SOIL SALINISATION IN SEMI-ARID REGIONS

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1. Introduction

1.1 Soil Salinisation and Landsat-Data

Aside from the lack of water, deflation and denudation, soil salinisation is one of the most important problems in arid and semi-arid zones of the earth (Röhmer, 1968). In order to fight against the loss of fertile land, the concerned affected areas have to be recorded, investigated and controlled. The possibilities and limitations of using Landsat-data for this purpose will be the subject of investigation.

1.2 Area of Investigation

As study-area, the Konya-basin in central Turkey has been choosen. This basin is a drainless, lacustrin plain of 10 000 km^2. The whole catchment area amounts to 22 000 km^2. It is enclosed by the Toros Mountains in the East and South and by the Anatolides in the West and North. The climate is semi-arid. Due to the water runoff from the surrounding mountains into the basin, the water table is relatively high. This induces a high affinity to soil salinisation, which is often increased by improper irrigation and drainage techniques.

1.3 Research Procedure

This research project can be subdivided in three main steps:

- Visual interpretation of Landsat image,
- Fieldwork and laboratory analysis of the soil samples
- Digital classification of Landsat-data

For the visual interpretation as well as for the digital classification the selection of the right scenes are of great importance (Hilwig, 1979). Apart from technological data, e.g. the quality of the spectral bands or cloud coverage, the relevant season has been the main criterium to obtain the best differenciation between saline and non-saline soils. Hence average data of the temperature, precipitation as well

as of vegetation coverage have been gathered (Figure; Thies, 1978). The months from July until September allow the best differenciation between salt effected and non affected soils.

It is the aim of visual Landsat image interpretation to obtain a soil salinity interpretation map. Such a map is based on image element analysis and on physiographic interpretation; it is used during the whole fieldwork period.

The timing of the fieldwork operation has been fixed in accordance with the choosen Landsat scene. Geomorphological and pedological observations are recorded on data cards, and representative soil samples have been collected for laboratory analysis. The visual interpretation of Landsat images and the corresponding fieldwork are the best premisses for the digital classification.

2. Satellite image data processing with respect to temporal analysis
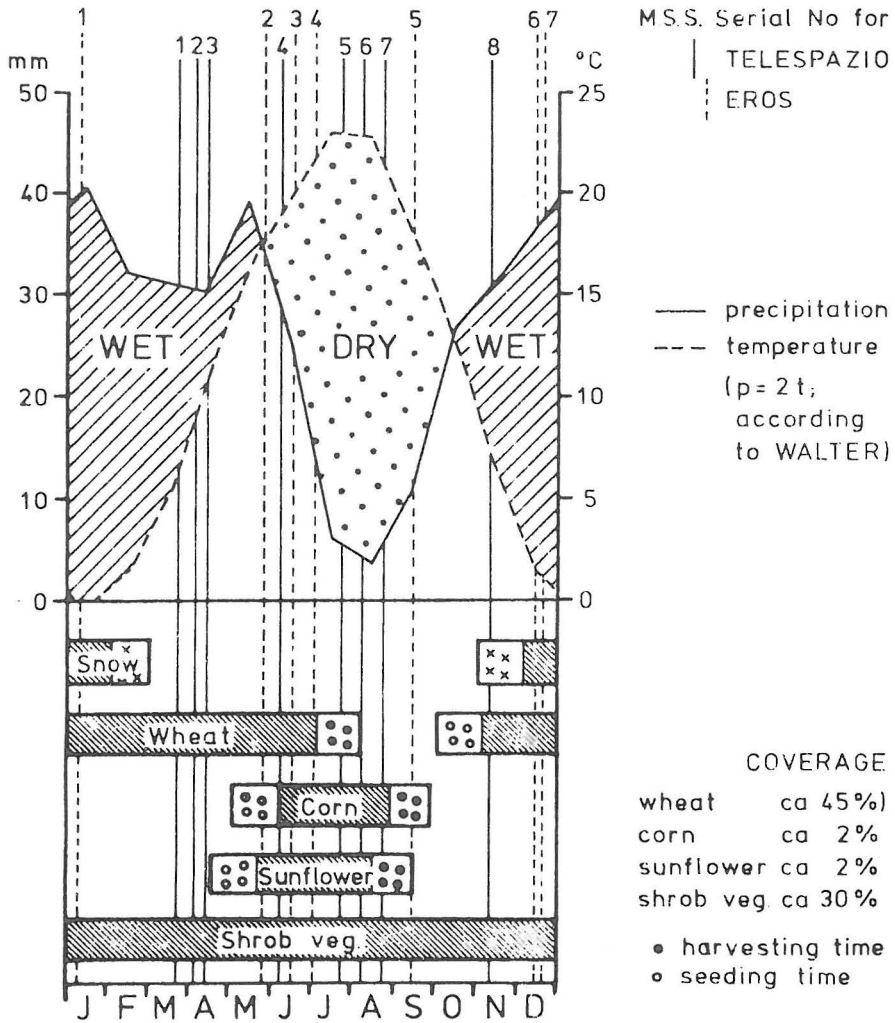
2.1 The DIBIAS concept
The Landsat images of this paper have been processed for the problems in question on the digital interactive image analysis system DIBIAS of the German Aerospace Research Establishment (DFVLR), Institute of Communications Technology. DIBIAS is designed for research oriented image processing mainly applied to earth sciences (Fernandez et al., 1976). The DIBIAS software system consists of about 150 programs in module technique divided into a varity of subsets: Input, output, utility, image manipulation, visual perception, operations, statistics, temperature, Fourier transformation, digital filtering, texture analysis, geometrical rectification, multispectral classification.

