

Multitemporal Effects in Regional Planning over a part of Semi-Arid Region of Paraíba, Brazil

Harendra S. Teotia

Federal University of Paraíba (UFPB)
DSER/CCA/UFPB, Areia-PB, Brazil

João Roberto dos Santos

Brazilian Space Institute (INPE)
São José dos Campos, SP, Brazil

Klaus A Ulbricht

German Aerospace Research Establishment (DLR)
Oberpfaffenhofen, Germany

ABSTRACT

The present study is a part of the CNPQ project no. 521477/96-4, which is being carried in the semi-arid region (lower part of the higher Piranhas) of the state of Paraíba in northeastern Brazil. The study presents an overview of objects, methodology, results and results of multitemporal effects of land use and land cover studies, through digital interpretation, mainly unsupervised and supervised (MAXCLAS) classification. Under this study, the supervised classification (MAXCLAS) is made up of the satellite data of two different years, using various computer programs of ERDAS software. Also, this study explains the different layers of information, limitations, utilities and implementation for the development of the semi-arid regions of the state of Paraíba. The project is divided into two phases. In the first phase the SPOT satellite data of the year 1987 have been analyzed and 15 land use and land cover classes (3 water classes, 2 urban classes, 5 cultivated classed and 5 forest classes), based on the their specific characteristics, have been classified. The accuracy assessment was made three times and finally, the over all accuracy was observed more than 90%. 2. Second phase: in the second phase, the SPOT satellite data of the year 1991 are being analyzed and will take time to finalize the complete project. The partial results of the project (only the first phase) are being described in this article. The complete results of both phases of the project will be presented and published later on.

1 INTRODUCTION

Land use / land cover is one of the affecting factors of the region's economy and the development. Remote Sensing methods are the fundamentals and essential to land cover mapping, in which landscapes are divided into various units, in accordance with their specific characteristics and correlation with the field conditions and gray values of the interpretation units. The study area has various physiological, geological, geomorphological and cultural features: slightly undulating and undulating topography, cultivated and uncultivated fields, rocky and stony areas, shallow to moderately deep and deep soils, poor drained lands, parallel and dendritic drainage pattern systems.

The present study is being conducted over a physiographic region "Região de Depressão do Alto Piranhas", in order to know the realistic assessment of the extent to which SPOT data can be used for the survey of the study area, and to provide basic information about the nature of the digital multispectral remote sensing data and how they can be used in different applications. Considering the needs for planning and managing the land for regional planning in the semi-arid parts of the state of Paraíba, we have to derive the digital land use and land cover information using image processing and GIS procedures and the latest Image Analysis Systems (ERDAS and ERDAS Imagine).

The results of the first phase (year 1987) are demonstrating a very good performance by SPOT imagery analysis through digital interpretation. It seems that the analysis of different year's SPOT data (multitemporal effects studies) may be more reliable for land use/land cover mapping in order to make a better regional planning for the semi-arid world. The SPOT imagery is also an extremely useful source of data for the integration studies of remote sensing and GIS technologies.

2 MATERIALS AND METHODS

2.1 Hardware:

- PC 486AT
- Printer
- Color Printer
- Bernoulli Box
- SVGA Monitor
- RGB Monitor
- Digitizing Table
- Cipher (Track-9)
- Plotter

2.2 Software

According to the institutional conditions, various types of Software can be used for digital analysis. For our research purposes, only two software were used:

1. ERDAS 7.5 and 2. ERDAS IMAGINE.

2.3 Field Materials

For digital interpretation, the fieldwork was very necessary. The field survey (detailed survey and field checking) was done three times in order to know the precision of the interpretation. The following field material was used: 1. Abney level, 2. Munssell Color Chart, 3. Spade, 4. Geological Hammer, 5. Pedological Hammer, 6. Binocular, 7. Camera, 8. Augers etc.

2.4 Topographical and other materials

Topographic map, Soil, Geological and Climatic maps and technical reports. SPOT images (B/W, Color composites and CCT tapes).

