major limitations concern the following aspects:

Soil erosion

Removal of natural vegetation from the slope lands and their conversion for cultivation exposed to soil erosion many extensive areas of the mountains regions and plateaux. This is particularly the case of the Rif Mountain, which is characterised by steep and long slopes, soft geologic material (marl and shale), and severe climatic conditions. Erosion rate in the Rif Mountain is one of the most severe once in the world (30 to 70 t/ha/year, MADRPM, 1991). Also, over grazing and cultivation of vulnerable land in arid and desert region have induced severe wind erosion.

Soil erosion is the most important soil degradation process in Morocco. The total annual soil loss is evaluated to 100 millions tons which correspond to 50 millions m^3 annual reduction in the storage capacity of the dams (MADRPM, 1991). A large effort is being done to limit soil erosion up stream of the dams (National Plan for Watershed Management).

Soil depth

Erosion processes remove the fertile part of the soils and thus reduce the effective depth to be exploited by roots. Calcium carbonate accumulation at shallow depth as caliche or soft deposits limits soil depth and thus the amount of available water to plants. This is a major constraint limiting the agricultural arable land in Morocco. A survey performed in different regions of the country (DVRA, 1987), showed that about 2 millions ha could be reclaimed by sub-soiling and stones removal. Already, 200,000 ha are reclaimed in these land management techniques.

Soil quality changes in irrigated perimeters

Many studies conducted in the irrigated perimeters have shown that irrigation leads generally to soil and water quality deterioration. The major degradations are: secondary salinisation, surface sealing, ground water recharge by drainage water, rising of saline groundwater, reduction of soil drainage, soil compaction, and loss of organic matter.

Most of the post management studies done in the irrigated zones of Morocco demonstrated that many soils, initially non-saline, became saline, after a number of years of irrigation. At present, the surface area of saline soils is estimated to about 350,000 ha (Badraoui, 1998). Most of this area is located in the Tafilalet, Ouarzazate, Bahira, Tessaout Aval, Moulouya, Tadla, Doukkala, and Gharb perimeters.

- The principal causes for secondary salinisation are:
- Drainage systems do not exist or not functioning properly;
- Saline groundwater rising and high evaporation;
- Using irrigation water having high content of salts and/or sodication hazards; and
- Absence of natural outlet for drainage water.

Loss of organic matter is also one of the major consequences of intensive cropping under irrigation. Irrigated soils in Mediterranean regions can be considered as incubators providing optimal conditions (humidity and temperature) for microbial activity and thus a rapid degradation of organic carbon. A mean annual variation rate of organic matter of - 0.09 % per year during the last 10 years was established in Doukkala region (Badraoui, 1998). This decrease of organic matter is attributed to the non-incorporation of crop residues into the soils. Crop residues contribute to about 30 % the total forage consumption in Morocco.

National soil database system

Soil inventory database

Although the importance of soil information was recognised from a long time, the availability of data on soils was always difficult to get and to use. A special effort therefore was made by the Ministry of Agriculture to establish a database for all the soil information available.

For the above objective, a national survey was performed to identify all the soil studies done in Morocco. The results were published in 1993 in a report untitled "Inventory of pedologic studies in Morocco" (MADRPM, 1993). Information is classified by which institution the study was done; including:

- Date;
- Scale;
- Author;
- Nature of the study;
- Region concerned with x and y co-ordinates;
- Area studied in ha;
- Availability of the documents;
- Place to purchase the documents; and
- A reference code;

One can consult either the printed document or the database at the division of cartography. Specifying the co-ordinates, one can obtain the list of studies available in the region of interest and when and where he can get the documents if they are available.

In order to establish a general soil map of Morocco, it was necessary to normalise the legend. An important effort of codification was performed and published (MADRPM, 1992a). Pedologists were invited to use the normalised descriptions, symbols, and interpretation norms. Unified colours were also proposed for the pedologic map and the constraints map. This soil database needs to be updated now to introduce the new studies realised during the last 8 years.

With the development of Geographic Information Systems (GIS) technology, it is necessary to complete the effort already done by introducing the georeferenced soil information.

This effort has started to be implemented at the regional scale. The "Management of Tadla Resources" project (MRT) is one example of the use of GIS technology to monitor soil quality changes under irrigation.

Soil information synthesised as digital soil map at the scale of 1:2,000,000 was used as an important information sheet to establish the agro-ecological map of Morocco (MADRPM, 1992b).

Agro-ecological zoning

In the framework of the land resources conservation orientation plan in rain-fed agricultural zones, an agro-ecological zoning was proposed (ISCRAL, 1994). The project was based on the analysis of soil constraints with respect to intensive agricultural development in non-irrigated areas. Homogeneous ecological zones were defined and delineated by overlying 5 digital sheets of information at 1:2,000,000 scale: the structural map, the satellite image, the bio-climatic map, the soil resources map, and the pastoral ecosystems map. A total of 263 agro-ecological zones were defined automatically. These units were grouped into 44 principal zones. At another scale, these principal zones were grouped again into 7 major categories.

SOTER map of Morocco

In the framework of the soil and geomorphic database establishment program for North Africa, a general Soil and Terrain (SOTER) map at the scale of 1:5,000,000 was realised in 1997(AGR/DAF/IAV Hassan II, 1997). The procedure used is detailed in the «Global and National Soil and Terrain Digital Database procedure Manual» edited by ISRIC (1993).

The map prepared should be considered as an exercise to be familiar with SOTER procedure. It needs more refinement and more data especially for the South and the eastern parts of Morocco, where soil information is scarce. Training of pedologists on SOTER procedure and its application is still necessary to be able to establish a complete database at a more detailed scale.

The Moroccan soil information system needs to be improved by:

- Updating the existent soil database;
- Establishment of new specialised national and regional GIS laboratories to improve the storing capacity and interpretation of soil information;
- Training of pedologists and technicians for soil database establishment and use;
- A national program of soil inventory and mapping is needed to complete soil survey in Morocco and to co-ordinate the activity between specialised scientific institutions, research centers, and the administration.

Map projection used in Morocco

Lambert conic conformal projection is used in Morocco. Four zones are defined in the following table.

Parameters	Zone I	Zone II	Zone III	Zone IV
First Standard parallel	31° 43' 30"	28° 05' 52".80	24° 29' 52".80	20° 53' 52".80
Second Standard parallel	34° 16' 57".60	31° 16' 30"	27° 41' 02".40	24° 09' 02".40
Parallel of origin	33° 18' 00"	29° 42' 00"	26° 06' 00"	22° 30' 00"
X_0	500000m	500000m	1200000m	1500000m
Y_0	300000m	300000m	400000m	400000m

The co-ordinates can be transformed to other projections such as Universe Transverse Mercator (UTM) projection system.

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Soil Information in the Maltese Islands

Sonya Vella[1]

Status of soil surveys in Malta

D.M. Lang is responsible for the only detailed study of the soils of Malta and Gozo (Lang, 1960). The soil survey was carried out from 1956-57 and finalised in 1960 with a soil map of the Maltese Islands published at a scale of 1:31,680 (2 inches to 1 mile). Lang's main objective of the soil survey was to provide basic descriptions of the soils and map their distribution as an aid to agricultural planning. In view of this he mapped differences in chemistry, physics, and biology of the soil, as reflected in soil colour, texture, and structure, in conjunction with the landscape type.

The geological and climatic controls have been very distinctive in the genesis of the soils of Malta and Gozo. However, the existing soils are complex and difficult to categorise owing to centuries of intense human activity. To accommodate for this, Lang used profiles relatively untouched by man. The principal modes of soil disturbance are carting, quarrying, manuring and terracing.

Soil constraints for agricultural production

The soils of Malta and Gozo are rather young or immature soils, due to the fact that pedological processes are slow in calcareous soils. The soils are described as largely artificial, being man-made or altered, and highly calcare-

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ous, so that in the Mediterranean climate the evolution of morphology is slow and the dynamic not clearly defined.

The climate of Malta and Gozo is a good example of the Mediterranean type: hot dry summers, having a high rate of evaporation and no rain warm and showery autumns normally with a rainfall deficit, short cool winters with enough rainfall for agriculture in most years, but leaving insufficient reserve in the soil to combat the warm drying springs again having a rainfall deficit. This uniformly arid climate is the reason for the restricted range of soils found in the Maltese Islands, and for the lack of development of noticeable humus horizons.

The carbonate raw soils and Xerorendzinas, (Kubiena 1953) are immature soils of similar genesis, both having developed from weathering of the Globigerina limestone. These fine textured limestones impede the percolation of rainfall, which accounts for the raw nature and high calcium carbonate levels of these soils. The total organic matter is in general very low.

The most striking feature of the soils is the high content of calcium and magnesium carbonates in the whole profile. Although the high amount of calcium carbonate influences plant growth by effecting uptake of certain nutrients, it prevents the accumulation of sodium in the exchange complex and hence minimises alkalinity hazards as a result of irrigation with highly sodic water. The relatively raw, newly exposed soils developed on the Blue Clay (Fiddien heavy clays) are sometimes markedly alkaline and slightly saline. These soils are either unused or producing only very poor crops because they are very difficult when wet and when dry are hard and rock-like. In some locations, heavy textured soils of the Xerorendzina group are salinised, and out of agricultural use.

The depth of the soil and soil material is very variable. On the ridges, plateaux and plains (erosion surfaces), the soils are very shallow ranging in depth form less than 20 cm to about 60 cm. Deeper soils occur only in isolated pockets. In the erosional and structural valleys, the soils are deeper (150 cm), but patches of shallow soils are very common, especially near the valley edges.

Although the extent of salt-affected soils is not well documented, there is plenty of evidence to suggest that salinity is a soil constraint for agricultural production. The hydrogeological features of the Maltese Islands, the Mediterranean non-leaching climate, and the scarcity of fresh-water resources, constitute predisposing factors for the accumulation of salts and provide the setting for salinity-related phenomena to emerge and develop. Irrigated land is by far the most productive, however, much irrigated land has already become saline, as is the case in the Pwales valley, where due to the seawater intrusion and over-abstraction of the groundwater resources, salt crystals may be observed on the soil surface. Studies by the Department of Agriculture have indicated that the problem of soil salinity is most salient in greenhouse production systems (Camilleri, 1999).

Environmental problems related to soils

The existing national legislation and policies (Box 1) are inadequate to provide a legal framework for the protection and conservation of soils. Provisions to protect soil against activities contributing to soil erosion (e.g. reclamation of watercourses, reclamation of land that is exposed and/or steeply sloping, deforestation and/or clearing of wild vegetation) are absent and need to be added. Current legislation is primarily directed towards regulating activities leading to soil disturbance in large quantities, and does not provide for the preservation of the soil's health, quality and fertility status.

The **Fertile Soil (Preservation) Act**, 1973 and the **Preservation of Fertile Soil Regulations**, 1973 [L/N 104/1973] protect fertile soil by prohibiting:

Unauthorised transport of soil.
Admixture of soil with material in ways which would sterilise it.
Deposition of material on soil, or covering of soil with material.
Building upon soil.
Deposition of fertile soil on land already covered with 1m of soil.
Deposition of soil in heaps or in any manner which would render it unsuitable for immediate cropping.

The **Rubble Walls and Rural Structures (Conservation and Maintenance) Regulations** [LN 160 of 1997] protects rubble walls and non-habitable rural structures in view of their exceptional beauty, their habitat for flora and fauna and their vital importance in the conservation of soil and water. This regulation prevents any person from demolishing or endangering by any means whatsoever, the stability and integrity of any rubble wall, and therefore indirectly controls soil erosion.

The **Motor Vehicles (Offroading) Regulations** [Legal Notice 196 of 1997] indirectly reduce erosion risk, by preventing activities that have an impact on soil structure. No person is allowed to drive any motor vehicle other than in a locality, which is marked as an offroading site.

Specific policies related to the conservation of soil are outlined in the **Structure Plan for the Maltese Islands (1992):**

Policy AHF4: Soil conservation and soil saving measures will continue to be mandatory on all occasions. Soil replenishment measures will be adopted where there are suitable opportunities.
Policy RCO24: Existing regulations concerning excavation and transport of sand and soil will continue.
Policy RCO25: Positive action will be taken to promote the repair of breached retaining walls on valley sides in order to prevent further soil erosion.

Box 1. National Legislation and Policies

Translocation and urbanisation effects

Since the date of issue of the soil map produced by Lang (1960), considerable translocation of topsoil and regolith has occurred, together with occasional mixing of soil with other material. These interventions have generally been associated with:

site clearance for development;

infilling of disused, or partly exhausted, quarries;

'reclamation' of land for agriculture and soft landscaping of development sites;

disposal of excavation debris;

overspill from development sites;

valley engineering projects.

The volume of soil relocated by the private sector is not recorded, and rough estimates derived from measuring the land areas given over to development have high margins of error, due to:

non-uniform soil depth

numerous developments scattered in the countryside (individual areas are difficult to estimate)

numerous small-scale and/or illegal (and therefore undeclared) developments that are not recorded in official documentation (e.g. trapping huts and other rural rooms);

illegal burial, dumping, translocation and/or mounding of soil, as well as illegal admixing of soil with other material.

Access routes

Following increased mechanisation of agricultural activity, numerous roads and tracks for vehicular access to remote rural areas were opened. In relatively recent times, many tracks have been widened and surfaced, some by the Department of Agriculture through an ongoing scheme for the improvement of rural areas, others by Local Councils, and the rest by individual farmers or groups of farmers. Whilst assisting farmers in reaching their land without undue hardship, this practice also has a number of important environmental impacts, including:

An increase in the quantity and velocity of runoff in the case of impermeable surfaces, especially if located on steep valley sides or within a valley bed. The ultimate effects include increased soil erosion and structural damage to rubble walls.

Tracks surfaced with spalls, hardstone dust, poor-quality asphalt/concrete, or other loose material gradually release gravel, which increases the physical erosive capacity of runoff water, thereby promoting soil loss and sedimentation of watercourses.

Soil erosion

Under natural conditions the soils are easily eroded in a climatic regime of a long dry summer and a wet season in which rain frequently falls in heavy showers. The actual field situation in Malta gives rise to most erosion in marginal areas, where the retaining stone walls are in a state of disrepair.

The phenomenon of soil erosion constitutes a major ongoing problem throughout the whole Maltese countryside, especially in valleys. Erosion appears to be on the increase owing to a number of factors, which include the following:

Dereliction and subsequent collapse of soil-retaining random stone walls;

Deliberate/accidental damage to soil-retaining random stone walls as a result of snail-collecting, offroading and motorised scrambling, and infrastructural and/or maintenance interventions such as trenching, dredging, and cleaning/'weeding' of country roads;

Breaching of soil-retaining random stone walls to provide new access points to fields;

Replacement of random stone walls with less adequate structures (for example walls that lack weep-holes often collapse when the soil becomes waterlogged);

Abandonment of traditional runoff management structures (e.g. tunnels constructed in rubble walling underneath cultivated land);

Clearing of vegetation from uncultivated land;

Localised deforestation;

Compaction of soil surfaces as a result of the passage of heavy vehicular traffic associated with offroading and motorised scrambling, as well as with general access and parking in (and/or around) popular recreational areas, hunting areas, trapping sites, agricultural areas and isolated rural buildings/hamlets;

Clearing of vegetation, deposition of material, compaction and inhibition of plant growth (using herbicides) for the preparation and maintenance of trapping sites;

Reprofiling of land into steep escarpments;

Excavation on sloping ground;

Downslope ploughing;

Modification of soil structure through the excessive use of fertilisers (nitrates, in particular, are known to oxidise soil humus, rendering the soil crumbly and readily erodible);

Lack of attention to incipient gullying;

Deposition of soil and other material (for agricultural reclamation, 'temporary' storage, or permanent dumping) on sloping ground prone to runoff-induced erosion, and on land exposed to wind;

Reclamation of land in valley beds and watercourses;

Construction of impermeable surfaces (e.g. buildings, paved areas) on valley sides and valley catchments;

Rendering rural tracks impermeable, especially those on sloping ground and within valley beds, thereby increasing the quantity and speed of water runoff.

Beyond a few specific case studies, there is little existing information on soil erosion in the Maltese Islands, and no systematic erosion status/erosion susceptibility database.

Photo 1. Rubble walls show their exceptional beauty, their habitat for flora and fauna and their vital importance in the conservation of soil and water

Photo 2. Even the existing regulation prevents demolishing or endangering the rubble walls increased soil erosion brings to their structural damage

In order to assess soil erosion in the Maltese Islands, a national team is currently undertaking preparatory works for a Soil Erosion/Desertification Assessment and Mapping activity scheduled to start in January 2000. This project is integrated within the Coastal Area Management Programme (CAMP) for Malta. The institutions responsible for the co-ordination of the various activities are the Priority Actions Programme/Regional Action Centre (PAP/RAC), the Land and Water Division of the Food and Agriculture Organisation (FAO/AGL), and the Environment Protection Department of Malta (EPD). The objectives of the erosion study are to introduce and apply the FAO/PAP consolidated mapping methodology to selected pilot areas and make recommendations for prevention/rehabilitation techniques.

The implementation of this project is based on the principle of sustainable development presented in Agenda 21; principles of the Guidelines on Integrated Coastal Area Management (ICAM) developed by PAP-UNEP and of Guidelines for Erosion Mapping and Measurement (PAP/RAC in collaboration with FAO). The expected project outputs will include basic digitised maps of erosion status and dynamics, supply of GIS and mapping equipment, photo catalogues and improved land use plans. The final product of this project will be the physical assessment of erosion-prone areas and its documentation in a cartographic database. This activity is in line with the implementation of the United Nations Convention to Combat Desertification. Through the ratification of this Convention, the Government of Malta has taken the first measures towards soil conservation.

Soil maps and supporting data

The only soil map of the Maltese Islands is that published in 1960 on a scale of 1:31,680 as a result of the study of the Maltese soils by D.M. Lang in 1956-57. The existing soil map has never been digitised because it is regarded as outdated and consequently of little use for land management and planning purposes. Since the date of issue of the national soil map produced by Lang, considerable translocation of topsoil, subsoil and regolith has occurred, together with occasional mixing of soil with other material. The soil descriptive and analytical data as a result of this survey are older than 40 years and do not correspond to the field anymore. This is especially true in areas having strong human-influence. A list of national maps and supporting data is included in Appendix A.

Conversion of national soil legend into international systems

In classifying the soils of the Maltese Islands, Lang adopted the system developed by Kubiena (1953) (Box 2). According to this classification system three sub-types were recognised: carbonate raw soils, Xerorendzinas and Terra soils.

Division	Class	Type	Sub-type	Variety	Locality/Series
A. Subaqueous					
B. Semi-terrestrial	BA. Semi-terrestrial raw soils	VI Rambla	12. Chalk Rambla		Ghadira Alcol
	BD. Salt soils				
C. Terrestrial	CA. Terrestrial raw soils	XXIII Syrosem	50. Carbonate raw soil		Fiddien, San Lawrenz, Nadur, Ramla, part S.B.
	CC. Rendzina-like soils	XXV Rendzina	60. Humid Rendzina	(36) Protorendzina	Malta E., Malta P.
				Mull rendzina	
			61. Xerorendzina	Xerorendzina	San Biagio, Alcol, Tal-Barrani
	CE. Terrae Calxis	XXXIII Terra	74. Terra fusca	(47) Earthy Terra fusca	Xaghra, Tas-Sigra
			75. Terra rossa	(48) Siallitic terra rossa	

Box 2. Classification of Maltese soils according to Kubiena (1953)

In the early 1970’s, an FAO consultant mission (Sivarajasingham, 1971) prepared a report on the soils of Malta within the scope of a WHO special Fund Project on Wastes Disposal and Water Supply to study the nature of the soils in prospective irrigation areas and to assess their suitability for irrigation with treated sewage effluent. On the basis of this study, areas of soils were demarcated on a topographic base map according to defined irrigation suitability classes. The same study provides a tentative classification of Maltese soils into families according to USDA (Box 3) and FAO systems (Box 4). A more detailed analysis of the classification of Maltese soils is included in Appendix B.

