

DETECTING POTENTIAL SITES OF *CANNABIS SATIVA* PLANTATIONS BY OBJECT-BASED, SPOT 5 HRG IMAGE CLASSIFICATION

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ABSTRACT:

Although *Cannabis sativa* planting and dealing are prohibited in Brazil, there are places in the country that we find illegal plantations. Traditionally, Federal Police uses helicopters and local knowledge to identify and destroy such plantations. The objective of this study is to identify potential sites of *Cannabis sativa* located in the semi-arid, southern part of State of Pernambuco, Brazil, using object-based classification of SPOT 5 HRG images. Image classification included multiresolution segmentation with algorithm available in the eCognition Developer software package. The identification of segments (objects) related to this illegal cultivation was conducted taking into consideration mainly the spectral and spatial patterns of interested target, presence of water reservoir for irrigation, type of surrounding vegetation, topography, and road or access proximity. The object-oriented image classification allowed a semi-automatic detection of features compatible to *Cannabis* plantations in the SPOT images. Results showed that the approach proposed in this study is feasible for identifying potential areas of occurrence of *Cannabis* cultivation in semi-arid regions and at a regional scale.

1. INTRODUCTION

Cannabis sativa is the most demanded, illegal drug in the world, ahead of anfetamins, cocaine, and opiates (UNODC, 2010). In Brazil, selling this drug is prohibited. One of the strategies to reduce the consumption of this drug is the identification and destruction of its plantations. Traditionally, *Cannabis* fields are identified by agents of Federal Police using helicopters and local knowledge acquired from previous missions (LISITA, 2011).

Object-based image analyses (OBIA) (HAY & CASTILLA, 2008; BLASCHKE, 2010) have potential to optimize identification of this target. The rationale is two-fold: OBIA considers not only target's spectral information but also other features such as size and shape or even surrounding characteristics; and, according to RATCLIFF (2010), *Cannabis* cultivation presents some spatial characteristics that allow computer modeling. This study aimed to identify potential sites of *Cannabis sativa* located in the semi-arid, southern part of State of Pernambuco, Brazil, using object-based classification of SPOT 5 HRG images.

2. METHOD

The study area corresponded to an area of 8,875 km² in the southern part of the State of Pernambuco (UTM coordinates between 9,030,000 mN and 9,095,000 mN; and between 402,200 mE and 557,400 mE). Climate is semi-arid with total annual rainfall below 550 mm, concentrated between December and May. Regional land covers are mainly

represented by Caatinga physiognomies. The test site included the following municipalities: Cabrobó, Carnaubeira da Penha, Floresta, Itacurubá, Mirandiba, Orocó, Parnamirim, Santa Maria da Boa Vista, Terra Nova, and Salgueiro. The region is locally known as *polígono da maconha* (polygon of marijuana). Field knowledge indicates that *Cannabis* plantations are located in isolated, masked areas. The stage of plant growth varied from small seedlings to mature plants (Figure 1). Soil and irrigation managements are mandatory for such plant growing process. Cultivations should be near some source of water (perennial or temporary rivers or ponds) and near roads or access.

Object-oriented, SPOT 5 HRG image classification was conducted based on both spectral and spatial patterns of plantations of *Cannabis sativa* and their surroundings. Image classification included multiresolution segmentation with algorithm available in the eCognition Developer software package. Description of segments (objects) of interest was another important step of the study. In the case of illicit *Cannabis* crops, the following parameters were considered (they were obtained from SPOT 5 multispectral and panchromatic images, land use and land cover map, slope map, and base maps): spectral pattern, geometry, maximum size, neighborhood, presence of water reservoir for irrigation, type of surrounding vegetation, topography, and road or access proximity.

The weight of evidences approach (BONHAM-CARTER, 1994) allowed modelling the relative importance of each spatial evidence as basis for parameters definition. Spectral

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patterns of *Cannabis sativa* cultivations and targets related to them were investigated through the analysis of spectral profiles derived from multitemporal series of Normalized Difference Vegetation Index (NDVI). NDVI was calculated using the equation $NDVI = (\rho_{NIR} - \rho_{RED}) / (\rho_{NIR} + \rho_{RED})$ where ρ_{NIR} and

ρ_{RED} are the values of surface reflectance for SPOT 5 bands 3 and 2, respectively. The spectral information was included in the OBIA classification through the inclusion of a thematic layer generated by Support Vector Machine (SVM) supervised classification technique.



