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Dudeen B.

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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.

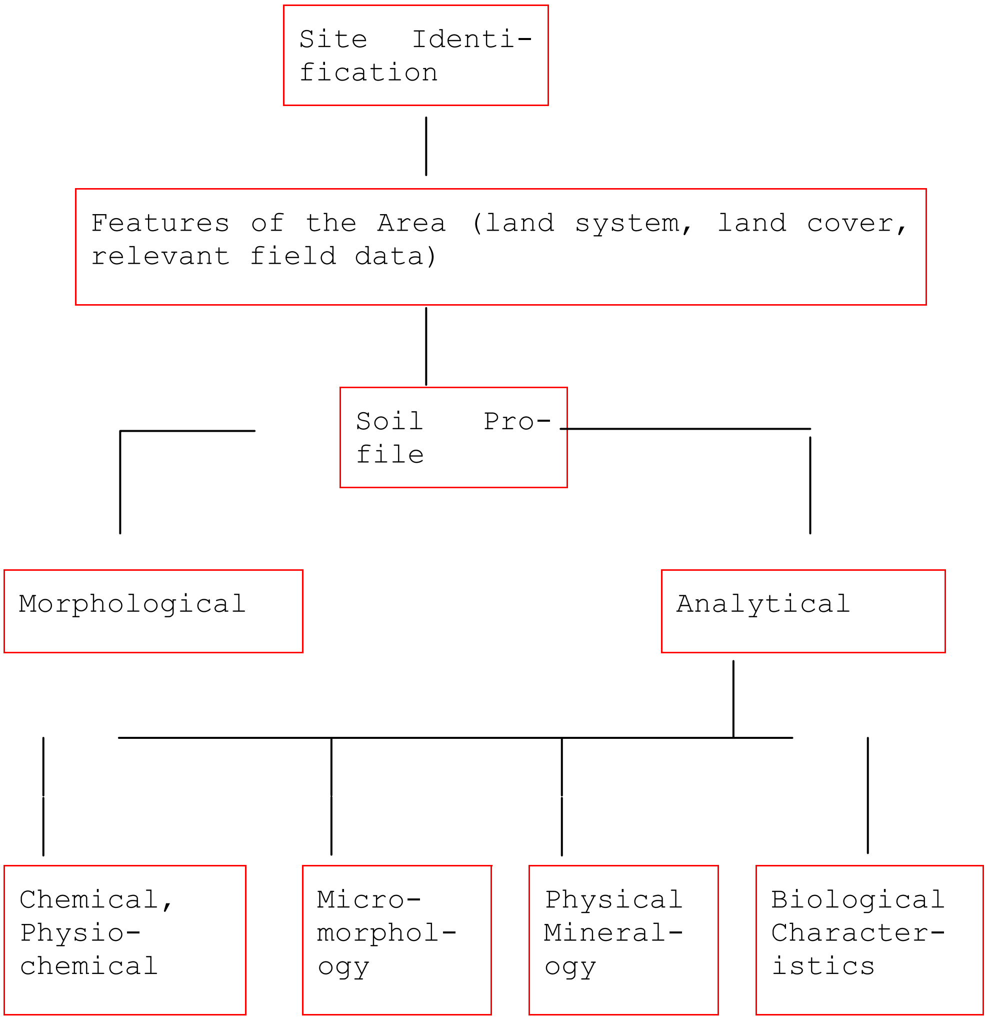
The morphological characteristics of each profile are examined for classification purposes according to the attached field sheet. The boundaries of each mapping unit were drawn on aerial photographs at a scale of 1:10,000 for Jericho and Gaza areas and at a scale of 1:25,000 for Hebron area. The soils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