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# REMOTE SENSING DATA APPLIED TO LAND USE SURVEY AT THE PARAIBA VALLEY

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## I. ABSTRACT

The objective of this study is to develop a methodology for land-use survey and to determine the land-use modification rates using data of LANDSAT system. The Paraíba Valley (state of São Paulo) was selected as test site. Both visual and automatic interpretation methods were employed to analyze seven land-use classes. They are: urban area, industrial area, bare soil, cultivated area, pastureland, reforestation and natural vegetation. By means of visual interpretation it is observed little spectral differences among those classes. The automatic classification of LANDSAT MSS data using maximum likelihood algorithm shows a 39% average error of omission and a 3,4% error of commission for the seven classes. The classification results were under the influences of the complexity of land-uses in the study area, the large spectral variations of analyzed classes and the low resolution of LANDSAT data.

## II. INTRODUCTION

The purpose of this study was to establish a methodology for land use survey and to determine the rates of land-use change using LANDSAT data.

The south of Paraíba Valley was selected as the study area because is one of the most industrialized and fastest changing regions of Brazil. The extremely rapid urbanization has led to unprecedented conversion of land-use from rural to urban. It has presented a challenge to planners on how to monitor the region with the best efficient way.

## III. METHOD AND ANALYSIS

Multispectral Scanner Subsystem (MSS) data from LANDSAT acquired on November

1973, September 1977 and January 1978 were available. In addition, aerial photographs of 1977 at the scale of 1:45,000, a topographic map and ground observations were also available to assist in the analysis of the data.

Computer compatible tapes of multi-spectral scanner subsystem data were analyzed using IMAGE-100.

The methods consisted of visual and automatic LANDSAT image interpretation. The analysis was performed on Taubaté subarea because it represents various land-uses of the whole Paraíba Valley.

The visual interpretation was performed as follows:

- Land-use mapping of Taubaté subarea (Figure 1) at the scale of 1:250,000 using LANDSAT imagery of channels 5 and 7 in order to obtain grey level classes for 1973 and 1977.
- An area with a land-use available (1:50,000) was selected as control for LANDSAT visual interpretation (Figure 2).
- Comparison between land-use map obtained from aerial photographic interpretation and grey level classes so as to evaluate the spectral features of different land-use classes, on the test site shown on Figure 2).
- Comparison was made between the areal extent of each land-use class obtained from LANDSAT and aerial photograph (Figure 2).
- Extension of the results to the whole study area.
- Evaluation of land-use changes from 1973 to 1977 to the area shown on Figure 1.

The automatic interpretation was carried out as follows:

- The area shown on Figure 1 was divided into 10 modules in order to select those which represented the study area.
- Rectangular areas of each land-use class were selected on the image monitor of the IMAGE-100.
- The land-use classes were divided into two independent sets: training areas and test areas.
- Maximum likelihood classifier was applied to the training areas.

The classification accuracy was evaluated using two techniques:

- Errors of omission and commission for each class were calculated using test areas;
- Comparison between areal extent calculated on aerial photograph and that obtained from automatic classification for each land-use class.

### III. RESULTS AND DISCUSSIONS

The visual interpretation allowed the identification of homogeneous grey level classes on channels 5 and 7. These analyses were performed for 1977 and 1978 data. By overlaying the results for each channel, it was obtained a map of spectral classes which was compared to the land-use map acquired from aerial photograph. This analysis permitted to identify broad land-use classes such as urban area, industrial area, bare soil, cultivated area, pasture, reforestation, herbaceous vegetation and forest for 1977. Unfortunately, the LANDSAT acquisition of 1978 was taken during the rainy season and with bad quality which did not provide distinguishable spectral responses of land-use classes (Figure 3).

In the test area, the grey levels of each land-use class were heterogeneous. Thus, it is difficult to associate a single land-use class to just one grey level. For example, cultivated area with different phenological stages, soil conditions, relief, agricultural practices etc. The lack of correlation between grey level and land use class shows that land use classes can not be mapped visually with precision using only the tonality of LANDSAT imagery. Other factors such as texture, spatial distribution and the size of the study target should be included to map visually the whole area.

A comparison between land-use information, collected from LANDSAT imagery, and aerial photography

demonstrated that the "built and urban areas" was underestimated on LANDSAT imagery, due to the difficulty for setting a boundary between the expanding built area and the adjoining pastureland. The industrial area was overestimated on LANDSAT imagery because its spectral response is similar to that of the bare soil. The bare soil class includes both the bare soil and embankment areas near the cities. This class was underestimated because of its small areal extent. The crop area was identified by its location on the Paraíba floodplain. A small percentage of the highlands is used for cropping. The crop area could not be associated with a single spectral response because of the timing factors, soil diversity and land management, even though it is occupied by rice plantation. The pasture class included both the natural grassland and cultivated pasture. It presents a great variety of tonal patterns on channel 5 and occupies the largest extension in area. The reforestation class was identified on channel 7 because of the high reflectance that produces light grey tones. The forest class includes natural forest, but presents some inclusions of the reforestation class.

