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VALIDATION OF SOIL USES AROUND RESERVOIRS IN THE SEMI-ARID THROUGH IMAGE CLASSIFICATION[1]

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ABSTRACT - The work evaluated the potential for discrimination of land use and occupation around reservoirs, using spectral information obtained by multispectral, hyperspectral satellites and images obtained with an ARP (remotely piloted aircraft). The research analyzed the performance of different images classification techniques applied to multispectral and hyperspectral sensors for the detection and differentiation of soil classes around the Paus Brancos and Marengo reservoirs, located in Settlement 25 of Maio. The classes identified based on surveys in campaigns carried out in 2014 and 2015 around the reservoirs were: water, macrophytes, exposed soil, native vegetation, agriculture, thin and ebbing vegetation, in addition to the cloud and cloud shadow targets. The performance of the classifiers applied to the image of the Hyperion sensor was, in general, superior to those obtained in Landsat 8 image, which can be explained by the high spectral resolution of the first, which facilitates the differentiation of targets with similar spectral response. For validation of the supervised classification method of Maximum Likelihood, Landsat 8 (08/24/2015) and Hyperion (08/28/2015) images were used. The results of the application indicated a good performance of the classifier associated with the RGB composition of the chosen Hyperion image (bands R - 51, G - 161, B - 19) in the detection of the classes around this reservoir, producing a Kappa coefficient of 0.83. The availability of data from the Hyperion sensor is very restricted, which hinders the development of continued research, thus the use of images surpassed by RPA is extremely viable.

Keywords: Landsat 8. Hyperion. Kappa index.

VALIDAÇÃO DE USOS DO SOLO NO ENTORNO DE RESERVATÓRIOS NO SEMIÁRIDO ATRAVÉS DE CLASSIFICAÇÃO DE IMAGENS

RESUMO – O trabalho avaliou o potencial de discriminação dos usos e ocupação do solo no entorno de reservatórios, mediante informações espectrais obtidas por imagens de satélites multiespectrais, hiperespectrais e imagens obtidas com uma ARP (aeronave remotamente pilotada). A pesquisa analisou o desempenho de diferentes técnicas de classificação de imagens aplicadas a sensores multiespectrais e hiperespectrais para detecção e diferenciação das classes do solo no entorno dos reservatórios Paus Brancos e Marengo, situados no Assentamento 25 de Maio. As classes identificadas com base em levantamentos em campanhas realizadas em 2014 e 2015 no entorno dos reservatórios foram: água, macrófitas, solo exposto, vegetação nativa, agricultura, vegetação rala e vazante, além dos alvos nuvem e sombra de nuvem. O desempenho dos classificadores aplicados à imagem do sensor Hyperion foi, em geral, superior aos obtidos em imagem Landsat 8, o que pode ser explicado pela alta resolução espectral do primeiro, que facilita a diferenciação de alvos com reposta espectral similar. Para validação do método de classificação supervisionada de Máxima Verossimilhança, utilizaram-se imagens Landsat 8 (24/08/2015) e Hyperion (28/08/2015). Os resultados da aplicação indicaram um bom desempenho do classificador associado à composição RGB da imagem Hyperion escolhida (bandas R – 51, G – 161, B – 19) na detecção das classes no entorno deste reservatório, produzindo um coeficiente Kappa de 0,83. A disponibilidade de dados do sensor Hyperion é bem restrita, o que dificulta o desenvolvimento de pesquisas continuadas, dessa forma a utilização de imagens obtidas por RPA mostra-se extremamente viável.

Palavras-chave: Landsat 8. Hyperion. Índice de Kappa.

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INTRODUCTION

The Brazilian semiarid region located in the Northeast region, presents a pluviometric regime marked by extreme irregularity of rains in time and space, where water scarcity is seen as a limitation on development, since the cyclical occurrence of droughts and their catastrophic effects are well known, making it necessary to search for convivial techniques (MAMEDE et al., 2012).

Reservoirs are considered a solution for water storage, especially in arid and semi-arid regions where rainfall is scarce and irregular throughout the year (LIMA NETO; WIEGAND; ARAÚJO, 2011). The presence of a small reservoir (dam) in the semi-arid northeast is a consequence of the policy adopted in this region, which aims to store water during rainy periods to keep it available during severe periods of drought.

For the spatialization and quantification of reservoirs and classes in their surroundings, studies such as Bhardwaj et al. (2015), Rabe, Van Der Linden; Hostert (2014), and Van Der Linden et al. (2014), used data from remote sensors in research related to the spectral behavior of targets on the Earth's surface, such as water, soils, land use and cover (types of vegetation and agricultural activities), which are extremely important, as they provide support for the interpretation of the data generated (COULTER et al., 2016). Remote Sensing is a technology that allows images of the Earth's surface to be obtained, by capturing and recording energy reflected or emitted by the surface (BHARDWAJ et al., 2015). It enables the development of studies to assess the use of refined land in semi-arid regions.

The use of images captured by satellites is very useful in studies aimed at assessing land use and occupation; however, it has some limitations due to the frequency in obtaining images, the presence of clouds that makes its use unfeasible, especially in the summer, high costs, low resolution and the need for specific knowledge for image processing (SAMSEEMOUNG et al., 2012).