2.5 Image Analysis/Digital Interpretation

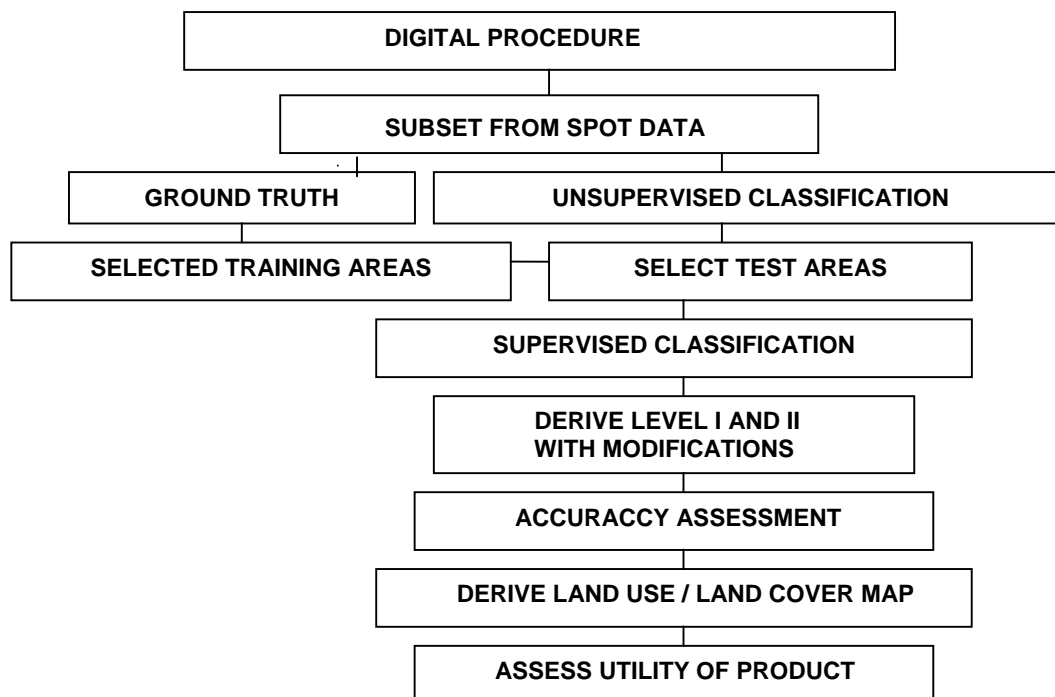
The research work was conducted by digital analysis. The main objective of this research through remote sensing is to apply the image processing and pattern recognition technologies in order to derive the land use/land cover maps for regional and local planning purposes. Level 1 B multispectral data from the SPOT -1 HRV scene dated 10 Mat 1987 (728/364) were used with ERDAS software operating on a PC's Limited 30486-based supermicrocomputer.

A 1,000-by 1,000-pixel subscene centered around Santa Luzia in the state of Paraíba, Brazil, was subset from 9-track magnetic tape for subsequent analysis.

Field studies conducted three times to provide the ground truth information, necessary for land use and land cover classification from the SPOT multispectral data. More than 60 unique sites, all contained within the study area, were visited and observations for land cover, land forms, and soils were made. These observations were used to conduct an unsupervised and supervised classification of the SPOT data.

Based on the detailed field observations, 63 training areas were selected, using the interactive capabilities of the ERDAS system, for the land cover classes of interest. The relevant statistics (means and variance/covariance matrices) were generated for these training areas and a maximum likelihood classification was applied to the entire 1,000 by 1,000 pixel image. After inspection of the initial classification, certain categories were aggregated and others deleted to reduce potential misclassification while still retaining maximum information. This resulted in the classification of a total of 15 categories (Table-1).

