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# Status of Soil Survey and Soil Information System in Morocco

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## Introduction

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

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

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

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

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

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

## Status of soil survey

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 1. Major soils types encountered in Morocco.

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

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

## Major soil constraints affecting sustainable agricultural production and development

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

## Soil erosion

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

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

## Soil depth

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

## Soil quality changes in irrigated perimeters

Many studies conducted in the irrigated perimeters have shown that irrigation leads generally to soil and water quality deterioration. The major degra-

dations are: secondary salinisation, surface sealing, ground water recharge by drainage water, rising of saline groundwater, reduction of soil drainage, soil compaction, and loss of organic matter.

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

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

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

## National soil database system

### Soil inventory database

Although the importance of soil information was recognised from a long time, the availability of

data on soils was always difficult to get and to use. A special effort therefore was made by the Ministry of Agriculture to establish a database for all the soil information available.

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

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

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

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

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

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

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

## Agro-ecological zoning

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

## SOTER map of Morocco

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

The map prepared should be considered as an exercise to be familiar with SOTER procedure. It needs more refinement and more data especially for the South and the eastern parts of Morocco, where soil information is scarce. Training of pedologists on SOTER procedure and its application is still neces-

sary to be able to establish a complete database at a more detailed scale.

The Moroccan soil information system needs to be improved by:

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

## Map projection used in Morocco

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

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

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

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