On the other hand, the use of remotely piloted aircraft (ARP's), popularly known as drones, allows the obtaining of aerial images of large areas at low cost, with higher frequency and with high resolution (in the scale of centimeters), which enables the large-scale use of this tool.

The existing land uses on the surface can be obtained by the classification of images, a technique used to extract information with different behaviors, allowing the incorporation of this information in geoprocessing programs. The classification methods (or classifiers) can be divided into classifiers by pixel or region and can take into account one or more image bands in the case of multispectral and hyperspectral images (GILBERTSON; KEMP; NIEKERK, 2017).

The objective of this research was to evaluate techniques for analyzing the areas of land use and occupation around the Paus Brancos and Marengo reservoirs, located in the 25 de Maio Settlement, situated in the municipality of Madalena - CE, through multispectral and hyperspectral data collected by landsat 8 and Hyperion sensors, respectively. Therefore, the study involved the analysis of reference spectra and quantification methods of these areas, through supervised and unsupervised satellite image classifiers, as well as the verification of the reflectance bands of the studied targets: water, macrophytes, exposed soil, agriculture, native vegetation, thin vegetation, ebb, cloud and shadow.

MATERIALS AND METHODS

The survey was carried out in 25 de Maio Settlement (25M) (Figure 1), where currently 425 families with about 2,000 inhabitants live, organized in 13 communities with 18 community associations and a cooperative. In the Settlement, there are small and medium-sized reservoirs, which are tributaries of the Banabuiú hydrographic basin, located in the municipality of Madalena - CE.

The studied reservoirs have different physical characteristics (Table 1) such as the area of the hydraulic basin and storage volume, and land use in the surroundings (agriculture, livestock, ebb and housing).

Table 1. Physical characteristics of the reservoirs in 25 de Maio Settlement.

Reservoir	Capacity (hm³)	Basin area (km²)	Water mirror area (km²)	Classification
Paus Brancos	5.5	21	0.57	Small
Marengo	18	75	3.1	Average

The study area is located in the Drought Polygon, with a predominance of semi-arid hot climate, according to the Köppen classification, characterized by a dry and hot period. Average temperatures are between 26 to 28ºC, with a rainy period, concentrated between the months of January to May. The average rainfall is 692 mm per year and the potential evapotranspiration rate is over 2000 mm per year, due to the high ambient temperature and the intense solar radiation. The basin is located on a crystalline base, a region of shallow soils with predominance of Luvisols (IPECE, 2009).

In order to better understand the use and occupation of the soil around the studied reservoirs (Paus Branco and Marengo), it was decided to consider an area with a minimum distance of one km through the *buffer* tool in the Arc Gis® 10.2 program, around the maximum contour of the hydraulic basin of each studied reservoir, to ensure the existence of different classes (Figure 1). This information was obtained through the Landsat 5 image of July 24, 2004, using the bands R-5, G-4 and B-3. An image from 2004 was used because it was a year with above average precipitation in which the surface reservoirs were supposedly full, in comparative analysis with other periods.

