ANALYSIS OF DEFORESTATION IN MATO GROSSO USING MULTI-TEMPORAL LANDSAT TM IMAGERIES

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ABSTRACT

This paper summarizes the result of vegetation cover changes in Mato Grosso State in Amazonia, Central-West of Brazil. The study area is covered by Landsat TM Imagery Path 227 and Row 69, where soybean plantation spreads along the Highway BR 163. With the Global demand for biofuel, it recently became one of the main export crops in Brazil, causing large-scale deforestation in the Brazilian Amazon. Using multi-temporal imageries of the same area, alteration of vegetation cover was analyzed, performing unsupervised classification using NDVI analysis. Also, visual interpretation of deforestation within anthropogenic polygons was done within the natural forests. As a result, we concluded that the forest cover decreased from 76% in 1991 to 13% in 2009 in that area.

Keywords— Deforestation, Mato Grosso State, Highway BR 163, soybean, NDVI

1. INTRODUCTION

Mato Grosso (MT), one of the nine Amazonian States of Brazil, suffered heavy conversion recently (Fig.1). Deforestation is a matter of concern all over the world, as a result of conversion by the national projects in several developing countries. Monoculture of soybeans, sugar-cane, beans and maize is common in the Brazilian Amazon, recently. In Brazil, soybean is one of the principal agricultural products for export. Of the total area of Brazil, soybean plantation larger than 1000 ha is 43%, and farms smaller than 10 ha is less than 2,7% (IBGE, 2009). Many cities were created along the main roads of Amazonia for soybean plantation in the last twenty years. They are Nova Mutum, Lucas do Rio Verde and Sorriso, among others, built by the Highway BR 163 in Mato Grosso. Sorriso, the city built 742 km North from Cuiabá, the capital city of MT, has the biggest plantation area of soybeans of the world (Fig. 2), with 578 thousand hectares (IMEA – Instituto Mato-Grossense de Economia Agropecuária, 2005).

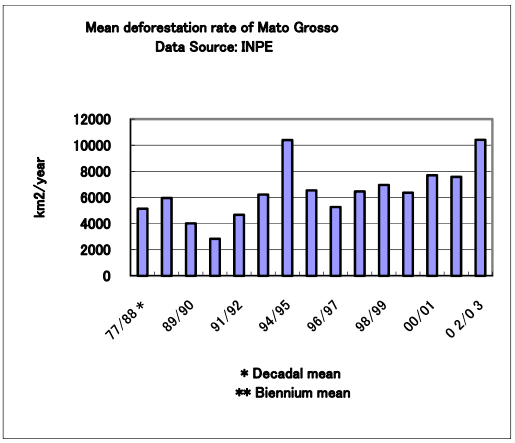

Fig. 1 Mean deforestation rate of Mato Grosso (MT)

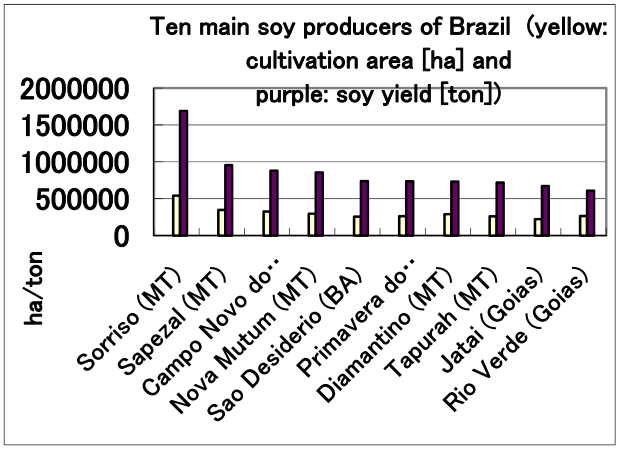

Fig. 2 Sorriso (MT) is the no.1 soy producer of the World in terms of the cultivated area. Seven out of ten main soy producers of Brazil is in Mato Grosso (MT) IBGE, 2004

BR 163 is a 1765 km long highway linking Cuiabá to Santarém (a big fluvial connection port of the Amazon River in Pará State, northeastern Amazon), known as Soy Road. This highway is still under construction and it is

paved: 98 km between Satarém and Rurópolis in Pará State, and 714 km between Guarantã do Norte and Cuiabá in Mato Grosso State (IMEA, 2005). The present study focuses on the deforestation being carried out along the Highway BR 163, which passes the cities of Nova Mutum,, Lucas do Rio Verde（Fig. 3）, and Sorriso (Fig. 4). This study proves the fact that in Amazonia, 80% of the deforestation occurs within 30 km from the main roads [1] [2]. In this present paper, unsupervised classification and NDVI analysis were performed to determine vegetation cover changes [3] between August 1991 and July 2009.