Ramla	sandy, carbonatic, calcareous, Typic Ustorthent
Nadur	coarse loamy, carbonatic, calcareous, Typic Ustorthent
Fiddien	fine clayey, mixed calcareous Typic Ustorthent
San Lawrenz	fine loamy, carbonatic, calcareous Typic Ustorthent
San Biagio	fine loamy, carbonatic, calcareous Lithic Typic Ustorthent
Alcol	fine loamy, carbonatic, calcareous, Rendollic Ustochrept
Tal-Barrani	fine loamy, carbonatic, calcareous, Rendollic Ustochrept
Xaghra	fine clayey, mixed calcareous Typic Ustochrept
Tas-Sigra	fine clayey, mixed calcareous Typic Ustochrept

Box 3. Classification of Maltese soils according to USDA system (Sivarajasingham, 1971)

Ramla	Calcaric Regosol
Nadur	Calcaric Regosol
Fiddien	Calcaric Regosol (in some places Chromic Vertisol sodic)
San Lawrenz	Calcaric Regosol
San Biagio	Calcic Cambisol lithic
Alcol	Calcic Cambisol
Tal-Barrani	Calcic Cambiso
Xaghra	Chromic Cambisol
Tas-Sigra	Chromic Cambisol

Box 4: Classification of Maltese soils according to FAO system (Sivarajasingham, 1971)

National soil institutions

In the absence of a national institution responsible for soil survey activities, mapping and monitoring, soil information has until the present day received little attention and remained a relatively undeveloped agricultural field in Malta. Soil information is very fragmented and linked to specific surveys and studies carried out by undergraduates or as part of environmental impact assessments for project location and development purposes.

The Agricultural Research & Development Centre has a soil fertility and salinity monitoring programme in relation to commercial fertiliser plans. The collection of soil data is restricted because of insufficient facilities for soil characterisation (field survey and laboratory analysis), and lack of expertise in soil science and soil geographic information systems. The laboratory methods for soil analysis are based on different methodologies (SSSA, FAO and MAFF) and are not standardised.

Suggestions for a Soil Information System in Malta

In the present situation, the need to provide the country with an operational tool for multifunctional use of the land and protection of the environment has never been as compelling as today, not only on account of Malta's EU accession prospects, but also in response to the demand by farmers and developers to obtain accurate information about the soil, this precious and limited resource.

Various objectives of soil protection dealing with predictions for safeguarding soil status, stabilisation and remediation require detailed knowledge about soils, their potential and actual loading.

It is proposed, therefore, to develop a soil information system for the Maltese Islands (MALSIS) to remedy current shortcomings and to allow for the preparation of thematic outputs that address a broad range of land use issues. This system would serve as a basis for decision making, policy regulation, planning and development at the national and regional levels.

The suitability of georeferenced soil databases has been demonstrated by a number of applications, which have already been made in different European countries. These applications include the protection of groundwater quality, the assessment of the risks of soil erosion, the assessment of drought hazards, the evaluation of land capability, the delineation of lands vulnerable to nitrate leaching, the assessment of risks of agrochemical pollution, the monitoring of vegetation ecosystems and desertification abatement.

Updating of the existing soil map for Malta is strongly recommended in view of the extensive translocation of soil and the urbanisation of significant tracts of former soil-covered land. In a report on the state of the environment in the Maltese Islands (Axiaq *et al.*, 1999), the need to survey the soil resources, and to develop a tool for the management of soil information, was identified as one of the most urgent priorities that the government should encourage and fund.

The implementation of many EU Directives aimed at protecting the environment requires detailed information about the soil resource base. Examples include:

EC Nitrate Directive (91/676/EEC);

Directive on Environmental Assessment (85/337/EEC);

Sewage Sludge in Agriculture Directive (86/278/EEC);

Habitats and Species Directive (92/43/EEC);

Directive on Integrated Pollution Prevention and Control (96/61/EEC);

Framework Directive on Waste (75/442/EEC).

The obligations originating from the Nitrate Directive, for example, require a soil data layer for delineating vulnerable zones, and a knowledge of the soil and crop growth conditions for the development of fertiliser recommendations and establishment of fertiliser (nutrient) plans on a farm-by-farm basis. In order to fulfil the obligations of the Sewage Sludge Directive, the background levels of heavy metals in soils must be determined before establishing rates of application of sludge on land.

Implementation and data acquisition

The recommended strategy for the development of a soil information system for the Maltese Islands is based on the Manual of Procedures for a Georeferenced Soil Database for Europe by the European Soil Bureau (Finke et al., 1998). It is proposed to carry out the required investigations and data acquisition by considering the Maltese Islands as a pilot area in the framework of the project to provide an increasing coverage of Europe with the construction of a 1:250,000 soil database.

As proposed, it is desirable to have pilot areas in most EU countries and national representatives should inventory regional and national interests. It is suggested to include the Maltese Islands together with Italy in pilot area no. 6 (Finke et al., 1998). In justifying the consideration of Malta as a pilot area, a number of important points can be highlighted:

The draft list of possible locations for pilot areas is lacking any representation from the central Mediterranean region. Therefore, the inclusion of the Maltese Islands as a pilot area would help in establishing the necessary representative coverage of European countries.

As a signatory to the Convention to Combat Desertification (CCD), national support exists to tackle the severe problem of land degradation in the Maltese Islands.

The choice of Malta as a pilot area would be a great source of experience; primarily for those involved at the local scale, but also for the technical experts.

If, according to preliminary analysis of existing data, it is concluded that Malta is unmapped, then compilation of data and development of a georeferenced soil database would be done according to standard methodology proposed by ESB/FAO thus eliminating the need for harmonisation of data.

As outlined in the Manual of Procedures (Finke et al., 1998), the work is to be carried out in a number of successive research phases. If Malta is identified and delineated as a pilot area, the following research phases should be carried out (Box 5). A more detailed diagrammatic representation is found in Appendix C.

Research phase	**Description**	**Comments**
Phase 1	Construction of a meta-database of existing information Overview of existing information within the pilot area (semantic and geographic knowledge) in a computerised metadatabase or a written report.	Existing information has been identified. The available soil data has been compiled into spreadsheets.
Phase 2	Screening, aggregation and use of existing data Data or maps screened on applicability and quality; useable maps are generalised to the appropriate scale; harmonisation of existing map legends to the definitions of soil bodies and soilscapes	Preliminary screening indicates that existing soil data is unsuitable for use. Verification of this is required.
Phase 3	Primary data acquisition Collection of new data in cases where: data is lacking or below standard; data cannot be harmonised; complementary data needed in addition to existing data; new forms of data are desirable	A programme of strengthening laboratory facilities and purchasing equipment is necessary. Technical assistance, together with extensive training of the national team, is needed to carry out the fieldwork. Estimated timeframe: 12 months
Phase 4	*Definition and delineation. Material collected is combined*	
Phase 5	Filling of the database Geometric, topographical and semantic parts of database are filled	
Phase 6	Validation Validation in a reference area to obtain an objective measure of predictive power of database	
Phase 7	Secondary data acquisition Use of pedotransfer function (PTF) and pedotransfer rules (PTR)	

Box 5. Research phases

Benefits and applications

The benefits of developing a Soil Information System for the Maltese Islands and potential applications in relation to national requirements have been identified and are listed in Box 6.

Applications of MALSIS	National Requirements
Description of the state of the environment	Detailed updating of the existing soils map was identified as an urgent priority by the expert panel in the State of the Environment Report (Axiaq *et al.*, 1999).
Environmental impact assessment	As established in the Environment Protection Act (1991), an impact assessment shall identify and assess the direct and indirect effects on the soil.
Risk assessment	Soil erosion risk maps could be used with hydrological data to model infiltration processes of unsaturated land zones.
Ecological rehabilitation of polluted sites	A soil database would provide a tool for drawing up policies for the protection of sites of scientific and ecological importance.
The base for research development, for new standard elaboration and for land use planning on appropriate level	A major problem in transferring technology and research to Maltese agriculture lies in the absence of detailed soil information.
Monitoring of the impact of natural factors and anthropogenic activities on soils	Extensive urbanisation, mixing and disturbance of topsoil is the major man-induced impact on soil which is not monitored.
Providing information for sustainable agriculture and rural development	Identification and protection of good grade agricultural land to ensure continued viability at present does not include soil quality criteria.
Providing information for the elaboration of soil and environment protection strategies	Soil information is a pre-requisite in elaboration of a Soil Code (the Code of Good Agricultural Practice for the Protection of Soil). At present there is no Soil Code for the Maltese Islands.
Providing information for the strategy and decisions on the control of soil fertility	The control of soil fertility is entirely absent from existing regulations and needs to be included. This is especially important in view of the need to adopt sustainable nutrient management plans, which have minimum impact on the environment.
Evaluation of soil protection measures and farm management practices	In the absence of a Code for the Protection of Soil, the farmers do not adopt soil protection measures. Soil information would provide the basis for recommending farm management practices, which aim at reversing trends in deteriorating soil quality.
Providing data for predictive models	In the absence of data on soils, predictive models cannot be applied. This is especially an important issue in the application of models for designating nitrate vulnerability of groundwater resources.
Serving as a basis of sound land use policy	In the absence of updated soil information, site inspections for evaluating applications for development permits reveal

	a large number of would-be coincidences wherein the interested sites are degraded beforehand.
Legal measures for soil protection (enforcement, penalisation, stimulation)	Provisions to protect soil against activities contributing to soil erosion are absent and need to be added to the national legislation.

Box 6. The benefits of the Soil Information System for the Maltese Islands

The current soil monitoring landscape in Malta is a highly scattered one. Apart from budgetary constraints for the establishment of a comprehensive national soil information system, there is not yet an unambiguous opinion about the institutional and organisational framework in which it could operate.

As recommended by the FAO/EC Technical Consultation on the European Soil Information System, national soil institutions should be responsible for collecting soil information and for monitoring of spatial and temporal changes in soil variables.

International efforts for co-operation should be directed towards establishing and strengthening of such bodies, so that local knowledge and experience is nourished. In the absence of a single organisation whether state-owned or private, responsible for soil information and soil monitoring in Malta, it is recommended that a permanent Soil Office should be established within the Department of Agriculture. This unit would be responsible for the management, maintenance and ownership of soil data.

Conclusion

The particular position of the Maltese Islands represents an important and strategic point of linkage between the European and the African reality from a geographic and climatic point of view. The development of a Soil Geographic Database for the Maltese Islands would constitute an important achievement in the extension of the European Soil Information System (EUSIS) to the Mediterranean Basin.

The creation of a georeferenced soil database for Malta and Gozo, compatible with the European Soil Bureau database, could be used to assess the sustainability of current soil use and management and to develop models for predicting potential uses and risks. At the national level, the driving force is an ever-increasing demand for harmonised and compatible soil data information by policy and decision- makers, planning regulators, environmental managers, agriculturists and civil engineers.

In comparison to other European and Mediterranean countries, the state of soil information in the Maltese Islands is relatively poor and insufficient to meet current requirements for agricultural production and sustainable use of land resources. Although at present knowledge is limited and the necessary expertise in soil information is lacking, it is a national priority to consolidate efforts towards the development of a soil information system for the Maltese Islands. Moreover, the creation of a permanent operational structure (a national soil office) would support Malta’s participation in a fully integrated Euro-Mediterranean Network of Soil Information.

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Appendix A: Supporting data

Type of map	Organisation	Area covered	Date	Scale	Remarks
Topographical maps	Public Works Department	Malta & Gozo	1968	1:2500	Available in print form
Topographical maps	Planning Authority	Malta & Gozo	1990	1:25000	Available in print and digital form
Topographical maps	Planning Authority	Malta & Gozo	1990	1:25000	Available in print and digital form
Geological maps	Department of Information	Malta & Gozo		1:25000	
Soil map	Department of Agriculture	Malta & Gozo	1960	1:31680	outdated
Permeability map	Water Services Corporation		1990	1:100,000	
Land registration (tenancy)	Department of Agriculture	Malta & Gozo	N/A		outdated
Land use (agriculture)	Department of Agriculture	Malta north (pilot area)			
Habitat data (rural)	Environmental Management Unit, Planning Authority	Selected areas			Circulation restricted

Appendix B: Soil Taxonomy of Maltese Soils

The classification of Maltese soils in accordance with the 7th approximation prior to the publication of Soil Taxonomy in 1975 places the carbonate raw soils and the San Biagio series of the xerorendzinas into the Entisol order of Soil Taxonomy. "Entisols are mineral soils with little or no evidence of pedogenetic horizons arising from a too short pedogenesis period, geomorphic instability or little weatherability of the parent materials."

Five Entisol suborders are recognised: Aquents (poorly developed wet soils), Arents (disturbed by man), Psamments (sandy), Fluvents (alluvial soils with irregular organic matter distribution in depth), and *Orthents* (other Entisols). Orthents are, by far, the most abundant Entisols in the Mediterranean region and account for the Entisols of the Maltese Islands.

Order: ***Entisol***
Suborder: ***Orthents:***
"Other Entisols."
Great Group: ***Xerorthents:***
"Other Orthents that have a xeric moisture regime."
Subgroup: ***Typic Xerorthents:***
"Other Xerorthents."
Subgroup: ***Lithic Typic Xerorthents:***

"Other Xerorthents that have a lithic contact within 50 cm of the mineral soil surface."

The remaining series within the xerorendzinas: Alcol and Tal-barrani series; together with the terra soils are classified as ***Ustochrepts***, a great group of the order ***Inceptisols***: "young, immature soils whose pedogenic features are less outstanding than in mature soils" (Torrent, 1995).

However, this great group is not present in the "Keys to Soil Taxonomy, eighth edition, 1998". The great group Ustochrepts was deleted from Soil Taxonomy in 1975 and replaced with the great group ***Xerochrepts***. The great group Xerochrepts was then deleted from Soil Taxonomy in 1998 and was replaced with the suborder of ***Xerepts***.

Order: ***Inceptisols***
Suborder: ***Xerepts:***

“Other Inceptisols that have a xeric soil moisture regime.”
The Terra soils were classified as Typic Ustochrepts. With regard to the latest Soil Taxonomy, these are likely to be ***Typic Haploxerepts***.

Great Group: ***Haploxerepts:***
“Other Xerepts.”
Subgroup: ***Typic Haploxerepts:***
“Other Haploxerepts.”

While the Rendollic Ustochrepts (Alcol and Talbarrani series) will likely be ***Calcixerepts*** in either the aridic or typic subgroups.

Great Group: ***Calcixerepts:***
“Other Xerepts that *both*:

Have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

Are calcareous in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Subgroup: ***Typic Calcixerepts:***
“Other Calcixerepts.”

With reference to the “Key to the FAO Soil Units” as contained in the “Legend of the Soil Map of the World” (UNESCO, Paris, 1974) the classifications are defined as follows:

Regosols:

“Other soils having no diagnostic horizons or none other than (unless buried by 50 cm or more new material) an *ochric* A horizon.”

Calcaric Regosols (Rc):

“Other Regosols which are calcareous at least between 20 and 50 cm from the surface”.

Vertisols (V):

“Other soils which, after the upper 20 cm are mixed, have 30 per cent or more clay in all horizons to at least 50 cm from the surface; at some period in most years have cracks at least 1 cm wide at a depth of 50 cm, unless irrigated, and have one or more of the following characteristics: gilgai microrelief, intersecting slickensides or wedge-shaped or parallelpiped structural aggregates at some depth between 25 and 100 cm from the surface".

Chromic Vertisols (Vc):

"Other Vertisols" having moist chromas of less then 1.5 dominant in the soil matrix throughout the upper 30 cm".

Chromic Vertisol sodic:

"Other Vertisols" with "an exchangeable sodium percentage (ESP) of more than 15 within 50 cm from the soil surface".

Cambisols (B):

"Other soils having a *cambic* B horizon or an *umbric* A horizon which is more than 25 cm thick."

Calcic Cambisols (Bk):

"Other Cambisols showing one or more of the following: a *calcic* horizon or a *gypsic* horizon or concentrations of soft powdery lime within 125 cm of the surface when the weighted average textural class is coarse, within 90 cm for medium textures, within 75 cm for fine textures; calcareous at least between 20 and 50 cm from the surface."

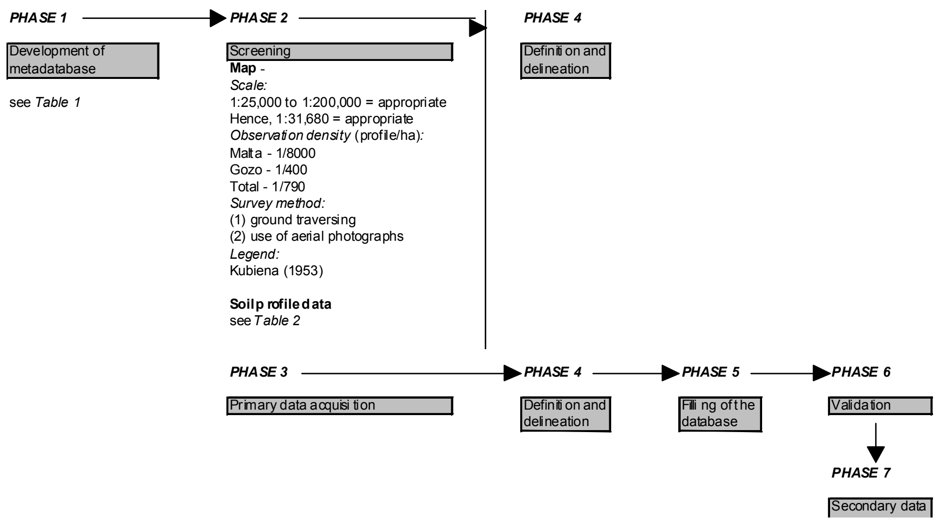
Calcic Cambisol lithic:

As above, with a "continuous hard rock within 10 cm from the soil surface".

Chromic Cambisols (Bc):

"Other Cambisols which have a strong brown to red B horizon (rubbed soil has a hue of 7.5YR and a chroma of more than 4, or a hue redder than 7.5 YR)."

Flowchart to illustrate the work to be done in a possible pilot area project in Malta for the 1:250.000 scale soil database according to the ESB Manual.



Requirements to existing soil profile data

Requirement	Status
1. The position (coordinates) of the sampling site is exactly known	
2. The data are descriptive of a whole soil profile down to the depth of 150 cm (59 in) or to the lithic contact, if shallower. They must refer to all soil horizons or lithological layers thicker than 10 cm, and include also important thinner layers (e.g. iron pans).	
3. Required attributes are the mandatory attributes described Chapter 7 (see Table 3)	
4. Attributes must be coded according to Manual (ESB, 1998)	
5. Analytical data must have been determined according to acceptable methodologies.	
6. There must be an acceptable estimate of the accuracy of the data provided by the owner.	
7. The sampling sites fit to the definition and are representative of the soil body as described by the Manual and can be assigned to it.	
8. There must be a minimum of 2 sampling sites for each soil body.	
9. Data in electronic bases and GIS will be preferable.	
10. Time dependent data must be valid otherwise redetermined.	
11. The data must be reproducible. Checks must be conducted regularly on the data of the national laborities by a designated laboratory.	

Legend
Mandatory
Optional

Status of Soil Survey in Lebanon
The Need for a Georeferenced Soil Database

Talal M. Darwish[1]

Introduction

Following the "Euro-Mediterranean Forum on Co-operation in Agriculture and Food Agro-industry" held in Capri (21-23 September 1998), the European Soil Bureau (ESB) decided to enlarge the "European Soil Geographical Database" for the whole Mediterranean Basin. The soil geographical database would allow for better land use planning and management of soil resources. In this regard, the Lebanese counterparts believes that the production of a geo-referenced soil database for Lebanon at 1:250,000 is a promising project for Lebanon, where the available complete soil maps covering the whole country need upgrading. This has an impact on the development of the agricultural sector as well.

Status of soil surveys in the country

In Lebanon, there is a Soil Department at the Lebanese Agronomic Research Institute (LARI), located in Tell Amara, which is affiliated to the Ministry of Agriculture. During the sixties and early seventies, this institute used to accomplish work on soil survey, mapping, and classification. For the period between 1975 and now, this Department has been suffering from the lack of experts, funding and laboratory equipment. The maps produced before 1975 do not cover the whole country. Existing soil maps cover dispersed areas at different scales ranging from 1:50,000 to 1:20,000. They were pro-

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duced for different purposes (i.e. suitability for irrigation, soil amendments and fertility aspects, etc.).

The only full-coverage soil map that covers the whole country, at a scale of 1:200,000, is dated 1952 was done by Bernard Geze. This map was a valuable contribution for the time when it was published and provided data also on a few representative profiles. Descriptions and analysis were done for a total of 52 sites or "points", of which 41 were represented only by one surficial surface sample. However the map of Geze represented a coherent work, which was based on aerial photos.

Lamouroux (1968, 1971), Osman (1974), Verheye (1973) and others contributed as well to the study of Lebanese soils during the sixties and seventies. The main topics of these studies were: pedogenesis on hard limestone, forms of iron in different soils in relation to soil colour, lessivage in red soils, rubification, soil formation on basalt, soil toposequence in arid climate and others.

Recent soil studies and projects have been taking place at the National Council for Scientific Research (NCSR), in co-operation with different universities, such as the American University of Beirut and the Lebanese University. Research aimed at studying the mineralogy of the Lebanese soils (Sayegh *et al.,* 1990), the mountain soil formation and genesis, properties and conservation as well as the mapping of semi-arid soils of North-eastern Beqaa (Tarzi and Paeth, 1975; Darwish *et al.,* 1986, 1987, 1988 a,b , 1995, 1997).