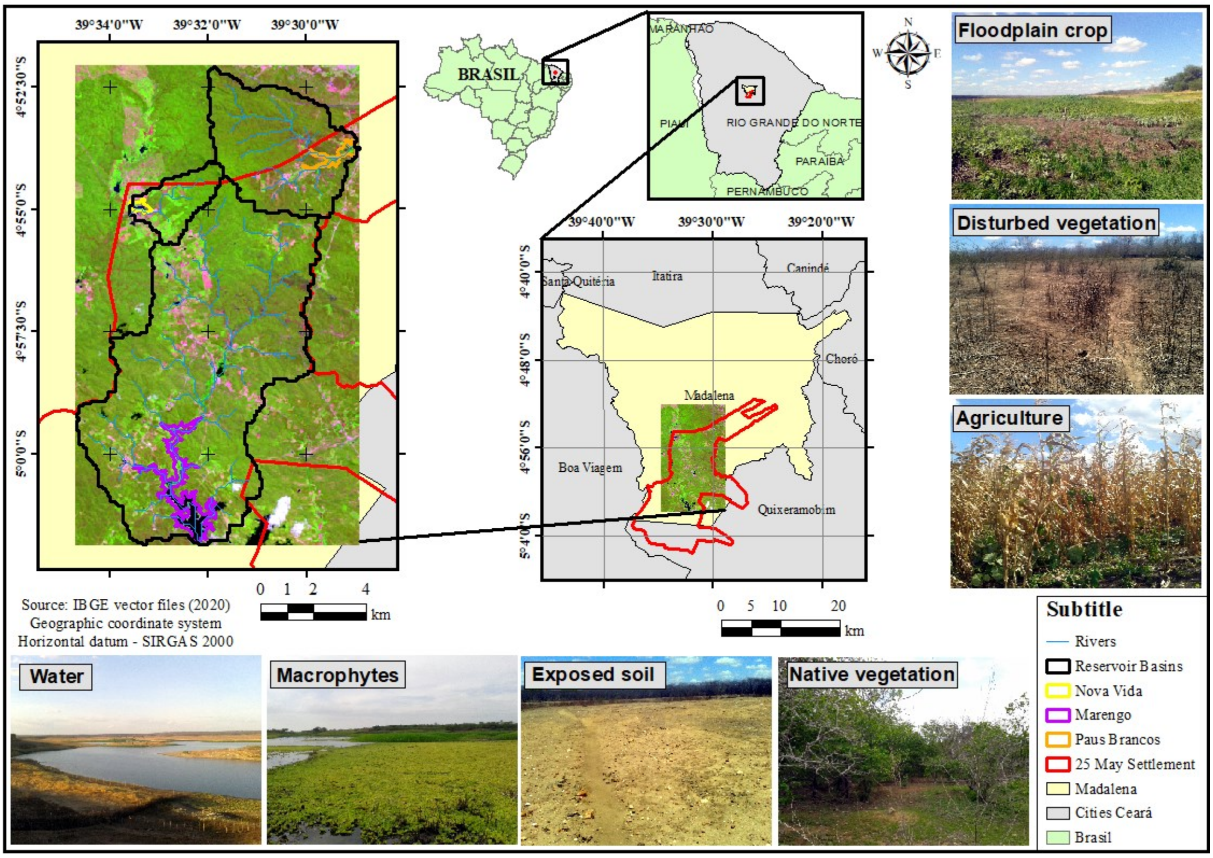

Figure 1. Location of the 25 de Maio Settlement in the State of Ceará, highlighting the hydrographic basins of the reservoirs considered.

Landsat 8

The digital orbital images of the Landsat 8 satellite were acquired free of charge on the *United States Geological Survey* website (USGS, 2013), the research development region is located on orbit 217, point 63.

The Landsat 8 satellites have an imaging range of 170 km north-south by 185 km east-west, a temporal resolution of approximately 16 days, a spatial resolution of 30 meters for the visible bands, and a 16-bit radiometric resolution (USGS, 2013). In this study, the image of 08/24/2015 was used, with extraction of information regarding spectral responses of the targets to identify different land uses. For geometric correction regarding the change in positioning for the southern hemisphere, since Landsat 8 images are referenced in the northern hemisphere, in the horizontal reference system WGS 1984, conversion tools were applied to zone 24 S, where the study area is located.

In the process of color composition of the image, Bands R-6 (1.57 - 1.65 µm), G-5 (0.85 - 0.88 µm) and B-4 (0.64 – h90.67 µm) were used in this sequence to generate a classification with colors that better portrays the different uses, with vegetation in shades of green, water bodies in shades of blue and degraded or urban areas with shades of red.

Hyperion

Hyperion is the first orbital sensor to produce hyperspectral images of the Earth's surface, installed on the Earth Observing One (EO-1) satellite and launched on November 21, 2000 by NASA (*National Aeronautics and Space Administration*) at an orbit of 705 km from the Earth's surface with an imaging range of 185 km north-south by 42 km East-West, spatial resolution of 30 meters and radiometric resolution of 12 bits. The sensor acquires data in 196 bands of 10 nm wide, in the range of 356-2577 nm of the electromagnetic spectrum (EROS, 2015).

The acquisition of the image was made through USGS (*United States Geological Survey*), which forwarded the request to the company EROS (*Earth Resources Observation and Science*). The hyperspectral image used in the work was acquired on October 19, 2014 (EO1H2170632014292110 KF_1R).

An image of the day 08/28/2015 was used and the reflectance was extracted to obtain the land uses. The Hyperion image was preprocessed by the ENVI®5.1 software. In this processing, the conversion of L1R data was carried out to the standard format of ENVI® 5.1. For this, a plugin available on the ITT Visual Information Solutions website, called Hyperion Tools, was used. This tool has an option for georeferencing the image from a "met" type file. The correction of the stripes, which are vertical lines where the pixels have erroneous values, was done by means of the interpolation of the values of the horizontal neighbors. A file with scale factors was also generated for use in atmospheric correction. The georeferencing of the image was carried out in the ENVI® 5.1 software using seven control points on features corresponding to the Hyperion image and a Landsat 8 image, which served as a reference. For the transformation, the UTM projection system, datum WGS-84ezonaUTM24 sul was used. After the georeferencing, the residue in pixel units was evaluated, followed by the sampling of the pixels of the Hyperion scene by the nearest neighbor method.

Image classification

The bands used for the RGB composition of the Landsat 8 satellite to determine the classes were bands 6, 5 and 4 in that order. This composition is known as false color and makes it possible to separate both distinct targets such as water, exposed soil and native vegetation, as well as targets with similar reflectance index, as is the case with macrophytes, ebb and thin vegetation, as reported in the research performed by Bhardwaj et al. (2015), and Dube and Mutanga (2015).

The bands used for the RGB composition of the Hyperion satellite to determine the classes were determined using the SVM classifier (*Support Vector Machine*). Processing was carried out using the *EndMAP-Box* 2.1 program, available on the website of the Humboldt University, Berlin Germany (RABE; VAN DER LINDEN; HOSTERT, 2014; VAN DER LINDEN et al., 2014). For classification, samples of the field classes were collected, and then the images were processed using the EndMAP-Box 2.1 program, to adjust and obtain all parameters and attributes. The Suport Vector Machine algorithm, was used to determine decision limits for class separation as well as the minimization of errors (MOUNTRAKIS; JUNGHOIM, 2011). The values of range and penalty parameter were 0.03 and 100.00, values were suggested by the program, after the calibration performed based on the points reported.