The rate of land use change on Taubaté subarea was determined based on the map obtained from the visual interpretations of LANDSAT imagery acquired in 1973 and 1977. Urban class presented a high areal increment that can be explained by the industrialization process which drew a high percentage of population. The class of bare soil has decreased from 1973 to 1977 because those areas that had been cleaned in 1973 were occupied by new industries. The increase of the area occupied by crops can be explained by the regulation of the Paraíba River which allowed full utilization of the flood plain. However, for the whole study area, there is a tendency of decreasing of cultivated areas. This tendency is more evident near the industrial centers of the study area.

By using automatic classification it was possible to identify 8 classes of land-use: urban area, industrial area, bare soil, cultivated area 1 (irrigated cropland), cultivated area 2 (nonirrigated cropland), pasture, reforestation area and forest. Tables 1 and 2 give the errors of omission and commission of each class. Generally speaking the errors of omissions were greater than errors of commission. Pasture class shows the smallest omission error because of its large extension and well defined spectral

responses in the four MSS channels.

Table 3 shows the data of areal extent obtained from aerial photography and digitalized LANDSAT data. It can be observed that pasture and cultivated area present small differences in both remote sensing products.

The results showed that LANDSAT data can be used for land-use surveys. The accuracy of this methodology depends on the physical features of the area under study and the complexity of land occupations. On the highlands the shadow effects make the identification of the land use classes difficult, and contributes to the increment in commission errors.

This methodology is being applied again in another region in order to evaluate the effects of physical and cultural features in land-use classification accuracy.

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Table 1. Errors of Omission and Commission from Land-Use Classes (Module 1).

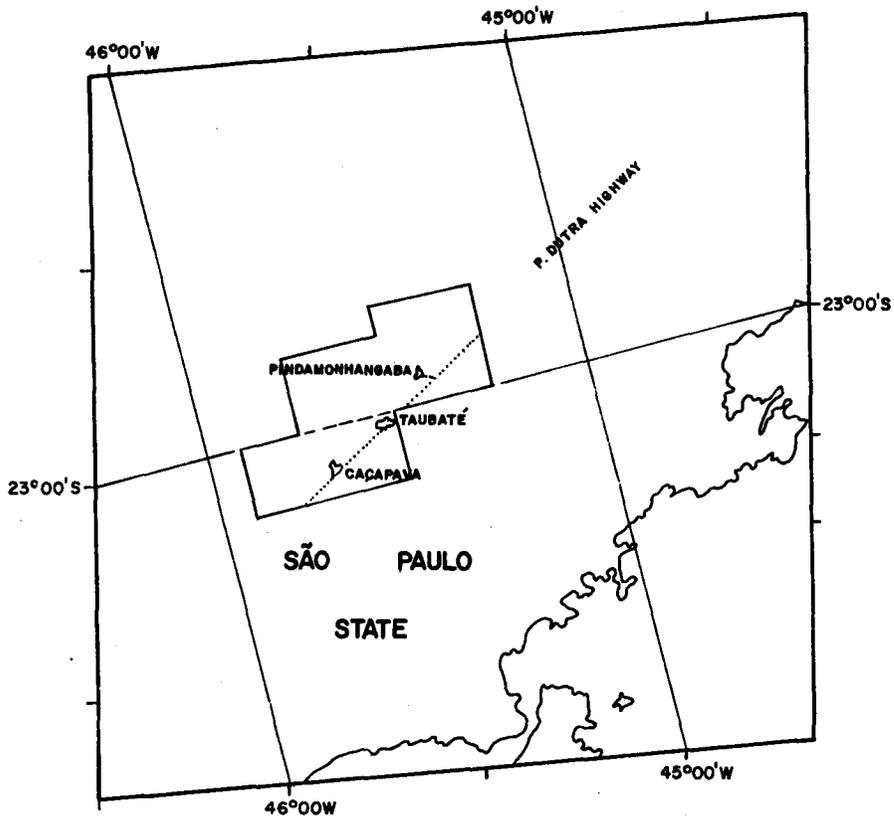
CLASS	ERRORS (%)	
	OMISSION	COMMISSION
BARE SOIL	43	4
CULTIVATED AREA 1	30	1
CULTIVATED AREA 2	15	7
PASTURE	4	2
REFORESTATION	33	6
FOREST	44	8

Table 2. Errors of Omission and Commission from Land-Use Classes (Module 4).

