SPOT IMAGERY FOR CLASSIFICATION OF URBAN LAND USE: A COMPARISON WITH LANDSAT TM IMAGERY - A STUDY OF BELO HORIZONTE AREA

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ABSTRACT

It was possible to identify the areas of urban expansion, the growth axes and the urban land use of Belo Horizonte Metropolitan Area (BHMA), Brazil, using TM and SPOT imagery. The information extracted from SPOT data and TM data were compared.

The various bands of SPOT and TM data area were interpreted and classified into 8 classes. To evaluate the quality of the products from TM and SPOT visual and digital classification are done. The visual interpretations are evaluated by a field survey, to check some information, and the digital classification are evaluated by the MAXIMUM LIKELIHOOD classifier.

The visual interpretation of SPOT imagery provided better details and better mapping accuracy. The comparation between the TM digital image classification and SPOT digital image classification didn't show the variability of details existent between them.

The areas of urban expansion and the principal sectors of BHMA growth are identified through the multidata MSS imagery and TM imagery.

This research showed the usefulness of SPOT data for urban monitoring.

Key words: Urban area, urban land use, urban expansion, SPOT data, TM data, maximumlikelihood.

1.0 INTRODUCTION

Identifying urban land uses and urban management must be systematic and periodical because they are useful for urban planning.

Since 1972, orbital remote sensing gives instantaneous and repetitive data which can be used in urban and environmental planning and it has been increased use in urban studies either because of spatial, spectral and radiometric resolution of TM and HRV-SPOT sensors.

Delavigne et al. (1986) pointed out that TM data have been accepted as an important improvement on the analyses of the land cover/land use and urban components in the big cities mainly because its spectral and spatial resolutions.

Nagarathinam et al.(1988) demonstrated that because of its high resolution. SPOT imagery is also useful for visual and digital anlyses in delineating of urbanized areas of Madras.

Poleé (1988) pointed out that SPOT false-color composites enlarged to the scale of 1:50,000 can be used for monitoring of urban growth, but additional field survey are recommended.

This paper is directed mainly towards a comparison between TM imagery and SPOT imagery. Through visual and digital interpretations of urban land use in Belo Horizonte Metropolitan Area (BHMA), Brazil. An urban expansion map to identify the principal sectors of BHMA growth was done using TM data.

2.0 DESCRIPTION OF STUDY AREA

Belo Horizonte is a large city and it is the administrative capital of the State of Minas Gerais, Brazil (figure 1). The city was founded in 1897.

Initially it was a planned city, with almost 100 years old, and now it is the third most populous brazilian city. When it was founded, the initial plan foresaw an area of 34 Sq.Km to be occupied with 300,00 inhabitants. In 1989 it covered 235 Sq.Km and 2,339,039 inhabitants. The city of Belo Horizonte and its adjoining suburbs, including 18 towns, form an administrative unit called Belo Horizonte

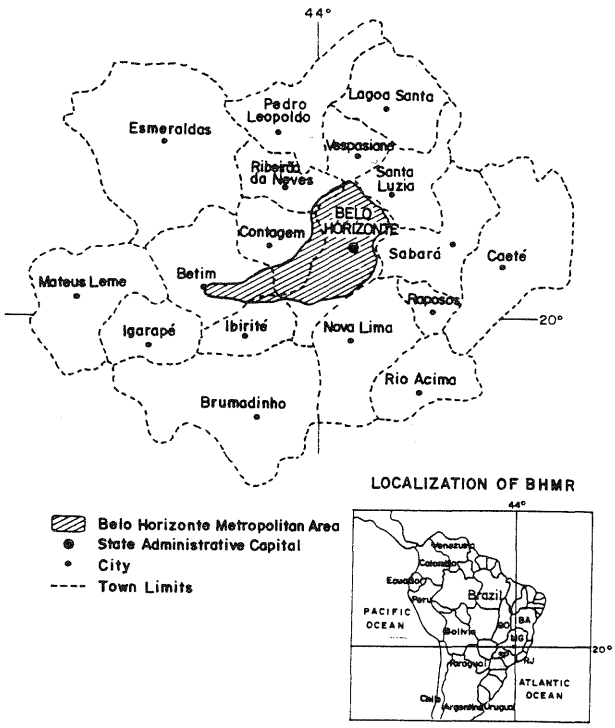

Figure 1 - Localization of Study Area

Metropolitan Region, which occupies a total area of 5,849.8 Sq.Km. The continuous urban space forms a geographic unit called Belo Horizonte Metropolitan Area (BHMA), which occupied a total area of 409,13 Sq.Km in 1990.