For supervised classification of Landsat 8 and Hyperion images, clustering algorithms (classificatory method) supervised by Maximum Likelihood were used. For this, it was necessary for a sample set of training data based on records in the field, containing examples of patterns of all classes existing *in loco*, be presented to the classifier to make decisions and conceive a map with the thematic classes. Several authors have developed research related to class quantification using hyperspectral images with the Hyperion sensor. Some mentioned only the wavelength ranges adopted to classify the image in order to obtain the classes, and have not been concerned with using specific and / or exact bands for the realization of the RGB composition, as in the works carried out by Galvão, Formaggio and Tisot (2005), Schramm and Vibrans (2007), Tisot, Formaggio and Rennó (2007), White et al. (2010), Xie, Wang and Shang (2011), and Jafari and Lewis (2012).

Evaluation of classifier performance

The assessment of the accuracy of the mapping in relation to the terrestrial truth was performed by comparing the data generated by the classifiers with the data obtained via a survey carried out in the field, using a portable Garmin GPS model. After confirming the classes for each sampled point, a file of values was created relating the sampling points to the terrestrial truth. Next, a *raster* image (matrix-type map) of the sample points was generated, and then, the statistical analysis of the supervised classification was carried out.

The model called Kappa is a statistical method that allows comparative analysis of the analyses of the maps obtained through remote sensing, within a certain limit (LANDIS; KOCH, 1977).

The assessment of mapping accuracy and quality was determined using the Kappa coefficient, developed by Landis and Koch (1977), and adopted by several authors in high impact and relevant research (BLANCO et al., 2014; GILBERTSON; KEMP; NIEKERK, 2017; PETROPOULOS; ARVANITIS; SIGRIMIS, 2012), as detailed in the

Equation 1.

$$k = \frac{P_0 - P_c}{1 - P_c} \quad (1)$$

In which:
k is the Kappa Concordance Coefficient; P_o is the observed concordance; P_c is the proportion of random concordance.

The Kappa index statistics is a map validation method that aims to measure the quality of a thematic map produced by the classification of a satellite image, having as reference another thematic map. There are six classes of Kappa statistics to determine the quality of maps (Table 2).

Table 2. Quality of classification associated with Kappa statistics values.

Kappa value	Quality of the thematic map
< 0.00	Very bad
0.00 – 0.20	Bad
0.20 – 0.40	Reasonable
0.40 – 0.60	Good
0.60 – 0.80	Very Good
0.80 – 1.00	Excellent

Calculation of the individual Kappa developed in the research allows the analysis of each use, providing an understanding of the influence of seasonality and class changes throughout the year, thus generating a better understanding of the representation of land use through satellite images. The calculation of this variable is described in Equations 2, 3 and 4.

$$k - individual = \frac{P_{0i} - P_{ci}}{1 - P_{ci}} \quad (2)$$

Where: k-conditional is the individual Kappa concordance coefficient; P_{oi} is the observed concordance; P_{ci} is the proportion of random concordance.

$$Poi = \frac{N}{P} \quad (3)$$

Where: P_{oi} is the observed concordance; N is the number of hits on the main diagonal of use; P is the total points of use obtained in the field.

$$P_{ci} = \sum C/100 \quad (4)$$

Where: P_{ci} is the proportion of random concordance; $\sum C$ is the sum of the usage column in the confusion matrix.

Application for reservoirs of the 25 de Maio Settlement using ARP data

In order to investigate the performance of the model in the classification of Landsat 8 and Hyperion images of the region studied in a period different from that initially analyzed in the research, another survey was carried out in the field in November 2015. The campaign concentrated efforts on characterizing the classes at the time, based on data from an overflight using an ARP in the portion of the Paus Branco reservoir closest to the bus, given the restricted battery autonomy of the equipment. This survey produced a map with a spatial resolution of 0.5 meters. Additionally, class points were raised in the hydraulic basin of the São Nicolau reservoir and surroundings with a navigation GPS.

For the validation of the classes, the procedure for surveying points of the different classes around the São Nicolau reservoir (Figure 2), also located in the 25 de Maio settlement, located south of the Paus Brancos reservoir and north of Marengo, was adopted. The points were obtained in a campaign carried out on November 16, 17 and 19, 2015.

During the campaign, six classes were identified in the surroundings of the São Nicolau reservoir (water, exposed soil, native vegetation, agriculture, thin and low vegetation) and more than two hundred points of the commented classes were surveyed during the period of collection. As no macrophytes were detected in this reservoir, the points used in the classification were obtained in a survey carried out in the Paus Brancos reservoir in the same campaign in November 2015.

The class validation process followed with the adoption of two images, one from the Landsat 8 multispectral satellite and the other from the Hyperion hyperspectral satellite. The two images were taken in August 2015, with the Landsat 8 image being taken on the 24th and the Hyperion satellite image on the 28th.

