AGROECOSYSTEMS AND LAND USE PLANNING IN CAMPINAS COUNTY, BRAZIL

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ABSTRACT:

In Brazil, the ecological science is just beginning to produce some good results using remote sensing and geoprocessing techniques. Particularly, the land use planning has stimulated researchers to work with satellite data and geographic information systems for better cartographic diagnosis, both in time and space. This paper illustrates how a team of ecologists has dealt with these problems in Campinas county (about 800 km^2), characterized by a high landscape diversity. Using the computer facilities of the Environmental Monitoring Center (EMBRAPA-NMA) and of the NGO ECOFORCE - Research and Development, SPOT and LANDSAT TM images and a Brazilian GIS, a digital database was created at the scale of 1:50,000 with more than 50 layers and 100 Mb large. It included digital elevation model, soil, stream and road networks, land use, agricultural parameters, faunistic habitats, etc. Since last year, the results have been used by the county authorities to plan the agricultural activities and to decree environmental protection areas.

1. INTRODUCTION

The evaluation of a production system sustainability is a complex matter, since there are not criteria and methods clearly defined or broadly accepted.

These difficulties increase when it comes to assess the sustainability of various production systems at different levels of perception: rural property, hydrological basin, rural community or county.

There is a lack of adequate methodologies to evaluate the agricultural sustainability of production systems, when they are considered as being integrated to larger ecological and socioeconomical systems, from the spatial and temporal points of view.

This paper summarizes the results of a multi-institutional project about the use of methodological tools. They are represented mainly by the GIS applications to the environmental impact assessment of different land uses. With the financial support from the Centro Internacional de Investigaciones para el Desarrollo (CIID) and the Red Internacional de Metodología de Investigación de Sistemas de Producción (RIMISP), several products were generated and are available at the Environmental Monitoring Center (NMA) and at the NGO ECOFORCE - Research and Development.

2. OBJECTIVES

2.1 Main objective

The main objective of this project was to develop a methodology to characterize and to assess, in small farms, the agricultural sustainability of different production systems, considering the micro-regional level (community, basin, county), and using GIS and satellite imagery.

2.2 Specific objectives

The main objective was translated into four specific objectives:

- To develop a methodology, based on GIS, for the characterization of the potential agricultural use of natural resources such as relief, soils, water and vegetation, in areas of small farms;

- To consolidate a methodology to characterize the present land use and the main production systems, using geoprocessing techniques, in areas of small farms;

- To develop a methodology, based on GIS, to characterize the environmental impact of agricultural activities;

- To consolidate a methodology, based on GIS, to evaluate the sustainability of small farms production systems at the community, basin or county levels

3. MATERIAL AND METHODS

3.1 Study area

Campinas County is located in the central-western part of the State of São Paulo, Brazil (22°53' S and 47°05' WGr). The total area of 781 km^2 is intensivelly cultivated, urbanized and industrialized.

The altitude varies from 500 to 1,100 meters and the annual precipitations from 1,300 to 1,500 mm.

3.2 Equipments and softwares

The digital cartography was made with the Image Processing and Geographical Information Systems (SITIM/SGI 340, Version 2.4), both developed by the National Institute of Space Research (INPE, Brazil).

The equipments included a PC-486 with 8 Mbytes RAM and 180 Mbytes hard disc, 5 1/4" and 3 1/2" floppy disc drivers and Super VGA color monitor; UVI-340 graphic board; A0 digitizing tablet; color electrostatic plotter and laser printers.

3.3 Methods

Four main methodological procedures were developed, based on GIS operations and in accordance with the specific objectives, for the study of:

- Potential agricultural land use;
- Present land use and production systems;
- Environmental impacts of agricultural activities;
- Production systems sustainability.

These methods were based on the use of a geocodified structure at the scale of 1:100,000.

