AGRICULTURAL DEGRADATION RISK CARTOGRAPHY USING REMOTE SENSORS AND GEOGRAPHICAL INFORMATION SYSTEMS. INTERNATIONAL TECHNOLOGY AND COOPERATION FOR FARMERS

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KEY WORDS: Agricultural degradation, Land evaluation, Watering valley, Geometric correction, Land use, Digital classification.

ABSTRACT

The quality and potentiality of the resources in an agroecosystem condition their economic development. Therefore, it is very important to work out a degradation risk cartography for the farming environment from the analysis of information about various aspects: climatic, phytogeographic, geomorphological, socio-economic and especially edaphic.

The processes of salinization and aeolian erosion, which work very quickly, are the main agents of degradation in the area located in the lower part of the Colorado river valley, causing irreversible damage in the short term. Therefore, the map-making process should be carried out as soon as possible so that maps can be used when decisions must be taken tending to avoid the degradation of the land.

It is in this context that the present work is done. Its aim is the production of thematic cartography of the area under study by using image interpretation techniques, soil survey, land evaluation and data analysis by means of geographic information systems.

As basic material SPOT images were used (HRV sensor). The visual and digital interpretation of these provided a definition of the land use at present, a variable that was contrasted with the potential land use obtained from the physical analysis carried out on the soil units.

The results show that the digital treatment carried out on the SPOT images makes it difficult to discriminate different types of crops under irrigation owing to the high spatial resolution and the low spectral resolution, but it is suitable to separate natural from artificial plant covers and to detect ecologically affected sectors.

INTRODUCTION

This work is a methodological essay focused on the application of remote sensors and GIS for the production of farming degradation risk cartography that contributes to an adequate assessment of resources in a farming area under irrigation.

The true knowledge of an area and its correct administration is the starting point for its economic development. It is not enough to possess a simple inventory of the energy, food and human resources of a country; it is necessary to understand the relationship between the elements that are available in the environment with a view to an adequate use of them.

A limited assessment of the sceneries that make up the natural environments results in irreversible stages of degradation caused by the uncontrolled human intervention.

GEOGRAPHIC SITUATION AND GENERAL FEATURES

This subject arises mainly from observations carried out in the area on different occasions and sectors. As it will be noticed through this work, this is an area located in a bioclimatic transition, with an evident economic fragility, where the soil is used intensively and irrigation is the rule.

It is placed in the SW of Buenos Aires Province, Argentina, between 39° 10'and 39° 55'south latitude and between 62° 00'and 63° 55'west longitude (Figure 1).

The region is crossed from west to east by the Colorado river and its climatic type is semiarid temperate. The area under study comprises a sector of 120,000 has. located north of the lower course of the Colorado river, out of a valley of 700,000 has.

BACKGROUND AND OBJECTIVES

In the 1960's, when this region became important, the first studies were carried out in order to determine the use capacity of the soils.