(a)



(b)



(c)

Figure 1. *Cannabis sativa* plantations in the semi-arid region of Brazil in three different growing stages: initial (a), intermediate (b), and advanced (c) growing stages.

Object-based classification was conducted by defining seven levels of segmentation (Figure 2). The last level included, among other classes, high alert (possible cultivation in the beginning of crop growing season) and maximum alert (possible cultivation in the peak of growing season) classes. GPS coordinates corresponding to *Cannabis* cultivations were obtained during field operations carried out by the Federal Police in June 2007 (Prometeu Operation), May 2008 (Colheita Operation), and May 2010 (Liamba III Operation). More detailed information about the location of study area was omitted on purpose due to internal policies of involved institutions.

3. RESULTS

Figures 3 and 4 show examples of spectral and temporal patterns of *Cannabis* cultivations and their surrounding Caatinga vegetation patterns that were classified as maximum alert. The cultivation, with an estimated area of 3 ha and 72,000 plants of *Cannabis*, was confirmed in the field and was destroyed by Federal Police agents in June 09, 2007 (Prometeu Operation). The temporal profile shows a strong seasonality of Caatinga physiognomies against an artificial growing pattern of *Cannabis* sites provided by water and nutrients supplies.

The maximum alert class represented around 1% of the area covered by the SPOT 5 HRG image. Among the 15 areas of *Cannabis* identified in the Prometeu Operation and located in the SPOT image, eight were rated by the image classification as maximum alert (accuracy of 53%). The image segmentation and classification also was able to identify other plantations detected in the Colheita Operation, as illustrated in Figure 5.

4. CONCLUSION

The object-oriented image classification allowed a semi-automatic detection of features compatible to *Cannabis* plantations in the SPOT images through the combination of spatial and spectral patterns in the classification process. Results showed that the approach proposed in this study is feasible for identifying potential areas of occurrence of *Cannabis* cultivation in semi-arid regions and at a regional scale. In some extent, the method can be adapted to other regions with similar challenge.

5. REFERENCES

- Blaschke, T. 2010. Object-based image analysis for remote sensing. *ISPRS Journal of Photogrammetry and Remote Sensing*, v. 65, pp. 2-16.
- Bonham-Carter, G.F. 1994. *Geographic Information Systems for Geoscientists: Modelling with GIS*. Ontario: Pergamon Press, 398 p.
- Hay, G.J.; Castilla, G. 2008. Geographic object-based image analysis (GEOBIA). A new name for a new discipline. In: Blaschke, T.; Hay, G.; Lang, S. (eds.), *Object-Based Image Analysis. Spatial Concepts for Knowledge-Driven Remote Sensing Applications*. Berlin: Springer, Lecture Notes in Geoinformation & Cartography, pp. 75-89.
- Lisita, A. 2011. *Semi-automated mapping of illicit Cannabis sativa cultivations in the semi-arid region of State of Pernambuco through data integration of SPOT 5 HRG images, ancillary geographical data and field knowledge*. Ph.D. Thesis. Brasília, University of Brasília, 210 p. (in Portuguese).
- Ratcliffe, J. 2010. Crime Mapping. Spatial and Temporal Challenges. In: Piquero, A. R.; Weisburd, D. (eds.), *Handbook of Quantitative Criminology*. New York: Springer Science and Business Media, pp. 5-24.
- UNODC. United Nations Office on Drugs and Crime. 2010. *World drug report 2010*. Available: <http://www.unodc.org/documents/wdr/WDR_2010/World_Drug_Report_2010_lo-res.pdf>. Access: March 16, 2011.