Accuracy assessments was conducted to compare the test areas of known reference data with the same areas on land use and land cover classification on a pixel -by-pixel base produced by supervised classification. Three to four test areas (polygons) were selected for each original class. Accuracy was assessed by intersecting the maximum likelihood classification results with their respective ground truth digital map, which revealed the pre-category agreement and disagreement. The data for the supervised and verified interpretation were then put in a table showing row-column totals, percent agreement by class and over all mapping. The digital image interpretation procedure is shown by the following flow diagram:



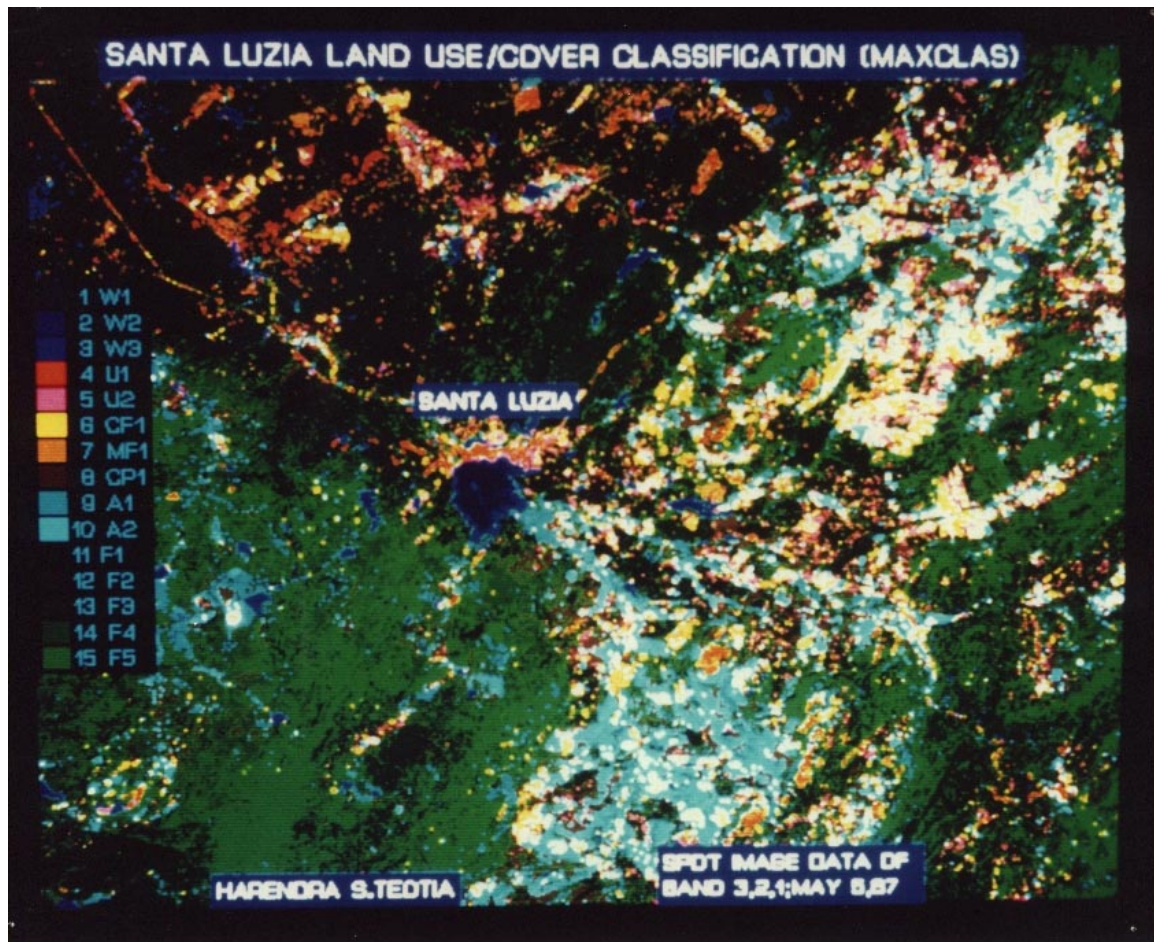


Figure 1: Land use and land cover map, derived from computer processing of the SPOT digital data, centered around Santa Luzia.