In possession of the usage points, the Landsat 8 and Hyperion images were spatialized, where the points that were under cloud or left over of cloud were excluded in either of the two images.

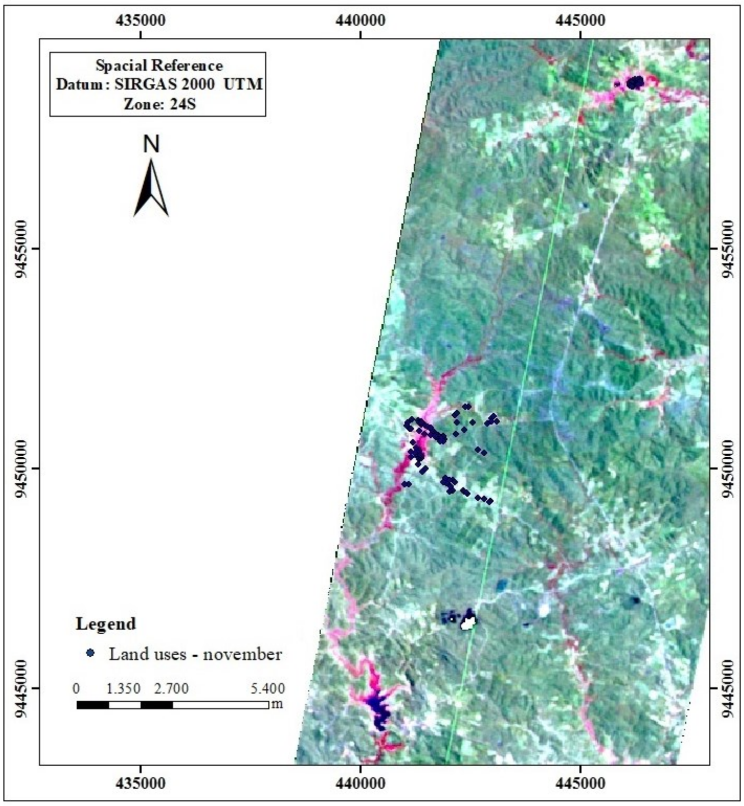

Figure 2. Spatialization of points surveyed in November 2015, around the São Nicolau reservoir to validate the classification of Landsat 8 and Hyperion images.

The efficiency of the classification of images from both Landsat 8 and Hyperion, for class determination, was evaluated through the Kappa index, and the points for the determination of this index were obtained through image processing product in Pix4Dmapper®, obtained through a flight performed with an ARP (remotely piloted air) on November 11, 2015.

ARP and image characteristics

The aerial image was obtained by an ARP type quadcopter, model *DJIPhatom FC-40* remotely controlled for spatialization of classes. The model used has a camera attached and captures images with a resolution of 1280 x 720 pixels, with a spatial resolution of 2.5 centimeters, obtained as a function of the flight height performed, which was 40 meters in altitude.

The flight parameters adopted were: flight altitude of 40 meters, GSD of 1.75 cm / px, camera angle of 90°, frontal overlap of 20%, frontal overlap of 20%, lateral overlap of 20%, fast mode shooting speed and fast ARP speed.

The captured image was used to validate the mapping of the classes obtained through the classification of Landsat 8 and Hyperion satellite images.

For the calculation of the Kappa index, 20 points of each class were used, and the image obtained by the ARP was small in scope, due to the limiting factor of the equipment's battery, which did not allow obtaining a larger image, which did not include areas of native vegetation and agriculture, taking into account only 5 classes, totaling 100 points used to determine the Kappa index. The image obtained through the flight over the Paus Brancos reservoir can be seen in Figure 3. The cloud and cloud shadow classes, in turn, were not characterized in this application, since imaging using ARP flies at low altitudes and, thus, did not detect those targets.