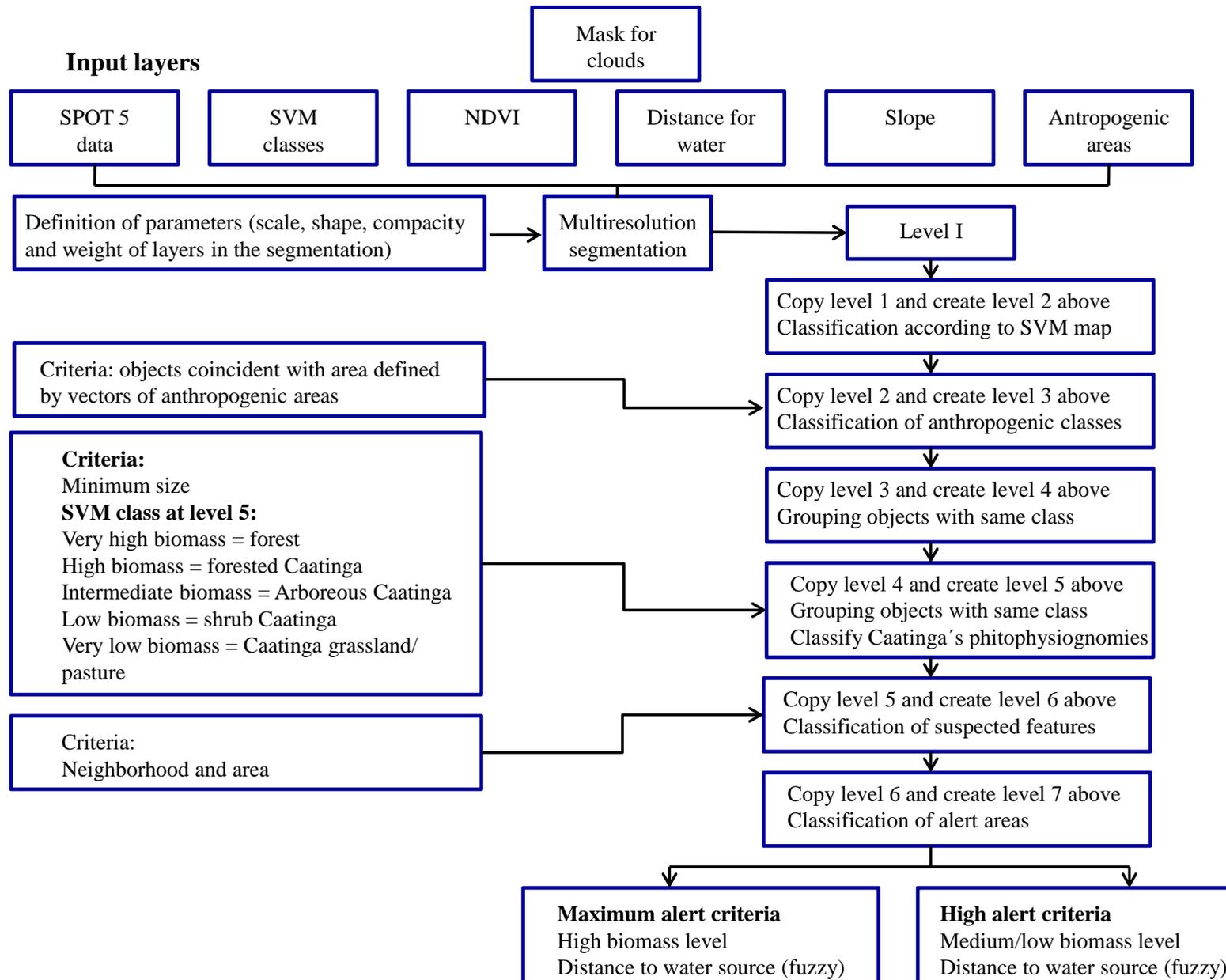


Figure 2. Flowchart of object-based classification to detect areas of alert for illicit *Cannabis* plantations.