2. DATA AND METHODS

All Two Landsat TM (Thematic Mapper) data were downloaded from INPE – CDSR and used for analysis: Landsat 5 TM scenes Path 227 Row 69 dated August 28, 1991(Fig. 3) and July 28, 2009 (Fig. 4. NDVI (Normalized Difference Vegetation Index) was used for comparing the alteration of vegetation cover, where

NDVI = (infra-red – red)/(infra-red + red).

Before performing unsupervised classification (ISODATA method), the 1991 scene was resampled doing polynomial rectification (Fig. 5). For that purpose, 20 GCPs (Ground Control Points) were picked up in both imageries and taking the georeferenced coordinates of 2009 imagery as reference (Fig. 6). The relationship necessary to transform a data value in the same imagery of 1991 into its value in the image of July 2009 is

$DN_I = a_{11}DN_A + a_{12}\,DN_B \quad DN_{II} = a_{21}DN_A + a_{22}DN_B$

Where DN_I, DN_{II} = digital numbers in 2009, DN_A, DN_B = digital numbers in 1991, a_{11}, a_{12}, a_{21}, a_{22} = coefficients for the transformation.

Categorization was used for determining water, forest, croplands, roads and urban areas. Also, deforested areas were obtained based on the summation of the cultivated areas, i.e., geometric polygons within the scenes. Each Landsat scenes were subset in 16 sub-scenes and for each of them was used measurement tool to obtain more accurate anthropogenic influences within the forests, taking as reference, the classification imagery.

3. MULTI-TEMPORAL ANALYSIS OF IMAGES

In the present study, deforestation was detected using the variation of digital numbers of bands corresponding to the NIR (near infra red) of different sensors. As vegetation presents strong reflectance between 0.7 and 1.3 μ m, band four was used for reference, in order to compare images of different years to detect deforestation. Consequently, NDVI was used for analysis to check the biomass variation

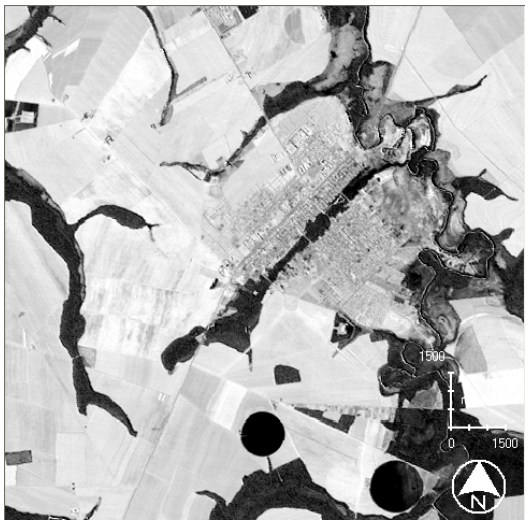

Fig. 3 Landsat 5 TM 227/69, July 28th. 2009. NDVI image of Lucas do Rio Verde, MT with Highway BR 163 passing through it in the middle of the image to northeast, to Sorriso, MT. (INPE-CDSR)

Fig. 4 Landsat 5 TM 227/69, July 28th. 2009. NDVI image of Sorriso, MT and Highway BR 163 bound for Santarem, PA. (INPE-CDSR)

throughout the years 1991 to 2009.

Equation used for Landsat TM:

NDVI = (band 4 – band 3)/(band 4 + band 3)

Tasseled cap conversion was also done to make clear visualization of the images during the visual analysis for better reference. An unsupervised classification was performed using the ISODATA algorithm. This method uses the minimum spectral distance formula to form clusters, beginning with arbitrary cluster means. The means of these clusters are shifted each time the clustering repeats and the new cluster means are used for the next iteration. This sequence are repeated until a maximum number of iterations has been performed. The convergence threshold was specified as 95%, i.e., as soon as 95% or more of the pixels stay in the same cluster between one iteration and the next, the job stops processing.

4. RESULTS AND DISCUSSION

From the above mentioned calculation, forest cover in 1991 was 76%, whereas in 2009, it was 13% of the full scene. Soybean plantation was expanding mainly along the Highway BR 163. Compared to the 1991 scene, croplands were growing without leaving space for forests nearby the Highway in 2009, as we can see in Fig. 3.

Also, within natural forest of Landsat TM scene of 2009, we could find many clear geometric division lines, showing the future cultivation area of some hundreds to some thousands hectares each, which was not included in our calculation of the present study (Fig. 7). If clearing takes place following those lines in the years to come, deforestation rate in that region will increase much more than presented in this study.

5. CONCLUSION

The result visually shows us that the Amazonian forest does not exist anymore along paved Highway BR 163, even far beyond a 30 km diameter from the road, as we can see in Fig. 3 and 4. Soybean plantation in Brazil expanded 88.8% in ten years (1995-2006) (Fig. 7), (Fig. 8) and (Fig. 9). In Mato Grosso State, the yield between 2009 -10 is expected to be 17.6 million tones (30% of national yield of Brazil), according to IMEA, 2009).

