USE OF REMOTELY SENSED AND TERRESTRIAL IMAGES IN SEARCH AND CLASSIFICATION OF AGRICULTURAL SOIL

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Abstract

With the rapid increase in population, and subsequent depletion of the limited natural resources, and being bordered by overpopulated famine-threatened neighbors, Libya must find and develop alternative resources for its present and future populations. Discoveries of vast reserves of water under the arid desert in the south, the country has made huge investments directed towards transporting large quantities of water to irrigate good agricultural soils in the north where most of the population reside. The purpose of this paper is to present a method that utilizes remote sensing techniques employing Landsat and SPOT images complemented with terrestrial color photos for the search and classification of good soils in semi-arid regions in the country. The results obtained using this method are compared to the results of the ground method that is now used by state authority. Compared to the classical ground methods, the method presented is less time consuming and more cost-effective.

Keywords: Classification, Land Application, Landsat, Remote Sensing Application, SPOT, Soil boundaries, Semi-arid regions.

Introduction

In the last few years, remote sensing techniques have proved their success and effectiveness in solving and monitoring many environmental problems specially when vast areas are involved. With the rapid advancement in computer technology (CPU memory size and high speed, affordable prices), many space platforms were put into orbit for continuous enviornmental data collection by many countries and international space agencies. This made the use and distribution of remotely sensed data widely spread worldwide.

Due to world population increase, global warming, desertification, and urban expansion the demand on the world limited agricultural soils is increasing more than ever. The search for good soil should be directed to the arid regions. "Soil color is probably the most obvious feature of the soil" (1).

The objective of this research study is to test and formulate an image processing technique that helps to identify and classify potential agricultural soils in semi-arid regions in the northern part of Libya, using mainly space satellite data. Due to the lack of field team investigators because of the vastness of the regions to be studied and of the limited resources, this technique should minimize the time and cost involved when compared to classical ground methods. Specifically this paper will present an image processing technique that utilizes the remotely sensed data collected by the famous Landsat and SPOT satellite systems complemented with terrestrial photographs to help identify and classify soils in semi-arid regions of Libya.

Data collection

The approximate boundary of the study area was predetermined by the field team who carried out the preliminary study by classical ground methods, which is done by taking typical soil cross-sections in grid format at every 750 meter. The dimension of the total area is 10 km. by 8 km. and its center is located at 30° 32' north latitude, 14° 28' east longitude. Landsat and SPOT data dated March 14th 1989 and March 29th 1989, respectively, availabe at Biruni Remote Sensing Center, were read to the image processing facility at this center. Topographical maps with a scale of 1/50,000 that cover this area are collected from the Survey Department of Libya along with old B/W aerial photographs which dated back to 1979. The prelimenary and final detailed soil classification maps of the area with scales of 1/50,000 and 1/20,000 and tabular soil types data were borrowed from the Secretariate of Agriculture of Libya. Many field trips were arranged for identifications of training sets and for taking photography of ground surface and typical soil cross-sections.

Procedure and Methodology

The procedure followed in this study is by identifying as many separable soil and land cover classes as possible, without going to the field. This is normally done by clustering algorithms commonly known as unsupervised classifications. However, this type of software is not availble. Therefore, it was carried out by human machine interaction. This was done by seperating different classes visually according to their colors on the image processing monitors. This was done for small areas called training sets, which represent the larger classes.

Normality for each training set was checked and forced for all bands in both Landsat and SPOT images. Then field trips were arranged to conduct the following:

1- locate the training sets in the field
2- identify the soil type within training sets
3- photograph ground surface and soil cross-sections in the same roll of film and under the same illumination conditions. Photographic films were used here due to lack of field spectrometer. After the films were developed they were scanned by drum color scanner.

Data analysis

From the aerial photographs, very limited soil boundaries could be identified due to their small scale of photography and because of the high fog level inhereted in the old film. Since the topographical maps were updated from these phorographs, the soil bounderies that are shown on these maps were very limited as well.