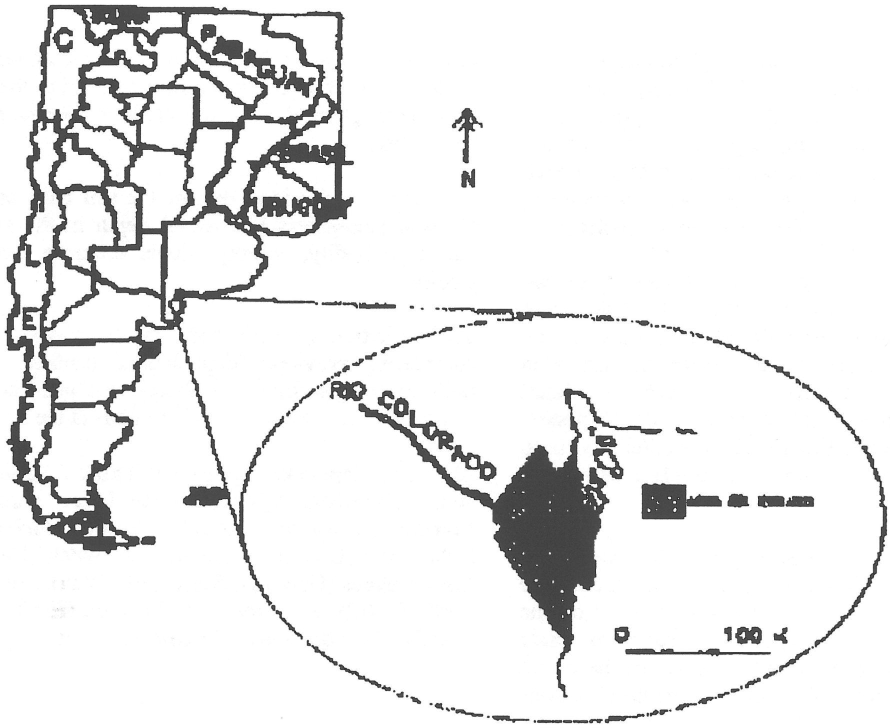


Figure 1. Located of Study Area.

When the satellite SPOT – 1 was put in orbit, in February 1986, new expectations arose for the analysis of the natural resources, for medium and large scales. With the new technology, several studies were made on the area.

Two studies are outstanding among them: the first one was carried out through the PNUD – ARG/81/002 project, with the participation of different regional, national and international organizations, such as FAO, CNIE, SAGyP and CORFO and aimed at the assessment of the area for recognition. The resulting cartography was to a scale 1: 600,000 and the interpretation of the SPOT images was done visually (PNUD et al,1987).

The second study was carried out by INTA. The technicians at this institute used aerial photographs taken in 1982 to scale 1: 20,000 on which they delimited soil series, ans LANDSAT images to scale 1: 500,000 on which they detected visually the main degradation patterns.

In the INTA study, all the information was processed digitally in a later stage, using the ERDAS and ILWIS systems, the result being a series of graphic databases.

The high spatial resolution of the SPOT images enables the work with greater scales than those obtained so far in the studies already mentioned. This possibility, combined with the use of the GIS, enhances the integrated analysis of the resources, and makes it possible to reach scales close to 1: 50,000.

Considering the advantages arising from the combined use of both techniques, we can set the following objectives:

_ To create a territorial division on the basis of land assessment criteria.
_ To draw computerized risk cartography that enables the assessment of the use capacity of the resources in the area.
_ To detect the sectors with possibilities of development, assessing their evolution and showing, where possible, the suitable land use to avoid the degradation of the environment.
_ To obtain information about the present land use and to contrast it with its potential use.

MATERIALS AND METHODES

In making the farming degradation risk cartography, we have used information coming from analogic databases, consisting of aerial photographs, satellite images and cartography.

We have also used existing information in digital format, consisting of a window that comprises part of two SPOT images from December 17, 1986.

As a great deal of the materials was outdated, they had to be brought up to date by means of control work on the land.

The satellite images and aerial photographs were handed over by CORFO – Río Colorado; the aerophotographic mosaics correspond to those published by Cappanini and Lores in their work "Los suelos del río Colorado"; while the topographical charts were purchased from the Instituto Geográfico Militar (IGM).

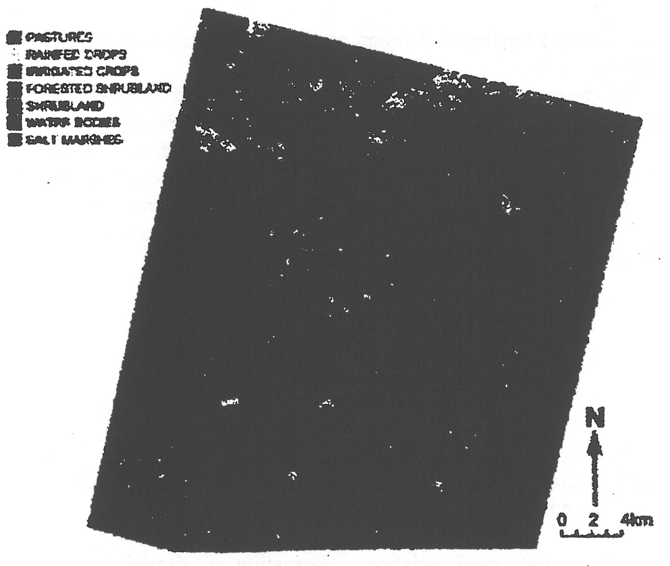
Digital Interpretation

The first activity is the digital interpretation of the image, which was done with the ERDAS program (v. 7.5). Essays were also made using the DRAGON program, that is not so powerful as the former, but has an interesting capability, such as the possibility of operating in two modes: low resolution, which allows the visualization of 320 x 200 pixels with 256 colours, and medium resolution, with 640 x 400 pixels and 16 colours.

