A GIS EVALUATION OF SOIL AND WATER MANAGEMENT FOR SUSTAINABLE AGRICULTURE IN EL FAYOUM GOVERNORATE, EGYPT

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BY

MAHMOUD ALI ABDELFATTAH ABDELRAZEK

B. Sc., (Soil Science), Cairo University, El Fayoum Branch, (1991)

M. Sc., (Soil Science), ITC, Enschede, The Netherlands, (1998)

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Cairo University

Supervised by:

1- **Prof. Dr. El Sayed Abd El Hay Khater**
Prof. of Soil Sci. and Vice Dean, Faculty of Agriculture at El Fayoum, Cairo University.

Signature: E. A. Khater

2- **Dr. Mahmoud Mohamed Shendi**
Associate Prof. of Soil Sci., Faculty of Agriculture at El Fayoum, Cairo University.

Signature: M. M. Shendi

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Approved by:

1- **Prof. Dr. Hassan Hamza Abbas**
Prof. of Soil Sci., Faculty of Agriculture at Moshtohor, Zagazig Univ.

Signature: H. H. Abbas

2- **Prof. Dr. Shawki Ahmed Sadek**
Prof. of Soil Sci., Faculty of Agriculture, Cairo University.

Signature: Sh. A. Sadek

3- **Prof. Dr. El Sayed Abd El Hay Khater**
Prof. of Soil Sci. and Vice Dean, Faculty of Agriculture at El Fayoum, Cairo University.

Signature: E. A. Khater

4- **Dr. Mahmoud Mohamed Shendi**
Associate Prof. of Soil Science, Faculty of Agriculture at El Fayoum, Cairo University.

Signature: M. M. Shendi

Date: 27 / 6 / 2002

ABSTRACT

The current study was carried out on the soils of Sinnouris District, El Fayoum Governorate, Egypt. The studied area lies between latitudes 29° 5' and 29° 35' N and longitudes 30° 20' and 31° 10' E. Over-utilization and inadequate management of the existing resources (i.e., soil, water and land use) are the main causes of unsustainable development in the studied area. Thus, the present study aimed to identify method for assessing land use sustainability index "LUSI" using GIS techniques. This index is a criterion for assessing agricultural sustainability considering the degree of land use suitabilities and the current land use. It is expected that the suggested methodology would be widely used, not just in the studied area, this was performed through some specific objectives, i.e., to conduct a detailed soil survey based on the geopedological approach, in order to determine soil properties and its relevant land qualities; to prepare a comprehensive database for the whole studied area based on field soil survey and the available data and materials; to conduct a land suitability evaluation "physical and economic" using the Automated Land Evaluation System (ALES); and to study the current land use map of the studied area. To fulfill these objectives a pilot study area at Sinnouris District was selected to implement the proposed methodology.

Aerial photo-interpretation was first undertaken for the preparation of geopedological map using stereoscopic analysis. Modified geopedological approach was applied by crossing the base soil map with the slope and texture maps. To minimize the fieldwork, an integration of the previous studies done at Soil and Water Department, Faculty of Agriculture El Fayoum has been considered. Geomorphologically, one landscape was identified which is the plain landscape, containing 12 landform and 34 mapping units. The mapping units were strictly verified in the filed, four transect sample areas including 11 soil profiles were selected to represent the different mapping units, besides, minipits and testing augers samples were intensively made. The soil profiles were carefully described in situ, the main physical and chemical characteristics of the different mapping units were determined and stored into ILWIS-GIS databases. The soils were classified up to the family level according to the protocol of the United States Department of Agriculture (USDA Soil Taxonomy, 1998). The main soils in the studied area are Vertisols, Entisols and Aridisols.