In 1997, with the establishment of the National Centre for Remote Sensing (NCRS) at the National Council for Scientific Research, a new era of soil related activities started through several projects:

- Mapping soil resources with the use of remote sensing and integrated information system for the creation of a unified soil map at 1:50.000 scale, and soil terrain database for Lebanon.

- Management of natural resources in the karstic Mediterranean areas. Project financed by the European Commission.
- A series of regional projects in pilot areas aiming at the following:
- Studying the impact of urban encroachment on land, its degradation and agricultural productivity. Protection of water and soil resources from heavy metal pollution.
- In 1999, in cooperation with the European Soil Bureau (ESB), of the European Commission, (EC), a new project started on updating the soil map of Geze at 1:250,000 with the implementation of the FAO-UNESCO Legend and the World Reference Base for Soil Resources (WRB) and production of a digital version.
- Co-operation with the ESB, and Centre International de Hautes Etudes Agronomiques Méditerranéennes (CIHEAM) Mediterranean Agronomic Institute of Bari (MAI-B) for the creation of the Euro-Mediterranean Soil Geographical Database at 1:1,000,000 scale covering the whole Mediterranean basin. This project will establish the Euro-Mediterranean network for soil information and would open the way for co-ordinated actions in order to addressing better issues like regional land use planing.

In this regard, recognition is due to the intention of the European Union to provide the participating countries with the necessary training and support for the creation of these soil databases. We reserve the right to emphasise that the methodology and the adoption of European standards will have to be tested in close co-operation between the national and European technical officers.

Given the fact that Lebanon is a small country (about 10.500 km^2) with stressed natural resources, there is much interest in detailed soil information for land use, land degradation and land suitability, based on soil and climate characteristics, and on crop requirements for better planning. Within this context, compatibility of European standards and European Methodology with the collected SOTER soil data will be tested both on relatively small as well as large scale.

Major soil constraints for agricultural production

It is well known that sustainable agricultural production must be based upon a soil information system that provides the necessary data for land users and planners. It is essential that the information be precise, rapid, objective and georeferenced. This soil information should contain data and materials on the main soil characteristics, and on the capability and suitability of the soil.

Then, with the help of irrigation and plant nutrition experts, an extension service could run on stations and farm experiments with different cropping systems, different soil types and variable pedoclimatic conditions. Consequently, information and skills are transferred to farmers. This would maintain technology transfer and the efficiency of agricultural production as well as the competence of the produce.

Before the Lebanese civil war, the National Institutions conducted, with the contribution of the FAO, many research on soil irrigability, fertility and productivity (FAO, 1969). Those works contained information on the fertiliser input and irrigation for cash crops. Nowadays, with the introduction of modern localised irrigation techniques and the advance of the production of zero residues fertilisers, the implementation of fertigation became a promising practice for crop improvement.

This implies an updating of the studies run in the sixties to meet the progress achieved in plant nutrition and irrigation. Lands that once were considered as marginal are able now to be cultivated and irrigated. This means the exploitation of not only the level lands irrigated with the furrow and macro sprinkler systems, but also the sloping lands irrigated thorough the drip systems.

This also means more reliance on nutrient input that could change the earlier adopted land capability classification. Trials show the possibility of overcoming some problems once responsible for the low soil productivity (like low water holding capacity of the soil, its high pH, light texture). This knowledge must be transferred to the farmers.

Environmental problems related to soils

The limited soil resources of Lebanon have their impacts in several categories of environmentally related soil problems. These are:

- ### Secondary soil salinisation:

  Because of an overuse of fertilisers and mismanagement of irrigation in the semiarid area and in the greenhouses on the coastal area secondary salinisation has been observed. In the absence of a crop rotation in stead of monoculture, salinity in some soils of El-Qaa area, Northeast Beqaa has been increasing steadily from 1 to reach 7 dSm.m-1 and more in 6 years (Khatib et al., 1998). Farmers abandon their lands and cultivate new areas with the same practice. Studies showed significant nutrient build-up and salinity problems under greenhouse conditions (Atallah et al., 1999). On the other hand, a good management of water and nutrient input resulted in more then 90% N fertiliser recovery and reduced the nutrient build-up and salinity hazards in Beqaa (Darwish et al., 1999a).

- ### Soil degradation due to chaotic urban encroachment

  On the coastal area of Lebanon, 200 km length and 8 km width, more than 24% of land is converted into concrete (Huyberts, 1997). Around 60% of productive soil around Tripoli, in North Lebanon, shared the same fate (Darwish et al., 1999b).

❑ Water and wind erosion

Until now, no studies quantified the soil water erosion extent and rate in Lebanon. In a study on erosion risk assessment using remote sensing and GIS in the central Lebanese karstic mountains (Qartaba- Jbeil area, 200 km^2), 6% of the territory was classed as very high prone to erosion, 88% as moderate and 6% at low erosion risk (Boukheir 1998; Faour et al., 1999). This indicates the extent of the problem and pressure put on land resources leading to ecosystem degradation in Lebanon. This process commences with soil erosion and ends up with soil degradation and desertification.

Specialised national scientific soil institutions and research centers

The National Council for Scientific Research (NCSR) and its National Center for Remote Sensing (NCRS) possess the scientific expertise and capability (Geology, Soil, Agronomy and Environmental science experts, Image processing, GIS and GPS) to be the Lebanese focal point of the Euro-Mediterranean Network. Table 1 provides the names and the qualities of the staff of the NCRS. NCSR and NCRS are also willing to co-operate with other Lebanese Institutions in the realisation of this important project as needs may arise. These potential institutions are LARI Tell Amara, Ministry of Agriculture, Lebanese University, and American University of Beirut.

Table 1. Specialised Soil Scientists at the Lebanese NCSR

Full Name	Speciality and Title
Mohamad Khawlie	Geology, Ph.D
Talal Darwish	Soil Science, Ph.D
Amine Shaaban	Hydrogeology, M.S.
Shadi Abdallah	Pedology, Irrigation. Eng.
Ihab Joumaa	Agronomist
Talih Masri	Agriculture, Ph.D
Ghalib Faour	Image processing
Theodora Haddad	Environment, M.S.
Mohamed Awad	GIS, M.S.

Available soil maps

The existing soil maps are old (Table 2). They reflect old taxonomies or soil classification systems. The soil data are also scarce offering a limited number of laboratory analyses. However, they have certain scientific value that could be updated. For this reason, it is good to start with something available, despite the difficulties in the interpretation originating from the difference in the approach, goals, taxonomy and evaluation methods.

Table 2. Available Soil Information on the Lebanese Republic

Cover	Scale	Theme	Date	Type of spatial object	Author	Provider	Delay to obtain (buy, digitising, negotiation to obtain)	Format GIS, Paper
Soil	1:200,000	Reconnaissance soil map of Lebanon	1956	Polygons and written report	Bernard Geze	Ministry of Agriculture	Original map and report are available at the Nat. Center for Remote Sensing (NCRS)	Paper. Plotted in digital format at the NCRS
Soil	1:20,000 and 1:50,000	Soil suitability for irrigation. The study covered scattered areas of Lebanon	1969	Polygons and written report	UNDP, FAO	Lebanese Agriculture Research Institute (LARI)	Maps are available only at LARI. Some original maps and final reports for some sheets are available at the NCSR.	Papers. Scanned maps. Reports. Plotted in digital format at the NCRS
Soil	1:200,000	Soil Mineralogy (Lebanon)	Late 70's published in 1990	Polygons and written report	A. Sayegh *et al.*	Nat. Council for Scientific Research NCSR	The original map and final report are available at the NCSR and NCRS	Paper, Report Plotted in digital format at the NCRS
Soil	1:50,000	Soil Families of Southern Lebanon	1973	Polygons and written report	W. Verheye	--	Available at the NCSR	Paper, Report Plotted in digital format at the NCRS
Terrain Units	1:50,000	Soil Classes and	1997	Polygons Database	T. Darwish *et al.*	NCRS	Available at the	Paper and digi-

and components		Soil Groups					NCSR	tal format
Soil components	1:50,000	Soil Types, crop suitability, erosion	1998	Polygons Database	T. Darwish *et al.*	NCRS	Under Execution at the NCRS	Paper and digital format
Land degradation	1:50,000	Land use changes, urban encroachment Tropoli, North Lebanon	1999	Polygons Database	T. Darwish *et al.*	NCRS	Available at the NCRS	Paper and digital format
Soil Pollution	1:50,000	Nature of pollution, Soil vulnerability in Central Beqaa…	1999	polygons	T. Darwish *et al.*	NCRS	Available at the NCRS	Paper and digital format

The projection used in the Lebanese maps is Lambert conical.

National soil legend

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 Legend. This forth-coming project with the ESB and CIHEAM will be a great opportunity to implement this legend on national and regional basis.

The first attempts to use the FAO-UNESCO revised Legend commenced with the project on soil and ground water pollution by NCRS in co-operation with ACSAD and the BGR of Germany. Also, there is an ongoing project for updating the Soil map of Lebanon prepared by Geze, which is being financed by the European Soil Bureau. But, it seems that identifying more clear boundaries between major soil units in the FAO-UNESCO Legend is not very appropriate and Soil Taxonomy, could be useful regarding the diagnostic power and implementation facilities of a soil map.

Meanwhile, farmers use their own Taxonomy and unfortunately little attention has been paid to the indigenous soil knowledge. I believe this is true not only for my country.

Laboratory methods used for soil analysis

The routine soil analyses executed in the Lebanese Laboratories (Table 3) are moisture content, pH, EC, texture, nutrient content etc. However, some of these analyses like the CEC for example are not executed any more in the Laboratory of Tell Amara. Other analyses, like exchangeable cations need adaptation to fit the nature of calcareous soils.

Table 3. Methods of Soil Laboratory Analyses executed in Lebanon

Type of analysis	**Method**	**Extracting solution**	**Equipment**
Moisture content	Oven-drying	-	Oven
Texture	Pipette-gravimetric and hydrometer	$(NaPO_3)13$	Pipette Robinson Hydrometer with bouyoucos scale
pH, EC	1:2.5 and saturation paste	*Distilled water*	pH-meter with electrode
Total $CaCO_3$ equivalent	Calcimetre Bernard	6N. HCl	Simple glass Calcimetre
	acid neutralisation method	1N. HCl	Acid-base neutralisation method
Active $CaCO_3$	Drouineau, Gehu-Franck	N/5 Ammonium Oxalate	Titration with K-permanganate
Organic Matter	Wet oxidation method, FAO, 1974	K2Cr2O7 in conc. H2SO4	Oxidation-reduction titration with ferrous sulfate
CEC	FAO, 1990, Rhoades and Polemio, 1977	1N. NaOAc, pH 8.2 and NH4Oac pH 7 or 1N NH4Cl in 60% alcohol.	Saturation of the soil with Na or NH_4, their removal and determination by flame photomery or distillation.
Exchangeable cations	Bray and Willhite	1N. NH4Oac, pH 7 or 1N NH4Cl in 60% alcohol	Ca & Mg by EDTA complexometry. K and Na by flame photometer
Total Nitrogen	Kjeldahl	Digestion and distillation	Block digester and distillation unit
Available phosphorus	Olsen	0.5N. NaHCO3	Photocolorimeter
NO_3		Water, KCl	Specific ion electrode and

			RQ Flex

International Institutions co-operating in soil studies in Lebanon

A weak presence of the international institutions involved in soil studies is observed in Lebanon. The reasons for that are many. To mention a few:

- The long and devastating civil war;
- The lack of national experts working in Lebanese organisations due to emigration;
- The relative absence of attractive national projects and plans for soil studies.

Among international institutions co-operating in this field are:

Table 4. International Institutions operating in Lebanon and having some relevance with soils and agriculture

Institution's Name	**Project**	**Co-operating National Institution**	**Starting year**	**Expected end of the project**
The World Bank	Rehabilitation of medium and small scale irrigation systems	CDR and Ministry of Water and Electrical Resources	1996	-
CEDARE, ISRIC	Assessment of land degradation	NCRS-NCSR	1997	1999
BGR, ACSAD	Soil and ground water protection from pollution	NCRS-NCSR	1998	2000. A new phase is possible.
ISPRA, JRC	RESMANMED	NCRS-NCSR	1998	2000
AUPELF-UREF	Soil erosion using RS technique	NCRS-NCSR	1998	2002
European Soil Bureau	Updating the Soil Map of Geze	NCRS-NCSR	1999	2000
FAO	SOTER at 1:200.000	Ministry of Agriculture	1999	2000

Given the fact that a national project aiming at the production of the SOTER database at 1:50.000 is being run at the NCRS, contacts have been made with FAO to give this national organisation technical and financial support. Discussions with the regional FAO office in Cairo are being undertaken to organise in Beirut, next year, a regional training workshop on the implementation of the SOTER database (ALES and SWEAP). Hopes are also for a better co-ordination with other national institutions, notably the Ministry of Agriculture.

Suggestions for improving the Soil Information System in Lebanon

A series of measures must be undertaken to address soil information in Lebanon. These are:

- The establishment of a soil agency or "Soil Office" able to avail and provide efficiently soil information at national and local level;
- Updating the available soil maps and filling the gaps in the soil mapping;
- Preparing updated digital versions of the available soil maps and georeferencing them;
- Enact appropriate legislation for soil conservation;
- Establish the national the soil database;
- Apply Land Use Planing 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. This would help towards the goal of sustainable agriculture and protecting the soil from degradation.
- Increase people awareness on the fragility of soil ecosystems through appropriate public and scientific channels as well as the NGOs;
- Lebanon is willing to co-operate with the ESB and CIHEAM for the creation of the Euro-Mediterranean Soil Geografical Soil Database at 1:1,000,000 scale to be presented at the 7th In-

ternational Meeting of Soils with Mediterranean Type of Climate to be held at Bari, Italy in September 2001;

- Lebanon is asking the ESB and CIHEAM to see the possibility of establishing a pilot project in the country for applying the ESB Manual of Procedures (Version 1.1) for the Georeferenced Soil Database at 1:250,000 scale.

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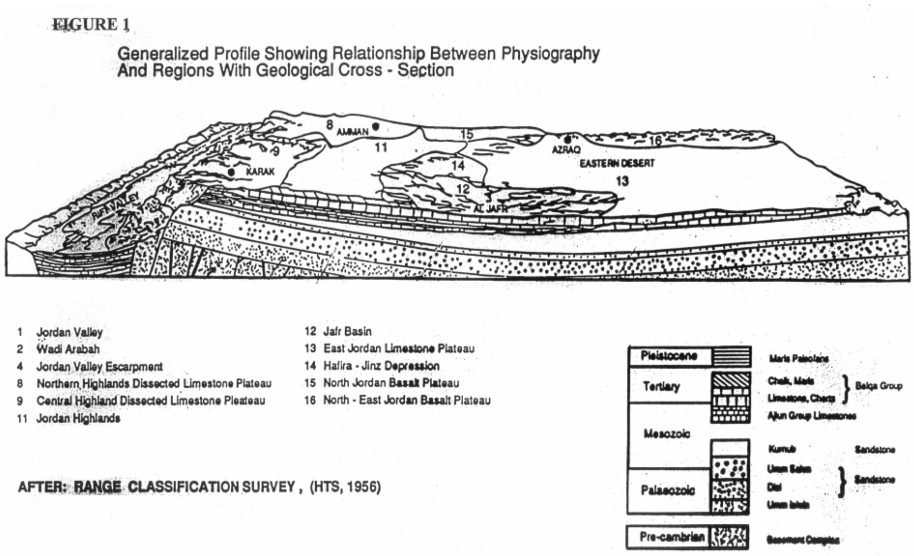
Soils of Jordan

Baker Al-Qudah[1]

Introduction

Within its area of 89,275 km^2, Jordan encompasses a wide area of physical parameters. Altitude values range from minus 392m at the surface of the Dead Sea to the 1,754m of Jabal Rum. The climate varies from sub-humid Mediterranean in the north-western part of the country with annual rainfall of about 630mm to desert conditions to the east over a distance of only 100km. The geology (Bender 1964, 1974) includes Basaltic rocks, sandstone, limestone, chalks, marls and cherts and various Pleistocene and Holocene deposits, both of alluvial and eolian origin. Extensive lava flows have occurred in the north of the country. This wide range in physical features has produced an equally wide range of soils and landscapes. (See Figure 1)



Similar soil studies were conducted also in different parts of the country. An estimated area of 80,000 ha was mapped at a scale of 1:50,000 in Balqa.

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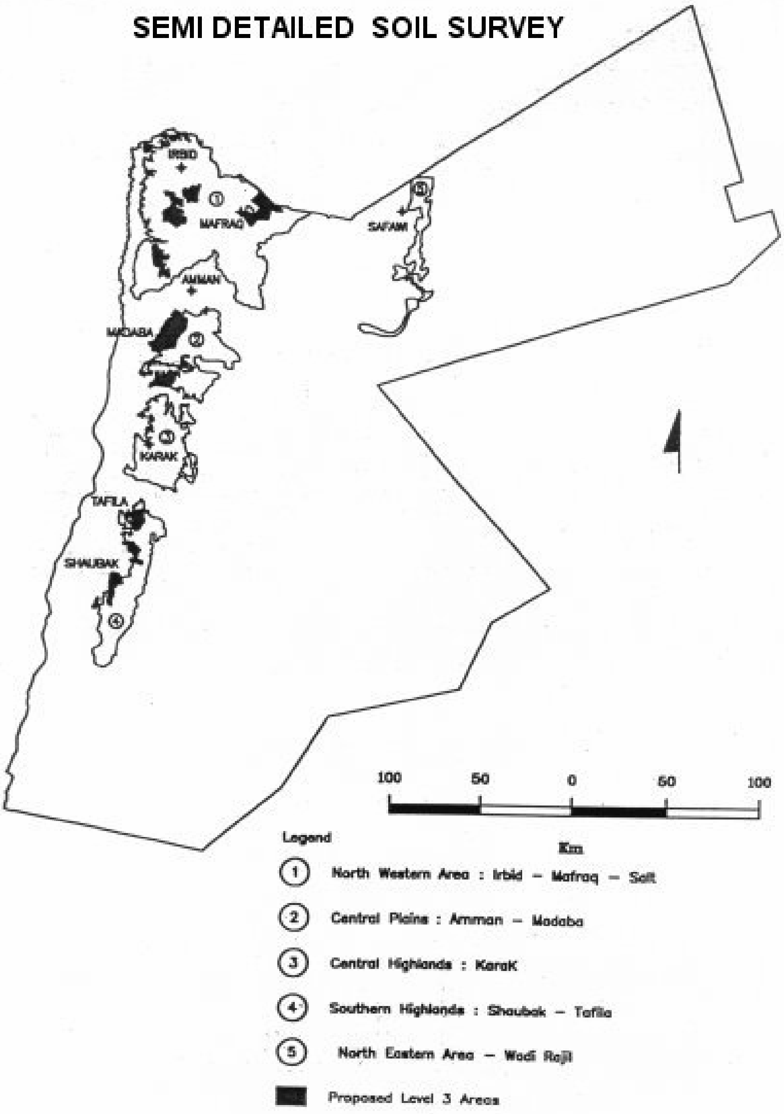
Status of soils survey in Jordan

Soil mapping and classification started in Jordan in the 1950s at a scale of 1:1,000,000, using the US soil classification system of 1938. Twelve great soil groups are recognized, the most common of which were grey desert soils, alluvial soils developed under desert climate, yellow soils developed under steppe conditions, and yellow and red Mediterranean soils developed where annual rainfall exceeds 250mm.

During the 1960s, West (1970) mapped the soils of Baqa'a Valley at a scale of (10,000) using the U S Soil Taxonomy (7th Approximation). The area covered by this study was about 6,700 ha. The dominant taxonomic units encountered were Xerochrepts and Chromoxerets. Usually these soils were located on gentle slopes and flat topography. Xerorthents were also identified in that area. However, their distribution was limited and they only occurred on the eroded slopes. This work was extended during

FIGURE 2



the 1970s to Irbid and Karak regions. A detailed survey was carried out for 2,500 ha, and a semi-detailed survey for 70,000 ha in Irbid region. (See Figure 2)

Similar soil studies were conducted also in different parts of the country. An estimated area of 80,000 ha was mapped at a scale of 1:50,000 in Balqa.