The analytical process on the image consisted basically of two stages: classification and geometric correction. The objective of the first one was to determine the different categories of land covers and uses existing in the region; the second one is an obligatory step as it is necessary to compare the digital interpretation with the map of soils and soil aptitude. Geometric corrections is done after completing the classification process to avoid alteration of the original values in the ND's composing the image.

For the classification of the image we used the supervised method. This is supported by the previous knowledge of the different land use and covers. The procedure is based on the multispectral classification, which comprises two basic methods to obtain the training samples. These are based on algorithms which use commonly used statistical classifiers (Bartolucci et al., 1979).

Thus it has been possible to define a thematic map with the different land use and cover categories (Figure 2).



Supervised classification of the Spot-HRV image

Figure 2.

Image Geometric Corrections

This process involves a spatial relocation of the pixels with the reference of a system of known cartographic coordinates.

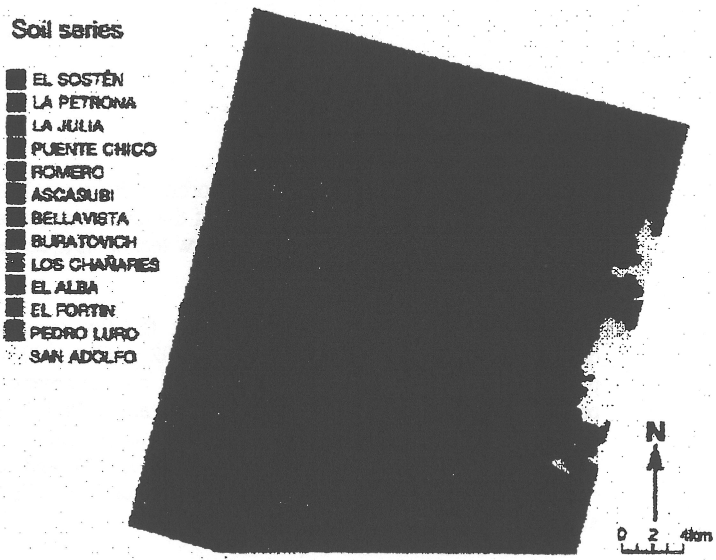
The reference documents were the four IGM charts, to scale 1:50,000 containing the area under study. Betweenn 5 and 6 cartographic control points were chosen for each topographical chart.

In the final stage of the process the ND's are taken to the new position. To achieve this, we have resorted to the method called "nearest neighbour". The size of the output pixel selected was 25 x 25 m..

A second activity is to delimit the soil units as a function of physical parameters like useful depth in the section, texture, colour, humidity, salinity, slope, drainage type and risk of erosion.

The definition of soils units at the series level was done considering previous edaphological studies, delimiting new units on the panchromatic photograms and carrying out field controls. Thus a soil map, with 13 units at the series level:

El Sosten (Haplacuol Típico), La Petrona (Hapludol éntico), La Julia (Ustortente típico), Puente Chico (Hapludol éntico), Romero (Torripsament típico), Ascasubi (Hapludol fluvéntico), Bella Vista (Ustortente típico), Buratovich (Hapludol ácuico), Los Chañares (Hapludol éntico), El Alba (Ustortente típico), El Fortín (Ustifluvente típico), Pedro Luro (Hapludol éntico), San Adolfo (Hapludol éntico) (Figure 3).



When the soil types were defined, the physical parameters used with the items contemplated by the LEIS program (Land Evaluation Information System), developed at the CSIC in Seville, Spain (De la Rosa, 1989) were made compatible so that they could be applied to the soil units defined in the areas under study.