BHMA's shape was determined by elements of its physical geography and an initial occupation factor related to mining activity.

It is located between a branch of Serra do Curral and the São Francisco Depression. Serra do Curral, a mountain of the pre-cambrian age, is extended in a general east-west direction forming the city's southern limit, separating it from other administrative subunits. It contributes to the different phytophysionomical patterns, resulting in an environmental situation and ecological effects affected by human interference (Maio, 1987).

At the foot of Serra do Curral there are lowered lands of sedimentary or crystalline nature, dominating the east and the north.

In this way, BHMA presents more factors restrincting urban expansion to east than in other directions.

BHMA has a lot of urban occupation problems due to its complex and uneven terrain. Such occupation is already responsible for extensive damage to the environment.

3.0 MATERIALS AND METHODS

SPOT and TM multispectral data on CCT (computer compatible tape) and on paper were used for this study, at scale 1:50,000, to identify classes of urban land use. TM data on paper at the scale 1:250,000 were used for making the urban expansion map.

Urban land use was divided into 8 categories (Table 1). Each class was used to interpret the original image information from TM data and SPOT data. The paper images were analysed and classified by visual interpretation.

The Maximum likelihood classifier was

done over digital information and the results were compared by the average of fractions correctly classified pixels.

Ground truth information was collected for these classes and the TM map and the SPOT map were compared by a field survey. The field survey was carried out in BHMA to check the results.

The urban expansion map was digitalized to improve the results for each years: 1975, 1980, 1985 and 1985. It was done to identify the principal sectors of BHMA growth.

TABLE 1. Classes of Urban Land Use

- high density built up areas
- medium density built up areas
- low density built up areas
- vegetated areas
- open spaces
- water surfaces
- industrial areas
- mining areas

4.0 RESULTS AND DISCUSSION

4.1 Urban Expansion of BHMA

BHMA has had a considerable urban area growth in 15 years. In 1975 it occupied an urban area of 246.30 Sq.Km and in 1990 this area occupied 409.13 Sq.Km. It represents an increase of 66.12% , an average of 4% per year

As we can see in figure 2, the greatest increase was between 1975 and 1980. The urban area of BHMA showed an increase of 32.2% during this period. The urban area showed an increase of 1,83%, the lowest increase rate, from 1985 to 1990 .

This variation in the growth rate can be explained by economic reasons, seeing that between 1975 and 1980 the biggest cities in Brazil were still feeling the little economic brazilian increased that happened between 1970 and 1972. This economic increase had started to decline, too fast, and the end of 1980 could be caracterized by the economic recession that contained brazilian urban growth.

Figure 2 shows that the urban area of BHMA had showed more increase in northwest and north direction. Those areas have the best conditions for urban occupation, regard to pedological, geological, geomorphological and declivit characteristics. Carvalho (1990 and 1985) demonstrated that the human occupation was done without planning and it has caused many environment problems, as slope slipping.

Belo Horizonte Metropolitan Area is an appropriate area for urban occupation, the only problem is being the high declivity areas, which should be avoid and preserved as green spaces or water sources. But the reality is different. Construction has been done in many different places, indifferent to specific technical requirements due to the nature of the terrain.

4.2 Digital Classification of Urban Land Use

In this part, it was first selected training set areas to realize the digital classification. After identifying the training set areas, classification statistics were generated. The statistics parameters of the training sets were used to classify the scene with the maximum likelihood classifier.

Seven urban classes were identified from analyses of digital classification of SPOT imagery. The area of the high density core of BHMA corresponds to the center and some older areas. Within this zone is located the business district as well as residencial zones interspersed with built up areas and houses.