2.2 Reading Landsat scenes with different image data format and definition of appropriate scenes
As a first attempt of evaluating temporal differences Landsat image data of the same region from different years (1975 and 1979) have been processed. Due to the diverse format specification of the Landsat data distribution centers EROS (South

KONYA

Height above sea level	1026 m	Ø Annual precipitation	315 mm
Ø Annual temperature	11,5 °C	Ø Annual PET	1600 mm

M.S.S. Serial No for TELESPAZIO EROS

precipitation

—— precipitation
--- temperature
(p = 2 t;
according
to WALTER)

COVERAGE

wheat   ca 45 %)
corn   ca 2 %
sunflower ca 2 %
shrob veg. ca 30 %

● harvesting time
○ seeding time

SELECTION OF LANDSAT - SCENES, ACCORDING TO LOCAL CLIMATOLOGICAL AND VEGETATIVE CRITERIA

Thies, 1978

918.

KONYA

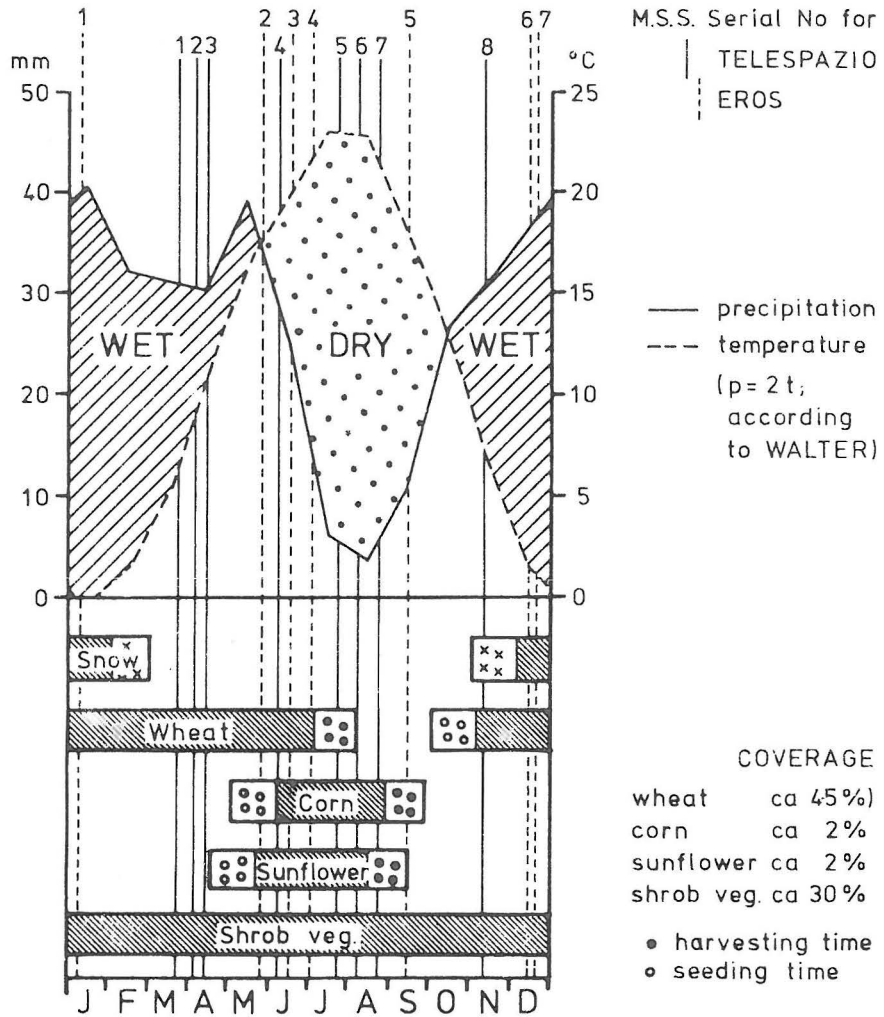| Height above sea level	1026 m	Ø Annual precipitation	315 mm
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M.S.S. Serial No for

TELESPAZIO

EROS

—— precipitation

– – – temperature

(p = 2 t;

according

to WALTER)

WET   DRY   WET

Snow

Wheat

Corn

Sunflower

Shrob veg.