After satellite data for both Landsat and SPOT were read to the image processing, and the training sets were chosen for as many spectrally separable classes as possible. Checks for normality in the three bands of SPOT and the six bands (1,2,3,4,5,7) of Lansat TM were forced. The maximum likelihood classifier was used in all classifications. Many bands of Landsat channels were combined in combinations of threes, fours, and fives to give different choices of classifications. However, when compared with the results of the ground methods which were considered 100% accurate, the digital classification resulting from the six band combination was the nearest to the results of the ground method as shown in Figure 2. The maximum likelihood classifier was used on the data from SPOT channels as shown in Figure 1. Then, results from both classifications were compared to the ground method as shown in Table 1. It should be noted here that the total area studied by the detailed ground methods amounted to 4,200 hectars located within the total area of study.

Table 1 comparison between classifications of SPOT and Landsat TM data.

class	SPOT			Landsat		
No.	No. pixels	area, hectars	%	No. pixels	area, hectars	%
A	7,851	314.04	7.48	12,037	1,083.33	25.79
B	58	2.32	0.06	326	29.34	0.70
C	23,231	929.24	22.12	12,837	1,155.33	27.51
D	7,643	305.72	7.28	3,198	287.82	6.85
E	27,304	1,092.16	26.00	8,500	765.00	18.21
F	219	8.76	0.21	206	18.54	0.44
G	5,136	205.44	4.89	1,201	108.09	2.57
H	12,321	492.84	11.73	5,741	516.69	12.30
unknown:	18,955	758.20	18.08	1,756	158.04	3.76
missing:	2,282	91.28	2.17	865	77.82	1.85

Based on the data presented in Table 1 above the following conclusions can be made:

1- class A is called "Lithic terriorthents, coarse loamy mixed (calcareous), thermal, (saline)" (2). This class located at the ground surface is made of coarse dark gravel, which made it warmer at the time of the satellites passes than the other type of surrounding soils. Since band 7 of Landsat TM is nearer to the thermal infrared than SPOT's channel 3. This gave Landsat more capability to delineate this class boundaries.

2- the areas of unclassified pixels in SPOT classifications are about five times that of Landsat classifications, even though the threshold criteria is maintained to the same level in both classifications. This observation confirms that Landsat has higher spectral resolutions.

3- for the rest of the classes, which are reasonably bright, both satellites gave nearly the same results.

4- the missing pixels in both classifications are due to not counting the external boundary and due to the geometric correction scheme followed.

5- the classes B, C, D, and H, which are called "Typic Torrifluvents, fine or coarse silty, mixed (calcareous), thermic, [deep, none saline]", are classified as good agricultural soil (2). The area of these types of soils amounts to 63.37% of the total area of the detailed groud study (2), but it amounts to only 41.29% in the classifications from SPOT imagery, and to 47.44% in the classifications from Landsat imagery.

Summary and Remarks

Based on the results of this study, the following conclusions may be made:

1- SPOT and Landsat images can be used effectively in the search and classifications of good agricultural soil in semi-arid regions.

2- the procedure followed in this study can save time and effort over preliminary studies, that are followed by classical ground methods.

3- results obtained from preliminary analysis of the data available indicate a good correleation between ground surface colors and cross-section colors in the regions under investigations.

4- the success of this method is highly dependent on ground truth and the normality of training sets.