Costa (1991) demonstrated that at this area the slope gradient increases from 2.6% to 100%, whereas altitude varies from 800 to 1,400 meters.

Immediately after the high density core there is a zone of medium and low density built up areas interspersed with some vegetated areas. In the periphery, not only the available open space is identified, but also the extend and direction of urban growth can be traced.

Mining areas have also been classified but industrial areas haven't.

Similar zones were identified using TM

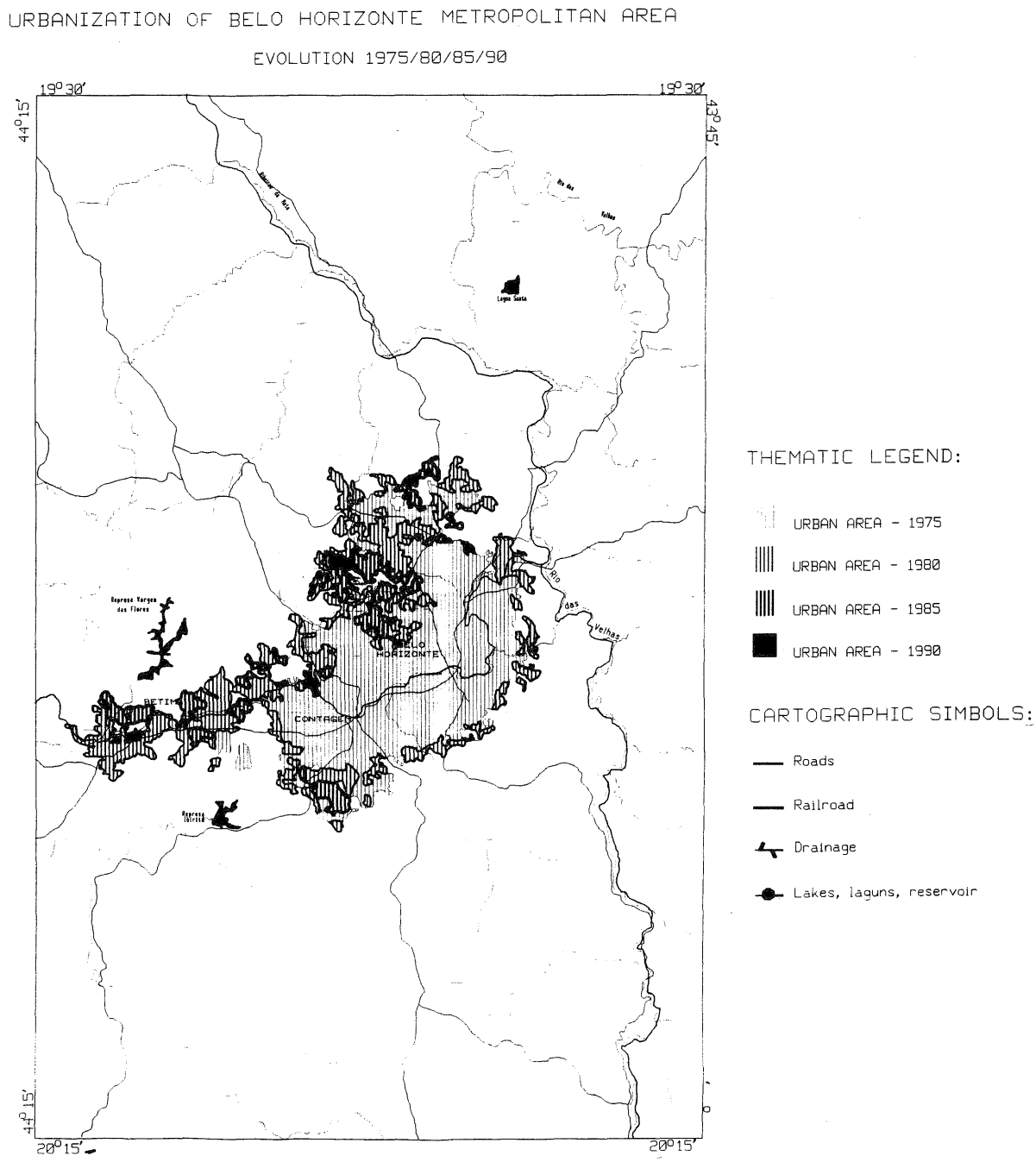

Figure 2 - Expasion of Belo Horizonte Metropolitan Area: 1975/1980/1985/1990

imagery and the results were compared to asses the levels of accuracy, as following.