Major soils of Jordan and their constrains

Since soil surveys have been mainly limited to localised projects in separate parts of the country, comparatively little is known about the soils of Jordan at a national level. The only exception is the outdated Moorman (1959) study. So far, there has been no attempt to assemble or re-evaluate all previous activities in order to establish a general soil map in current terms. However, according to our present knowledge and based on all previously published soil studies and available data, the following soil taxonomic units, according to USDA Soil Taxonomy, have been identified in Jordan (Rihani, 1983; ACSAD, 1980). (see Figure 3)

Soils developed under Xeric Moisture Regime

Soil Taxonomy Order: Inceptisols

Great Group: Xerochrepts

These soils have an ochric epipedon and calcic subsurface horizon under a xeric soil moisture regime, which prevails in the rainfed and mountainous areas. They are developed on both upper and lower slopes. The Xerochrepts of Jordan are well represented by subgroups such as Vertic Xerochrepts, on the lower gentle slopes, and Lithic and Calcixerollic Xerochrepts on the upper, slightly convex slopes. These are generally productive soils. The main limiting factors for their utilisation in agricultural production are the effective soil depth to bedrock and the content of rock stones and gravel in the profile and on the surface.

Soil Taxonomy Order: Vertisols

Great Group: Chromoxererts

These are the Vertisols developed under a xeric soil moisture regime. They are deep, clayey soils, developed on hard limestone and basalt, and are distributed on level to nearly level areas in the Irbid basin in the North, and Madaba and Karak in the South. The Chromoxererts are well represented by subgroups such as Typic and Entic Chromoxererts. These soils are inherently fertile, have a high water-holding capacity and are well suited for all cereal crops. When fruit trees are planted in these soils, their root systems might be damaged because of the moderately wide cracks, which develop during the dry season.

Other soils such as Xeralfs, Xerolls and Xerorthents have a limited occurrence and distribution. These can be found in the mountains of Ajloun, Blaqa'a and Shoubak. Major constrains to these soils are shallowness, stoniness and steep slopes.

Soils Developed under a Torric (Aridic) Moisture Regime

Soil Taxonomy Order: Aridisols

These taxonomic units cover about 60% of the total area of Jordan. In addition to their aridic soil moisture regime, these soils are characterised by having an ochric epipedon and one or more pedogenic subsurface horizons. The dominant suborder is represented by Orthids. The most common subsurface horizons in the Aridisols of Jordan are the calcic and gypsic horizons. Aridisols with a cemented calcic horizon are also found in Jordan, especially in the northern plateau.

Great Group: Calciorthids

These are Aridisols with an ochric epipedon and subsurface calcic horizon. They contain high amounts of lime in the subsoil and in the parent material. Sometimes the calcic horizon becomes indurate, decreasing the rootability of the soil. These soils are distributed in the steppe region where rainfall is very low. Water harvesting therefore, can be very profitable on such soils. Land use is restricted to grazing during the spring season. Due to the high silt content in these soils, soil crusting is one of the major limitations because germination becomes very difficult.

Great Group: Gypsiorthids

These soils are distinguished by the presence of high gypsum amounts, deep in the profile. Some gypsiorthids have gypsum in all the horizons. They are common in eastern and south-eastern parts of Jordan (Sirhan basin and Mudawarah). Rainfall is very limited in these areas, not exceeding 50 mm annually, and the only possible land utilisation is grazing (Hunting Technical Services Ltd. 1956). However, the presence of gypsum or salts could severely decrease grass growth and production. The plant species are also specific to these conditions.

Great Group: Camborthids

Camborthids are Aridisols that have an ochric epipedon and a cambic subsurface horizon. Most Camborthids are deep and found on flat or gentle slopes. They are associated with Entisols and Calciorthids. The color of the cambic horizon is darker than the topsoil.

These soils have much less calcium carbonate content than the calciorthids. The extent of these soils in Jordan is very limited compared to other Aridisols. Crusting due to high silt content is one of their constrains.

Great Group: Salorthids

These are the very salty soils occurring in wet places in the desert, where capillary rise and evaporation of water concentrate the salts into a salic horizon. The Salorthids are usually deep and wet, but the dissolved salts make the soil physiologically dry because of the osmotic pressure. The Salorthids are good soils for crop production if the salts are leached beyond the root zone and irrigation water is available. Salorthids occur in Jordan around Azraq Oasis, the Qa-Disi mudflats and in some places in Wadi Araba. In these areas, Salorthids are associated with Torrifluvents and Torripsamments.

Soil Taxonomy Order: Entisols

These are very young soils. Some of them have an ochric epipedon at the surface, especially when they are protected from erosion. They are good soils for agriculture unless a lithic or paralithic content is present. In Jordan, they are mostly stony or sandy and are associated with the Aridisols. The main great groups observed are the following:

Great Group: Torrifluvents

These are the Fluvents of arid climates that are not flooded frequently or for long periods. They have a torric moisture regime and most of them are saline or alkaline. They are distributed in mud-flats such as Qa'Disi in the South, and Qa-Khana near Azraq in the North.

Great Group: Torripsamments

These are Entisols formed on sandy parent materials that could be poorly graded sands, shifting or stabilised sand dunes, and under torric soil moisture regimes. They have low or very low water-holding capacity and high infiltration rates and posses single-grain texture, mainly formed by quartz with or without coating. This coating is mainly iron oxides that give the red colour to the material inherited from the argillaceous sandstone near these soils. Some are slightly calcareous or saline due to the presence of shale fragments.

These soils are generally deep unless a lithic or paralithic contact is present. They are sometimes gravely and associated with gypsum. They occur mainly in Disi, Mudawarah and Wadi Araba regions. They are good soils for agricultural production if irrigation water and fertilisers are available. Descriptions of typical profiles are presented in Appendix I

Great Group: Torriorthents

These are the Orthents of arid climates that are dry or salty. They are gravely or of sandy loam texture and are associated with Torripsamments. They occur in the eastern desert and the southern sandstone plateau.

Major environmental soil problems

Soil salinity and sodicity

Due to the prevailing arid conditions, salinity is the major threat to irrigated soils, outside the highland to the west down in the Jordan Valley and to the east in the desert plateau. However, irrigated soils of Northern Jordan Valley are not threatened by salinity because winter rainfall is sufficient to leach down accumulated salts of the preceding spring and summer seasons. Salinisation increases along the north- south transact in the Jordan Valley.

Generally, the content of soluble salts in the soils increases with decreasing rainfall; notable exceptions being Wadi soils, which have additional leaching from run- off water. Study of the data shows soils with xeric moisture regime generally have surface and sub-soil ECe values around 0.9 ms/cm, soils with transitional xeric- aridic have ECe of 2.4 and 2.1 ms/cm in top and sub-soils, respectively. Whilst aridic soils have ECe values in excess of 60 and 20 ms/cm in top and sub-soils.

Structure deterioration

Man often changes soil structure, unfortunately, by several kinds of activities related to operations carried out at the wrong time or performed on soils that are not suitable for it. The result will be structure deterioration. It was observed that removal of permanent vegetation causes a strong suppression of the biological activities on and in the soil. As a result, the equilibrium that exists between biological and physical processes of structure formation is disturbed and physical processes become most important.

Another consequence of soil miss- management is tillage. Especially, in sandy soils in southern parts of Jordan, tillage increases the danger of wind and water erosion, both of which cause structure deterioration by stratification. In clayey soils, as in Irbid, the effect of tillage is the destruction of soil aggregates into their original constituents (sand, silt, and clay). These are then sorted by water and form a dense structure either in the form of a single grain or stratified crust.

Moreover, riding with heavy vehicles causes mechanical pressure, vibration and searing. Consequently, the total pore volume decreases and compaction and sub-surface plow-pans may be created. As a result, the effective rooting depth will be affected.

Soils maps available in Jordan

The systematic soils survey and land classification in Jordan started in 1989, where a combined team of expatriate consultants and Jordanian staff mapped the soils of Jordan at different levels of details, through a project that lasted for a period of about 72 months.

The initial survey (Level 1) was a reconnaissance study in which careful analysis of LANDSAT remotely sensed imagery and aerial photography was substantiated and expanded by field observation in sample areas and traverses of an overall density of one observation site every 7.6 km^2. Broad soil types thus were defined and grouped into appropriate mapping units and shown on a 1: 250,000 scale map. The report and an album containing different maps for Level 1 were completed in 1994.

Areas delineated as having some potential for agriculture on the above basis were then subjects of a semi-detailed soil survey. Panchromatic SPOT imagery combined with LANDSAT thematic mapper were used at a scale of 1: 50,000 to provide additional and more detailed information to form the basis of a preliminary soil map.

Field survey at an overall density of 3,5 observations/km^2 provided detailed information on the soils, landuse, topography etc. to permit a detailed classification into soil types and soil mapping units. The later map at scale 1:50,000, together with its accompanying report, form an accurate and reliable basis to identify priority areas for agricultural development.

Then, the priority areas were mapped at a scale of 1: 10,000 with an observation density of 15 observations/km^2. The various levels of soil survey and landuse studies generate a very considerable volume of data: soil characteristics being recorded at nearly 42,000 observation sites throughout the Kingdom at levels 1, 2 and 3. (See Figure 4)

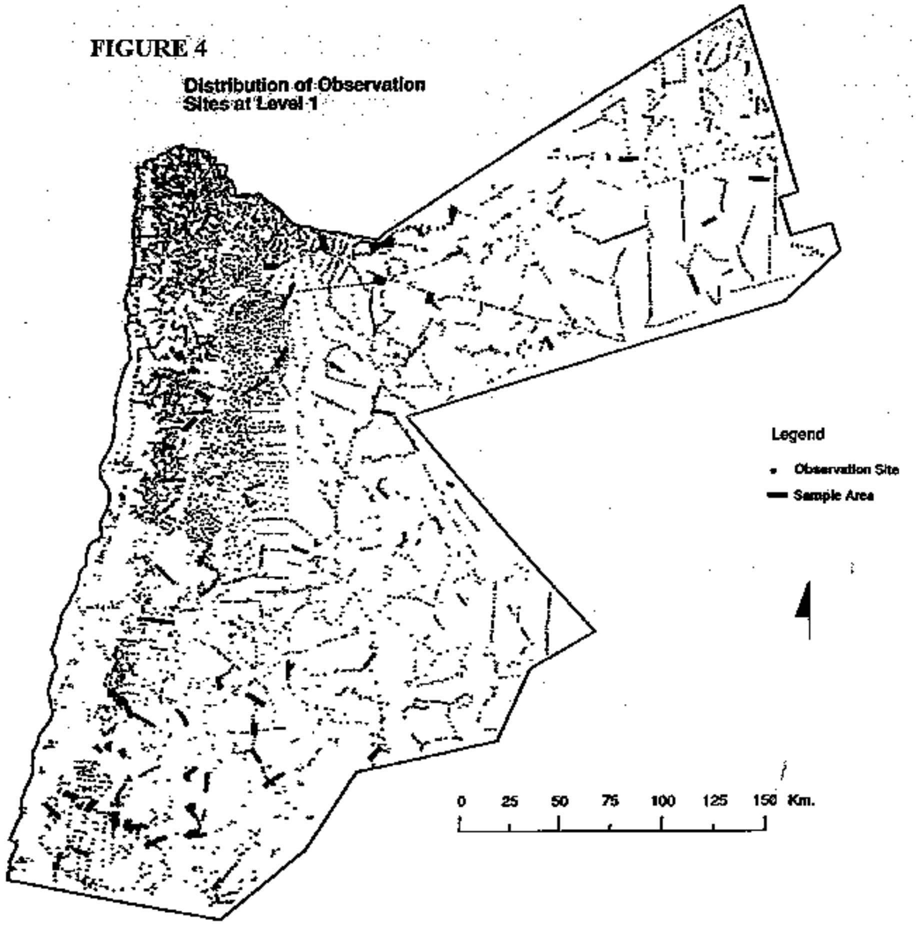


FIGURE 4
Distribution of Observation Sites at Level 1

To cope with the accumulate data a geo- coded database was then established. Without computerised methods, the data would fill several filing cabinets and could only be revised after a great deal of manual effort. The data are being stored in six microcomputers with a total of about 2,000 megabytes of storage. User-friendly access procedures have been developed which will enable the trained staff to use it. This will permit the user to pose complex questions and request information on a very wide and comprehensive range of soil and landscape details.

This database has made the collected data readily available and easy to manipulate. However, it has only the ability to manipulate data associated with points on the landscape. A frequent requirement of soil survey and land use studies is that they answer queries on where land of particular characteristics occurs. Traditional map preparation can provide only a single answer to such questions. To enable a range of thematic maps to be made quickly and readily, a Geographic Information system or (GIS) has been set up. This will permit new models to be devised from the basic datasets using new criteria set by scientists, planners and others, as needs dictate.

Map projections used in the country

The Royal Jordanian Geographic Center is the focal point for map production for the country. The projections used in producing maps are as follows:

1. Ed 50: European datum 1950.
2. UTM: Universal Transverse Mercator.
3. JTM: Jordan Transverse Mercator.
4. PB: Palestine Belt.

Specialised scientific institutions or research centers on soils

Several institutions are addressing the soil problems in Jordan. While primarily involved in water delivery and other development matters in the Jordan Valley, the Jordan Valley Authority (JVA), has done much work on soil classification, land drainage and salinity evaluations (Mitchell 1975) . It has also performed some applied research on crop response to irrigation. The Jordan Valley Authority does not maintain agricultural research staff, but has nevertheless useful information for growers regarding soil data.

The University of Jordan has no formal extension responsibility but has an active and relatively broad research program in the Jordan Valley and in the steppe area.

The Ministry of Agriculture, through its Department of Soils and Irrigation, is involved in both research and extension regarding soils. Soil information is available in hard copy, such as maps at different scales and in electronic media in the computers.

The present information needs to be translated into an easy language so as to be understandable by the extension staff and the farmers. Hence, there is an urgent need for substantial expansion of both research and extension programs if soils problems are to be solved or even contained, especially in the view of the rapid rate at which new technology and products are being introduced.

Conversion of national soil legend

The soils of Jordan show a wide variation in their characteristics, covering six of the US Soil Taxonomy soil orders. These soils where classified according to the above mentioned soil classification system and the appropriate units were correlated with definitions by the Soil Map of the Arab World, established by the Arab Center for the Studies of Arid Zones and Dry Lands. (ACSAD/SS/P16/80, Damascus 1980).

Laboratory methods used for soil analysis

The laboratory investigations included the analysis of soil and water samples in order to determine soil characteristics and possible relationships between soil and groundwater salinity. These tests were carried out according to the "Soil Survey Investigations Report No. 1, Soil survey Laboratory Methods and Procedures for Collecting Soil Samples", USDA, SCS, Revision August 1982 as recommended by. The Arab Center for the Studies of Arid Zones and Dry lands (ACSAD)

Soil analysis cover the following:

- Particle size.
- Bulk density and porosity.
- Soil moisture content at 1/10, 1/3 and 15 atmosphere tensions or representative samples.

- pH of water-saturated soil paste.
- Analysis of the saturation extracts for the determination of the electrical conductivity and soluble Calcium, Magnesium, Sodium, Potassium, Carbonate, Bicarbonate, Chloride, Sulfate and soluble nitrate.
- Cation exchange capacity (CEC).
- % Gypsum and Calcium Carbonate content.
- Gypsum requirements.
- Total Carbon, total Nitrogen, C/N ratio, and O. M.
- Total and assemble Phosphorus, in surface sample.
- Clay minerals identification.
- Water samples analysed to determine electrical conductivity, pH and soluble Cations, as described above.

Institutions doing soil studies in Jordan

A major component of the National Soil Map and Land Use Project, which was executed during the period 1990- 1995, was the setting up of a soil survey section or a soil department within the Ministry of Agriculture, which can use the database accumulated by the project. The main aim was to provide information to a wide range of planners and users, and which can respond quickly and effectively to requests for additional information on soils and land.

To achieve this, a training programme was set up, which has introduced eleven new graduates and five technical field assistants to the skills and procedures of soil survey and land evaluation. The programme has consisted of both formal and informal, on-the-job training. Suitable candidates were selected and attended courses in the UK. on remote sensing interpretation and data management systems; and computers section staff have completed courses at the University of Jordan on GIS methodology.

So, the Soil Department at the Ministry of Agriculture is doing at present soil studies in Jordan.

Suggestions for improving the actual Soil Information System in the country

- We suggest to establish a regional soil and water database network, based on unifying the electronic media used;
- Teaching small farmers how soils differ by on-site examination and by the visual aids. Attention should be given to the following:
- Soil depth, texture, permeability, erosion, slope, traffic pans, surface crust and natural fertility.
- A manual could be developed for the above permanent and temporary characteristics.

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Appendix I

Soil Profile Description

Information on the Site

Profile No.: PA264
Series 1 Phase: Had 1 / Gravelly
Soil Mapping Unit: level I:ISS (114)
Soil Classification: USDA (1990): Sandy-skeletal, gypsic, calcarcous, hyperthermic Family of Typic Gypsiorthids (FBDD)
ACSAD: RHY t 1/2 a: Typic Gypsiorthid
FAO/UNESCO: CLjy: Yermic-Gypsic Calcisol
Author: Austin Hutchcon
Date of examination: 25/11/91

Location: 1 km E of Jafr Aumary road
Sample -Area No.:
Map sheet: 1:25,000: 3353-11-WW - 1:100,000: 3353 - 1:250,000: Azraq
Coordinates: Geographical: 36.86727 E/ 31.65659 N
JTM: 487413 E/ 503133 N

Elevation: 542 m asl
Landform: Position: Lower slope gravel plain
Land System: 13/12 (Dissected ptateau and gravel terraces) -- 13.12.0 [GIS]
Land Facet: 1 (Gently undulating gravel plain with bedrock)
Microrelief: Class: Even (<25 cm)
Type: Undulating

Slope: Gently sloping (2 %), rectilinear to NNW

Land Use: 4.4 Unvegetated, bare
Plant/Crop:
Climate: Mean annual precipitation:
Mean annual temperature: Air: 19.4° C 1 Soil (50cm): 22.3° C
Soil moisture regime: Aridic
Precipitation zone: 0-50 mm p.a.
Nearest raingauge: Azraq (F 9)
Administrative unit village: (Zarke Governorate)

General Information on the Soil:

Geology: Limestone [q2 FLuv.gravels (Lisan) (Bender 1968)]
Parent Material: Alluvium (gravelly texture)
Drainage: Surface Runoff: Slow
Soil Drainage Class. Well drained
Surface Cover: Gravel (60 %)
Surface Feature: Patina
Soil Surface Conditions: Dry/Moderately hard
Erosion: Nil
Soil Depth: 265 cm +
Diagnostic Horizon or Property: Gypsic at 75 cm

Profile Description

0 -5 cm Reddish yellow (7.5YR 6/6) dry and strong brown (7.5YR 4.516) moist; clay loam; weak medium platy breaking to moderate medium subangular blocky dry slightly hard; moist loose; moderately sticky; moderately plastic; many fine (0.5-2 mm) irregular pores; 10 % angular chert coarse gravel (20-75 mm); strong reaction to HCl; gradual smooth boundary to:

5 -17 cm Yellowish red (5YR 5/6) dry and red (2.5YR 4/6) moist; very gravely fine sandy clay loam; very weak fine subangular blocky; dry loose; moist loose; non-sticky; slightly plastic; common fine (0.5-2 mm) tubular pores; 45 % platy chert coarse gravel (20-75 mm); 2 % medium (5-15 mm) soft gypsum crystals; violent reaction to HCL; clear wavy boundary to:

17 - 75 cm Light brown (7.5YR 6/4) dry and strong brown (<7.5YR 5/6) moist; extremely gravelly sand; massive; dry very hard; moist loose; non-sticky; non-plastic; many fine (0.5-2 mm) tabular pores; 70 % rounded chert coarse gravel (20-75 mm); 25 % small (<5 mm) moderately hard gypsum crystals; strong thick gypsum coating of gravel; strong reaction to HCL; abrupt smooth boundary to:

75 - 95 cm Light brown (7.5YR 6/4) dry and strong brown (7.5YR 5/6) moist; sandy loam; massive; dry very hard; moist very firm; non-sticky; non-plastic; many fine (0.5-2 mm) irregular pores; 5 % irregular chert gravel (5-20 mm); 60 % large (>15 mm) hard gypsum crystals; strong reaction to HCl; clear smooth boundary to:

95 - 165 cm Reddish yellow (7.5YR 7/5) dry and strong brown (7.5YR 5/6) moist; silty clay loam; weak coarse subangular blocky breaking to moderate fine subangular blocky; dry hard; moist very friable; slightly sticky; slightly plastic; common fine (0.5-2 mm) irregular pores; 5 % irregular chert gravel (5-20 mm); 10 % medium (5-15 mm) moderately hard gypsum crystals; violent reaction to HCL; abrupt smooth boundary to:

165 - 265+ cm Pink (7.5YR 7/4) dry arid strong brown (7.5YR 5/6) moist; very gravelly silty clay loam; weak coarse platy breaking to moderate medium subangular blocky; dry slightly hard; moist very friable; moderately sticky; moderately plastic; common fine (0.5-2,m) tubular pores; 50 % sub-rounded chert coarse gravel (20-75 mm); week thin $CaCO_3$ coating of gravel; violent reaction to HCL.

