

MULTITEMPORAL EVALUATION OF THE GEOPHYSICAL SURVEYING IN THE JURUA'S PETROLEUM AND GAS NATURAL CAMPS USING TM/LANDSAT IMAGES PROCESSING AND GEOPROCESSING TECHNIQUES.

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ABSTRACT:

From the beginning of the 80's, the PETROBRÁS, Brazilian petroleum company, started the hydrocarbonets economic exploration in Urucu (AM), in the West Amazon region. This paper presents multitemporal study of the specific area of the Urucu (AM) region called Jurua's petroleum and gas natural camps in which the land used changed due to the geophysical surveying, opening roads, drilling wells etc carried out during phase of delimitation petroleum and natural gas camps. Using TM/Landsat images (001/63C path-view) of 1987 and 2002 years and applying image processing algorithms such as: geometric corrections and contrast enhancements it obtained the best combination of those image's spectral bands to detect specific characteristics of the terrain. In the environmental of the Geographical Information System SPRING 4.0, it carried out analyses using algorithms of algebra of maps and another functions aiming at measuring and quantifying principals transformations related with petroleum surveying activities in study area. The results gathered confirm the potentiality of the methodology in detecting, measuring and quantifying the transformations occurred in areas of intense coverage of tropical forests.

1.0) Introduction

1.1 Generalities:

From the 80's on, PETROBRÁS started an economic exploration of hydrocarbonets in the petrolific province of Urucu (AM), and that has become a national reality, whereby the production of petroleum represents nowadays 20% of national production, and such endeavor has an estimated capacity to last about 50 years.

The petrolific province of Urucu, conceived as an enclave into West Amazon, distant nearly 370 Km from Coari city, is surrounded by diverse environmental protection, *inter alia*: there is no road along the pipeline Urucu-Coari for avoiding urban migration and consequent deforestation; tree species rooted up along construction works were planted again in higher density on the same region; lodgings were not built, nor were other kinds of urban constructions for accommodating workers in the region. Therefore, workers teams take turns fortnightly as a way to avoid human population fixation; pipeline pressure constant monitoring by strategically placing leaking preventive disaster devices along its extension etc. The PETROBRÁS wishes to turn the petrolific province of Urucu into a new energetic source using natural gas as energetic source.

1.2 Aim

The main objective here presented is to test Geoprocessing Methodology inserted into Geographic Information System according to its capacity to execute multitemporal environmental changes analysis that take place in a predetermined swath over the petrolific province of Urucu (AM).

1.3 Study Area

The study area is located in the petrolific field of Jurua, in the Coari district, part of State of Amazonas (Figure 1), approximately limited by the following geograpyhic coordinates:

Longitude: West 66 ° 0' 00" and 66° 22' 00"

Latitude: South 4° 35' 20" and 4° 50' 00"



Figure 1 – Study area (Jurua field) inside Coari district and the municipal division of the State of Amazonas.

2.0 Materials and Methods

2.1 Materials:

2.1.1 LANDSAT-TM images

It was used images of the LANDSAT's Thematic Mapper sensor, series LANDSAT 5 and 7 respectively, path-row 001/63, in GEOTIFF format, acquired in August 1987 and February 2002. Both images were produced by DGI-INPE and they have some cloud cover.

2.1.2 Cartographic map

It was used the topographic map produced by Diretoria do Serviço Geográfico (DSG), UTM coordinate system, scale 1/100000 covering the study area, in GEOTIFF format, to

obtain control points used in geometric correction and registration of those TM images.

2.1.3 Geographic Information System (GIS)

It was used the GIS SPRING 4.0, a coupled geographic information/image processing software developed at INPE (Câmara *et alli*, 1996).

2.2 Methods:

2.2.1 Multispectral bands choice

It was tested all TM's multispectral bands in terms of response to detect deforested areas and the best combination was achieved by using bands 4, 5 and 7, all of them in the infrared regions, due to the higher response from vegetation cover and bare soils.

2.2.2 Geometric correction and enhancement contrast

It was used 15 ground controls points extracted from DSG's topographic map, both scenes were converted to the UTM coordinate system, using a first-degree polynomial rectification algorithm, this procedure yielded a registration accuracy equal to 0.9 pixel. The 1987 scene was used as reference to coregister 2002 scene that assured a good image-to-image registration. In order to preserve the radiometric integrity, it was used a nearest-neighbor interpolation method.