Table 1: Paraíba Land Use and Land Cover Classification

No.	Mapping Units	Description	Pixels	%
1.	W1	Deep to very deep water	3137	0.32
2.	W2	Moderately deep to very deep water	2994	0.30
3.	W3	Very shallow to shallow water	5275	0.53
4.	U1	Dense Urban area	11469	1.15
5.	U2	Sparse urban and barren rocky land	23013	2.30
6.	CF1	Cotton cultivated and fallow land	29571	2.96
7.	MF1	Mixed cultivated and fallow land	19821	1.98
8.	CP1	Mixed cultivated and pasture	106459	10.65
9.	A1	Alluvial with dense shrubs/trees	17943	1.79
10.	A2	Alluvial cultivated and eroded land	42429	4.24
11.	F1	Sparse Caatinga forest and rocky land	49884	4.99
12.	F2	Sparse to mode. Dense Caatinga forest	285754	28.58
13.	F3	Mode. Dense to dense Caatinga forest	84347	8.43
14.	F4	Dense Caatinga mixed forest on undulating land	147773	14.78
15.	F5	Dense Caatinga and mixed forest on hills	170111	17.01
Total			1,000,000	100.00

Table 2: Accuracy assessment

Map Units	W1	W2	W3	U1	U2	CF1	MF1	CP1	A1	A2	F1	F2	F3	F4	F5
Map Accuracy %	95	100	100	58	86	53	88	83	80	80	79	94	94	83	89

3 RESULTS AND DISCUSSIONS

Figure 1 is a land use and land cover map, derived from computer processing of the SPOT digital data, centered around Santa Luzia, of the 15 categories. Tables 1 and 2 are the enumeration of the classification for the entire study area. Visual inspection of on-screen displays of land cover classification detail and comparison with reference information, revealed them to resemble closely field observation. However, a more rigorous, quantitative measure of accuracy performed using the test areas, indicated that some categories were classified and mapped more reliably than others. There was a little confusion among agriculture and forest categories. This confusion may be due to the spectral similarity between these categories.

It is evident that some categories, especially forest and water, were mapped consistently better than others, and the classification accuracy typically worsened as the level of detail increased.

4 CONCLUSIONS

1. Digital interpretation of SPOT data of 20m resolution imagery was found more reliable for determining detailed assessment of land use/land cover classes and surface hydrology.
2. It was observed that the high-resolution SPOT image could be used effectively for semi-detailed mapping of the Semi-Arid regions of the state of Paraíba.
3. Classification became less accurate as the level of detail was increased. The relatively low accuracy of some categories at level II was attributed to cross-confusion among the related categories.
4. The supervised classification (per pixel maximum likelihood classification-MAXCLAS) of SPOT data offers the most satisfactory results. For detailed planning, a more conventional approach (Aerial Photointerpretation) should be used.
5. The SPOT images are an extremely useful source of data for the purpose of regional/local planning process.

5 ACKNOWLEDGEMENTS

The authors wish to thank the National Science Foundation of Brazil (CNPQ) for the funds to conclude this research work through project no. 521477/96-4. Authors are also grateful to the Federal University of Paraíba (CCA/UFPB) and the German Aerospace Establishment (DLR) to provide the Laboratory facilities and necessary material to execute this project.

6 REFERENCES

Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E. Witmer, 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data. U.S. Geological Survey Professional Paper 964, pp. 28.

Kennard, W.C.; H.S.Teotia; and D.L.Civco, 1988: The role of an automated GIS in the development and management of renewable natural resources of northeastern Brazil. In: XVI ISPRS Congress, Kyoto, Japan. International Archives of Photogrammetry and Remote Sensing 27 (89), pp. 220-231.

Teotia, H.S., 1981: Soil and Land use studies over arid and semi-arid parts of NW and Central India, based on the optical interpretation of Landsat imagery. Katholieke Universiteit te Leuven (KUL), Leuven, Belgium. Ph.D. Dissertation, pp. 304.

Teotia, H.S. and Ulbricht, K. 1992. The Integration of Remote Sensing and GIS Technologies for Land Development and Irrigation Potential in the State of Ceará, NE, Brazil. ISPRS-General Convention, Washington, D.C., August 2-14. Intl. Arch. Photogramm. Remote Sensing XXIX, Comm. VII, pp. 466-472.

Ulbricht, K., H.S.Teotia, W.D. Heckendorf and D.L. Civco, 1995: International Scientific Cooperation. Application of Remote Sensing for Developing Purposes. Published in ISPRS-Journal of Photogrammetry and Remote Sensing.