The Integrated Land and Water Information System (ILWIS), was used as a data processing environment, it has been intensively used in all the processing steps of the present study, all its vector and raster facilities were used for making maps, overlaying, crossing, calculating and classifying purposes. The Automated Land Evaluation System (ALES), was used to perform land suitability evaluation, on the basis of the FAO land evaluation framework, through building up expert system and decision trees. Land use types were mapped based on the existing crop rotation maps and local interviews. Summer and winter land use maps were prepared to fulfil the requirements of the proposed methodology.

Following the FAO land evaluation framework, by means of ALES software, the land physical suitability evaluation was done. Ten land use types were selected based on the former research studies carried out in the studied area and several interviews during the fieldwork from March to May 2000. The selected land use types are: cotton, wheat, maize, sorghum, rice, sugar beet, onion, olive, mango and citrus.

Five land qualities were considered based on the requirements of the selected LUTs, i.e., salinity & alkalinity, nutrient availability, moisture availability, oxygen availability and rooting conditions. The physical evaluation results indicated that the southern and middle parts of the studied area (high and moderately high terraces) are classified as moderately and highly suitable. Whereas, the northern parts "the low terraces", as near as Qarun Lake, are mostly classified as marginally or not suitable due to their salinity and or alkalinity constraints.

A general economic land evaluation was done, Net Present Value (NPV) and Benefit Cost Ratio (BCR) were used to give an overview of the economic situation of the current land use types. The results of the economic evaluation indicated that: 1- Mango, onion, olive and cotton are the highest profitable land use types concerning both NPV and BCR; 2- Sugar beet, although, is a newly introduced land use type in the study area, its economic situation is acceptable and promising; and 3- Rice, wheat, sorghum and maize, the main and essential cereal crops for home consumption are economically fall in the middle of the rating concerning both net present value and benefit cost ratio.

Considering the land physical suitability of the ongoing land use types and the current land use types, in ILWIS-GIS environment, the Land Use Sustainability Index "LUSI" was calculated as an index for assessing agricultural sustainability. This index was used as an indicator to appraise the sustainability of the on-going land use types. The results of Land Use Sustainability Index (LUSI) indicate that most of the selected land use types are classified as sustainable land use which are: cotton, wheat, maize, rice, onion, mango and citrus, two of them are classified as highly sustainable land use types: sorghum; and olive and only one land use is classified as somewhat sustainable land use which is sugar beet.

Key words:
Sustainable agriculture, Soil & Water management, Land use types, Land Evaluation, El Fayoum soils, GIS, ILWIS and ALES Systems.

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INTRODUCTION

1. INTRODUCTION

1.1. BACKGROUND

In the last few decades, the term sustainability has become a key concept to describe the successful management of the agricultural resources, particularly soil and water, to satisfy changing human needs, while maintaining or improving the quality of the environment and conserving natural resources (TAC, 1988), although methods to assess sustainability are still being developed. The concept of sustainability shows many factors therefore ecologists, environmentalists, agronomists, economists and politicians use it with different conditions. In addition, the sustainability of land management systems varies in space, according to climate, soil, technology and societal conditions. Sustainable farming system varies also in time, as they evolve and may collapse, frequently together with the corresponding socio-systems. Because of its complexity, sustainability is difficult to measure directly and requires the use of appropriate indicators for assessment. A sustainable land management system must satisfy a large variety of requirements, including technological feasibility, economic viability, political desirability, administrative manageability, social acceptability, and environmental soundness. Real world conditions at farm and policy-making levels needs to be substantially improved to achieve sustainable land management.

Worldwide, the increasing population, the problem of deterioration of soil and water, the concern for a safe environment and the conservation of natural resources lead to uncertainties in meeting future needs for food and other production and call for a sustainable use of natural resources (Oskouei, 1997).

In most developing countries, agriculture remains the engine of the economic development and a more sustainable agriculture is more likely to provide the long-term benefits required to achieve sustainable development and poverty reduction. The foundation for sustainable agriculture is maintenance of biological production potential, particularly maintenance of land and water quality, and genetic diversity (Dumanski, 1996).