Note: Analytical analyses ere available for horizons: 1 / 2 / 4 / 5

PROFILE No: PA264 (1.analysis)

LAB No.	DEPTH	SAND	SILT	CLAY	SAND Coa-rse	SAND Med	SAND Fine	SAND Very fine	GRAVEL	TXT.	PSC	BD	POR	PERM
	cm	3A3 % of < 2 mm							%	3A3	3A3	4A3a g/cm3		
188	0- 5	53.3	36.7	10.0	3.5	13.6	21.0	15.2		fSL	M			
189	5- 17	48.2	38.5	13.3	7.6	12.6	16.8	11.2		L	M			
190	75- 95	65.4	25.8	8.8	6.4	16.6	31.3	11.1		fSL	M			
191	95-165	30.5	58.9	10.6	2.1	3.6	11.6	13.2		SiL	M			

DEPTH	MOISTURE 10 kPa	MOISTURE 33 kPa	MOISTURE 1500 kPa	pH Paste	EXTRACTABLE BASES Ca	Mg	Na	K	CEC	CEC/clay	Na exch	ESP	ECe	SAT
cm				8C1	5B5a meq / 100 g				5A10a	8A1a rat	8D1 meq/100g	5B6b	5D1b mS/cm	8A %
0- 5				7.1			2.5		5.9	0.59			31.0	21.6
5- 17				6.9			5.9		5.7	0.43			76.8	30.4
75- 95				6.8			40.0		3.8	0.43			119.6	47.0
95-165				6.7			25.1		8.8	0.83			122.1	50.0

DEPTH	Ca CO3 tot	GYP-SUM	GYPS REQU	SOLUBLE CATIONS Ca	Mg	Na	K	SOLUBLE ANIONS Cl	SO4	CO3	HCO3	NO3
cm	6E1a %	6F1d %	6F5 t/ha	6N1b	6O1b	6P1a	6Q1a meq / l	6K1d	6L1d	6I1a	6J1a	6M1a ppm
0- 5	35.5	2.0		173.0	51.0		1.5	271.9	20.6		1.6	160
5- 17	40.0	3.9		515.3	104.7		0.6	738.7	14.2		1.4	581
75- 95	41.5	19.3		194.2	65.8		0.4	1150.4	16.4		1.3	311
95-165	41.5	3.2		610.6	159.4		0.4	1189.9	50.0		1.4	564

DEPTH	SALT tot	SAR	P total	P avail	N total	Org.C total	C/N	OM	MICRONUTRIENTS Cu	Zn	Fe	Mn	B
cm	8D5 %	5E	6S1a ppm	6S2 ppm	6B1a %	6A1d %		%	ppm				
0- 5	0.43		1400	2.00	0.015	0.17	11.6	0.30					
5- 17	1.50												
75- 95	3.60												
95-165	3.91												

Outprint of JOSCIS - National Soil Map Project, SSLRC/NTS/MoA, Jordan (14/07/93)

Agriculture and Soil Survey in Egypt

Hasan Hamdi[1] and Sayed Abdelhafez[2]

Introduction

Agriculture in Egypt represents a milestone in the national economy as it has its special historical background. Irrigation projects that lead to a better use of the available fresh water are very important for the sustainable agricultural development. However, changes introduced in any national equilibrium result in a number of other changes and precautions ought to be considered to prevent land deterioration.

Soils and agriculture

Egypt covers an area of almost one million square kilometres in North Africa and Western Asia. Almost percent of this area are now occupied by more than 65 million inhabitants, who are mainly concentrated in the Nile Valley and the Delta as well as in the coastal zone along the Mediterranean Sea. Thus the population density is one of the highest in the world amounting to almost 1,700 inhabitants per km^2.

The Nile Valley has a flood plain of about 18-km wide, bordered by flat terraces. The Delta, however, has an area of 220 km wide at the coastline, and is 170 km long. Seven old *deltaic* branches led the water of the Nile to the Mediterranean Sea. These are now reduced to two main branches, Rosetta and Damietta. Rainfall is scarce with the exception of the coastal littoral zone, where almost 100-150 mm falls per year, particularly in the west.

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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.

Formerly, Egypt was self-sufficient agriculturally and during the 1960s production grew at a rate of 3% annually, but the pace slowed down to almost 2.5% per year in the seventies and eighties.

The major challenge Egypt is facing at the present time is the need for better development and management of the natural resources to meet the demand of a nation growing at a rate of 2.2% annually. It has been said that Egypt is truly the gift of the Nile, but investment, conservation and development of this gift would have never been realised without the tremendous efforts exerted by the Egyptians throughout the history.

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.

Generally, it could be said that there exist two geomorphic units in the central part of the Delta, namely the young *deltaic* plain and the Mediterranean coastal plain. The following soil units are distinguished as young deltaic plain and aeolian deposits.

The deposited gravel and sands were laid down in the Pleistocene and recent geological eras. These types of gravel are to be seen in many parts of the Nile Valley where they form a series of terraces at various heights above the valley floor. These terraces were formed by the river at successively lower levels as it gradually deepened its bed channel.

The clay that covers the flat floor of the valley and most surface of the Delta forming the arable land of Egypt has all been deposited by the floodwater in the course of the recent geological period.

Sedimentation of the Nile suspended matter took place mainly during the flood period (August, September and October). However, after the construction of the High Aswan Dam, the suspended matter has enormously decreased all the year around.

Water resources in Egypt, are dependent entirely on Nile water, which amounts to 84 billion m^3 per year. The average annual evaporation and other loss in the High Dam Lake have been estimated at 10 billion m^3, leaving a net usable annual flow of 74 billion m^3 of water. Under the agreement with the Sudan in 1959, only 55.5 billion m^3 of water were allocated to Egypt. The total capacity of the High Aswan Dam is 120 billion cubic meters.

Struggling for development, several issues forced their way in the search for ground water in the Delta and Valley as well as in the desert areas and Sinai Peninsula. Ground water in the Western Desert is deep and non-renewable, but the amount is huge, reaching 40,000 billion m^3 with salinity varying between 200-700 ppm. or 0,31-1,9 ECe.

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.

Since the construction of the High Aswan Dam, the flow of the river has been regulated by storage in Lake Nasser. The water level in the lake should not exceed 175 m a.s.l. on the 1st of August of each and every year. The maximum design water level for the dam is 182m a.s.l., which corresponds to 162.00 billion cubic meters. Also, the constructed Toshky spillway can release water to the Toshky depression in the Western Desert when the reservoir level exceeds 178 meter a.s.l. . Hence, there exists now little possibility of a high flood down stream of the High Aswan Dam.

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 in the near future.

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 so-called 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 addition, the promotion of exports of agricultural commodities is essential, as the country should profit from the free trade areas between the Arab and the African countries and taking into consideration the advantages between Egypt and the EU and USA partnerships.

To increase yields two approaches have been followed. One of them was developed during the 1980's for the horizontal expansion of agriculture into the desert areas by identifying the most suitable zones through the use of the remote sensing techniques.

Meanwhile the Ministry of Agriculture and Land Reclamation of Egypt emphasise the vertical plant expansion, particularly for wheat and maize. Wheat yield has increased from 1,2 to 1,8 tons per ha and maize from 1,7 to 2,3 tons per hectare. The Agricultural Research Centre through different trials has adopted a short duration rice variety and less water consuming, which requires 2,430 m^3 of water per ha compared to the old varieties which consume 3,645 m^3 of water per hectares.

Status of soil survey

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 emphasised 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 Organisation.

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, coloured 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).

Following are brief descriptions of the different soil associations, giving their distribution, formation, morphology and other characteristics.

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 1 gives detailed information at suborder and great group level for the three soil orders.

Table 1. Classification of the soils of Egypt at order, suborder 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

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 (photos 1 and 2).

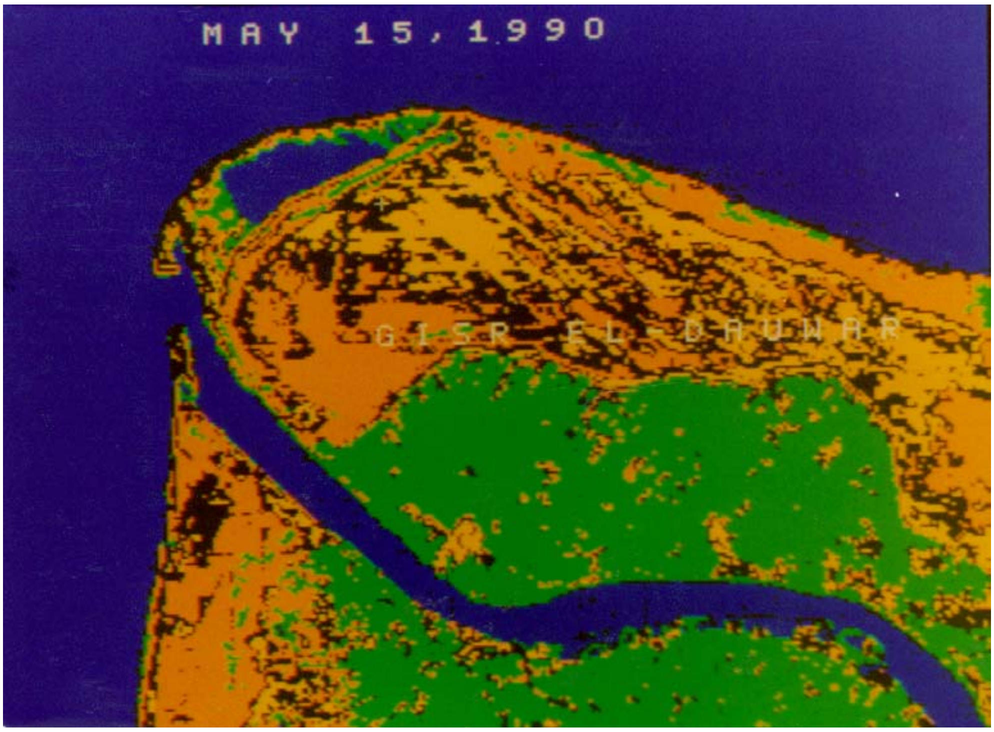

Photo 1. Landsat TM 1990 of Bourg El-Arab El-Hammam area showing different soil classes produced by VIEWS 100 digital image processing system using Supervised (Parallelepiped) classification

Major soil constraints

A number of tasks have been performed by means of Remote Sensing techniques; namely, urbanisation for instance, that is categorised as the head of economical problems, facing Egypt's development.

It represents the nature of Egypt's environment, which shows the demographic distribution, since people are concentrated near fresh water in the Delta and Nile Valley. The loss of fertile land annually amounted to almost 60,750 hectares. Examples are demonstrated in different cities and villages throughout the country as in Assiut, Kafr El Sheikh, Tanta, Minya El Kamh, Dikirinis and Qualiubiya.

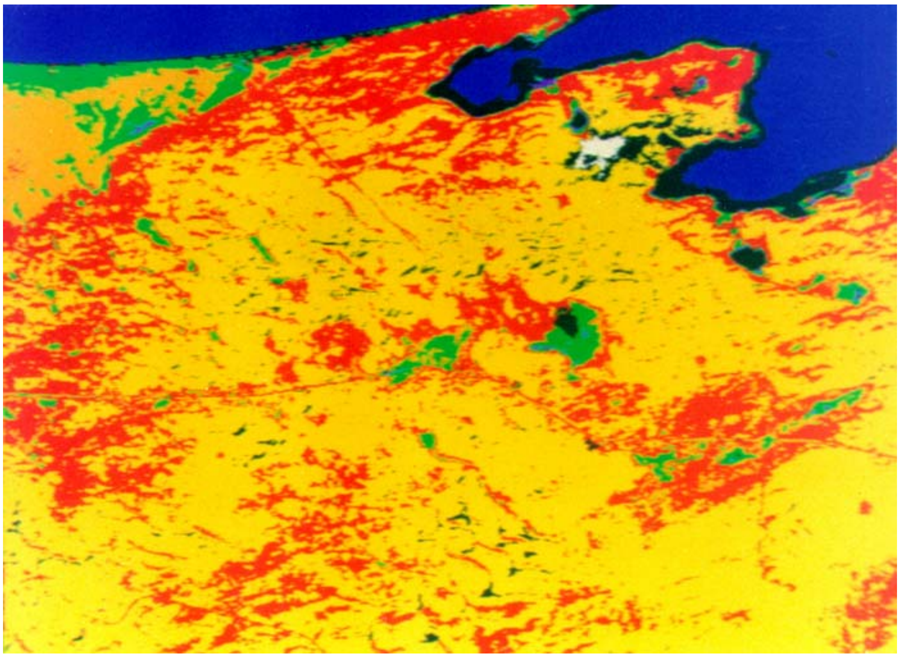

Photo 2. Parallelepiped classification of the foreshore line of North Sinai.

Green: Low lying area covered with vegetation
Red: Undulating sandy plain
Orange: Severely saline and moist soils
Yellow: Almost flat and gently sloping
Black: Water logged soil
Blue: Water

This phenomenon needs decisive solutions as it affects tremendously agriculture production. Other land degradation processes that affect several aspects of economic and agricultural development include:

- Salinisation;
- Scraping of soil surface for brick industry;
- Pollution with pesticides and industrial waste;
- Sand encroachment; and
- Wind and water erosion

Examples are demonstrated for land loss due to urbanisation in the Kafr el Sheikh City between the periods of 1932 (Topographic Map at 1:100,000 scale), 1958, (Soil Survey Map at scale 1:2,500), and 1985 (aerial photographs).

Air photographs having a scale of 1:10,000 and Computer Compatible Tapes (CCT) containing data from Landsat MSS taken on 10-3-1989, when classification was carried out, parallelepiped and supervised the classification method. Computer output is shown in Map 1)

It has been estimated that the total area of Kafr el Sheikh City in the base map of 1932 was 79 ha. In 1958 this area has increased to 212 ha and in 1985 to 555 ha. The calculation in 1985 was done by applying aerial photo interpretation.

Lately in 1989 by applying remote sensing techniques the area had increased again to 741 ha. Taking into consideration the economical evaluation, the loss from agricultural production has been calculated to almost 1.5 million Egyptian pounds per year. Also for Minya El Qamh City urbanisation has increased almost 500 percent (Table 2).

Table 2. Increase of urbanisation for Minya El Qamh City

Year	Average of settlement	Increase	Percentage of increase
1937	31	-	-
1967	71	40	228
1990	233	161	514

The second soil constraint is salinisation. Salinity is monitored through remote sensing technique, using multi-spectral scanner sensors MSS and Thematic Mapper taken during the summer season of 1990.

The CCTs contain the cultivated area of the Delta as well as salt affected soils and settlement. A coloured photograph has been prepared for salinity zones in the Delta.

The maximum likelihood classification method discriminates the different stages of salinity. The turquoise colour and the very dark blue represent the extremely saline soils. The highly saline soils have a dark violet colour, while the moderately saline soils have a pale violet colour and the plant cover seems to be healthy without a homogenous appearance. The non-saline soils are shown by the red colour and the plant reflectance is homogenous having high biomass content (photo 3).

The area of each class of salinity in the Nile delta is amounted to 30,936 ha for extremely saline soils; 56,292 ha for highly saline soils; 35,989 ha for moderately saline soils and 92,181 ha for non-saline soils respectively (Hamdi et al., 1992).

The changes in soil salinity have also been recorded between 1960 and 1990 for a number of Governorates. Examples are given for Souhag (Upper Egypt) and Sharkiya (Lower Egypt) where 1,700 and 760 samples are recorded.

A comparison of salinity hazards between 1960 and 1990 was made for Souhag. On a map of 1:100,000 scale were plotted all the recorded samples and this revealed that most of the previously classified moderately saline soils were rendered as non-saline due to a better water management by constructing an efficient drainage system. As result the percentage of non-saline soils increased from 82 to 94.6.

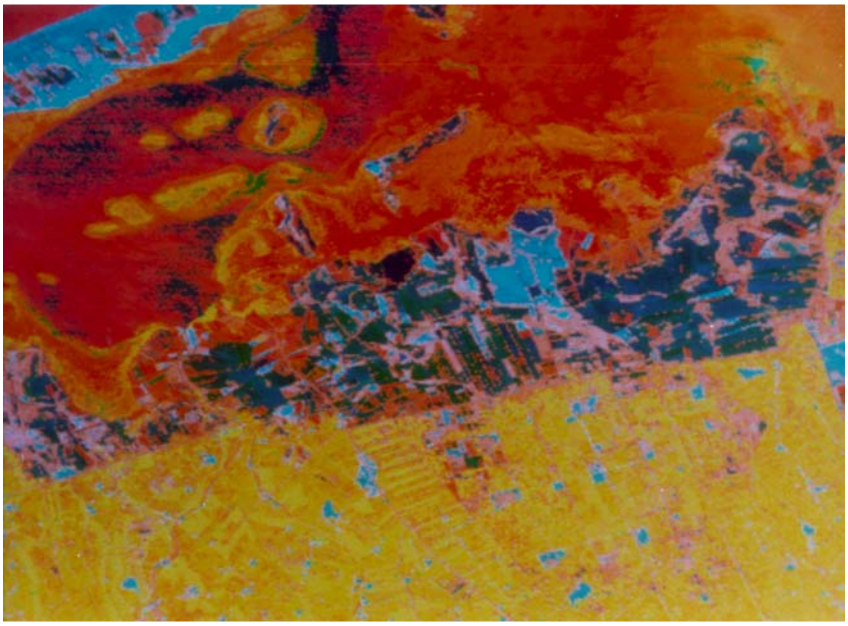

Photo 3. PCI image processing of the northern part of the Nile Delta

By using 10 multi-spectral Landsat Thematic Mapper images change detection has been outlined, for a 10 years period from 1984-1993. The scene covers the western two-thirds of the Nile Delta and a portion of the adjacent Western Desert. The image shows the status of agricultural land in the Western Desert. The reduced productivity class is orange coloured, the urbanisation yellow and the reclaimed lands in the desert and coastal zones are shown in six-dark colours, according to the year of reclamation (Pax-Lenney Mary et al., 1996).

In ten years urbanisation removed almost 8,313 ha from agricultural production in the Western Desert representing a 10.3% increase in the urban land use during this period. On the other hand, reclamation in the desert and coastal regions brought about 93,000 ha into agricultural production between the period December 1986 and April 1993, which represents an increase of about 43% in the amount of cultivated land in these areas. However, urbanisation could be considered as the major constraint for agriculture production and development in Egypt .

Also soil degradation has been monitored between 1977-1990 on the shore coast of the Delta. Values reveal a reduction amounted to 309 ha. The loos of land are the result of Mediterranean Sea water intrusion into the Rosetta Promontory during 13 years. Processing of multispectral scanner MSS Landsat and Thematic Mapper TM-Landsat shows a loss of fertile lands (Table 3 and photos 4 and 5).