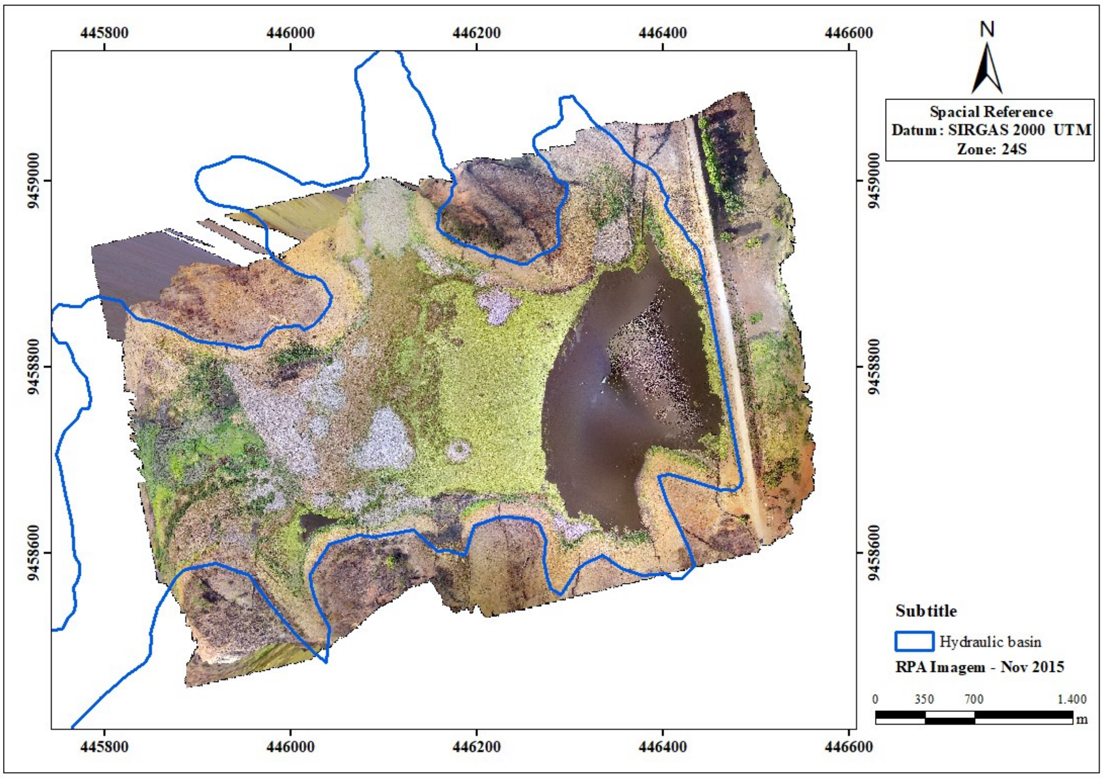

Figure 3. Image of the Paus Brancos reservoir obtained through the ARP to validate the classification of the Landsat 8 and Hyperion images.

RESULTS AND DISCUSSION

Determination of Hyperion image bands

Due to the amount of bands that the Hyperion sensor has, it was necessary to determine the bands that present superior results in the separation of the classes evaluated in the present study. The weights of the most important bands were evaluated using the supervised SVM classifier, used in several studies in order to accurately determine the classes (BLANCO et al., 2014; PETROPOULOS; ARVANITIS; SIGRIMIS, 2012). The algorithm identified a ranking with the performance of each of the 155 bands in the Hyperion image classification process, which resulted in a Kappa coefficient of 0.81, considered excellent.

In order to obtain the bands that could express the classes with high accuracy through a simpler and more common supervised classifier, as is the case of the Maximum Likelihood method, we sought to determine the best RGB composition, among the ten bands with the best performance, found through the SVM classification. The bands found to be the best for an RGB composition were: 51 on the R channel (red), 161 on the G channel (green) and 19 on the B channel (blue) (Table 3).

Table 3. Performance of the Hyperion satellite bands for class determination.

Band	Performance (%)	Rank
161 - G	92.7	1º
148	91.6	2º
145	91.6	3º
146	91.5	4º
206	91.5	5º
216	91.4	6º
197	91.3	7º
19 - B	91.2	8º
143	90.9	9º
51 - R	90.9	10º
Kappa = 0.81 – Excellent		

George, Padalia and Kushwaha (2014), in a research carried out in the western Himalayan region, seeking to differentiate tree species through hyperspectral images through the Hyperion satellite, used the SVM classifier to determine the targets, obtaining a Kappa coefficient of 0.79, showing the efficiency of this classifier in the spatialization of vegetation cover.

Application for reservoirs of the 25 de Maio Settlement using ARP data

In this application, the same band compositions proposed in the initial stage of the soil class classification research were used (Hyperion R-51, G-161, B-19 and Landsat 8 R-6, G-5, B-4). Again, the general Kappa values found using the Hyperion image (0.73 and 0.83, with 5 and 3 classes, respectively) were higher than the values obtained using Landsat 8 (0.39 and 0.49 with 5 and 3 classes, respectively), as can be seen in Table 4.

The validation of the classes did not include the classes native vegetation and agriculture due to non-imagery by the ARP of the areas containing these classes. The cloud and shadow targets were also not validated since the ARP flew at an altitude below the clouds to generate images at high resolution. Consequently, the data extracted for description and identification of the landscape classes became more reliable and faithful to the reality of the field both in relation to spatialization, as well as in relation to fidelity in the description and identification of the land cover.

Table 4. Kappa values found through supervised classification. around the Paus Brancos reservoir.

	Hyperion	Landsat 8
Considering 5 classes		
Water	0.87	0.87
Macrophytes	0.76	0.80
Exposed soil	0.43	0.01
Thin vegetation	0.69	0.04
Ebb	0.93	0.24
Kappa value	0.73	0.38
Quality of the thematic map	Very good	Reasonable
Considering 3 classes		
Water	0.85	0.82
Macrophytes	0.72	0.68
Ebb	0.92	0.27
Kappa value	0.83	0.55
Quality of the thematic map	Excellent	Good

Both hyperion and Landsat 8 results were better in the analysis considering 3 soil classes, where the three classes considered were water, macrophytes and ebb, which is directly linked to the size of the ARP image area, which included a small area largely occupied by these three classes and due to the spatial resolution of landsat and hyperion images being larger than those of the images obtained by ARP.

The general Kappa obtained through the supervised classification of Hyperion was 0.83, considering 3 classes, being classified as excellent, as can be seen in Table 3.

