Soil Productivity Classification in the North Western Part of Egypt (Bahig Command Area), Based on Landsat-5 TM Data and Land Information System (SAADA)

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Introduction

The existing soil and land classification systems have become more complicated and detailed, being based on the genetic and morphological characteristics of the soil, they do not facilitate the prediction of crop suitability or crop yields. There is an urgent need to classify the soils in newly reclaimed areas on the basis of their potential productivity. This will enable the decision makers to plan agricultural expansion activities on a reliable basis.

The soil productivity classification uses individual crop productivity potential to define areas that are similar in productivity (FAO, 1976). Most crops respond differently to soil properties. Crops exhibit individual ranges of tolerance for distinct soil properties (SYS, 1985). The computer aids enabled the processing of large columns of crop and soil data for rational matching and the comparison of soil log characteristics with comparable response characteristics.

HARGA et al. (1984) classify the land on the north western coast of Egypt according to the British system (BIBBY & MACKNEY, 1969) into four capability classes; II, III, V and VI. ABDEL RAHMAN et al. (1991) introduced a soil suitability classification system to calculate suitability indexes for 20 crops in the arid region.

Satellite images provide more accessible data from electro-optical sensors. They provide the most accurate source of information on the spatial extension of terrain units. The spectral characteristics of the objects are very useful in defining the exact boundaries of ground truth units.

The current study aims at classifying the soil in the north western part of Egypt on the basis of productivity. The study area represents one of the most promising locations for new agricultural expansion. The establishment and management of the Bahig canal and its tributaries stress the great future importance of this area. Digital processing of satellite images was used to produce an accurate base map for different soil and landscape features. 200 soil logs were localized on these maps and soil samples were collected and analyzed. The System Analysis of Agriculture Development Alternatives (SAADA) model (NELSON, 1989) will be used in the current work to classify the soil.

Location and Environment of the Study Area

The study area is located between latitudes 30 °40' - 31°00'N and longitudes 29°15' - 29°50'E. the area is situated parallel to the north-western coast of Egypt. It is bordered by the towns of King Mariut, Borg El-Arab and Sidi Abdel-Rahman on the north, while the Bahig canal forms the southern border.

The total command area is about 52,000 feddans, all irrigated from the Bahig canal. The flooding irrigation system is dominant in the area, though some patches are irrigated by the sprinkler system. The soils range from sandy to clayey texture on calcareous parent material. The topography is fairly level to nearly level. The area is characterized by a wide variation in the vegetation cover.

Methodology

Digital Analysis of Satellite Images

A number of computer programmes, mainly Categorical Analysis (CA) and Landsat Categorical Processor (LDCP) were used to categorize Landsat digital reflectance and calculate the area of each category.

The supervised technique based on the maximum likelihood method was applied, where the pixels of the training sets are used by the spectral pattern recognition programme as the basis for the statistically compared spectral signature of the whole scene. The selection of training sets in the study area was done on the basis of the available topographic maps, with scales of 1:100,000 and 1:25,000, field observation, and visual interpretation of the Landsat false colour composite image.

Soil data

200 soil profiles were studied and soil samples were collected. The location of the soil profiles was mainly selected based on aerial photo and satellite image interpretation. Soil properties were examined in the field and in the laboratory. The measured soil properties include 5 micron texture class, bulk density, water permeability, air permeability, horizon depth, salinity, alkalinity and the presence or absence of caliche.

A relation between the 5 micron texture, on the one hand, and CEC, bulk density and permeability, on the other hand, was conducted and used in coding soil data for land productivity classification (GAD, 1992; ABDEL RAHMAN, 1992). The available data were coded numerically and fed into the SAADA system.

Results and Discussion

Satellite image interpretation

Non-supervised classification. - A non-supervised image classification was performed in the beginning, depending only on the reflection of different soils and land use.

The classified images were used in the field work, besides aerial photographs and topographic maps within the scale of 1:25,000. By following the different reflections in the satellite image, it proved to be possible to predict different soil and land use types. 200 soil logs were chosen on the base of these documents. Also, different land use types were verified in the field and identified on the images.