J F M A M J J A S O N D

COVERAGE

wheat   ca 45 %)
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Thies, 1978

Dacota, USA) and Telespazio (Italy) specific input routines have to be used. While EROS data have to be merged out of four stripes, data from Telespazio represents already a total Landsat scene of 185 x 185 km^2. A slight decrease of contrast with respect to EROS data from 1975 could be noticed in colour-composites of Telespazio data from 1979. In a next step appropriate subscenes of the Konya plateau in Central Turkey have been defined for the different years using the track ball for fitting control on the screen display. For these subscenes of about 29 x 29 km^2 ground truth data have been gathered in situ during a three months term.

2.3 Geometric correction and registration with respect to one data format

A geometric correction has been applied for the EROS data, taking into account the overscan and the earth rotation. For the Telespazio data only an enlargement in y-direction (column) with the factor 1.425 was necessary. A coarse registration has been elaborated by using a number of control points within the two scenes of different years. These control points yielded a mean shift in x- and y-direction of one scene with respect to the other. With this procedure a deviation of about twenty pixels still remained. Therefore a fine geometric rectification for registration of the two temporarily separated scenes has been applied in addition. For this rectification an interpolation with the least squares method was used (Haberäcker et al. 1979). The parameters of the mapping functions between the reference image (scene from 1975 was used by definition) and the "distorted" image (scene from 1979) have been computed with first order polynominals (linear approach). By determining control points all over the scene on the DIBIAS monitor screen a satisfying result of a r.m.s. error of less than one pixel (80 m) in both directions could be reached. This enables change determination of two different scenes to an accuracy of pixel size. The absolute degree of precision is still in the range of several pixels. For the purpose in question the degree of geometric precision was sufficiently solved. It seems to be rather difficult to reach a

better accuracy due to the lack of maps with fine resolution.

Finally some erroneous scanlines in different spectral bands have been corrected by means of a two-dimensional spline interpolation (Winter 1978).

2.4 Choice of training areas and maximum likelihood classification

The relevant land-cover classes have been defined following the ground truth experience and the specific circumstances in question. Eight classes have been defined for classification: two types of vegetation, four degrees of salinization, water, and mountain areas (spare vegetation, no salinization). Representative training areas for the defined classes have been selected through a detailed field work. These areas have then been identified and entered as polygons, describing the limits of the areas and representing a fifth channel merged to the four Landsat bands.

Before entering the above defined training areas extensive quality control has been investigated by classifying the training areas of the various classes, computing confidence limits for the accuracy, and applying contingency table analysis (Winter 1978, Haberäcker et al. 1980). For the supervised classification of the two scenes under investigation the maximum-likelihood-algorithm with rejection class has been used. Several approaches with different variance parameters have been attempted for minimizing the probability of misrecognition.

2.5 Trend evaluation by means of differences of corresponding classes in different years

Finally each class has been extracted from the classification result, computing the absolute surface-cover in squarekilometers. Change and trend determination for the multitime imagery have been evaluated for each class using logical operations and image addition. Statistics could then be computed from a level slicing operator.

All reproduction of the processing results has been performed upon film recorder as pseudo-colour coded images.

3. Discussion of classification results

3.1 Classification of individual Landsat scenes

The classification scheme differentiates between 8 categories

    4 classes of soil salinisation degrees
    2 classes of arable land
    1 class of mountain area
    1 class of water

This classification scheme has been applied to both scenes (1975 & 1979). The scene of 1979 (Telespazio) shows a slightly inferior contrast due to poor quality of the CCT, as compared to the scene of 1975 (EROS). As a consequence a higher degree of misrecognitions appeared in the 1979 scene: In the mountainous area, e.g., the 4th class of salinisation was often misclassified. This is due to the similar reflectance properties of both classes. On one side the salinisation class, which is a complex of dark soils and small water bodies, and the dark magmatic material of the mountains on the other side.

3.2 Multitemporal classification

Following the individual classification step, a change detection procedure with respect to the two temporarily separated scenes has been employed. A weak increase of soil salinisation, and correspondingly a small decrease of non affected areas was found.

Because of the classification problems mentioned before, the results of the change detection analysis have to be regarded separately for every class.

4. Conclusion

The investigation and classification procedures described above demonstrate:

- The correct choice of Landsat scenes according to local climatological and vegetative criteria, as well as the accurate coordination between Landsat image interpretation and fieldwork, are of eminent importance for the results of digital classification.

- There were no technical difficulties in combining Landsat-scenes from different distribution centers.

- Geometric rectification procedures in order to combine separated scenes, show satisfying results.

- Change detection are strongly influenced by the quality of the classification made forehand, hence every analized class has to be regarded individually in its result.

- Semi detailed surveys (ca. 1 : 50 000 scale) in arid zones supported by digital procedures (classification and change detection), may obtain increasing significance.

Literature

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