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PLANIMETRIC AND THEMATIC MAPPING POTENTIAL OF LANDSAT MSS IMAGERY FOR INTEGRATED SURVEYS OF SOUTH BRAZILIAN NATURAL RESOURCES

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SUMMARY

This paper attempts to analyze the planimetric and thematic mapping potential of visually interpreted Landsat MSS bulk images for application to integrated surveys of Brazilian natural resources.

From the results of many operational applications, it was observed that the maps made from the images meet the planimetric and thematic requirements of third order maps in accordance with the norms of the Brazilian Geographic Service - DSG.

Maps requiring detail with minimum dimensions greater than 100 metres, can readily be obtained from the interpretation of Landsat MSS imagery. The thematic accuracy of such maps also fulfills the basic requirements for regional surveys, so that the maps provide an excellent basis for monitoring operations and the assessment of natural resources.

INTRODUCTION

The production of base maps and their transformation into thematic ones may require, depending on the region to be mapped, high financial investment.

In many cases, the accuracy required for these maps, mainly those used in regional inventories, is compatible with the use of medium and small scales.

In this respect, the larger scales are very expensive and not necessary.

Furthermore in mapping extensive areas such as Brazil, large scales (say 1:10.000) would not be feasible. In this case the medium and small scales solve the problem partially.

For inventories that require higher levels of detail, the orbital data associated with data of other sensors like SLAR, can be the solution for planimetric and thematic mapping, because of the large area covered by each image, the low cost of mapping and their easy acquisition.

Among the orbital images, those obtained from the Landsat program are the most used in Brazil.

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Nevertheless, reliable information on the planimetric and thematic potential of Landsat MSS imagery under southern Brazilian conditions is still lacking (see CARNEIRO, 1976).

This paper summarizes the preliminary results of Landsat applications in Brazilian conditions, as a first approach for establishing future monitoring operations in that region.

2. MATERIAL AND METHODS

A Landsat image-Bulk form - (Band 5) in scale of 1:250.000 taken at June 5, 1974 was used.

An area corresponding to the coordenates 53º 30'N 54º00'W in longitude and 29º00'S - 54º00'W in latitude was delimited and visually interpreted. Topographical maps corresponding to this area were reduced from 1:50.000 to 1:250.000 by using a Map-O-graph reflecting projector and the necessary comparisons were made.

For testing the planimetric error of the Landsat scene the following formula was used:

$$RmSp = 5,7.\ 10^{-4}\ Sm,$$

where RmSp, is the root mean square of the planimetric error (meters) in the tested points, and Sm, is the representative fraction of the map or image used.

In addition, the accuracy of linear measurements was determined by comparing topographic poligonals established both on topographic maps and Landsat imagery. Every poligonal was defined by 10 alignments and, in every vertice the UTM coordinates were measured.

The distance between every two vertices both on the ground truth and Landsat was calculated by using the formula $d^2 = (X_A - Y_B)^2 + (Y_A - Y_B)^2$ where d is the distance between A and B, X_A is the abciss of point A, X_B, is the abciss of point B, Y_A is the ordinate of point A and Y_B, is the ordinate of point B.

Finally a simple linear regression equation was established by correlating both ground truth and Landsat data.

3. RESULTS AND DISCUSSION

3.1 The planimetric mapping potential of Landsat imagery in the area of study.

The average planimetric error for maps of class A in scale of 1:250.000 is 142,5 metres.

The average planimetric of the Landsat was estimated to be 207,95 metres in 39 points tested in the area of study.

The map of distortions, shows a highly sistematic tendency of the errors. By using 3 to 5 control points per image, the precision can be considerably increased, making more effective the utilization of these images.

However, it must be taken into consideration that the utilization of scene corrected images-Precise form- can lead to better geometric results. They were not used because of their poor radiometric fidelity.

Even so, the estimated error (207,95 m) is within the acceptable limits cited by COLVOCORESSES (1974), KRATKY (1974) and WONG (1975), among many others, and is within the limit specified for maps of class B (in this case 285 m - double of class A).

The linear accuracy measured from poligons established both on topographic maps and Landsat imagery is illustrated in table 1.