Table 3. Degradation of Rosetta Promontory during a 13 years period

Landsat	**Area in ha**	**Difference in ha**
MSS 1977	2,447	
TM 1990	2,138	309

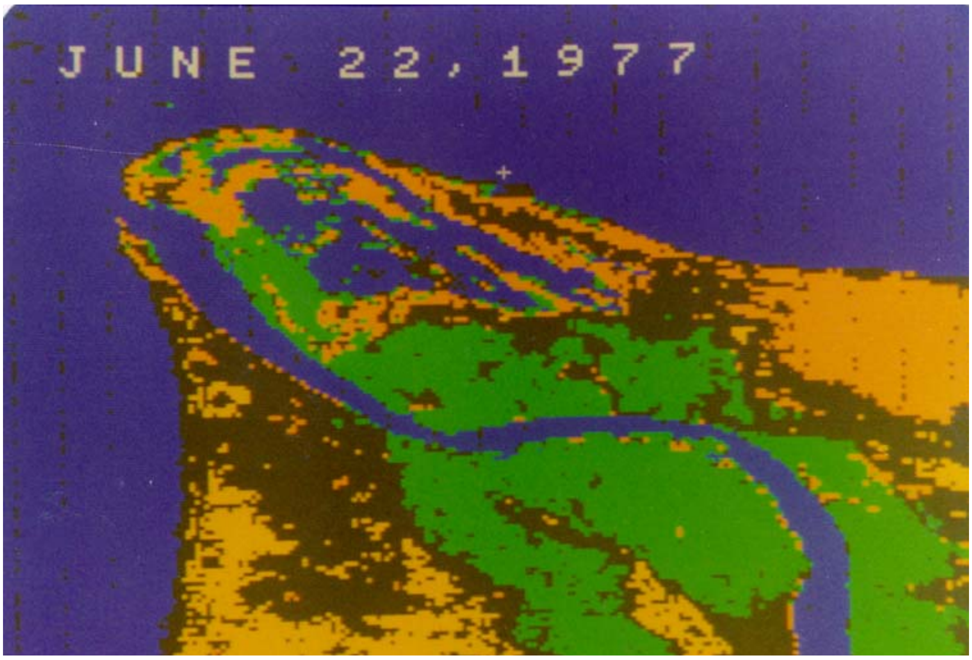

Photo 4. Maximum likelihood classification LANDSAT MSS for Rosetta promontory

False colour Green: cultivated area
Blue: water
Yellow and orange: sand
Black: sand covered with shells or gravel

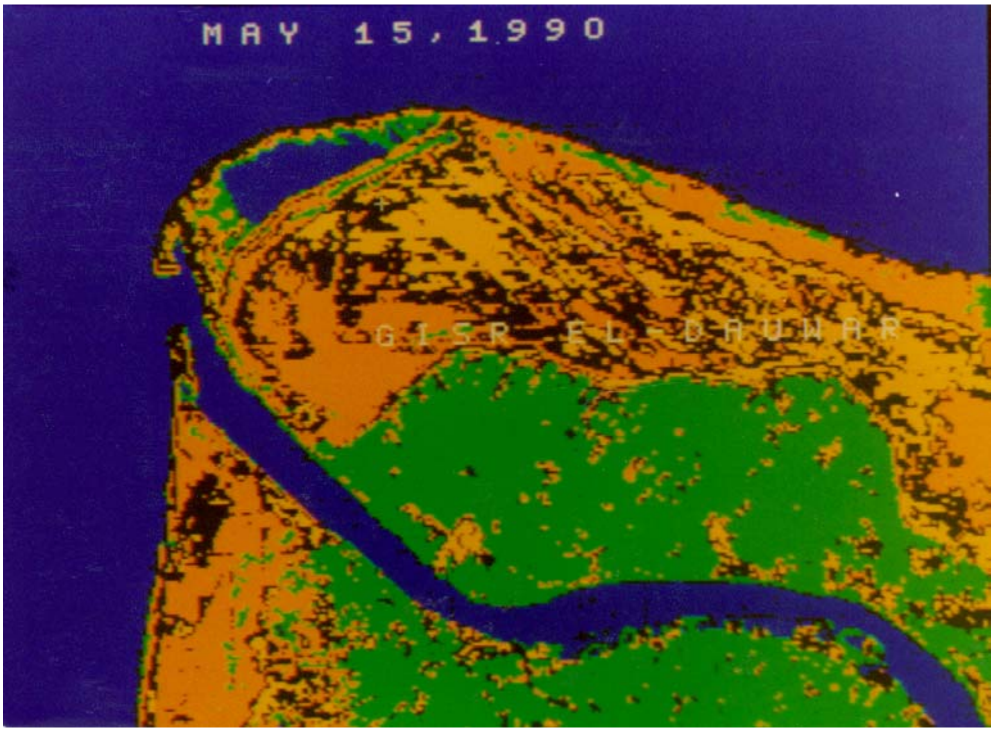

Photo 5. Changes in land use for 13-year period for the Rosetta promontory.

Specialised institutions in soil science or related fields in the country

The scientific specialised institutions are the following:

- Soils and Water Science Departments of the Egyptian Universities: Cairo, Ain Shams, Alexandria, Assiut, Zagazig, Menoufiya, Tanta, Mansoura, Suez Canal, Minya, El Wadi El Gadid and Al Azhar.
- Soil, Water and Environment Research Institute, Agriculture Research Centre, Ministry of Agriculture and Land Reclamation, Giza.
- National Research Centre, Soil and Water Use Laboratory, Dokki.
- General Authority for Rehabilitation Projects and Agricultural Development (GARPAD), Dokki.
- Atomic Energy Authority, Agricultural Section, Inshas.
- Salinity Laboratory, Ministry of Agricultural and Land Reclamation, Alexandria, Bacus.
- The Desert Research Center, Ministry of Agricultural and Land Reclamation, Matariya.
- Executive Authority for Land Improvement Projects (EALIP), Dokki.[3]
- National Authority for Remote Sensing and Space Sciences, Heliopolis, Alf Maskan.
- The Egyptian Survey Authority, Ministry of Public Work and Water Resources, Giza.

[3] The developing objectives of "EALIP" are to increase agricultural production, which leads to improved food security and to increase the income of rural population. This is achieved through obtaining data from the survey of soil and water and by applying land levelling, gypsum addition, subsoiling, and instalment of effective drainage system.

- Geological Survey Organisation, Cairo
- Military Survey.

There are no international institutions in Egypt carrying out soil survey studies.

Soil maps

The following maps are available in different institutions in Egypt:

- Soil maps for different areas at scales of 1:2,500, 1:10,000, 1:100,000 showing salinity, texture, soil and water depth and soil fertility (macro-nutrients).
- A National Soil Association Map, scale 1:5,000,000.
- Soil Classification Maps for certain desert areas, prepares by using remote sensing techniques and digital image analysis.
- Computer compatible tapes, covering the whole country for 1990, 1991, and 1993 are all available at the Soil and Water Research Institute of the Ministry of Agriculture.
- Soil Physiographic Maps at scale 1:50,000 (aerial photographs), covering areas in Upper and Lower Egypt, as well the area around the Desert Road, (Cairo-Alexandria), which comprises the reclaimed lands in the Western Desert. All these maps are available at the Soils Department, Cairo University.
- Collection of Soil Classification Maps at scale of 1:100,000, covering 48 coloured sheets for the cultivated areas. This collection is available at the Academy of Scientific Research and Technology.

The above maps have been produced using Topographic Maps of the National Survey Authority, available at scales of 1:250,000 and 1:100,000. Their compilation is done using the existing data and a great number of exploratory field studies all over the country.

- The following maps are available at the National Authority for Remote Sensing and Space Sciences:
  - Soil Maps for the Nile valley and the Delta, scale 1:100,000 (hard copy);
  - Digital Soil Map for Sinai Peninsula, scale 1:100,000;
  - Soil Maps for Siwa Oasis and Toshky, scale 1:25,000 (digital);
  - A Soil Map (hard copy) for the Eastern Desert (at scale of 1:250,000) is actually in preparation;
  - Soil Map and Land Use Map for the area of Halayib and Shalatein as well as for the Siwa Oasis, scale 1:25,000.
- Soil Classification and Land Productivity Maps for Bahariya Oasis, North Sinai, East Owaynat and some valleys on the Red Sea area are available at the Soils Department, Ain Shams University.
- Soil and Land Evaluation Maps for Alexandria and surrounding areas of the North Coast are available in digitised version at the Soils and Water Department, Alexandria University;
- At the Desert Research Centre, the following maps have been prepared:
  - Soil maps and Land Capability maps for the soils of Southern Egypt, Toshky, as well as Kharga and Dakhla Oases developed in GIS format at scale 1:100,000 and 1:25,000;
  - Soil maps and Productivity maps for the north coastal littoral of Egypt, scale 1:100,000 (digitised);
  - Soil maps for the soils of Lake Nasser, Korkor, Klabsha and Adendan, as well as for the Soils of Bahariya Oasis (under preparation), scale 1:100,000;

  - Soil and Land Capability maps for desert soils of Egypt, scale 1:100,000.

- Digitised information maps representing gypsum requirement, sub-soiling, salinity, and water table depth for improved soils in the different Governorates, are available at the EALIP offices in Dokki.

Laboratory methods

All laboratory methods of soil analyses are almost the same of those used in different international institutions, like FAO.

The analyses include: texture, fractionation of sand, silt and clay (not for all profiles) organic carbon, $CaCO_3$-content, gypsum, water content, pH 1:1 or 1:2.5, soluble cations and anions in water extract; saturated paste or 1:5, and cation exchange capacity.

Available Equipment

The following are the equipment present in the different institutions of the universities and research centres. All the research institutions have their computers and certain laboratories are relatively well equipped. The Soil and Water Research Institute has a well equipped remote sensing unit, containing digital image analysis systems, view 100 and PCI with the new modified software. Other equipment includes radiometers, scanner, and photo enlarger.

The Desert Research Centre has a good GIS laboratory. The Soils Department of Ain Shams University has recent computers having high storage capacity.

The National Authority for Remote Sensing and Space Sciences is located in a well equipped institute with the necessary hardware and software for data processing.

Suggestions for Improving the Soil Information System

Large increases in food production are needed for the world's increasing population of 6 billion inhabitants in 1999. This can be obtained by putting more lands under cultivation, particularly in the developing countries, and by improving operation and management of existing irrigation schemes. FAO have stated: "If this improvement could be carried out perfectly on 50 million hectares, the return in increased production would be enormous and might bring as much as 25 billion US dollars."

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 the developing countries.

The proposed establishment of a soil and water database should be welcomed in order to introduce and better arrange the huge existing information to the internationally accepted approach of "SOTER." for instance (Abdel Rahman, 1992).

The initiation and establishment of an Euro-Mediterranean Network of Soil Information will also give an excellent opportunity for the training of natural environmental specialists in order that they can apply modern information technologies.

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, digitising 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 Bureau guidelines;
- Continuous up-dating of the database system and of the hardware equipment.

Acknowledgement

It is our pleasant duty to express sincere appreciation to the Mediterranean Agronomic Institute at Bari, for this kind invitation to attend this meeting aiming at the establishment of an Euro-Mediterranean Network of Soil Information for all the countries of our region.

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Soil Survey in Cyprus

Costas Hadjiparaskevas[1]

Introduction

Cyprus is an island in the Eastern Mediterranean region with an area of 9, 250 Km^2. The island's topography includes two mountain ranges, the Pentadactylos in the North, which rises up to 1,024 m and Troodos in the centre, rising 1,951 m. The plain of Mesaoria lies in between them.

The climate of Cyprus is typical as for the other countries of the Eastern Mediterranean having mild winters and long hot summers. The mean annual precipitation is about 500 mm with large variations in rainfall and rain distribution from year to year. Over the last three years for example, annual precipitation has been much below the mean average and water in the reservoirs is now at about 10% of their total capacity. The quantities of water available both for drinking and irrigation purposes have not been adequate, hence the Government has been looking at other potential sources such as desalinated and recycled water.

In 1998 the cultivated area was estimated at 134, 000 ha of which 80, 000 ha consisted of annual crops, 43, 000 consisted of permanent crops and 11,000 ha seasonal crops while the state forestland is about 18% of the total area of the country.

Status of soil surveys

Systematic soil studies and soil classification surveys started in Cyprus in 1957 aiming at collecting information and data about the physical and chemical properties of soils and at preparing soil maps for the areas surveyed mainly for agricultural purposes.

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The first soil classification system used was based mainly upon the formation, the origin and the parent materials of soils. Accordingly, soils were classified as Red soils, sedentary soils, and alluvial or colluvial soils. Usually, an examination of the master horizons (A, B, C, D) including soil physical and chemical analyses were carried out in order to classify the soils of these groups into soil series and types.

The FAO soil classification system was introduced in Cyprus in 1970. Through this system a new effort was undertaken to establish a common international language in soil classification.

Within the national framework of soil survey, a system of soil horizons has been adopted in the procedure of the soil map preparation. The soil horizons, which are used for identifying soil-mapping units, are called diagnostic horizons.

The definitions used in this system are drawn from those adopted in the Soil Taxonomy of the U.S.A. Department of Agriculture 1975 (Soil Survey Staff 1975). The definition of these horizons have been summarised and sometimes simplified in accordance with the requirements of the FAO-UNESCO legend for the soil map of the world (FAO-UNESCO 1974).

As a result of local observations in soil studies and investigations, the following diagnostic horizons derived from the FAO system have been adopted during soil surveys: Mollic, Ochric, Argillic, Natric, Cambic, Calcic and Gypsic.

In order to separate soil units, a number of soil characteristics (i.e. textural changes, hydromorphic properties, carbonate content, etc.) are used and a number of soil orders and sub-orders have been consequently recognised.

According to the FAO system and taking into account the local experience a number of soil orders have been recognised, which correspond to the following general definitions: Lithosols, Regosols, Rendzinas, Solonchauks, Solonetz, Vertisols, Cambisols, and Luvisols.

Land use classification

The land use classification and potential cropping pattern map of Cyprus (Land Use of Cyprus, Natural Vegetation and Agricultural Use, Republic of Cyprus, 1999) has been prepared to present the main agricultural productive zones and natural vegetation. This map has been completed in 1999 at scale 1:250.000 based on data and records from the land use map (Land Use Map, Department of Agriculture, 1971) and recent agricultural farm survey and Forest Department.

Criteria used in land suitability classification

In order to prepare Land Use Suitability Classification map the following factors have been taken into consideration:

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

Land suitability classes

Five suitability classes have been mapped. These are numbered from I-V, in the decreasing order of suitability. Classification assumes the availability of water supply for irrigation purposes. Besides that, each suitability class indicates the crops that can be successfully grown on each class of soils.

Class 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.

Class 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 suitable for deciduous trees, vines and vegetables.

Class 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.

Class IV

This class includes soils having unfavourable 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.

Class V

The soils included in this class are completely unsuitable 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 unfavourable physical and chemical conditions.

Major soil constrains

Generally speaking, soils in Cyprus can be divided into two major categories. The first category includes deep soils located mainly in the valley areas. The second one includes shallow soils lying on geological formations of the mountain and semi mountain areas.

Deep Soils

Despite the fact that soils included in this category are deep they have some limitations concerning their productivity.

- In some areas soils are heavy due to the texture and vertic properties (clay content is up to 60%);
- Large parts of the cultivated land are classified as calcareous with calcium carbonate content up to 40-60%;
- The great majority of soils have pH values on average rising from 7.5-8.6;
- The mean value of organic matter into the cultivated soils is less then 1% due to the hot climatic conditions and higher mineralisation rates.
- Salt concentration in few areas is high due to their geological origin and pedogenic formation of the soil horizons. .

Shallow soils

The soils of this category are formed mainly on igneous rocks and on calcareous sedimentary layers. The shallow soils in the valley areas are the very well known red Mediterranean soils on conglomerate (accumulations of loose materials). Their limiting factor for agricultural use is not only the shallow depth but also other parameters such as:

- Shallow soils on hard rocks usually are accompanied by severe erosion and soil degradation;

- Shallow soils or marls with drainage problems and high calcium carbonate concentration up to 70% in some geological layers.

The above different limiting factors determine the kind of cultivation (c: crop), productiveness (p: productivity), and cost (e: expense) per unit.

This situation is not existing on a rather theoretical aspect but it’s a reality for the Cypriot farmers. They are producing under unfavourable conditions. If the severe water shortage is added to the picture then it becomes evident that the future of the agricultural sector is not so promising.

Having mentioned all the above unfavourable conditions, the Cypriot Government would welcome any suggestion or proposals to overcome the existing productivity limitations.

Environmental problems

The subject of "acute environmental problems" for the time being is not so severe in Cyprus. The concentration level of heavy metals for instance in soils and water is very low compared with the European Union regulations. This is favoured by the lack of heavy industries and nuclear power stations in Cyprus, however the country is faced with different environmental problems, such as:

- Soil erosion and soil degradation as the result of the heavy rainfall in winter period followed by high temperatures and dry weather conditions during the summer;
- Nitrate pollution due to the excessive use of nitrogen fertilisers in shallow soils with high runoff;
- Due to the lack of water, it’s a common practice among the farmers to remove soil from one area to another leaving behind escavations and open pits;.

- The use of brackish waters irrigating clay and shallow soils is causing increasing salinity problems;
- Fertile land is used for urbanisation other than for agricultural purposes;
- Recycled water from domestic tertiary treatment of sewage sludge is being used for the irrigation of forage crops. At full implementation of this programme the recycled water is expected to cover around 12% of the country's water needs.

Institutions or research centres dealing with soils

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, soil fertility and the physical soil properties.

A lot of research work on fertilisation, recycle water use and many other relevant sectors have been established. Furthermore A.R.I. is in close co-operation with different centres and institutions in Europe and the Near 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.

Available soil maps

All the existing soil maps are mainly prepared for agricultural purposes. The first efforts in Cyprus for soil mapping where based on the topographical sheets at scale 1:5,000. The purpose of these initial surveys was to study the physical properties of the soils. At a letter stage, a soil map at scale 1:25,000 was prepared for the main agricultural developing areas, including dams and water reservoirs.

As a common practise, for each irrigation project a detailed land suitability map was developed at scale 1:5,000. The next step on soil mapping was the preparation of the General Soil Map of Cyprus at scale 1:200,000 based on the FAO Legend, which was published in 1970.

The most recent soil map of Cyprus was based on the World Reference Base for Soil Resources (WRB) system published by FAO-ISSS-ISRIC (1998) and was prepared in electronic (GIS) format and printed at scale 1:250,000 in 1999.

Concerning the areas that haven't been surveyed by any means, other methods have been used such as extrapolation, photo interpretation as well as revision of the general soil map of Cyprus. For small countries, like Cyprus, maps at small scale can not be successfully used for local land-use planning. In such cases only detailed soil maps are useful.

Cyprus didn't create its own detailed soil taxonomic system because up to 1960 it was an English colony and due to this the background on soil classification is rather limited. Considering this, no effort was made to develop a national system but to propose the acceptance of an existing soil classification systems.

Since 1970 the decision was to follow the F.A.O. classification system for two reasons. The system was not so complicated compared with other international systems and the system itself was not too much data demanding. Moreover, the decision for establishing a world soil map by the FAO was another occasion to introduce this system.

In regard to copyright considerations on soil data, the general policy is that those data belong to the owner who generate them. The access to soil maps is not limited. A general law provides protection of copyright and no specific consideration on the above subject exists.

Code of practice for agricultural use of land

The Government’s policy concerning the agricultural production and the sustainable use of land resources is that the highest possible effective and efficient utilisation of land resources should be done.

The term "efficient use” includes the maximum utilisation of land and with "effective use" the goal is to obtain optimum yield per unit of land. The overall strategy is to maximise positive effects of land resources and minimise environmental hazards. Between the agricultural production and the environmental protection there is a continuous interaction, which should not be competitive but complementary for balanced development.

Very recently a code of practice has been formulated and applied in Cyprus. This code refers to the amount, the form, the time and method of chemical application on soil’s surface, aiming at the protection of both soil and ground water resources from pollution due to run off and depletion of the chemicals.

The code is addressed to the land users and farmers aiming their information and education on the existing measures and rules. Some of these rules are:

- Fertiliser application is allowed at a certain distance from water sources (not less than 50 m);
- Protective measures must be taken in slopping areas to prevent soil and fertiliser run off (i.e. vertical plowing to the slope, opening small furrows, creating small benches etc.);
- Restrictions for agrochemical use (mainly herbicides and long lasting chemicals);
- Rotation of cultivation.

Soil Analyses

The usual soil analyses and methods used in Cyprus are as follows:

- Total Nitrogen: Kjeldhal method
- Nitrate Nitrogen: Ion selective electrode
- Phosphorus: Sodium bicarbonate extracting (Olsen method)
- Exchangeable cations (Na, K, Ca, Mg): Ammonium Acetate method (Richards)
- Soluble (Na, K, Ca, Mg) and (Cl, HCO_3, CO_3, SO_4): Water extractable (Richards)
- Boron: Hot water extractable (Berger and Truog)
- Micronutrients (Fe, Zn, Mn, Cu): DTPA Extractable (pH 7.3)
- Mechanical analysis: Bonyoucos method
- Calcium Carbonate: Titrimetric method
- Organic matter: Potassium Dichromate method
- Electical conductivity: Saturated paste
- pH: Soil: water 1:5
- Cation Exchange Capacity: Ammonium Acetate method

Presence of International Institutions in Cyprus

As mentioned above, other than the Agricultural Research Institute, which conduct some soil activity, there are not specialised soil institutions in Cyprus, therefore efforts are being made to establish a close technical co-operation with other international soil centres.

Recently a technical co-operation between the Federal Institute for Geosciences and Natural Resources, Hanover, Germany and the Ministry of Agriculture, Natural Resources and Environment, of Cyprus was carried out. The subjects of this co-operation were:

- the study of calcareous soils, and
- the long- term erosion measurements.

The reason for carrying out these studies is due to the fact that Cyprus may be regarded as being the most representative country of the Eastern Mediterranean with its typical Mediterranean soils and climate.

The first project started in 1981 and was completed in 1986 and the second was initiated in 1988 and completed in 1998 (Michaelides and Krone, 1999).

The results of the projects have shown the following conclusions.

Calcareous soils

- Results from five-years measurements indicates that about 36% of the total area of Cyprus is categorised as slightly to high calcareous;
- The available rooting volume is limited by the underlying strata;
- The high $CaCO_3$ content and the silt fraction reduce infiltration rates and enhance water erosion;
- Calcium concentration in the soil solution inhibits phosphorus and nitrogen uptake.