The worst result found in the classification of the Landsat 8 image is due to the presence of agricultural use within the hydraulic basin of the Paus Brancos reservoir, which shows the satellite's limitation in the separation of the agriculture, ebb and macrophyte classes (Figure 4). The similarity of the reflectance values between the macrophyte, ebb and agriculture classes clearly shows the care that must be taken when analyzing the results generated in the Landsat 8 image classifications, as in some cases the confusion or inversion of existing real information is clear in the field. In this way, some classes are almost impossible to be separated and determined through multispectral image, even if the classification is obtained through a detailed set of points of the classes surveyed in the field.

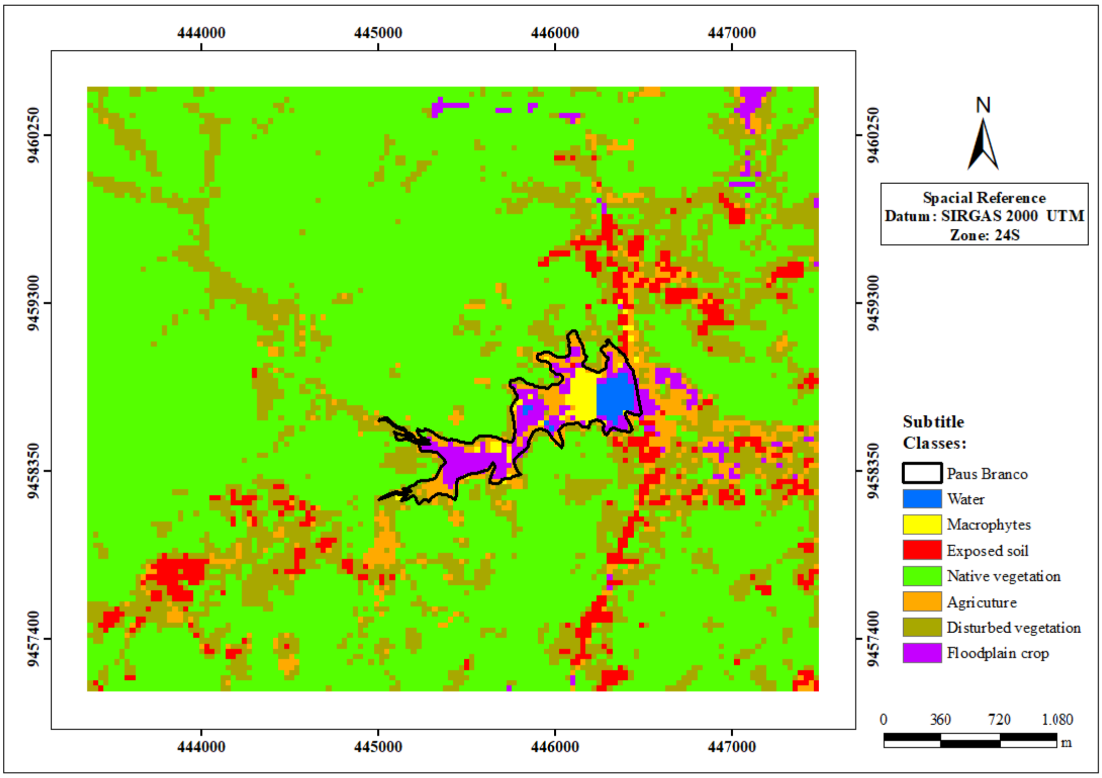

Figure 4. Supervised classification generated from the Landsat 8 image (08/24/2015) around the Paus Brancos reservoir.

Figure 5 shows the spatialization of the classes obtained through the supervised classification of the Hyperion satellite image by the Maximum Likelihood method, which presented excellent results according to the produced Kappa values. The product generated from this classification is very consistent with reality, reinforcing the thesis that hyperspectral images have great efficiency in the spatialization of both homogeneous and different classes, which reinforces the gain of the results obtained through the Hyperion sensor.

Jafari and Lewis (2012), in a research carried out for spatialization of targets on the soil surface through Hyperion and Landsat 8 images, proved that the higher spectral resolution of hyperspectral images can improve the discrimination of both similar and heterogeneous components, with very different results, higher than those obtained by multispectral satellites such as the case of Landsat 8.

Blanco et al. (2014) stated that hyperion spectral image resolution is robust enough to assess land use, providing an effective and reliable tool to evaluate anthropogenic activities, and the results can be applied as a tool for managing, planning and monitoring land use and also in the recovery of degraded areas, thus playing a major role as an environmental management tool.

The results obtained through the confusion matrix for the Hyperion image, as detailed in Table 5, show that the sparse vegetation and exposed soil classes have similarities with other classes, which can be directly linked to the area covered by the ARP image. On the other hand, the classes water (correct 18 of 20 points) and ebb (correct 19 of 20 points) had almost 100% efficiency, showing the importance of using hyperspectral images in the separation and determination of these classes.