4. RESULTS

For the evaluation and cartography of the potential agricultural land uses, using GIS (Objective 1), various procedures were utilized, generating many products:

1. Digitizing of the contour map (1:50,000);
2. Digital generation of the hipsometric map;
3. Digital generation of the declivity map;
4. Generation of the soil map, with field surveys;
5. Digital generation of the erosion risk map;
6. Digital generation of the potential agricultural land use map;
7. Generation of the hydrological, basins (Figure 1), and catchments maps;
8. Generation of the vertebrate habitats map, with field surveys.
9. Overlays of the potential agricultural land use map and the vertebrate habitats map, using boolean operations;
10. Analysis, validation and synthesis of the methods for potential land use evaluation.

For the characterization of the present land use and the main production systems, using GIS (Objective 2), satellite images (LANDSAT/TM5 and SPOT), topographical maps and ground truthing, various procedures were utilized and products generated:

1. Legend generation, characterizing the present land use. The different land uses were related to the vegetation type, from the more stable (forests, for example) to the more unstable (annual crops);
2. Preliminary delimitation of the main agroecosystems in Campinas county, based on LANDSAT TM and SPOT images, at the 1:100,000 scale;
3. Digital processing of the satellite images with SITIM;
4. Integration of the analogical interpretation and the digital classification for 10 different land uses or ecosystems;