Long- term erosion measurements

- Many parts of Cyprus are characterised by severe topsoil erosion losses and the most fertile part of the soil has been subject to soil loss caused by water (heavy rainfall) and human induced factors (deforestation, and cultivation of marginal land);
- Loss of soil is higher under no vegetation cover conditions. After the vegetation cover has been removed, it makes little difference whether

initial plowing was up and down the slope or across the slope;

- High erosion hazards are more severe for calcareous soils than for non calcareous soils;
- Soil loss is proportional to the intensity of rainfall and not the quantity of rain.

At present, no project or any other form of close collaboration is in progress. The Cyprus delegation therefore, welcomes the idea of this Euro-Mediterranean Network of Soil Information and is committed to be an active partner of the Network.

Conclusions and Suggestions

- The establishment of an efficient and permanent Euro-Mediterranean network on soil information for regional and international collaboration is a much needed requirement;
- We support the approach for a common soil information system on which all members agree. We understand that the European Soil Bureau of the European Commission will provide the required methodology;
- The definition of uniform guidelines for soil mapping, sampling, analyses etc and the same soil classification system that will be used will facilitate the efforts for the establishment of a "common soil language";
- The sustainable use of land and environmental protection must be a true challenge for planners and decision-makers at all levels;
- All the existing institutions and research centres in the region dealing with soil science can be used as the basis for further co-operation;
- Technical and financial support is required for those countries that are interested to collaborate with the European Union;
- Uniform laws concerning the copyright on soil data and maps provided to the Euro-Mediterranean Network should abide all the countries;

- For small countries like Cyprus, it is recommended not to adapt in soil mapping smaller scales than 1:250,000 for their national territory.

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Agro-pedological Studies in Algeria

Mohamed Ramdane[1]

Introduction

Man has been connected with soils in Algeria since he became a farmer several thousands of years ago. For a long time, knowledge on soil has been especially related to its fertility, irrigation and drainage, liming of acid soils and extension of agriculture to new lands.

The Russian soil scientist Dranitsyne (1915) was among the first researchers who started a scientific study on soils in Algeria. He was one of those who identified, at the beginning of the past century, the red soils, the solonchaks, the rendzinas, the waterlogged soils and, on mountain areas, the podzols. His classification of Algerian soils is still much close to the present one.

C.F Marbut (1923), the American naturalist and soil scientist, follower of Dokuchaev ideas on soil formation, showed the extension of chestnut soils in Algeria. In 1948 Z.Y Chokalskaya, made a synthesis of the knowledge of that time on the soils of Africa in general, and of Algeria in particular. In her monograph, she describes 3 major types of soils: chestnut soils, mountain forest soils (brown and light brown) and brown-red soils. She highlights also the presence of podzols, of saline and alluvial soils.

In the 40’s De Villars, studied in detail the soils of Algeria. He was mainly concerned with the pedogenesis of the Grande Kabylie soils and the formation of Vertisols.

One should appreciate the great contribution of I.P Guerassimoc for the study of soils of Algeria. In

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1949, he distinguished the brown forest and maquis soils as a peculiar genetic type. He classified most of chestnut soils of Marbut among the brown and grey-brown soils. In his opinion, calcareous brown soils prevail in the north of the high plateau whereas the grey-brown soils with calcareous crust in the south. He also identified the grey-black soils - or the *touares*.

The scientific study of Algerian soils has developed greatly only after the setting up of the *Bureau des Etudes Scientifiques* on May 15, 1961. J.H. Durand made an important research work on the soils of Algeria and their classification. He distinguished 25 main types of soils and subdivided them into 2 groups: zonal and azonal. Durand recognised the great importance of red soils and classified them separately by subdividing into terra rossa, carbonate red soils, yellow red soils and rubified red soils. He was among the first pedologists to identify podzolic soils developped on non-calcareous permeable rocks and on impermeable silico-aluminate rocks. He established also a map of Algerian soils at the scale 1:500,000 and a map of red soils and crusts.

Scale of studies

Pedological studies were made at different (medium and large) scales. The medium scale studies (1:100,000, and 1:50,000) are generally those that allow determining large units of soils and their major morphological characters. They are generally accompanied by a complete study of natural factors of soil pedogenesis (geomorphology, vegetation, and climate), with specific emphasis on favourable or limiting factors of land management. These types of soil surveys allow establishing soil suitability maps for different crops and provide information in view of land and water development projects. They are very important for any regional management plan (development of the steppe areas, setting up of irrigated schemes, etc).

A large-scale soil map (1:20,000, 1:10,000) often follows the medium scale soil mapping. These types of soil surveys provide useful information for the suitability of soils for different crops and focus mainly on the following characteristics: texture, structure, soil depth, presence of crust or crusting, salinity, waterlogging, etc. These soil data are used for land and water development projects.

In Algeria, about 5,400,000 ha were studied at scale 1:100,000 and only 38,366 ha at scale 1:10,000. More than one million hectares were surveyed at 1:50,000 scale and 557,358 hectares at the scale of 1:20,000. The Oranic, the Chéliff-Mina and Algiers are the most important surfaces studied at the large and medium scale (1:20,000, 1:50,000). The other regions (Soummanm, Chot-Chergui, Zahrez-Sersou, Hodna and others) are essentially mapped at scale 1:100,000. Within these regions there are areas surveyed at the scale of 1:50,000 and 1:20,000, however they cover quite smaller surfaces (less than 100,000 ha). Out of the 13 regions that constitute Algeria, only in 6 regions some small surface areas were studied at scale 1:10,000. Hydraulic planning of these areas was the main reason for such detailed surveys.

Soil Classification

Soils were studied and classified in Algeria according to the soil classification system used by A.N.R.H., which is based on the French classification. The system is adapted however to the conditions of Algeria and reflects the experience acquired by several soils scientists who worked in Algeria and in North Africa. The major classification units are the class, the sub-class, the group and the sub- group. They are used in generalised studies and for small-scale maps.

Ch Killian., G. Aubert, J. Buolaine., J. Bricheteau , G. Gaucher and P. Dutil were some of the French pedologists who contributed the most to the study of soils before the independence of the country.

Ch. Killian studied especially the red soils. G. Aubert studied calcareous crust soils and salt-affected soils. He prepared also an agro-pedological map at scale 1:20,000 and the map of saline soils of Relizane plain.

J. Boulaine made several research studies on Algerian soils. The most important of them is his impressive monograph: "Study of Chelif plain soils". He also studied the soil forming factors of Relizane plain and Oued Rhiou soils.

G.Gaucher also studied the soils of the plains of Relizane and Oued Rhiou, as well as those of the Sig region. Other pedologists to be mentioned are J. Brichteau who made a draft study of the soils of Tlemcen-Ternni region and P. Dutil who was one of the rare pedologists who dealt with the soils of Aurès and Sahara.

It is to be noticed that during the colonial period, only the large agricultural plains with a high presence of Europeans in the north of the country were pedologically studied. The other regions were simply ignored.

Since the attainment of independence, the institution that succeeded the Service of Scientific Studies - the present *Agence Nationale des Ressources Hydrauliques* (ANRH) - started setting up a detailed inventory for soil resources. Important pedological studies were made between 1963 and 1986. They were carried out by both Algerian pedologists and foreign specialists invited within the framework of co-operation.

These pedological studies have practically covered all the northern plains. In the high plateaux and Saharian Atlas, relatively important surfaces were surveyed and mapped. In the Sahara, soil studies were carried out essentially in the oases and around the wells and the water points.

The total mapped surface area exceeds 7 million hectares. The surface of inventoried soils reaches 6.5 million hectares, of which 1,347,000 hectares are suitable for irrigation and 1,060,000 ha are covered with saline soils.

The lower levels of soil classification include the family, the series, the type and the phase. They allow a more detailed description of the soils and are used in the medium and large-scale mapping

The main classes of soils identified in the pedological studies are:

- Class of row mineral soils
- Class of poorly evolved soils
- Class of calci-magnesic soils
- Class of vertisols
- Class of iso-humic soils
- Class of iron sesquioxide soils
- Class of waterlogged soils
- Class of salt-affected soils

Soil-crop suitability and land capability classes

In all agro-pedological studies performed in Algeria, specific reports that show crop suitability for different types of soils accompany the soil maps. . Crop suitability maps (under dry and/or irrigated farming) are established for groups of crops: cereals and fodder, vegetables, industrial and shrub crops.

The main properties of soils considered for establishing crop suitability maps are: depth, texture, coarse elements, structure, pH, the presence or absence of crust or crusting, active calcium carbonates, waterlogging, and salinity.

Soils are also classified by category according to their suitability for irrigation. They are considered to be suitable on the basis of their chemical, physical and physico-chemical properties (geomorphology, topography, climate, etc), without taking into account water availability (if water is available or not). Five classes are distinguished.

Class 1

This class includes deep soils, of medium to fine texture, well structured and well drained. Topography is regular and slope is irrelevant. These soils have priority for agricultural development since they do not present major problems or constraints for the cultivation of crops. They are suitable for all the crops grown in Algeria.

Class 2

The soils of this class are generally deep or moderately deep, of medium to fine texture and well structured up to an average soil depth. There may be an impermeable layer (50-60 cm depth) that may cause the formation of a perched water table after introducing irrigation. Topography is regular or slightly undulated with low slopes.

These soils are suitable for major crops, however they posses some restrictions for some of them. They are more specifically favourable to industrial crops. Some minor land management interventions are necessary (stone removal or surface land levelling).

Class 3

This class includes deep or moderately deep soils of medium, fine or very fine texture. Soils are generally well structured down to a given depth and then can exhibit salinity or waterlogging problems once the presence of the watertable reaches approximately 1-meter depth. Topography is regular or moderately undulated and slope can be as high as 5 percent.

These soils should be used for rotational crops. Major reclamation problems are drainage and desalination to be corrected before implementing irrigation projects.

Class 4

The soils of this class have a high variability in soil depth. They are coarse to fine textured and posses poor structure properties. The presence of inclusions within these classes can be also high. Often soils could be salty or waterlogged with the presence of the watertable at shallow depth. Topography is regular or undulated and the slope can reach up to 10 percent.

This zone is often pedologically heterogeneous, with limited suitability for irrigation, therefore, they should not be included in major land reclamation projects that require drainage, desalinisation, and land levelling improvements for instance. Alternatively, dry farming is more recommended. Crop suitability of these soils is often limited to some cereal, fodder and vegetable crops.

Class 5

This category includes soils that cannot be irrigated for different reasons: urban area, oueds beds, swamps, high steep slope, mountain or uneven area, very high salinity and waterlogging problems, presence of crusts (calcareous or gypseous) at shallow depth, etc.

Major land reclamation works to be carried out for this class are land levelling, stone removal, desalination, drainage, deep ploughing, and establishment of wind breaks.

The development of agriculture in Algeria depends largely on irrigation. However, in defining the most suitable areas for irrigation, soil information and agro-pedological studies are more than necessary. The following are some descriptions for the most important hydrological regions of the country (Régions de Planification Hydraulique R.P.H.).

R.P.H. 1 – Orania

Orania is one of the most pedologically surveyed regions in Algeria. The agro-pedological studies made in this region cover a surface area of 350,000 ha. Soils suitable for irrigation cover 178,374 ha and salt-affected soils cover 44,537 ha.

Pedological studies cover almost all large plains and agricultural valleys of Orania: Valleys of

Tafina Isser (about 10,000 ha at scale 1:20,000), Telagh (40,000 ha at scale 1:50,000), Saida (14,000 ha at scale 1:20,000), Habra (20,000 ha at scale 1:20,000), Sig (10,600 ha at scale 1:50,000) Oran-Arzew (11,600 ha at scale 1:10,000) and plateaux of Abdellys (8,000 ha at scale 1:50,000) and of Mostaganem (26,000 ha at 1:50,000).

R.P.H. 2 Chelief - Mina

Agro-pedological studies in this region comprise 3 main morphological units: Chéliff valley, Mina plain and the coastal plains. They cover a total area of 176,268 ha, of which 96,850 are suited for irrigation and 41,268 ha are salt-affected soils. Most of the studies were carried out at scale 1:20,000 (140,598 ha). Some other 30,000 hectares were mapped at scale 1:100,000 (geo-morphological study of Achaacha plateau) and only 10,700 hectares were surveyed at 150,000 scale (Deurdeur plain, El Attaf and Moyen Chéliff).

The most important morphological unit is certainly Chéliff valley that includes the upper, middle and low Chéliff plains covering 85,000 ha approximately, of which 60,000 hectares consist of irrigated soils.

In Mina plain and its extensions (Sebka Ben Ziane and Guerouaou), soils suitable for irrigation cover an area of 32,392 ha. Coastal plains of Ténès-Cherchell are not very extended. Total surface area of soils suitable for irrigation is less than 3,000 ha.

R.P.H. 3 – Algiers region

In Algiers region, the total area covered by soil surveys is about 313,046 ha, of which 191,358 ha are suitable for irrigation. The main morphological units studied in this region are Mitidja plain, Algiers Sahel, Aribs-Béni-Slimane plain, the valleys of Isser and Sebaou oueds and Ouzera region (Medea).

The studies were mainly made at scale 1:50,000 (305,323 ha) while at scale 1:20,000, were surveyed 89,300 ha and at scale 1:10,000, only 16,183 ha.

The largest study is the one of Mitidja that covers 128,470 ha. It was mapped at scale of 1:50,000 and subsequently repeated at 1:20,000 scale for some small areas (East, West and Centre). The studies of Algiers, Sahel and of Aribs-Béni-Slimane plain cover each a surface of more than 40,000 ha and were surveyed at scale 1:50,000.

R.P.H. 4 –Soummam

The most important study in this region is the one carried out in 1965 by ENERGOPROJECT. It was made at 1:100,000 scale and cover 921,600 hectares, corresponding to the whole watershed of oued Soummam. A part of the watershed (250,000 ha) – the high Sétifiennes plains – was the subject of a geomorphological study at scale 1:100,000. Other parts of the watershed were equally covered by pedological studies at 1:50,000 (El Asnam plain – 4,000 ha, Soumam valley, 23,000 ha, Aïn Zada plain – 32,000, Ftaissa plain – 10,000 ha), and at 1:20,000 scale (low Soummam – 2,000 ha, Tilesdit plain – 4,000 ha) and at 1/10,000 (middle Soummam – 9,000 ha). In total, in this region 32,432 ha irrigable lands were inventoried, from which 10,442 ha are covered with salt-affected soils.

R.P.H. 5 – Constantine

A total area of 139,285 ha of soils was mapped in the Constantine region, of which, 90,166 ha are found suitable for irrigation and 4,782 ha are salt-affected soils. The studies made at 1:100,000 scale amount to a total surface of 83,885 ha (Teleghma plains – 6,640 ha, Merouana – 7,665 ha, Batna – Touffana – 58,680 ha and the watershed of Rhumel -11,000 ha). Only two studies were made at scale 1:50,000 (Bir Chouhada plains – 8,000 ha and Batna El Mahder – 9,200 ha) and at scale 1:10,000 was surveyed the Ain Djasse plain with about 9,300 ha. The remaining part, 8 studies amounting to a total of 28,900 ha, were studied at scale 1:20,000.

R.P.H. 6 Annaba

In this region, 93,873 ha of soils were mapped at different scales, which allowed assessing about 57,327 ha of lands as suitable for irrigation and 11,737 ha of as salt-affected soils. The most important studies are those of Kébir Ouest – Fetzara plains (46,000 ha at scale 1:100,000), West Annaba (6,700 ha at scale 1:50,000), East Annaba (15,000 ha at scale 1:50,000 and 6,000 ha at 1:20,000 scale), low Seybouse (6,500 ha at scale 1:50,000) and Bounamoussa (19,100 ha at 1:50,000 scale) and 5 additional studies of different surfaces at 1:20,000 scale.

R.P.H. 7 – Chott Chergui

This region is mainly pastoral while agriculture is poorly developed and dominated by cereal crops. One important soil survey was made at scale 1:100,000, for the areas of El Biodh (205,820 ha) and of Arbaouets (274,250 ha), which are to be developed for integrated pastoral management. One agro-pedological study at scale 1:50,000 was made for the Synclinal of El Bayadh (85,000 ha) and another one at scale of 1:20,000 for the Ain Skhouna scheme (7,000 ha). These studies allowed identifying 6,982 ha of soils suitable for irrigation and 47,498 ha of saline soils.

R.P.H. 8 Zahrez - Sersou

This region of high plateaux in the north where cereal growing prevails and pastoralism in the south, was studied at different scales that in total cover over 824, 941 hectares. Pedological studies were made at scale 1:100,000 on large areas (Touil and Nahr Ouassel Oueds – 71,000 ha, Sersou plateau – 400,000 ha, Aïn Oussera plain – 50,000 ha, Zahrez-Gharbi basin – 256,000 ha and Maalba-Tisselouine plain – 35,600 ha). The other studies made at scale 1:50,000 cover less than 10,000 ha and those at scale 1:20,000 cover and even less than 1,000 ha.

All these agro-pedological studies allowed identifying about 108,819 ha of soils suitable for irrigation and 32,625 ha of salt- affected soils.

R.P.H. 9 – Chot Hodna

The pedological maps of this semi-desert region cover more than one million hectares, 164,000 of which are classified as soils suitable for irrigation and 269,000 ha are covered by saline soils. Two important studies at scale 1:100,000 cover 910,000 ha (Hodna basin) and 83,000 ha (Bou Saad plain). Two additional pedological studies were performed at 1:50,000 scale (Ksob and Aïn Rich plain – 13,500 ha each) and five soil surveys at scale 1:20,000 covering a total area of 13,580 ha.

R.P.H. 10 – Medjerda – Mellegue

The surface of mapped soils in Medjerda-Mellegue region cover 316,423 ha, of which 127,778 ha are lands suitable for irrigation and 13,887 ha are salt-affected soils. Agro-pedological studies at scale 1:10,000 cover a total surface area of 187,200 ha (Aïn Beida plains – 40,000 ha, Gasses – 20,000 ha, Meskiana – 15,000,ha Morsott – Tebessa – 6,200 ha, and finally the high Constantine plains – 106,000 ha). At 1:50,000 scale, 95,500 ha were mapped (Aïn Hassainia and Sellaoua-Announa – 7,658 ha, Tebessa plains – 42,000 ha, Lutaud Chemora – 40,000 ha). Finally, six studies were made at scale 1:20,000 (49,460 ha in total) and only one at 1:10,000 scale (105 ha).

R.P.H. 11 – Aures – Nementcha (Chott Melhir)

The agro-pedological studies made in this region cover more than 700,000 ha, of which 173,000 ha are suitable for irrigation and 118,000 ha are saline soils.

Aurès-Nementcha region includes two large distinct areas:

Chott Melrhir area, and

Messad area,

In the Chott Melrhir area, the main studies are those of El Outaya plain (33,000 ha at 1:100,000 scale and 4,000 ha at scale of 1:20,000) of Khangat Sini Nadji (64,000 ha at scale 1:100,000) and Zeribet El Oued plains (184,000 ha at 1:100,000 scale).

In Messad area, two important studies were made at 1:100,000 scale: Mekhareg plain (18,000 ha) and Messad Aïn Ibel region (384,000 ha). In Aurès-Nementcha region, some other studies were made at 1:20,000 scale.

R.P.H. 12 – South Atlas

In this region, only two agro-pedological studies were made, i.e. in Brezina plain at scale 1:50,000 (19,110 ha) and at scale 1:20,000 (3,500 ha). They allowed identifying 9,772 hectares of soils suitable for irrigation and 7,543 ha of salt-affected soils.

R.P.H. 13 . Sahara

All the pedological studies made in Sahara are concentrated in its northern part. The total surface area of soils mapped in this region cover more than one million hectares, 110,000 of which are suitable for irrigation and 495,000 ha are salt-affected.

The pedological studies are subdivided in the West, in the Centre and in the East of the northern part of Sahara. In the west, there are studies at 1:50,000 scale for the valleys of Saoura (23,000 ha) and Zousfana (30,000 ha) oueds and at scale 1:20,000 for the Abadla plain (22,000 ha).

In central Sahara, the most important study is the one of Toua Gourara (256,000 ha at 1:100,000 scale). In eastern Sahara, there are four studies at scale 1:100,000 covering a total surface area of 670,000 ha: Rhir Souf oued (250,000 ha), Hassi Messaoud zone (150,000 ha), Gassi Touil area (200,000 ha), and Aïn Amenas Area (70,000 ha). Some other pedological studies, covering small areas were made also at the scales of 1:20,000 and 1:10,000.

Conclusion

Except for the far south, important pedological studies and soil surveys were made in large surface areas throughout Algeria. However, considering the extension of the country and the prospects of agricultural development, this inventory is far from being complete. A final estimation for all the lands of Algeria suitable for dry or irrigated farming is a must for the near future.