The urban area chosen for this study are spectrally very close in nature integration and is very common some confusion at the digital classification.

But when a comparison is made between the SPOT and TM data (Table 2), we can see that the classified data of SPOT increase the accuracy in the vegetated areas, medium density built up areas, open spaces and water surfaces. TM classified image increase the accuracy in the high and low density built up areas and mining areas.

TABLE 2 - MATRIZ OF CLASSIFICATION

MATRIZ OF CLASSIFICATION ACCURACY OF TM DATA

	N	1	2	3	4	5	6	7
veget.areas	2.8	93.3	0.0	0.0	1.5	0.7	0.1	1.6
high density	2.5	1.8	77.2	9.3	1.2	1.3	4.4	2.2
med. density	2.2	0.0	10.1	75.4	9.8	0.1	0.2	2.1
low density	3.3	0.2	0.3	9.5	76.4	5.3	0.1	4.9
open spaces	6.4	0.7	0.7	0.8	41.8	41.8	0.2	0.2
water surface	4.2	1.3	1.6	0.0	2.0	0.7	90.2	0.0
mining areas	0.3	2.6	4.9	1.5	5.1	2.6	0.0	83.0

CLASSIFICATION ACCURACY= 80.47%

MATRIZ OF CLASSIFICATION ACCURACY OF SPOT DATA

	N	1	2	3	4	5	6	7
veget.areas	3.7	94.8	0.1	0.0	0.1	0.0	0.0	1.3
high density	3.8	0.0	47.0	15.9	0.9	0.5	24.5	7.4
med.density	0.7	0.0	3.9	84.8	3.8	0.0	0.1	6.8
low density	2.0	0.0	0.2	7.4	67.4	6.6	0.0	16.4
open spaces	5.6	0.0	0.0	0.0	14.3	80.1	0.0	0.0
water surface	0.0	0.0	1.6	1.0	1.6	0.0	91.8	3.9
mining areas	1.2	5.8	10.7	31.5	13.4	0.4	1.6	35.3

CLASSIFICATION ACCURACY= 73.11%

Despite the results, the digital classification didn't show the separability between TM and SPOT datas. It was dued to complexity of urban environment. It has many differents targets (as vegetated areas, asphalt and concrete) and they are spectrally very close in nature integration, making very difficult to classify urban areas.

4.3 Visual Interpretation of Urban Land Use

The urban environment is very complex, as was showed before.

But visual interpretation has some differences comparing to digital classification. The human feeling can perceive more important details than a computer. For example, a texture pattern, tone, colors and the spacial continuity is very important to define urban classes and it can be noted by human eyes.

Therefore, in visual classification is possible to see the differences between TM and SPOT data.

At the SPOT mapping the high density build up is better defined than at TM mapping. The area is samaller in SPOT map (13.54 Sq.Km to SPOT and 20.0 Sq.Km to TM) but at checking field we can see that it corresponds to the reality, including the medium density build up and the low density build up.

Some industrial areas were checking and it was concluded that at TM mapping it was superestimated and in SPOT mapping it almost corresponded to real area. Mining areas were better defined at TM map than SPOT map.

Comparing the SPOT map with field checking, principal higher density built up areas (including high and medium denisty) correspond to principal administrative cities of BHMA: Belo Horizonte, Contagem and Betim. It was dued to the improve of spatial resolution of SPOT image, which eliminates the boundary pixels misclassification.

Vegetated areas were better traced at TM map. It was due of its better spectral resolution.

5. CONCLUSION

This study presents a mapping of urban land use throught TM/LANDSAT data and HRV-SPOT data, which proved to be of great value. SPOT imagery was found to be useful for visual analysis in delineating urbanized areas.

It was showed that tone, colors and texture differences are sufficient for visual classification of urban land use. Areas with a specific combination of those three factors were possible to be identified on the image and it facilitated the identification of urban land use classes.

