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Agriculture and Soil Survey in Egypt

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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.

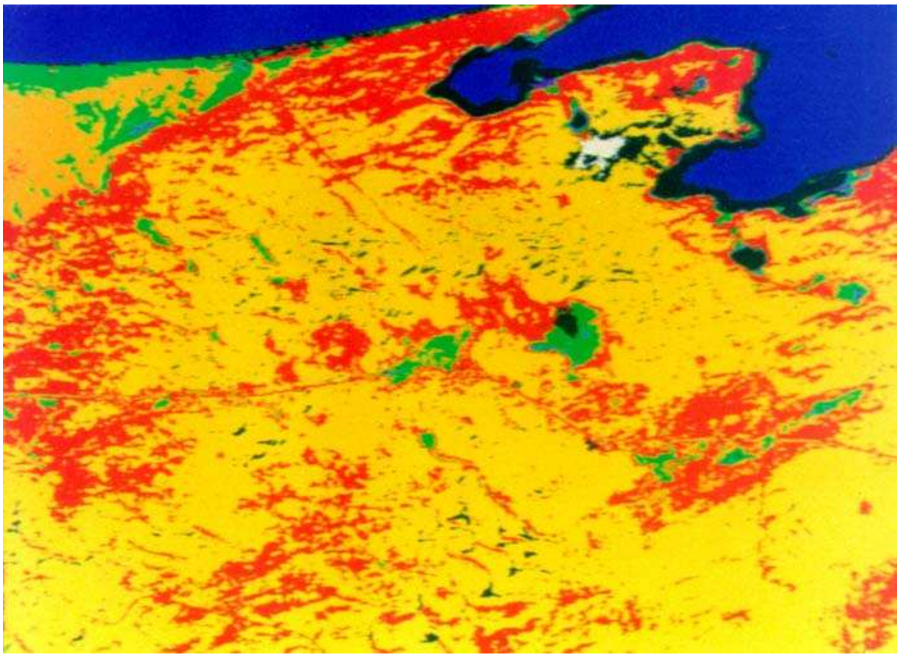

Photo 2. Parallelepiped classification of the foreshore line of North Sinai.

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.

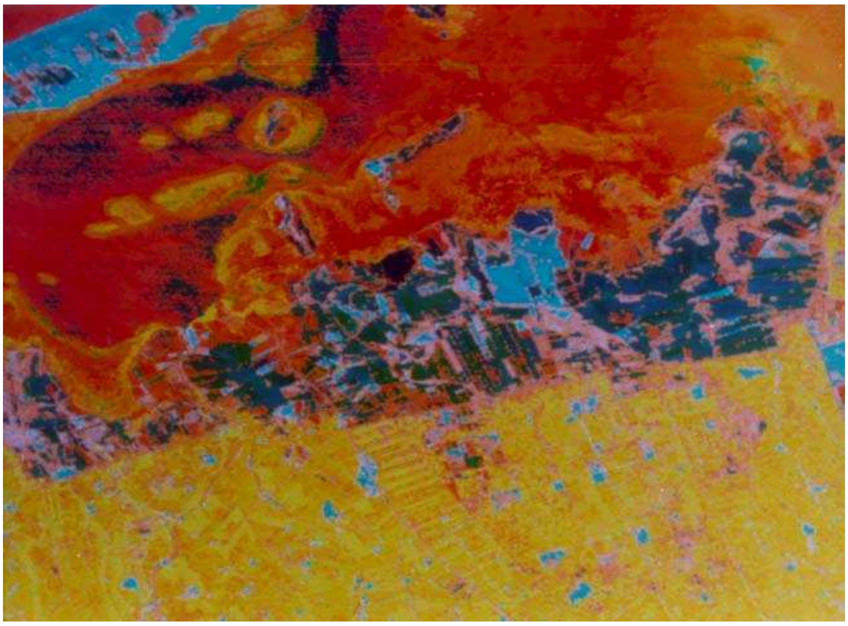

Photo 3. PCI image processing of the northern part of the Nile Delta

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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