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History and Status of Soil Survey Programs In Turkey and Suggestions on Land Management

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Abstract: The history of soil survey programs in Turkey dates back to the early 1950's, with Soil Taxonomy being widely used by research centres and universities since the development of its first approximation. The FAO/UNESCO system with its recent World Reference Base has also been frequently used on many occasions and soil correlation meetings throughout Turkey. Detailed soil analyses are being undertaken in a number of research laboratories and university departments. The University of Çukurova, Department of Soil Science together with the General Directorate of Rural Affairs are conducting a study on the updating of the Turkish Soil Map using earlier reconnaissance surveys accomplished by the latter and other research establishments.

This paper also summarises the need for a sustainable land management approach based on agroecological zones, which have been developed by considering the historical indigenous knowledge of Anatolia.

I. -Introduction

The late Prof. Dr Kerim Ö. Çağlar pioneered in Turkey in the early 1950's modern research in soil science and soil survey, which was summarised in his study on "Turkish Soils". The work contained a schematic soil colour map showing 11 soil classes, which included among others, the dry and Chestnut Dark Yellowish Soils, the Mediterranean – Aegean and South East Anatolian zone of Red Soils, the North Eastern Anatolia and Eastern Black Sea Region with Black Soils (Çağlar, 1958).

Oakes (1958) undertook another soil survey work, which yielded to a soil map of 1:800.000 scale. This reconnaissance survey, which was accomplished in a relatively short period of time, was based on the geologic and topographic maps of the country comprising also soil analyses for selected Great Soil Groups. The author classified the Turkish soils according to Baldwin et al's (1938) Soil Classification System with mapping units showing soil phases such as slope, stoniness, drainage and salinity.

In the early 1960's, the task of classifying and mapping soils in Turkey, to be accomplished at a more detailed level than in the past, was conveyed to the former General Directorate of Soil and Water (GDSW) or the present General Directorate of Rural Services (GDRS). These studies were meant to be part of the small-scale reconnaissance soil map of Europe, which was prepared from 1966 to 1971 using 1:25,000 scaled topographic maps. For more detailed work on land use planning, the Great Groups established according to Baldwin et al (1938) system, together with selected phases, were used for provincial (1:100,000) as well as basin mapping purposes (1:200,000).

The primary soil studies using the earlier version of Soil Taxonomy (Soil Survey Staff, 1975) were accomplished by De Meester (1970) and Boxem and Wielemaker (1972) on the Konya Plain (Central Anatolia) and the Küçük Menderes Valley (Western Anatolia) respectively. From 1973 to 1984, many soil survey reports of the GDRS enabled planners to develop the strategies needed for solving problems related to land use planning and accomplishing the proper legislation (State Planning Office –SPO, 1973; 1979; 1984) and 1995 (Official Gazette, 1995).

However, land use legislation was rarely applied in reality due to political reasons, as well as uncoordinated actions by the government agencies. This caused the mismatch between land quality (LQ) and land use (LU) resulting in land resource consumption (Kapur et al. 1998; Cangir et al, 2000) and increasing land degradation in the country. The following are some examples of land degradation resulting from the mismatch between land quality and land use.

a) The whole urbanised and industrialised Kocaeli region (Western Turkey), is based on areas prone to earthquake occurrence risks (with 20,000 casualties of the 17th August 1999 earthquake) (Cangir et al. 1999; Ekinci, 1999), which are the fertile lands that could have been used for agricultural development.
b) The historical Mersin City (on the Mediterranean Coast, Southern Turkey) (Dinç et al, 1996) has had its major and significant expansion in the last 3 decades. Almost all of its surrounding fertile arable lands were used for urban buildings. The city area increased approximately 4.3 times from 1963 to 1975, 3.6 times from 1975 to 1993 and 15.7 times from 1963 to 1993.
c) The cotton textile industry, as well as the urbanisation in Kahramanmaraş (Southwest of Turkey), has consumed high quality agricultural lands throughout the province. The city was established about 3,000 years ago and historical records suggest that the city area was about 28 ha in the 15th century. In 1950, the area was about 200 ha and increased to 1,800 ha by 1978. The GDRS study (1996) showed that the current area is about 3,300 ha. Almost all the changes in 1985 resulted in the reduction of surface areas of Land Capability Classes (LCC) I, II and III (Gündoğan et al, 1999).

Similar other examples of misuse could be given for other areas throughout the country. They all indicate the deficiency in the application of legislation and lack of co-ordination.

The General Directorate of Rural Services is the responsible government agency for soil survey and mapping. Using the GDRS maps and making translations to the USDA Soil Taxonomy new versions (Soil Survey Staff, 1975 and 1999) has been the usual practice for many Turkish Universities. However, it is primarily the Department of Soil Science of the University of Çukurova in Adana that provides the major contribution in mapping and soil survey. The Department works in close collaboration with the Working Group on Land Degradation and Desertification (WGLDD, Secretariat at the Çukurova University) of the International Union of Soil Sciences (IUSS) and European Soils Bureau (ESB) Network initiated by the CIHEAM-Bari of the European Union. Other soil surveys and land use studies are also undertaken by the Soil Science Departments of the Universities of Aegean and Ankara.

II. - Institutions and research centres on soils in the country

Over the last three decades, soil surveys have received particular attention especially for the purposes of land use planning and the sustainable management of natural resources.

Turkey has a total land area of 78 million ha. About 28 million ha are used for arable farming, however the farmland is threatened by a rapidly growing gigantic transportation and construction industry which is in need of large spaces, mainly on prime soils that have access to marketing centres and metropolitan areas.

Thus, the country is primarily in need to consider the re-establishment and renovation of the previously functioning Soil Survey Service transformed as the GDRS. The major emphasis should be given towards the development of interdisciplinary management plans for the different agro-ecosystems of the country.

The renovation of the soil survey activities of GDRS in Turkey could follow the example of the earlier Macaulay Soil Research Institute (MSRI) to its updated version of the Macaulay Land Use Research Institute (MLURI) in Aberdeen, Scotland. The Ministry of Agriculture and Forestry, and GDRS are also linked with long-term research and monitoring sites and stations with some of them described below:

- The GDRS Karapınar Erosion Control Station (Central. Turkey) with a current project undertaken on the “Biodiversity, Soil Development and Monitoring of Land Degradation versus Husbandry Conservation” (Akça et al. 2000). The monitoring part concerns a span of 35 years of reclamation of the Karapınar Desertification Site and aims to develop measures of land degradation versus sustainable land use.

- The Akyatan Lagoon Agroforestry Project, which investigates the attributes of soil development on sand dunes in relation with tree associations of the area. A significant part of the project is linked to economic analyses (Baki et al, 1998; Tatar et al. 1998; Serteser, 1999).

The General Directorate of Rural Services (GDRS)

The GDRS is the responsible government agency for all the aspects of rural development. Its main tasks are soil survey and mapping, watershed management, development of rural and agricultural infrastructure, roads, drinking water, and management of sewage system in rural areas. The agency has set up a network of twelve Research Institutes and has trained a scientific staff needed for addressing agriculture services, and specifically emphasising on environmental protection.

The present GDRS activities and responsibilities in the area of soils are to sustain soil and water management, monitor soil fertility of agricultural soils, make environmental impact assessments, and create the national soil database. To foster these activities, within the GDRS, in 1999 were established the National Information Centre of Soil and Water Resources. This centre is now digitising available soil maps at scale of 1:25,000 and is setting up the national database for soil and water resources.

The Çukurova University

The Department of Soil Science of the University has carried out soil surveys of the Çukurova region (337,000 ha, 1:25,000 scale) and Northern Cyprus (326,000 ha, 1:25,000 scale). To accomplish these surveys, additional information was obtained from the Remote Sensing Laboratory of the University, which is equipped with the latest software and hardware technology.

In addition, in collaboration with the State Farms Agency, the University has surveyed a total of 24 State Farms of the Ministry of Agriculture (361,980 ha, 1:25,000 scale) together with 14 basins (853.188 ha) of the Southeastern Anatolian Irrigation project area (Turkish acronym GAP Project) funded by the GDRS. The only maps available in digitised format at 1:25.000 scale at present are from the GAP area and are prepared by the GDRS and the University of Çukurova (Dinç et al. 1993).

GDRS's National Information Centre of Soil and Water Resources and the Çukurova University are jointly preparing the most recent project which will utilise a bottom-top approach, making a synthesis for the GAP area of the earlier GDRS soil maps of 1:25.000 scale with a final product of 1:1.000.000 scaled map. The project to be accomplished by the year 2003 will comprise translation of the most recent version of the Soil Taxonomy (Soil Survey Staff, 1999), FAO (FAO/UNESCO, 1990) and WRB classifications (FAO-ISRIC-ISSS, 1998). The first stage of the project ie preparation of the Soil Typological Unit (STU) map based on the WRB for the ESB (Lambert et al. 2000) soil database has already been completed.

Further on, the Department of Soil Science of the University of Çukurova has accomplished several soil survey studies related to environmental management. These include the coastal-wetlands (Silifke Natural Park and Akyatan lagoon), karstic zones (Kızkalesi Archaeological Park), mountainous regions (Taurus Mountains), and sites with significant type of soil moisture regimes as the GDRS's Karapınar Erosion Control Station (13,000 ha).

The General Directorate of State Hydraulic Works

The Agency has completed maps at the scale of 1:25.000 showing soil suitability for irrigation of several large basins of the country. These maps have been successfully used in water management of these basins.

The Aegean University

The Department of Soil Science of the Aegean University has undertaken local soil surveys of the Küçük and Büyük Menderes Basins of the Aegean Region (Western. Turkey), as well as the preparation of the salinity map of these basins. A recent task undertaken by the Department is the assessment of the management parameters for the deltas of the Aegean Region. A research group is conducting erosion studies, assessing the movement of the sand dunes and its environmental impacts.

The Ankara University

The initial studies on soil surveys in the country using the Baldwin et al (1938) system of soil classification were started by the Agricultural Faculty of Ankara University. Presently, the Department of Soil Science of the Faculty is affiliated in many countrywide studies aiming the assessment of soil erosion and its impact on the environment. Specific studies are being performed in collaboration with the GDRS. They include the preparation of soil and land use maps of the Beypazarı region (Central Turkey) and the Çubuk Basin (Central Turkey).

III. - Laboratory methods used for soil analyses

Laboratory methods used for soil analyses by the GDRS and Universities are as follows:

- Particle Size Distribution Analyses by Bouyocous (1962)
- pH in 1:1 and 1:10 soil water, soil $CaCl_2$ solution, Soil KCl solution
- Calcium Carbonate, by Schlichting and Blume (1966)
- Cation Exchange Capacity, by U.S. Salinity Laboratory Staff (1954)
- Organic Carbon, by Schlichting and Blume (1966)
- Total Nitrogen, by Kjeldahl (Bremner, 1965)
- Free iron oxides, by Jackson (1979)
- Clay minerals, by Jackson (1979)
- Micronutrients, by Lindsay and Norwell (1978)
- Available P, by Olsen (1954)
- Salinity, by U.S Salinity Laboratory Staff (1954)
- Micromorphology analyses, by FitzPatrick (1993)
- Microbiological analyses (Black, 1965)
- CO_2 production (Black, 1965)
- Dehydrogenase (Black, 1965)
- Saccaraze enzyme activity, by Hoffman and Pallauf (1965)
- Total and denitrification bacteria count, by Tomlinson-Hochstein (1972)
- Mineral nitrogen content (Black, 1965)
- Nitrate, by Fabig et al (1978)
- Nitrite, by Nicholas and Nason (1957)
- Ammonium, by Deutche Einheitsverfahren (1983)
- Bulk density (Black, 1965)
- Porosity and pore size distribution (Vomocil, 1965)
- Saturated hydraulic conductivity (Klute, 1965)
- Unsaturated hydraulic conductivity (Klute, 1965)
- Infiltration rate (Bertrand, 1965).
- Potassium (Pratt, 1965)
- Gypsum, by X-ray powder diffractometry

IV. - Major soil constraints and their impact on agricultural production and on the environment

There certainly are numerous problems related to environmental quality and land degradation occurring nationwide on the intensively cultivated 28.053.000ha of land. The implications of environmental degradation and constraints on agricultural productivity can be listed as follows:

soil erosion is a menace in almost 73.8% of the cultivated land accelerated by the average elevation of Turkey which is about 1,100m. The process has started since the Neolithic period (app. 8,000 years BP), with increased paces during the Greek, Roman, Byzantine and Ottoman periods. Erosion is quite severe especially on the widely extensive sloping lands with shallow soils.

Urbanisation remains the biggest threat to the fertile farmland of the country. Land resource consumption, resulting from the mismatch of land quality with land use, such as occupation of prime land by urban buildings and infrastructure, is more evident than ever.

Loss of bio-diversity resulting from the misuse of agricultural marginal lands, such as wetlands, sand dunes, and conservation areas.

Exploitation of soil as a non-renewable resource by the construction industry, namely as a) dam wall filling material, b) brick production by quarrying and land stripping.

Excess use of fertilisers leading to:

- soil and water pollution;
- over exploitation of limited phosphorous resources which are expected to be depleted in the near future following the probable extinction of world P resources;
- decrease of soil chemical quality by occupation of exchange sites of lattice clays;
- development of micro-nutrient deficiencies;
- accumulation of Cd,
- decrease of the biological quality of the soil by impeded activity of mycorrhiza.

Overgrazing, cultivation and stubble burning, causing the destruction of soil organic matter and reduction of biological and physical soil qualities by loss of biomass, soil organic carbon and soil structure destruction together with the enhancement of atmospheric carbon.

Over irrigation, causing salinity and destruction of soil physical properties.

Irrigation of steppe-mild aridic lands in Central and East Anatolia (Newhall, 1972) causing interferences in the hydrologic cycle since the Neolithic.

Irrigation of indigenous tree crops, like olives and pistachio causing destruction of soil structure and resistance to erosion, reduction of mycorrhizal activity, decreased resistance to disease and disturbances in the hydrologic cycle.

V. - Suggestions for optimal soil and crop management

The highly variable climate and topography of the country is responsible for the development of a wide range of soil types. For example, in the Black Sea region, there are areas with annual precipitation of more than 1,600 mm. Consequently Spodosols/Podzol and Ultisols/Podzoluvisol-Acrisol occur, whereas the Central part of Turkey has places averaging 200 mm/year precipitation, which is characteristic for the formation of Aridisols/Cambisol-Calcisol.

In between these two extremes, Entisols/Leptosol - Fluvisol, Vertisols/Vertisols-Fluvisols, Inceptisols/Cambisol - Calcisol - Andosol, Mollisols/ Cambisol-Calcisol - Kastanozem, Alfisols/Luvisol and rarely Histosols/Histosol are distributed throughout the country. Therefore, the land use concepts should be based on the variability and quality of soils, along with climatic and topographic properties. Other important aspects impacting the natural ecosystems, such as population pressures, marketing and industrial development, are to be considered as well. Thus, the determination of agro-ecosystem/agro-forestry zones for Turkey could denote the following belts, which could stand against the misuse of natural resources (Eswaran, et al. 1996, 1998) (Figure1);

The tea - hazelnut zone in the Black Sea region (Northern Turkey) characterised by acid soils (Ultisols/Podzoluvisol-Acrisol and Spodosols/Podzols).

Barn feeding and/or limited rangelands. - Oak Forest belts in the Central and Eastern regions of Turkey, on marly steppe soils (Inceptisol-Mollisol/Calcisol-Cambisol) and Entisols – Andisols/Leptosol - Andosol) respectively.

Olive, pistachio, carob, and almond tree belt in the Mediterranean, Aegean regions (West, South and Southeast Turkey) (Mollisols-Alfisols-Inceptisols-Entisols/Cambisol-Luvisols-Calcisols-Leptosols).

Cereal belt, Barn feeding and/or limited range lands in Central Turkey on Mollisols/Cambisol-Calcisol, Vertisols-Aridisols-Inceptisols/Vertisol-Fluvisol-Cambisol-Calcisol.

Vineyard and fig tree belt in the Aegean Region on Alfisols-Mollisols and Entisols/Luvisol-Cambisol-Calcisol and Leptosol.

Cotton, maize belt in South and Southeast of Turkey on Vertisols/Vertisol-Fluvisol.

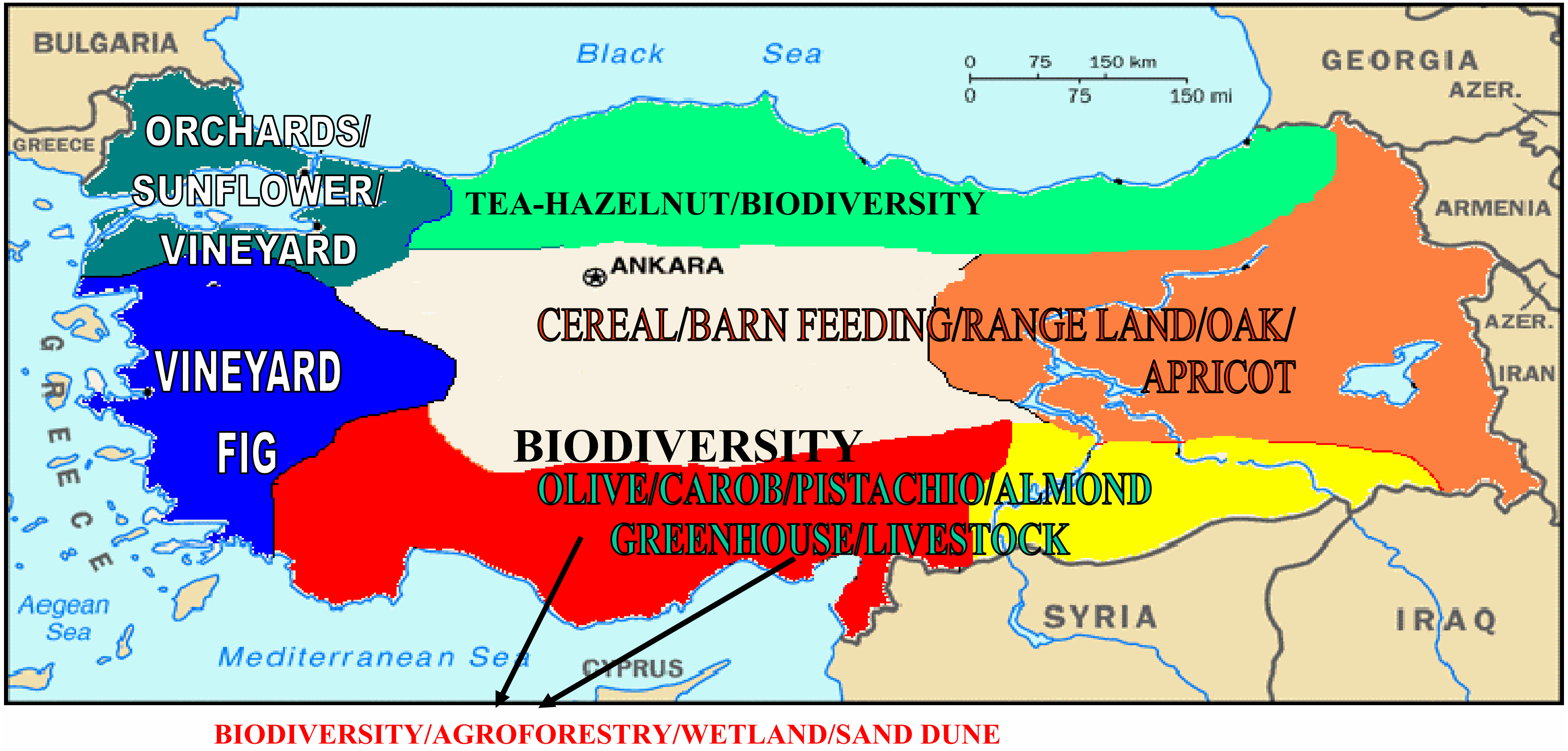
Greenhouse, livestock farming on Mediterranean vegetation (maquis of oak/carob/pistachio/olive/myrtus) in the karstic ecosystem of the Mediterranean region of Turkey on Alfisols-Entisols and Mollisols/Luvisol-Leptosol and Cambisol.

Biodiversity, agroforestry in the wetland / sand dune ecosystem with tree vegetation (Pinus pinea, Acacia cyanophylla) in the South and West of Turkey on Entisols/Leptosol-Fluvisol.

Orchards/vineyards and sunflower belt in the Northwest of Turkey on Mollisols and Vertisols/Cambisol and Vertisol-Fluvisol.

Preservation of indigenous technical knowledge (ITK) and crops available since the Neolithic period against the so-called cash crops of high income is very important. This could be done in collaboration with International Institutes and Research Centres.

Figure 1. AGROECOLOGICAL ZONES OF TURKEY



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