The comparison between Tm digital image classification and Spot digital image classification didn't show the variability of details existent between them.

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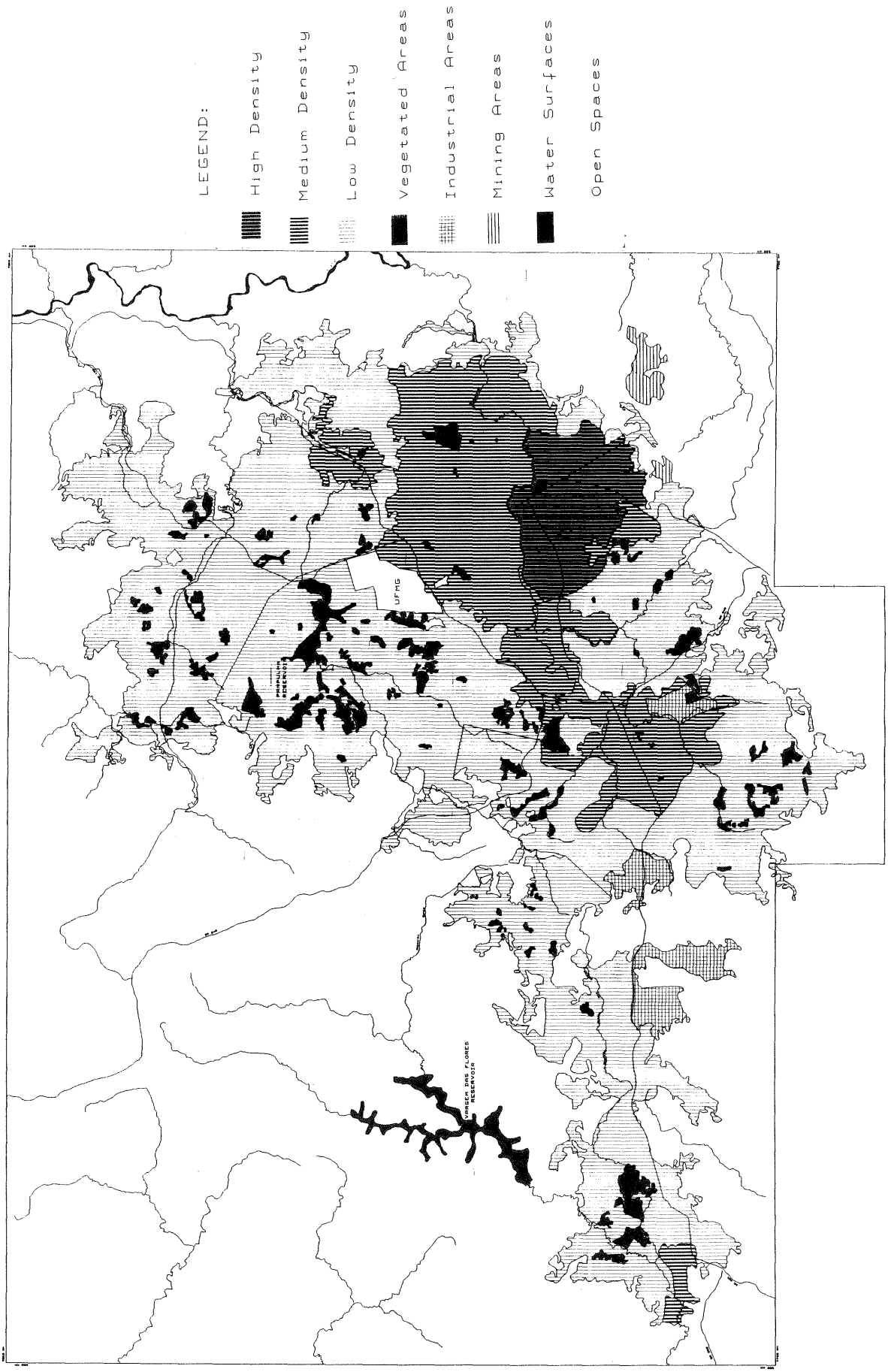