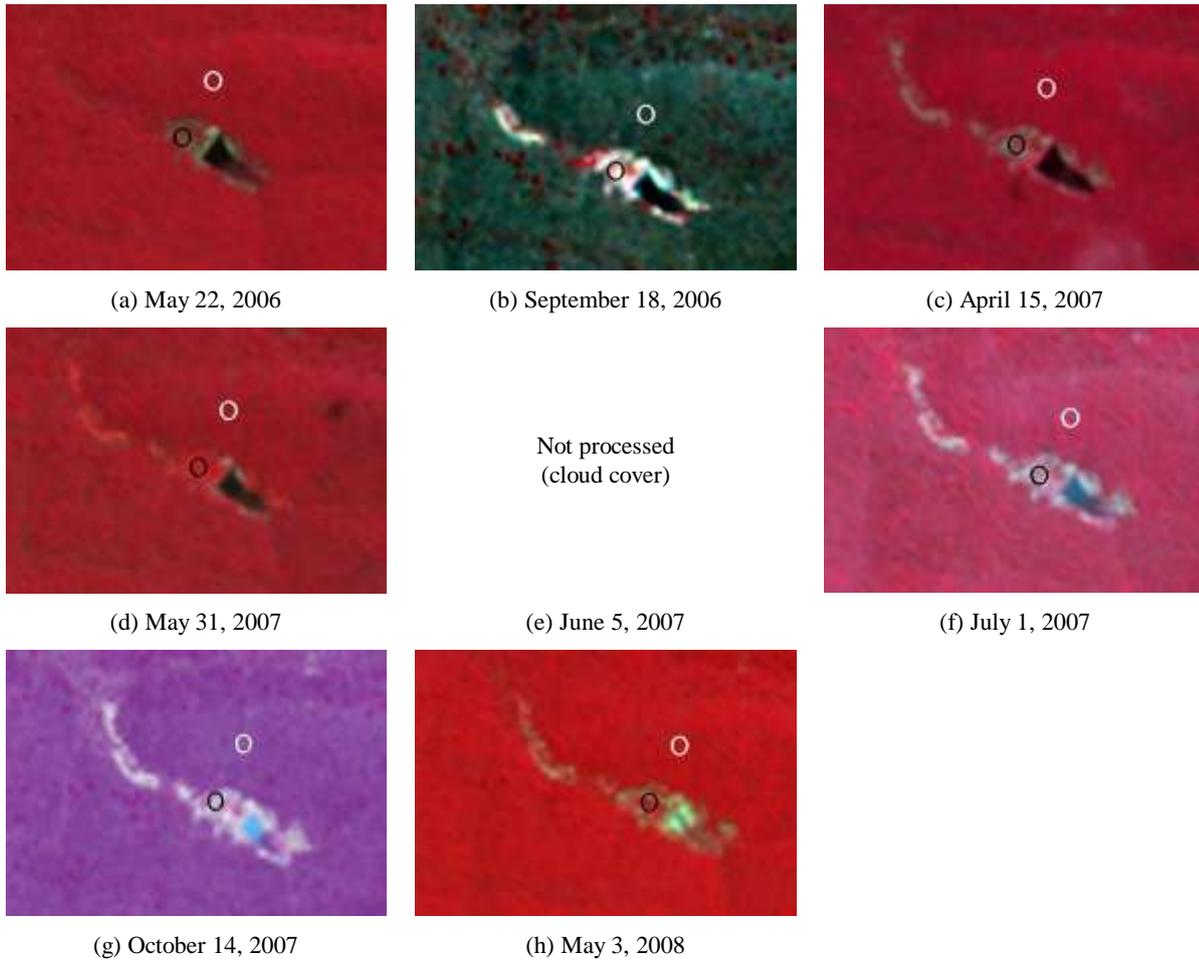


Figure 3. Example of illegal production of *Cannabis sativa* (black circle) surrounded by natural Caatinga vegetation (white circle) shown in a multitemporal series of SPOT 5 color composite sequence (a - h). Existence of cultivation was confirmed in the field by Prometeu Operation (plants were destroyed in June 09, 2007).