Supervised classification of satellite images - The results of field work, laboratory analysis and aerial photo checks were used in an integrated manner. The maximum likelihood supervised classification technique was applied to classify the whole command area into different soil types and land use categories. 49 training sets representing 13 general classes were fed into the computer and resulted in classifying the study area into the following categories: 9 soil types, water, urban, agriculture and sandy areas. Table 1 shows the characteristics of the different soil types.

Land classification

Soil salinity. - The study area is compiled in 6 map sheets. Areas of different salinity categories are presented in Table 2.

It is found that most of the study area (75%) is characterized by non-saline non-alkali soils of EC < 4, SAR < 13 and ESP < 15. The slightly saline soils (EC 4-8 mS/d, SAR < 13 and ESP <15) represent 17.7% of the study area. Patches of saline alkali soil represent 4.75% of the total command area.

Soil bodies and drainage spacing. - The application of the SAADA system made it possible to nominate a certain soil body and drainage spacing for each of the 200 soil logs studied.

Table 1
Characteristics of different soil types

Class Number	Definition	Colour
1	Deep; highly calcareous; non-saline and medium textured soils; 162/107/106/103/200/51	Purple
2	Deep; highly calcareous; non-saline and medium textured soils. Surface layer has less lime accumulation. Calcic horizon in subsurface layers; 154/30/97.	Yellow
3.	Deep; highly calcareous; saline, non-alkali and medium textured soils. 120/63/66/16/1/131	Light brown
4	Deep; slightly calcareous; non-saline and coarse textured soils; 87/60..	Dark green
5	Shallow; highly calcareous; non-saline, and medium textured soils; 179.	Cyan
6	High altitude rocky and used mainly for urban areas	Dark orange
7	Light texture; highly calcareous with calcic or petrocalcic horizon and slight salt conent (11)	Green 1
8	Deep; calcareous;slightly saline. Cultivated. 15/102/-119 (44)	Green 2
9	Wetland-irrigated fields having different soil characteristics	Blue

Table 2
Salinity distribution in the Bahig Command Area (in feddan)

Sheet Name	Salinity Class					
	1	2A	2B	2C	3	4
Al-Amriya A	3504.04	469.10	133.57	-	-	-
Al-Amriya B	1951.98	4220.70	161.97	-	95.16	69.85
Mahatit Bahig	8788.63	2100.06	-	-	739.83	415.09
Borg El-Arab	11038.3	253.35	295.80	265.64	1241.48	-
El Hammam E	6329.92	-	-	-	-	-
El Hammam F	5468.60	1716.48	-	-	-	-

It was found that the study area includes 31 different soil bodies. Each of these is defined by a particular crop productivity outcome.

Most of the Bahig command area requires a drainage spacing range of 40 to 150 m. However, some patches require extreme spacings (i.e. < 20 m and > 150 m), depending on the soil texture and permeability conditions.

Conclusion

The soil productivity classification showed the advantage of providing specific crop-soil information. The SAADA system could also provide valuable information about different crop suitabilities and about the costs of land reclamation, which includes land levelling, soil leaching, the addition of soil amendment, and the installation of subsurface drains.

Remote sensing provides an accurate basis for soil sampling and mapping.

The Bahig area includes 31 different soil bodies, each characterized by a particular productivity response in the case of 30 crops. The distance needed between sub-drains ranged between 40 and 150 metres apart. The reclamation costs range from 500 to 750 Egyptian pounds per feddan.

Summary

An area of about 52,000 feddans was studied to determine the soil productivity, methods and costs of reclamation and the land capability classes. A non-supervised classification of Landsat TM data was carried out and soil samples representing the different types (categories) were collected and analyzed using an integrated computer programme, SAADA model. Information about soil suitability and reclamation costs were obtained and presented in two kinds of maps. The total area of each soil body and reclamation cost class were measured. The results obtained proved that the data derived from LIS when coupled with the information taken from satellite images with appropriate ground truth are highly suitable for determining the method and cost of soil reclamation, and its productivity classes.

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