However, in November, 2009, the Brazilian government announced that clearing of Amazon was the lowest in 20 years, since the government started monitoring deforestation in 1988. Further studies are needed to understand if it is the result of enforcement measures for promotion of sustainability of forests or it is simply the consequence of world economical recession.

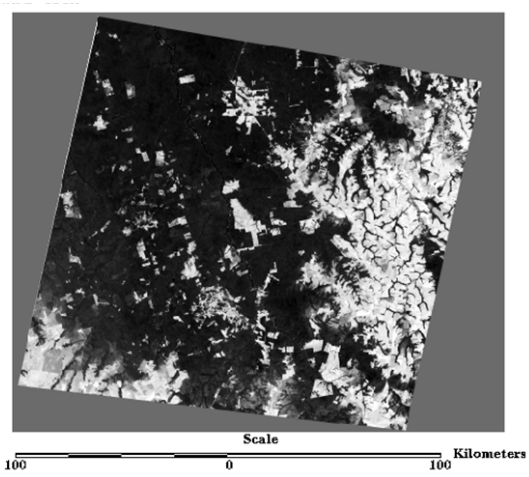

Fig. 5 Rectified NDVI image of Landsat 5 TM image Path 227, Row 69 of August 28, 1991. (INPE-CDSR)

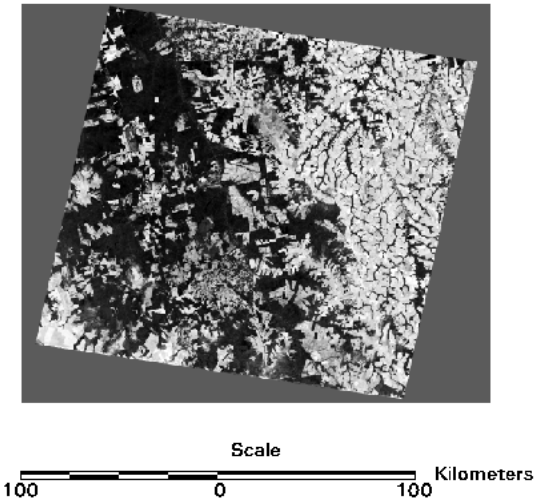

Fig.6 NDVI image of Landsat 5 TM image Path 227, Row 69 of July 28th. , 2009. (INPE-CDSR)

Fig. 7 Expanding soybean plantation nearby Lucas do Rio Verde, MT. Landsat 5 TM image, RGB 543 Path 227, Row 69 of July 28th. , 2009. (INPE-CDSR)

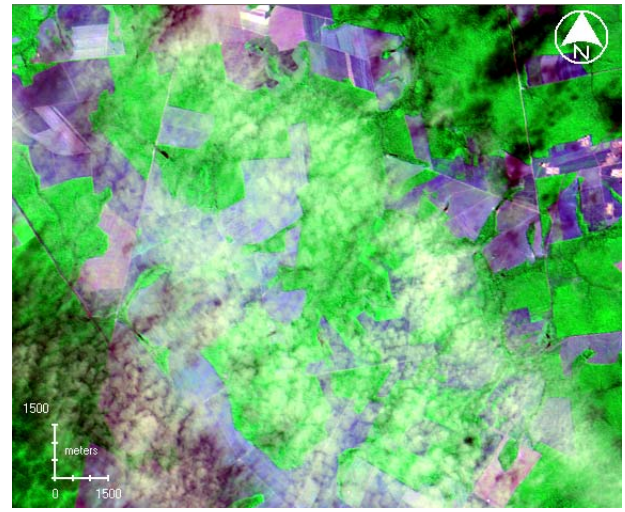

Fig. 8 Forest burning at Lucas do Rio Verde, MT. Landsat 5 TM image, RGB 543 Path 227, Row 69 of July 28th. , 2009. (INPE-CDSR)

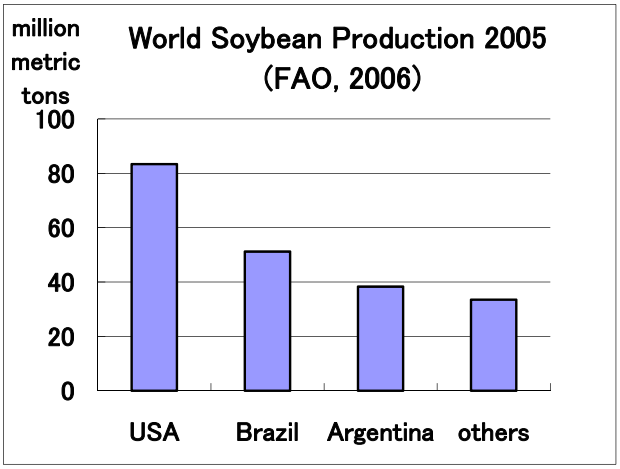

Fig. 9 World Soybean Production 2005, FAO, 2006

6. REFERENCES

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