Table 1. Comparison between poligons established both on topographic map-1:50.000 - and Landsat imagery.*

Alignment	Ground Truth-m.	Landsat m.		Relative error-m.	Error m/1000
0 - 1	5.497,38	5.455,99	-	41,39	7,53
1 - 2	6.378,81	6.306,71	-	72,10	11,30
2 - 3	6.529,98	6.541,12	+	11,02	1,71
3 - 4	4.127,00	4.197,12	+	70,12	16,99
4 - 5	15.828,63	15.534,35	-	294,33	18,60
5 - 6	3.962,00	3.823,98	-	138,82	35,03
6 - 7	4.347,58	4.204,26	-	143,32	32,97
7 - 8	9.889,55	9.784,75	-	104,85	10,60
8 - 9	6.162,35	6.039,97	-	122,38	19,86
9 - 0	6.883,81	6.868,86	-	14,95	2,17
Total	69,607,09	68,757,11	-	849,98	
Average				85,00	15,68

By analysing this table, it can be observed that the average error of 15,68 metres for every 1000 metres of survey, even being high, fulfills the requirements of pre-investment or reconnaissance surveys as mentioned by HILDEBRANDT (1978).

The existing correlation among the ground truth and Landsat data can be expressed by the following linear equation:

$$Y = 41,93 + 1,02\ x \quad (r = 0,99)$$

Where x, is the value of Landsat data.

* The author gratefully acknowledges the contribution of Mr. Ennio Giotto in measuring and analyzing these data.

It is interesting to observe the sistematic tendency of the ground truth data to be higher than the Landsat (that is why the value of a in the equation is negative).

3.2 The natural resources of the area of study.

The study was conducted in two test-areas where complete knowledge of soil units, vegetation and hydrological systems was already acquired.

3.2.1 Soil mapping tests

The results obtained both from the Landsat interpretation and soil type map (ground truth) are illustrated in table 2.

Table 2. Comparison of the interpretation carried out on Landsat and soil type map.

Soil Units*	Ground Truth-ha.	Landsat-ha.	Error-%
Cruz Alta	26.262,0	26.301,0	+ 0,14
Guassupĩ	19.851,0	19.896,0	+ 0,22
Charrua	6.718,8	6.692,7	- 0,39
Tupanciretã	2.697,7	2.701,0	+ 0,12
São Pedro	1.527,3	1.406,0	- 7,50
T O T A L	57,056,8	56,996,7	8,37(absolute)

* For detailed technical description on the soil units see Brasil - MA (1973) and table 3.

The high average accuracy obtained in these two test - areas (98,33%) shows how amenable the Landsat images are to soil mapping.

It is important to note, that this accuracy was obtained for specific test-areas. It is possible that on a regional level, it will not be so high.

A more complete analysis is shown in table 3.

In this table a qualitative and quantitative description of the major soil groups occuring in this region is made based on their visual characteristics presented on images of bands 5 and 7 and color composites.

The characterization of the major soil groups shows strong relation with the relief and can be interpreted by the variations of color, gray tone and drainage network (all of them associated with relief).

3.2.2 Vegetation Cover Mapping

For the visual interpretation of vegetation, band 5 (1:250,000) and the infrared color composite were the most informative (see CARNEIRO

Table 3. Visual characterization of major soil groups in the study area.