Figure 3 - Urban Land Use of BHMA. Information Obtained From TM Image

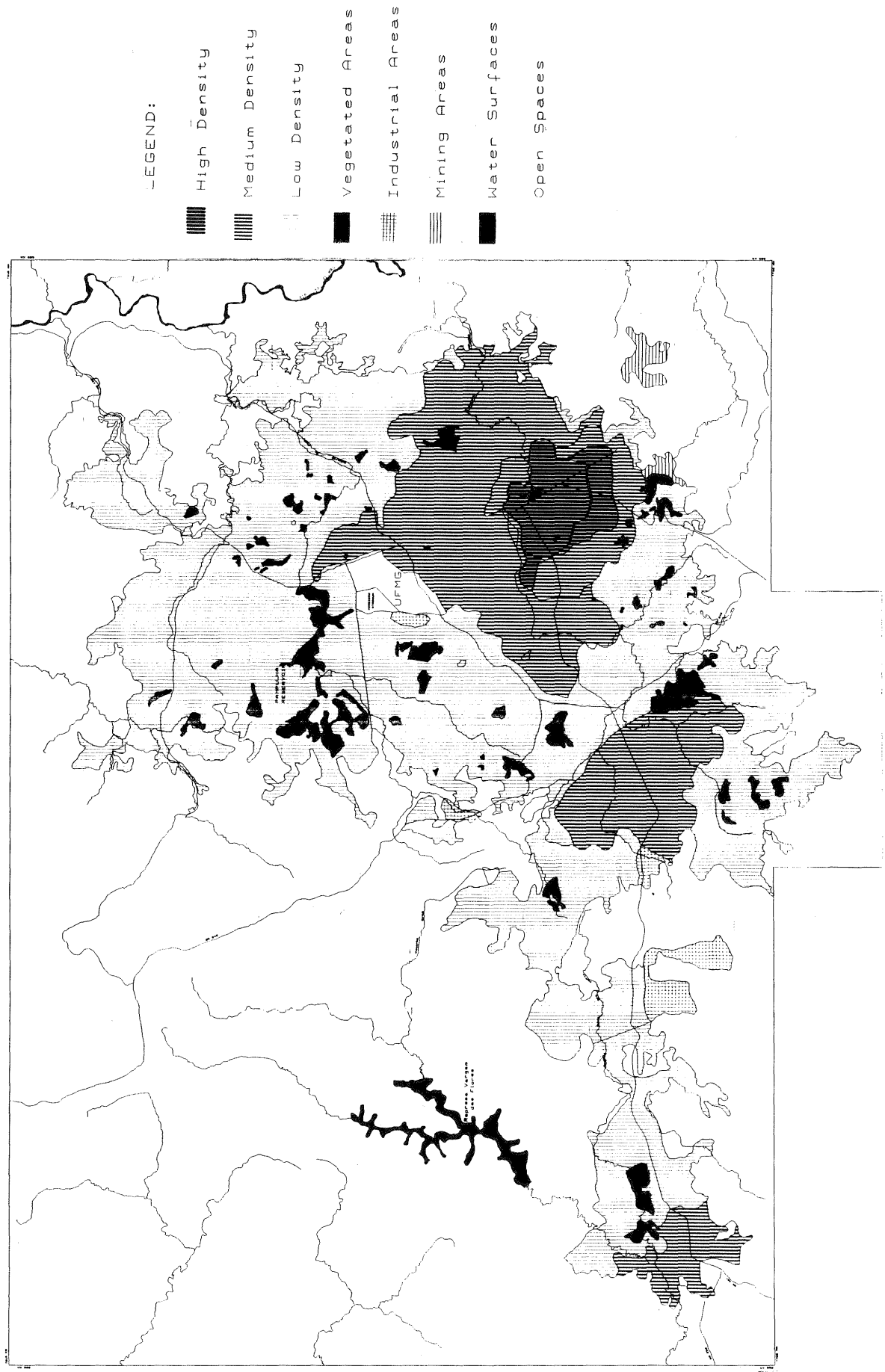

Figure 4 - Urban Land Use of BHMA. Information Obtained From SPOT Image