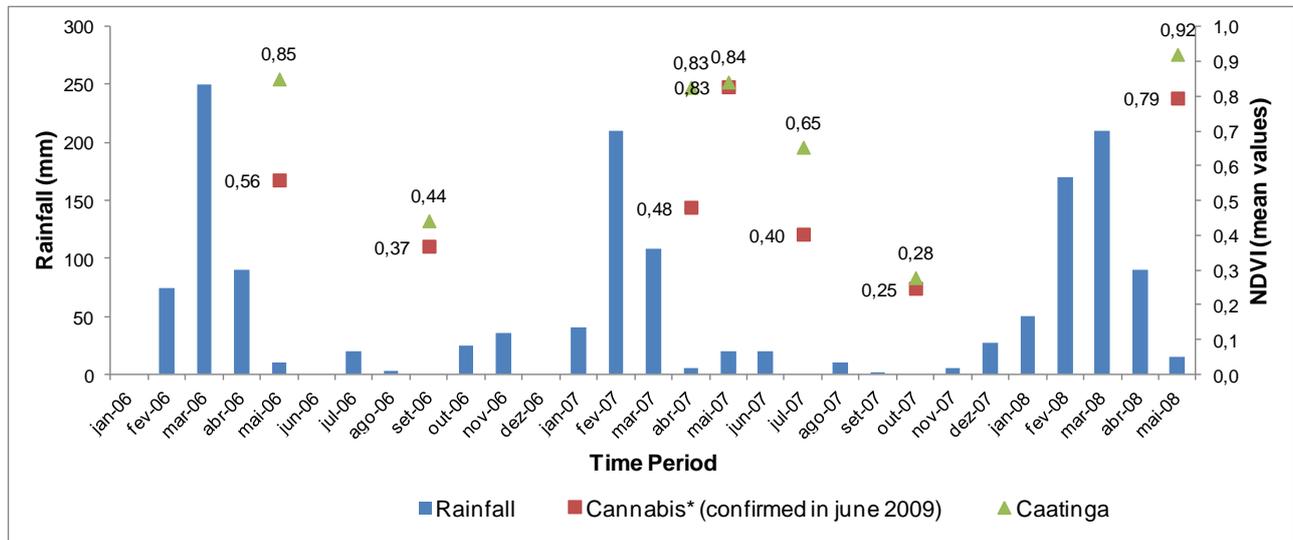


Figure 4. Mean average NDVI values of *Cannabis sativa* and surrounding Caatinga vegetation from the sites shown in Figure 1.

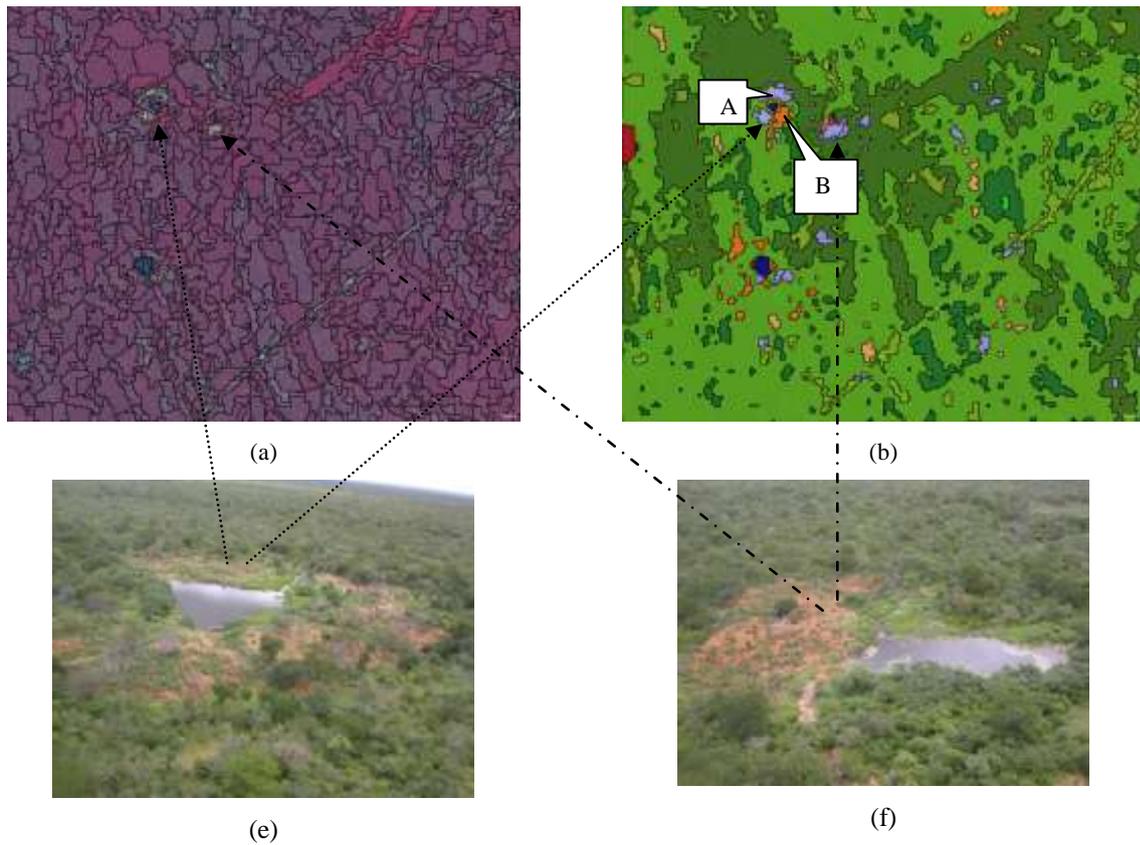


Figure 5. Segmentation result (a) and object-oriented classification (b) of SPOT 5 HRG scene (overpass: May 31, 2007), highlighting segments corresponding to plantations of *Cannabis sativa* confirmed in the field campaign. Light purple colored segments (A) correspond to the high alert identification. Orange colored segments (B) correspond to the maximum alert identification. Photos (e) and (f) are panoramic views of *Cannabis* cultivation obtained from helicopter in a field campaign conducted on May 19, 2008.