Photographic Patterns	B Latossolic soils			B Textural soils			little developed soils			Hydromorphic
	1 DRL 2			RYP 3			Non Hydromorphic soils			Humic gley
							Litholic soils			
	PL	Medium	Clay	Medium	Clay	BRL	R 5	VOR 6	OR 7	
Tone	light to medium gray 030-0,70	light gray 0,05-0,10	medium gray 0,20-0,30	light to medium gray 0,10-0,50	medium gray 0,30-0,60	dark gray 1,00 - 1,30	dark gray 0,70-1,00	medium gray 0,30	light gray to medium 0,20-0,40	dark gray 1,30 - 1,70
Color	145 m.g. and 12.s.Red	3. deep pink	12.s. Red	15.m.Redand 18.I.PY.Red	13.deep Red	Br 11.v. Red	13.deep Red	12.s. Red	3. deep Pink	21. blackish
Texture	Rough to coarse	Rough	Rough	Fine to Rough	Rough	Coarse	Coarse	Rough	Rough	Smooth
Drainage network	Dendritic and Sub-dendritic +++	Sub-dendritic +++	Sub-dendritic +++	Dendritic and Sub-dendritic +	Dendritic and Sub-dendritic +	Subdendritic +	Sub-dendritic +++	Dendritic and Sub-dendritic +++	Sub-dendritic and parallel +++	Indefined +
Relief	Ondulated +++	Ondulated +++	Ondulated +++	1.Ondulated +++	Ondulated ++	v.ondulated +++	Mountainous.+++	V.ondulated +++	Ondulated +++	Flat +++
Vegetation	Forests barren-lands, Fields +++	Grass-fields gallery forest +++	Grass fields gallery forest +++	Grass fields +++	Grass fields and Gallery forests ++	Native forests and Agri-fields +++	Native forests +++	Grass fields ++	Grass fields and Gallery forests ++	Swampy vegetation +++

1 - Purple Latossol
2 - Dark red latossol
3 - Red yellow Podzol

4 - Brown Red Laterite
5 - Mountainous Relief
6 - Very ondulated Relief
7 - Ondulated

+++ Very informative
++ Informative
+ Partially informative

and SILVA, 1976).

Based on the Landsat imagery, the following stratification could be made:

1. Native Forest (sub-tropical forest)
1.1 Native forest associated with agricultural fields
1.2 Gallery forest

2. Planted forest

3. Fields
3.1 Open fields
3.2 Fields with swamp vegetation

The following results were obtained:

Total area	=	263,748,96 ha.
Native forest	=	11,520,0 ha. (4,38% of the area)
Planted forest	=	194,40 ha. (0,079% of the area)
Fields	=	252,034,56 ha. (95,55% of the area)

In an attempt to establish a "backlook" of the vegetation in the area of study, complete mapping using panchromatic black and white airphotos (scale of 1:60,000) from 1966 was made.

The following results were obtained:

Total area	=	263,748,96 ha.
Native forest	=	12,240,0 ha. (4,64% of the area)
Planted forest	=	214,56 ha. (0,082% of the area)
Fields	=	251,292,40 ha. (95,28% of the area)

The "backlook" is very important to establish the tendency of development in the vegetation.

In the present case, a small increase of planted forests, represented by Eucalyptus spp., - 20,16 ha - and reduction of native forests - 720,40 ha. was observed.

On the other hand, the area of agricultural fields increased approximately, 740,16 ha (soy beans and wheat plantations).

This is a normal tendency for the whole state of Rio Grande do Sul. Every day more agricultural fields occupy the place of forest cover (see SILVA, 1979).

In some other areas, that difference (720,40 ha.) is 20 times greater (14,408,0 ha.).

3.2.3 Drainage network system

The study of drainage network systems can reveal important information on the topographic, geologic and pedologic nature of the area, as well as valuable data to watershed management planning.

This information, when considered together, are very useful in agricultural/forestry and hidrological regional planning.

A quantitative summary of the drainage system of the region is illustrated in table 4.

The average error of 15,9% is not great and is caused by the impossibility of interpreting first and second order channels which are responsible for the hydric erosion and are normally intermitent.

The drainage system of the region was easy to be interpreted through Landsat and was very important in the spatial positioning of the interpretation.

Table 4. Comparison of parameters extracted from Landsat and ground truth for analysis of the drainage system.

	Ground truth	Landsat	Error	%
Total length (km)	2,368,6	1,992,0	-376,6	15,9
Drainage density (m/ha)	8,68	7,38	1,38	15,9

4. CONCLUSIONS

Based on the results obtained in the present study, it can be concluded that the application of Landsat MSS imagery to regional monitoring of natural resources in southern Brazil is highly recommended.

The validity of that application is further justified by the repetitive character of the program and its low cost of mapping (about US$ 0,045/Square Kilometer).

By using 4 to 5 control points per image a planimetrically corrected map can be obtained with linear resolution ranging from 11 to 294 metres with planimetric average error (RMSp) of 208 metres.

The thematic accuracy ranged from 85 to 98% considering the different natural resources studied.

5. LITERATURE CITED

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