After the geometric correction, both scenes were submitted an enhancement linear contrast to emphasize the best separation between vegetation cover and bared soil.

The figure 2 shows the TM whole scene of 1987, after the geometric correction and liner contrast operations. The red rectangle points out the study area.

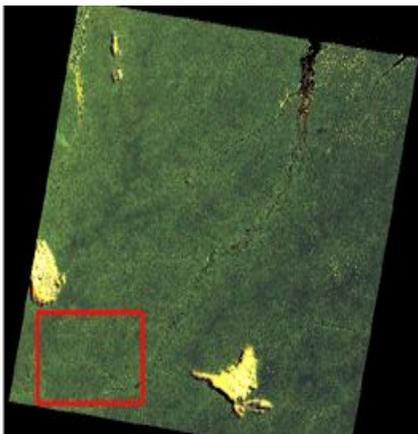


Figure 2 – Color composition of the 1987 TM's multispectral bands (band 7-red; band 5-green; band-4-blue) after geometric correction and linear enhanced contrast operations.

2.2.3 Digital input data of deforestation polygons

By inputing digital algorithms data of several deforestation polygons in vector format, located in both TM images, such polygons are related with petroleum prospection activities, e.g., seismic survey, prospection gas and oil wells.

All inputed polygons data were associated with thematics classes in GIS as following:

- anthropic_87 and 02: referent anthropic occupation in 1987 and 2002 scenes;
- roads_87 and 02: referent small roads/paths in 1987 and 2002 scenes;
- seismic_87 and 02: referent small glades opened in the forest to seismic survey in 1987 and 2002 scenes;
- general glades_87 and 02: others glades opened in the forest for petroleum activities like wells in 1987 and 2002 scenes;
- clouds/shadows_87 and 02: referent small areas with clouds and their clouds presents in 1987 and 2002 scenes.

The figures 3 and 4 show the polygons after having their data computerized.

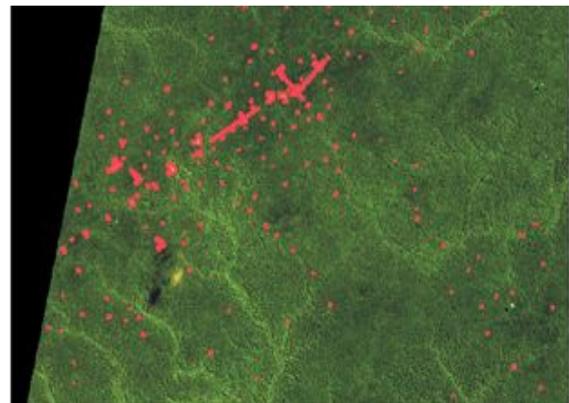


Figure 3 – TM 1987: Study area: deforested polygons after digital input data tasks

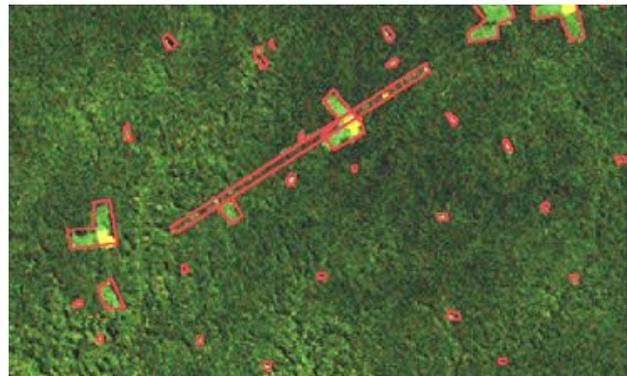


Figure 4 – TM 1987: Study area: detailed deforested polygons show glades of seismic survey, paths, glades for helicopters points landing and gas wells.

2.2.4 Spatial Analysis

Using the information plans with vectorial files of deforested polygons for each scene, inside SPRING 4.0, they were carried out by special analysis tools: algebra of maps, measures classes and Kernel's density estimator.

Algebra of the Maps

The algebra of maps uses special languages for algebraic geoprocessing (LEGAL), using focal, local and zone operators.

