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in

Zdruli P. (ed.), Steduto P. (ed.), Lacirignola C. (ed.), Montanarella L. (ed.).
Soil resources of Southern and Eastern Mediterranean countries

Bari : CIHEAM
Options Méditerranéennes : Série B. Etudes et Recherches; n. 34

2001
pages 159-170

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

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Introduction

Following the "Euro-Mediterranean Forum on Cooperation 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 georeferenced 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 capabil-

ity 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 Begaa…	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 op-

portunity 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.

References

Atallah, T., Darwish, T. and M. Moujabber (1999). Modality of fertigation of protected cucumber and nitrogen use efficiency under field conditions. International Atomic Energy Agency TECDOC XXX:41-50 (in English).

Boukheir, R. (1998). Apport de la Teledetection et du SIG pour la gestion de l'erosion hydrique du sol dans la Region cotiere du Liban; Projet pilote: Jbail-Qartaba. Memoire DEA. AUPELF-UREF. Beirut (in French).

Darwish T. (1986): View on the genesis of Rendzinas soils of Lebanon. Lebanese Science Bulletin, V.2 (2) 45-56 (in French).

Darwish T. (1987): The fertility criteria of Rendzinas soils in Lebanon. Bulletin of Institute of Pedology "Dokoutchaev", Moscow. XL, 12-15 (in Russian).

Darwish T., Gradoussov B., Sfeir S. and L. Abdel Nour (1988a): The mineralogical and chemical composition of clay and the characteristics of mountain soils in Meten-Chimaly area, Lebanon. "Pochvovedenye" N.4, 85-95 (in Russian); and Soviet Soil Science 20 (6), 86-96 (in English).

Darwish T., Gradoussov B., Sfeir S., and L. Abdel Nour (1988b): Regional peculiarities of pedogenesis in Oriental Middle East. Lebanese Science Bulletin, V.4 (2), 65-74 (in French).

Darwish T. Nimah M. and T. El Massri (1995): Mineralogical composition of some Lebanese Mountain Inceptisols. Third International Meeting on Red Mediterranean Soils. May 1995, Chalkidiki, Greece: 134-136 (in English).

Darwish, T. and Zurayk, R. (1997). Distribution and nature of Red Mediterranean Soils in Lebanon along an altitudinal sequence. CATENA 28 (1997) 191-202 (in English).

Darwish, T., Haddad, T., Faour, G., and M., Abouda-her. (1999a). Environmental changes due to land use changes in Tripoli area, North Lebanon. 6th International meeting on Soils with Mediterranean Type of Climate. Barcelona, Sopain, 4-9 July, 1999: 845-847 (in English).

Darwish, T., Atallah, T., Hajhasan S and A. Chranek (1999b): Water and N Fertilizer Utilization of Spring Potatoes in Central Beqaa, Lebanon. International Atomic Energy Agency TECDOC XXX: 51-62 (in English.

FAO (1969). Enquete pedologique et programmes d'irrigation connexes. LIBAN. Rapport Final, Volume II. Pedology.375p (in French).

FAO-ISRIC-ISSS. 1998. World Reference Base for Soil Resources (WRB). World Soil Resources Report 84, FAO, Rome.

Faour, G. R. Boukheir, T. Darwish, A. Sha'aban, and M. Khawlie (1999). Risk assessment of soil water erosion in the Karstic area of Lebanon. 6th International Meeting on Soils with mediterranean Type of Climate. Barcelona, Spain, 4-9 July, 1999: 634-636 (in English).

Geze, B. Carte de reconnaissance des sols du Liban au 1/200.000. Beyrouth, 1956. Avec notice 52p (in French).

Huyberts, E. (1997). L'occupation de la cote Libanaise. Observatoire des recherches sur Beyrouth et la reconstruction. Lettre D'information, N 10: 19-23 (in French).

Khatib, M. N. Darwish, T. M. and Mneimneh, M. A. (1998): Anthropologic soil salinization in the Lebanese Arid Region. International Symposium on Arid Region Soil. Izmir, Turkey. 21-24 September 1998: 136-143 (in English).

Lamouroux, M. (1968a). Les sols bruns et les sols rouges partiellement brunifies du Liban. Cah. ORSTOM. Pedology, N1:63-93 (in French).

Lamouroux, M. Paquet, H. Millot, G. and Pinta, M. (1968b). Note preliminaire sur les mineraux argileux des alterations et des sols mediterraneens du Liban. Bull. Serv. Cart. Geol. Als. Lor. V.20 (4): 227-292 (in French).

Lamouroux, M. (1971) Etude des sols formes sur roche carbonatees. Pedogenese Fersiallitique au Liban. These. Publication ORSTOM. 314p (in French).

Osman, A. (1974). Quelques aspects pedogenetiques sur basalte sous les conditions Mediterraneannes. MAGON, I.R.A.L. Publication N 53.21p (in French).

Ryan, J. and Ayubi, A. G. (1981). Phosphorous availability indices in Calcareous Lebanese Soils. Plant and Soil, 62:141-145 (in English).

Sayegh, A. Kazzakah, K El-Khatib A. Sfeir, S. and M. Khawlie (1990). Soil mineralogy of Lebanon. SRLWDD. FAO. 71P (in English).

Tarzi, J. and R. Paeth (1975). Genesis of a Mediterranean Red and a White Rendzina soils from Lebanon. Soil Science. 120:272-275 (in English).

Verheye, W. (1973). Formation, classification and land evaluation of soils in Mediterranean areas, with special reference to Southern Lebanon. 122p (in English).