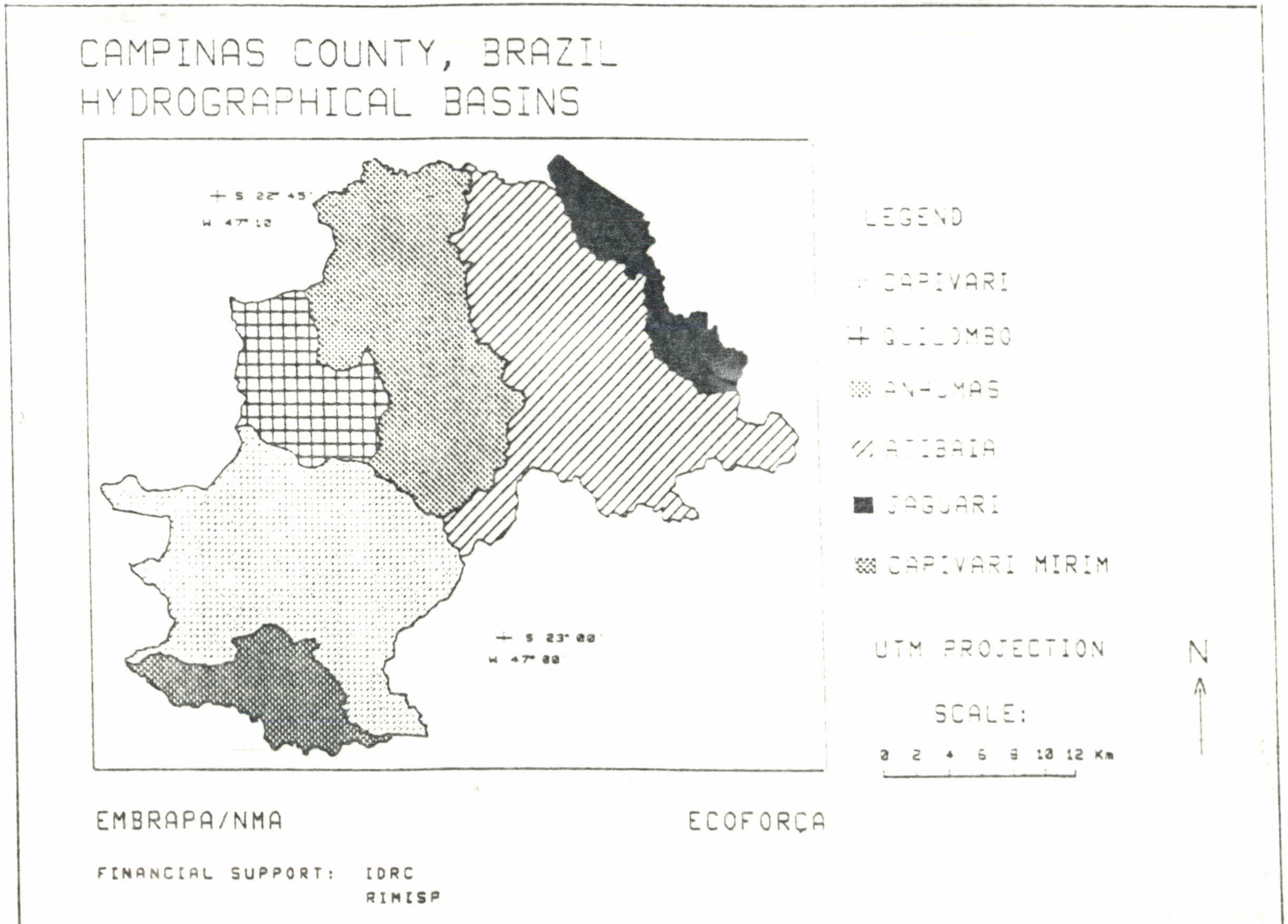

Figure 1. Map of the hidrographical basins, Campinas, Brazil

5. Ground truthing. Identification and final characterization of the agricultural land uses;
6. Digitizing of the final land use map;
7. Identification and characterization of the main production systems. The ECOFORCE has systematically surveyed the small farmers in Campinas county, collecting also informations from medium-sized and big producers, using methodologies already successfully tested in other parts of the country;
8. Cartography of the main production systems spatial distribution, in relation to the land use (Figure 2);
9. Quantification of the relative importance of the production systems, based on the occupied area and the studied properties;
10. Evaluation of the productions systems variability within each one of the main land uses;
11. identification and classification of the production systems main environmental impacts, direct or indirect, permanent or temporary, local or regiona;
12. Quantification of the production systems environmental impacts for one hectar of each land use type, based on field data and on bibliographic references;
13. Generation of a numerical database with the the production systems main environmental impacts;
14. Analysis, validation and synthesis of the methods of characterizing the present land use and the main production systems.

The evaluation and cartography of the environmental impacts of agricultural activities (Objective 3), using GIS techniques, were made by crossing the numerical data about the production systems with the cartographical data stored in GIS. This database was related to the different land use types through GIS.

The followed, tested and evaluated procedures were:

1. Generation of the environmental impact map for each land use type and production system, in terms of soils (Figure 3);
2. Generation of the environmental impact map for each land use type and production system, in terms of air;
3. Generation of the environmental impact map for each land use type and production system, in terms of surface water resources;
4. Generation of the environmental impact map for each land use type and production system, in terms of fauna;
5. Generation of the environmental impact map for each land use type and production system, in terms of vegetation;
6. Ground truthing. Implementation of three environmental impact scenarios (minimum, medium and maximum) for each studied natural resource;
7. Generation of a final synthesis map of the environmental impact caused by each production system, based on the individual environmental impact maps (1 to 5) for each natural resource (soil, air, surface water, fauna and vegetation);
8. Consolidation of these maps into a final map of the critical areas for environmental impacts caused by agricultural activities, considering the different resources;
9. Analysis, validation and synthesis of the methods of evaluating the environmental impacts of agricultural activities, in different production systems.

Finally, for the evaluation of the agricultural sustainability at the micro-regional level (Objective 4), crossings between numerical data about the production systems and the digital cartographic database have been done, trying to assess the spatial-temporal dynamics of the land uses and the interactions between the various production systems.

5. CONCLUSION

The use of geoprocessing techniques for agroecosystems monitoring represents a new way of integration of spatial and numerical data.

This paper summarized how a team of ecologists has worked for the assessment of the main production systems sustainability in the Campinas county, Brazil.

The results included analytical and synthetic maps, generated thanks to the use of GIS facilities.

This database has been continuously improved and updated, and is available at the Environmental Monitoring Center (NMA-EMBRAPA) and at ECOFORCE.