LEGAL¹ uses operations sentences with grammatical rules to generate a map, in raster format, with the principals changes occurred in those polygons in the period between 1987 to 2002, in the study area. The operations sequences using the thematic classes implanted with LEGAL are shown bellow:

```

{
// Defining variables and categories
Thematic deforested area 2002 ("seismic_02"), deforested area
1987 ("seismic_07"),
Results ("crossing_results1");
//Recovering plans
deforested area 2002=Recover (Name = "seismic_02");
deforested area 1987= Recover (Name = "seismic_87");
// Creating new information plan
results=New(Name="crossing_results2",
Resolution X=30, Resolution Y=30,
Scale=60000);
//Defining the relations among the classes
results = Attribute (Category END = "crossing_results")
{
"GG87N02": (deforested area 1987.Class == "generic glades"
&& ! (deforested area 2002.Class == "generic glades")),
"GG87E02": (deforested area 1987.Class == "generic glades"
&& deforested area 2002.Class == "generic glades"),
"GG02N87": (deforested area 2002.Class == "generic glades"
&& ! (deforested area 1987.Class == "generic glades")),
"SG87N02": (deforested area 1987.Class == "seismic_87"
&& ! (deforested area 2002.Class == "seismic_02")),
"SG87E02": (deforested area 1987.Class == "seismic_87" &&
deforested area 2002.Class == "seismic_02"),
"SG02N87":( deforested area 2002.Classe == "seismic_02" &&
! (deforested area 1987.Class == "seismic_87"))
}; }

```

Being:

GG87N02: generic glades existing in 1987 but not in 2002;
GG87E02: generic glades existing in 1987 and 2002;
GG02N87: generic glades existing in 2002 but not in 1987;
SG87N02: seismic glades existing in 1987 but not in 2002;
SG87E02: seismic glades existing in 1987 and 2002;
SG02N87: seismic glades existing in 2002 but not in 1987.

Measuring Classes

Using the information plans with vectorial files of the deforested polygons for each scene, it was possible to calculate the area in Km² of each class for 1987 and 2002 years in the study area, so allowing to measure the principals transformations occurred over petroleum exploration.

Kernel's density estimator

The algorithm Kernel's density estimator carries out an estimative of the points or areas patterns². Using the information plans with vectorial files of deforested polygons for each scene, it generated a new information plan, in raster format, plotting possible lines of seismic survey in the study area.

¹ More details about LEGAL language see in CAMARA *et alli* (1996).

² More details about Kernel's density estimator see in CAMARA *et alli* (1996).

3.0 Achieved Results

3.1 Spatial Analysis – Algebra of Maps

After the application of operations sentences in LEGAL language, it generated a new information plan, in raster format, whereby it is possible to visualize the principals changes occurred in terms of deforested areas from classes. that have already been defined: GG87N02, GG87E02; GG02N87; SG87N02; SG87E02 and SG02N87 that were plotted.

The figure 5 shows the results of maps algebra application.

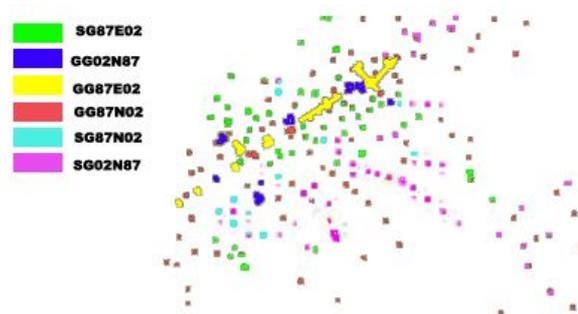


Figure 5 – Information plan resulted of the algebra of maps, in raster format, with principals changes occurred in terms of deforested areas in the study area

3.2 Spatial Analysis – Measures classes

The Table 1 presents the results, in terms of area in Km², of principals thematic classes of deforested polygons obtained from digital data input.

Class	Area in 1987 (Km ²)	Area in 2002 (Km ²)
Generic Glades	13,87	21,17
Seismic glades	1,62	2,63
Another activities	1,10	2,10

Table 1 – Area (Km²) of deforested polygons: 1987 to 2002

3.2 Spatial Analysis – Measures class

The Table 2 presents the results, in terms of area in ^x, of principals thematic classes generated by algebra of maps.