CLASS	ERRORS (%)	
	OMISSION	COMMISSION
URBAN AREA	19	1
INDUSTRIAL AREA	77	1
BARE SOIL	62	4
CULTIVATED AREA 1	38	9
CULTIVATED AREA 2	39	6
PASTURE	10	3
REFORESTATION	58	4
FOREST	39	1

Table 3. Percentage of Area occupied by Land-Use Classes using LANDSAT and Airplane Data - (September 1977).

CLASS	AREA (%)			
	MODULE 1		MODULE 4	
	AERIAL PHOTOGRAPHS	LANDSAT DATA	AIRPLANE	LANDSAT DATA
URBAN AREA	-	-	20,62	11,97
INDUSTRIAL AREA	-	-	0,58	1,85
BARE SOIL	0,39	0,01	0,32	1,86
CULTIVATED AREA	24,50	24,56 <sup>1</sup>	22,96	19,52
PASTURE	69,07	58,38	47,36	45,74
REFORESTATION	2,22	11,84	5,61	7,74
FOREST	3,82	5,21	3,35	11,32



**LEGEND**

- ..... Roads / Highways
- ☞ Cities

Fig. 1 - Test-Site Taubaté.

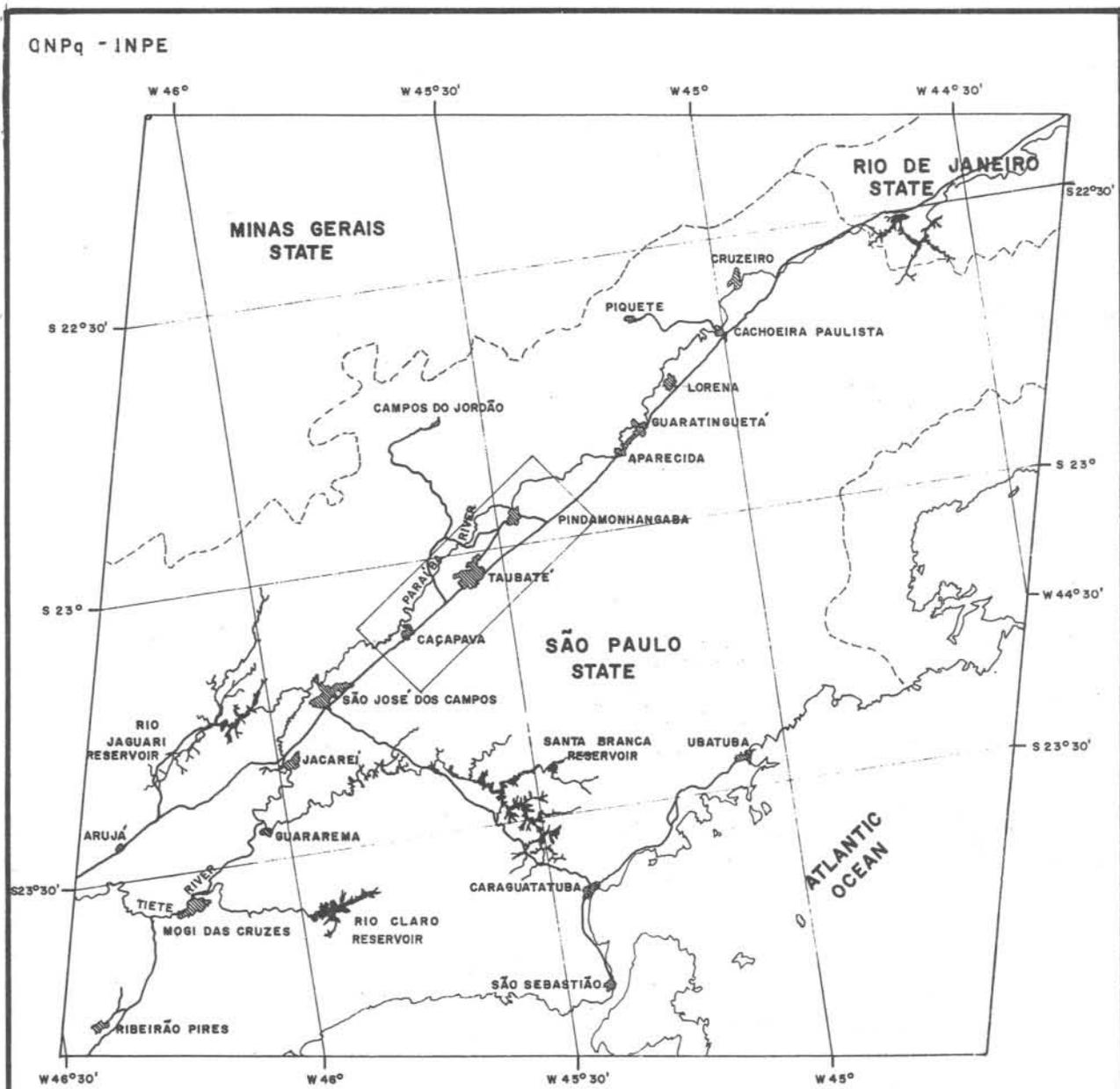
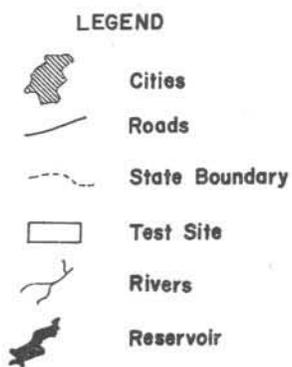
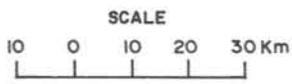