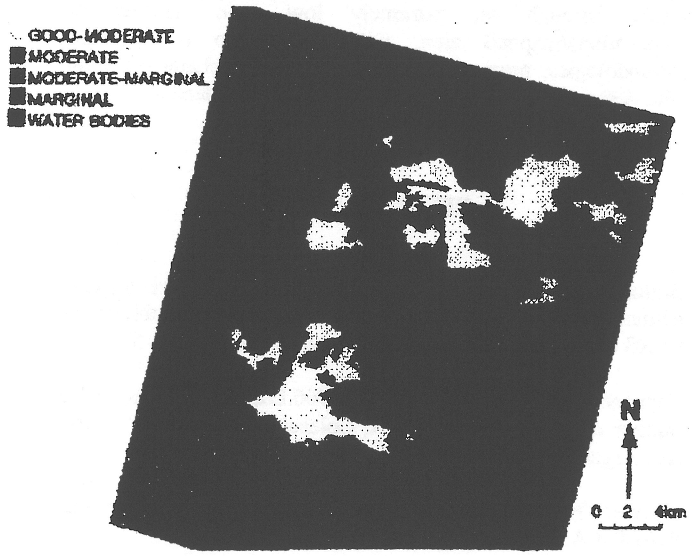
Because of the regional features it was necessary to alter the final definition of the classes of use capacity. LEIS produces four types. Class one is excellent; here the existing crops do not have restrictions for their development. In our case, class 1 already has an important restriction: bioclimatic deficiency.

From this factor, the restrictions are placed in successive classes and they grow as a function of their loss of quality for the development of farming.

Reclassifying the soil map in GIS (Eastmann,1989), four classes are created:

Class 1, the most suitable, includes the bioclimatic deficiency.
Class 2, includes aeolian erosion processes and the bioclimatic deficiency.
Class 3, considers salinization processes and the bioclimatic deficiency.
Class 4, includes the interaction of the three processes.

This way the first three classes are considered moderate in a different degree and the last one as marginal (Figure 4).



Categories of land suitability

Figure 4.

RESULTS AND DISCUSSION

Before combining the present use of the soil coming from the supervised classification of the image with the potential use of the soil arising from the application of the LEIS to the soil units, it is necessary to analyze the reliability of the of the completed digital classification.

This test is done through a confusion matrix where the rows are occupied by the sample classes selected for verification and the columns by the land use categories defined from the classification.

Through this matrix it is possible to reckon the overall reliability of the map, relating the elementes of the diagonal with the total elements in the sample. The confusion analysis produced a reliability of 85.5 %.

Potential and Present Use of the Land

The relationship between the above-mentioned maps can be observed in the following table 1:

	1	2	3	4	5	6	7	8
A	512	697	7402	1155	234	67	28	6
B	2351	15019	28210	19630	20680	1671	872	98
C	399	774	19088	999	681	239	278	390
D	250	1291	34566	933	439	424	92	518

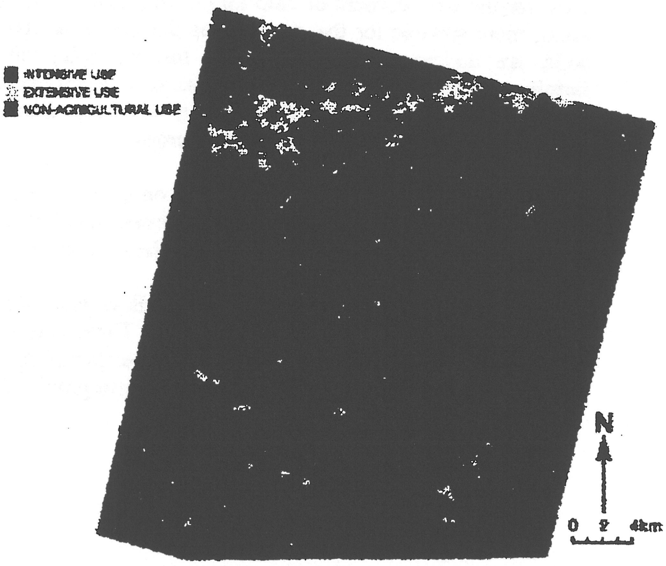
Table 1. Relationship between present use and potential land use expressed in hectares.

The columns correspond to the land use categories and the rows to the aptitude classes defined by the LEIS.

A_ Good to Moderate
B_ Moderate
C_ Moderate to Marginal
D_ Marginal

It is important to note that the table show eight land use categories and the map only shows seven. The reason for this difference is that for the cartographic representation the categories shallow water bodies and deep water bodies grouped in one category.