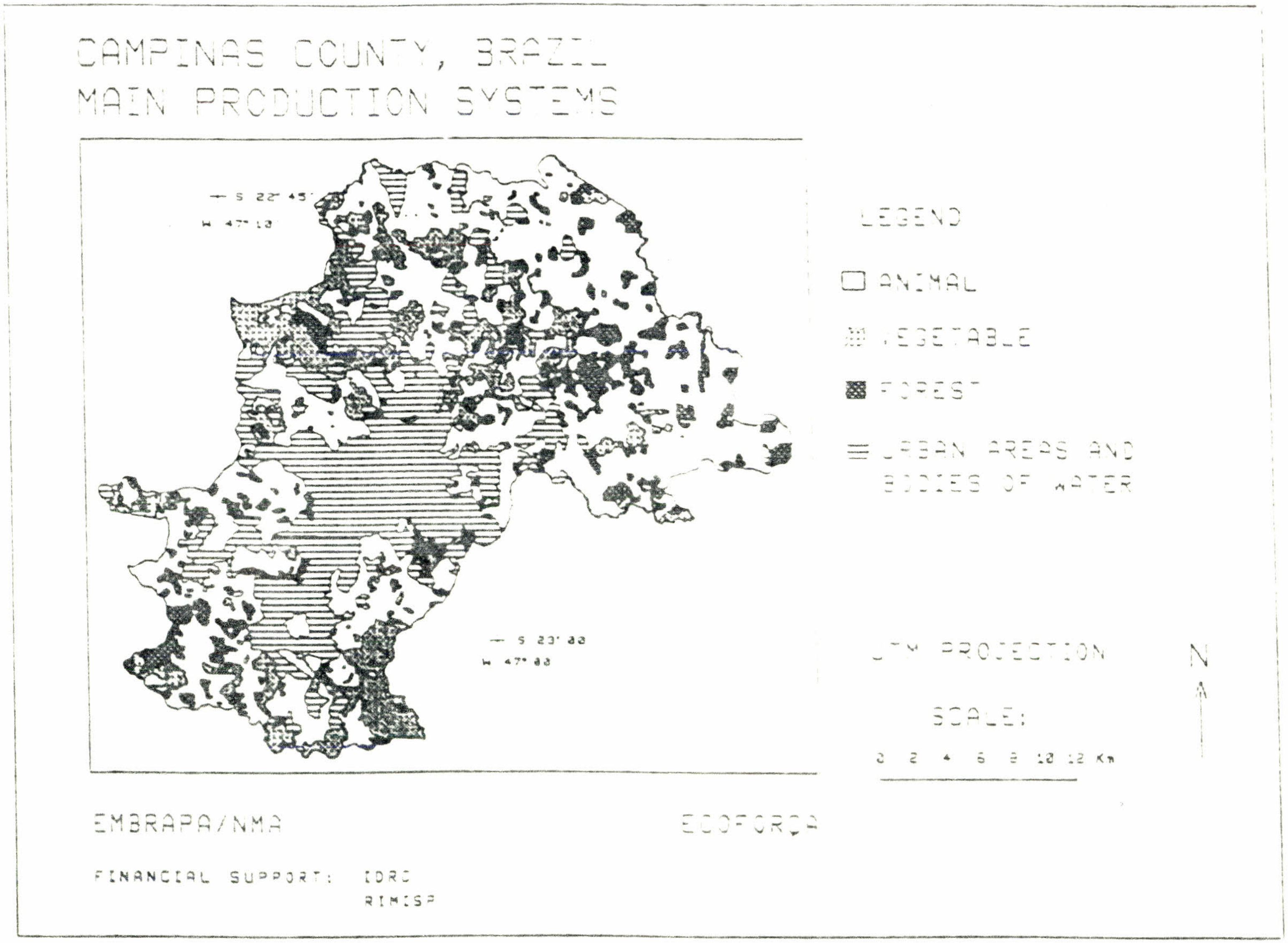

Figure 2. Map of the main production systems, Campinas, Brazil