FIG. 2 - TEST-SITE WITH PHOTOGRAPHY CONTROL



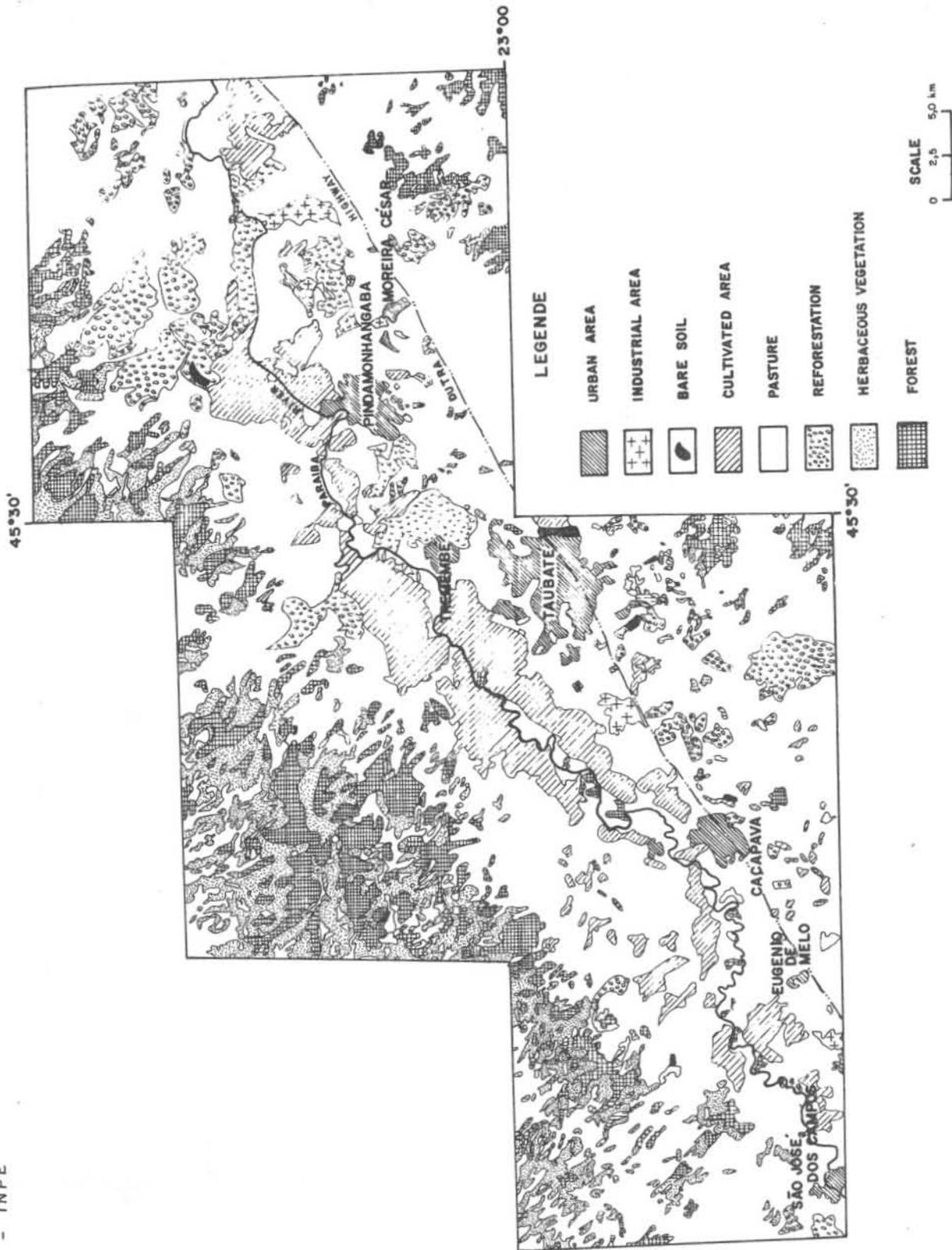


FIG. 3 - LAND-USE MAP OF TEST-SITE TAUBATÉ (1977)