Joining the information from both maps (land aptitude and present use), it is possible to produce very useful cartography for the regional planner, as it provides an alternative that allows the differentiation of areas with intensive farming from those with extensive farming and natural cover (figure 5).

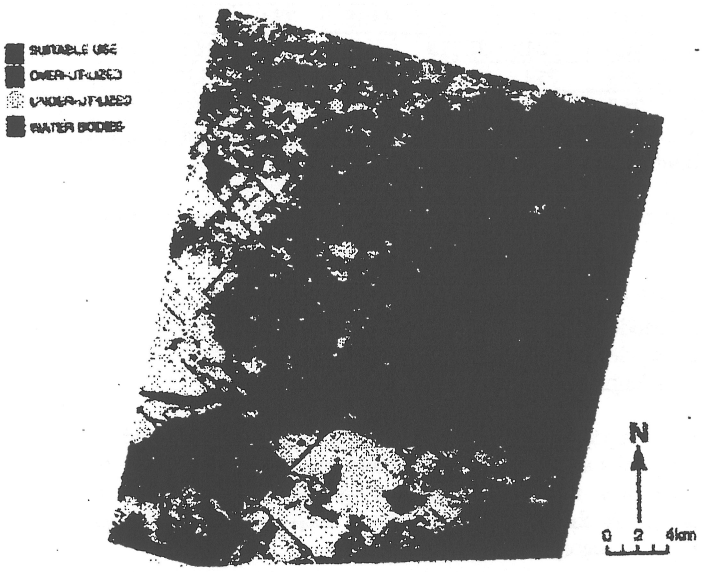


Classes of land use intensity

Figure 5.

A more interesting possibility is the one offered by Figure 6 where it is possible to differentiate the areas that are subject to an adequate use, those that are underexploited and those that are overexploited.

The tabulated values show the reality of the region; only 4.64% of the crops under irrigation are in soils with good or moderate aptitude, the rest is distributed among the categories presenting important restrictions and the greatest percentage, 21.6%, is found in soils with a marginal aptitude.



Cross-tabulated map of current land use versus land suitability

Figure 6.

The figures show farming overexplotation in the less favorauble area for the development of crop under irrigation, while other areas, more suitable for that purpose, as the moderate aptitude soils, are underexploited. The scrub, for wxample, without farming activity, occupies about 1,400 has. of soils with good to moderate aptitude. Although this is not a very large area, it is suitable for the development of intensive crops.

Most of the scrub (41,000 has.) is located on soils of moderate aptitude which are also suitable for the development of crops tending, in this case, to avoid the effects of the aeolian erosion.

The uses natural grassland and dry and fallow land show a distribution that is coherent with the reality. These classes are not problematic because it is an extensive use; therefore, they do not degrade the fertile layer of soil in the term provided that there is no overgrazing.

CONCLUSIONS

One of the aims of the assessment of land in a region is to turn the units under study into cartographic units for soil management, trying to increase the benefits that a producer, a community or a country may obtain from the land. The methodology developed here made it possible to achieve fast and reliable results in the area under study concerning the qualities of the various land units and the requirements of the uses on them and it also provided the possibility of selecting the suitable use. The experience acquired allows us to state the following conclusions:

1) The production of updated farming degradation risk cartography of quality is possible from information obtained by combining obsolete cartographic sources, images coming from remote sensors and data collected through field work, using the integrated and analytic capacity of the geographic information system (GIS).
2) Such cartography, applied to the assessment of land, becomes a useful tool for the planning of the farming sector, as the soil use capacity maps allow the adoptions of correct solutions by tending to the development of the most suitable areas and at the same time trying to avoid the degradation of the most ecologically depressed units.
3) The implement of a GIS, applied to land assessment, is highly advisable for countries, such as Argentina, which have a clear farming vocation. Its database, which can be quickly updated, is adaptable tot he dynamic characteristics of a scenery, offering the possibility of a follow-up of the behavior of the area in the course of time.

By using remote sensors and GIS it was possible to obtain valid results through an extremely low ratio number of observations/mapped area, with respect to conventional methodologies, presenting at the same time a characterization with descriptive parameters which are easy to understand.

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