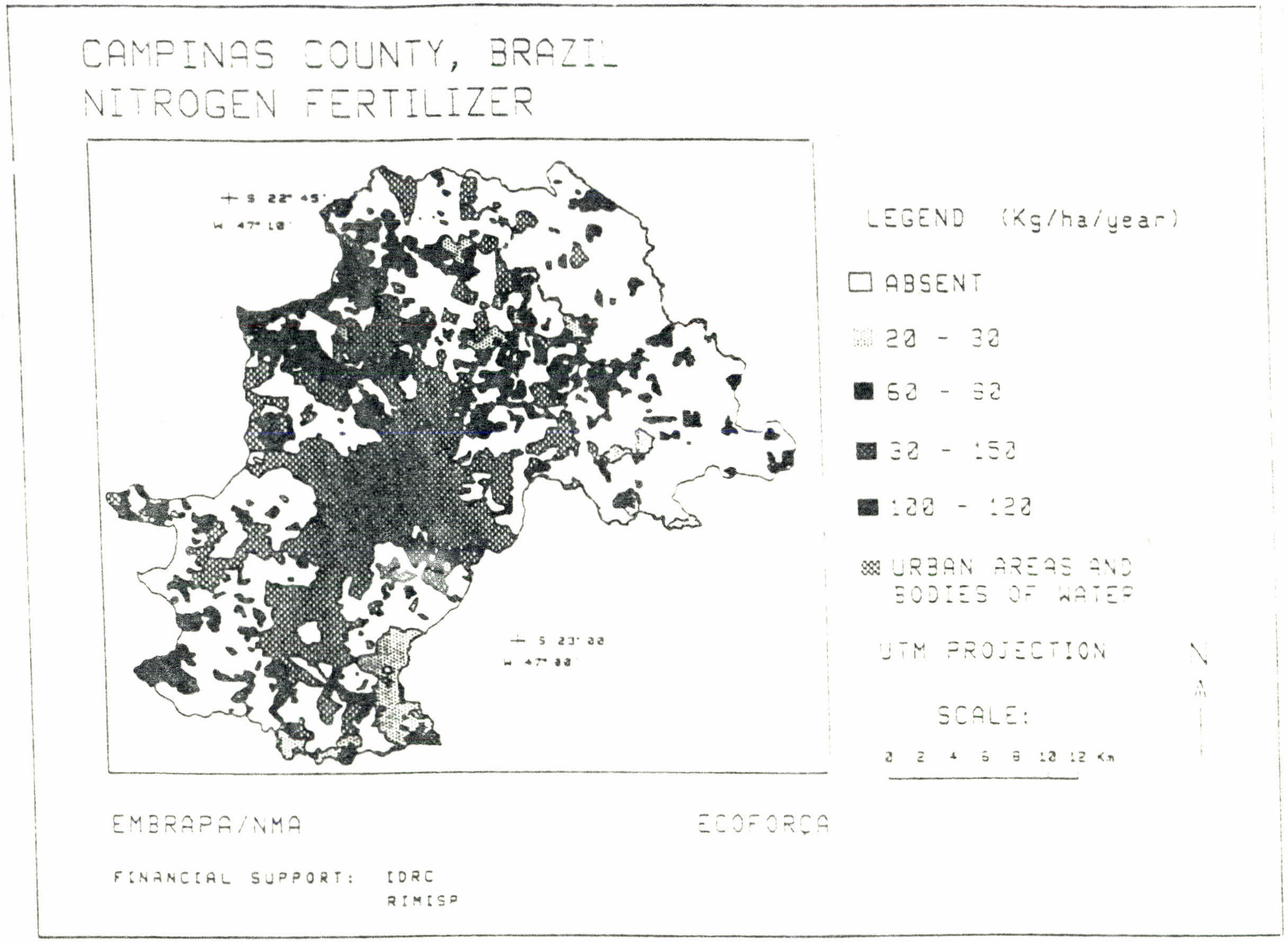

Figure 3. Map of the nitrogen fertilizer, Campinas, Brazil