Class	Area (Km ²)
GG87N02	13,87
GG87E02	21,17
GG02N87	15,30
SG87N02	1,62
SG87E02	2,63
SG02N87	2,10

Table 2 – Thematic classes areas (Km²)

By the results shown in Table 2 it is possible to conclude:

a) Based in the results presented by the classes GG87N02 and GG87E02, the generic glades in 1987 (13,87 Km²) were increased of 7,3 Km² in 2002;

b) Therefore, because the results presented by the class GG02N87, there is a possibility to occur some process of restoration of the vegetation on the glades during the years between 1987 to 2002;

c) Based in the results presented by classes SG87N02 and SG87E02, the seismic glades in 1987 (1,62 Km²) were increased of 1,01 Km² in 2002;

d) Therefore, because the results presented by the class SG02N87, there is a possibility to occur some process of restoration of the vegetation in the seismic glades during the years between 1987 to 2002.

3.3 Spatial Analysis – Kernel's density estimator

The Figure 6 presents the results of the application of the Kernel's density estimator. The lines plotted in the image may be correspondent to seismic surveys lines; therefore, these results need to be checked with maps or geographics coordinates of these lines, which were not available for the authors during this research.

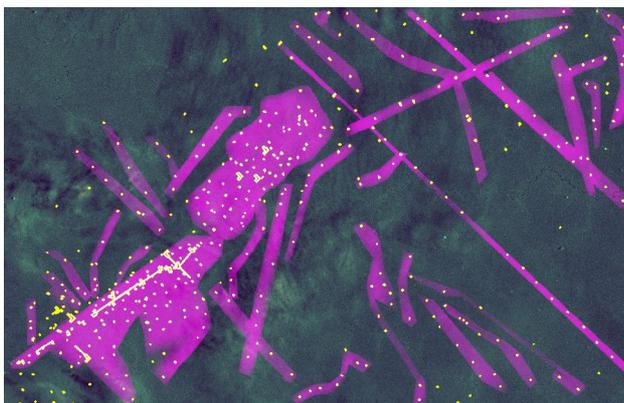


Figure 6 – Possible seismic survey lines obtained by Kernel's density estimator.

4.0 Conclusions

The results obtained still are tentatively as part of the doctorate research with a broader scope. Therefore, it was possible to locate, identify and measure, in multitemporal analyses, the principal changes occurred in the land used by applying remote sensing images processing and geoprocessing of thematic data in GIS environment.

Certainly, these results need to be confirmed with results obtained in the field yet not available at the time of this research. Notwithstanding, it was possible to confirm the likelihood to apply spatial analysis tools to monitor process anthropic in regions of difficult access like the Amazon Brazilian.

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References and Selected Bibliography

ALMEIDA-FILHO R., SHIMABUKURO. *Digital Processing of a Landsat-TM time series for mapping and monitoring degraded áreas caused by independent gold miners, Roraima State, Brazilian Amazon*. In: Remote sensing of Environment, Elsevier, London, N. 79, pp. 42-50, 2002.

CAMARA, G. S.; FREITAS, U.M.; GARRIDO, J. – *Spring: Integrating remote sensing and GIS by object-oriented data modelling*. In: Computer & Graphics, 20: (3) 395-403, May-Jun 1996.

ELETRONORTE. *Cenários Energéticos para Amazônia*. Belém, PA, 1998

HUETE, A.R; JACKSON, R.D.; POST, D.F. *Spectral Response of a Plant Canopy with Different Soil BackGround*. In: Remote Sensing of Environment, Elsevier Science Publishing Co., New York, N. 17, pp 37-53, 1985.

IESA - *Aproveitamento dos Hidrocarbonetos do Estado do Amazonas – Região do Urucu: Estudo de Impacto Ambiental*. Rio de Janeiro. 1991.

PETROBRAS. *Notícias à imprensa sobre URUCU (AM)* - Rio de Janeiro, 1999.

SCHOWENGERT, R.A. *Techniques for Image Processing and Classification in Remote Sensing*. Academic Press, Inc, London, 249 p., 1983.

VINK, A.P.A. *Land Use in Advanced Agriculture*. Springer-Verlag, Berlin, 395 p. 1975