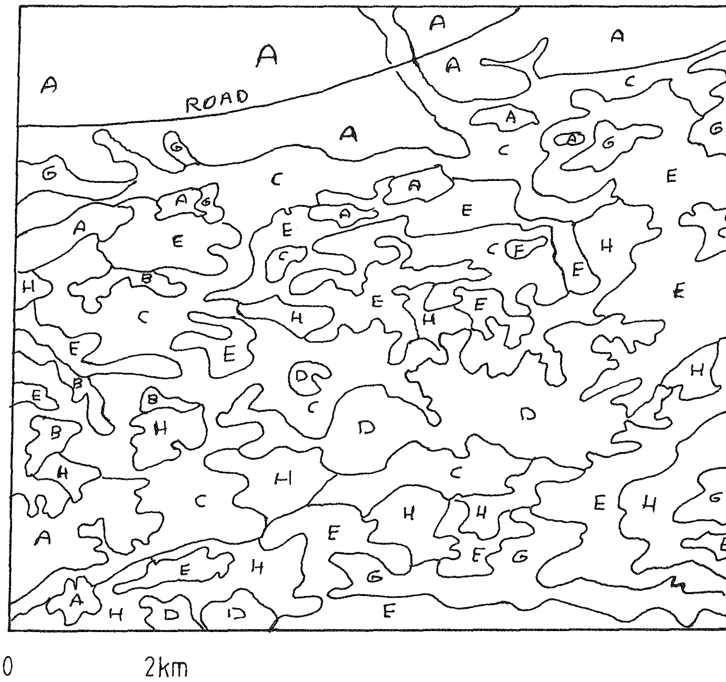

Figure 1 Soil boundaries from SPOT data classifications

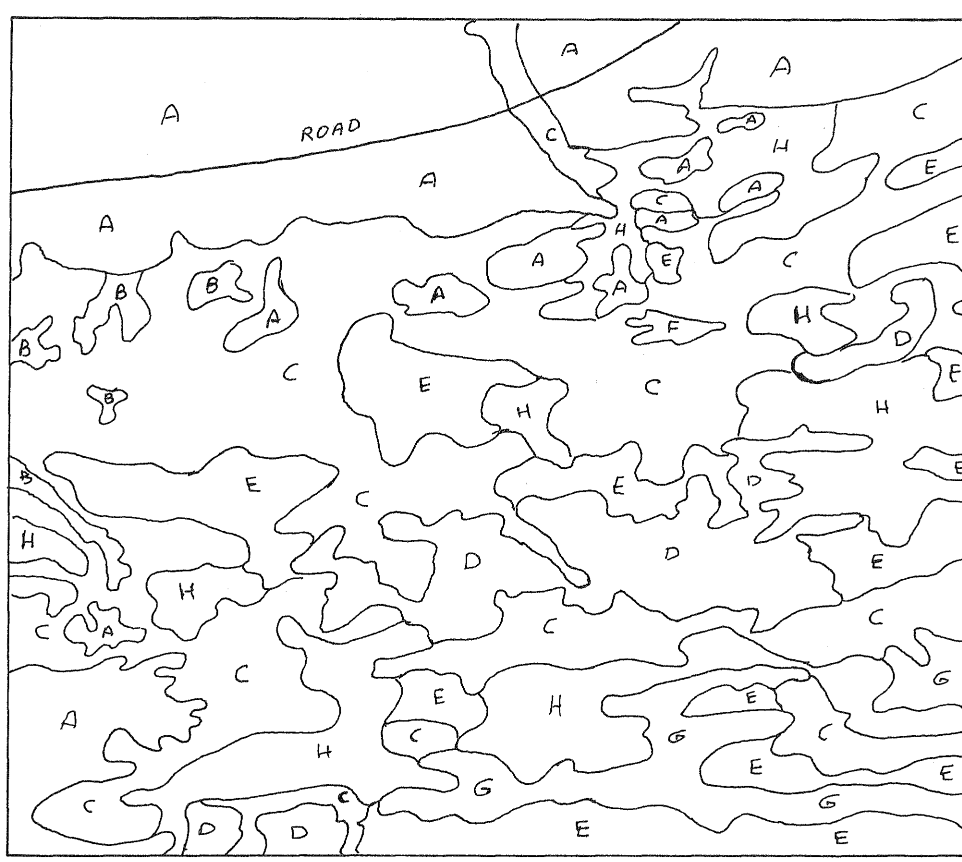

Figure 2 Soil boundaries from Landsat data classifications

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