The application of hyperspectral sensors, such as Hyperion, has, however, some limitations such as availability, cost, continuity, complex processing and analysis, in addition to the area of imaging that is very narrow, being necessary, in many cases, the acquisition of a set of scenes for covering an area, especially when they present more expressive distances in the East-West direction (DUBE; MUTANGA, 2015; MUTANGA; ADAM; CHO, 2012).

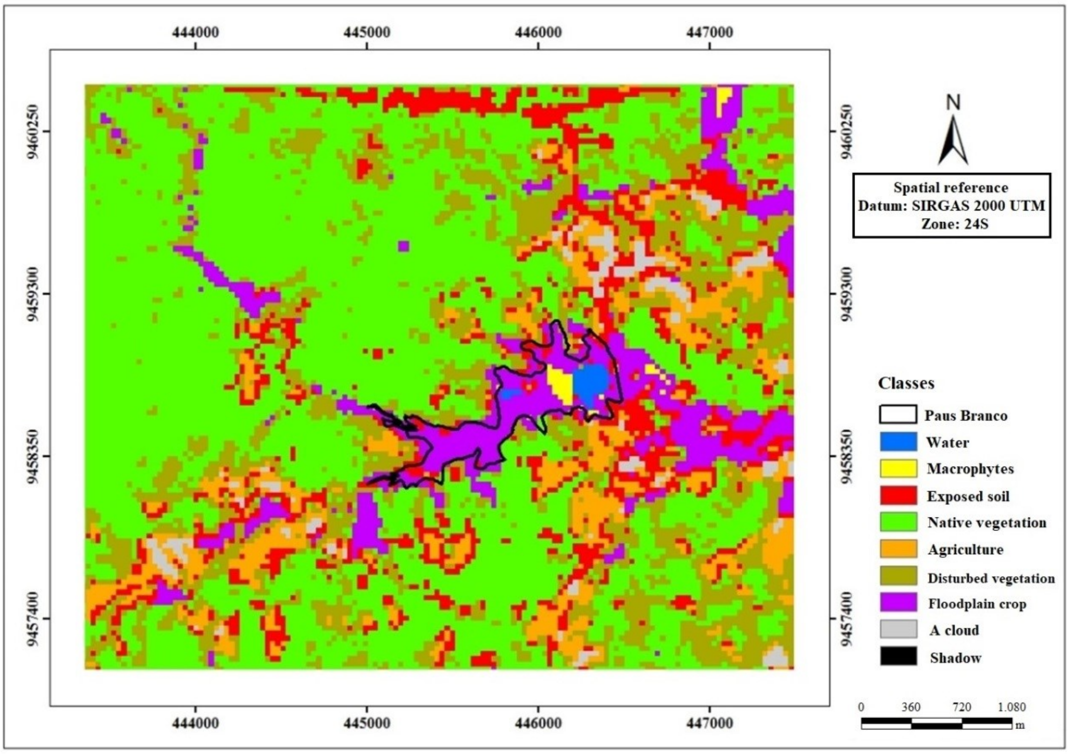

Figure 5. Supervised classification generated from the Hyperion image (28/08/2015) around the Paus Brancos reservoir.

Table 5. Confusion matrix resulting from the supervised classification, Maximum Likelihood, of the Hyperion image of 08/28/2015 in the vicinity of the Paus Brancos reservoir, considering 5 and 3 soil classes.

Matrix obtained with 5 classes							
P_o - Observed concordance							
Thematic Map							
		Water	Mac.	Soil	V. thin	Ebb	∑
Terrestrial truth	Water	18	0	0	0	2	20
	Macrophytes	3	16	0	0	1	20
	Exposed soil	0	0	10	5	5	20
	Thin vegetation	0	0	2	15	3	20
	Ebb	0	1	0	0	19	20
	Sum	21	17	12	20	30	100

Matrix obtained with 3 classes					
P_o - Observed Concordance					
Thematic Map					
		Water	Macrophytes	Ebb	∑
Terrestrial truth	Water	18	0	2	20
	Macrophytes	3	16	1	20
	Ebb	0	1	19	20
	Sum	21	17	22	60

The individual Kappa results show that in the analysis with 5 classes, the Hyperion satellite presented higher values in relation to the results found by landsat 8 satellite in 4 of the 5 classes. Only macrophyte use presented individual Kappa better in Landsat 8 (Kappa = 0.80 – excellent) than Hyperion (Kappa = 0.76 – very good), as can be seen in Table 6. In the analysis performed considering only 3 classes, the individual Kappa values of the Hyperion were higher in the three soil classes (water, macrophytes and ebb) (Table 6).

Table 6. Kappa values found through the supervised classification of Landsat 8 and Hyperion images, around the Paus Brancos reservoir in August 2015.

Use	5 classes		3 classes	
	Hyperion	Landsat 8	Hyperion	Landsat 8
Water	<u>0.87</u>	<u>0.87</u>	0.85	0.82
Macrophytes	0.76	<u>0.80</u>	0.72	0.68
Exposed soil	<u>0.43</u>	0.01	-	-
Thin vegetation	<u>0.69</u>	0.04	-	-
Ebb	<u>0.93</u>	0.24	0.92	0.27
General Kappa	0.73	0.39	0.83	0.49
Map quality	Very good	Reasonable	Excellent	Good

CONCLUSIONS

The Hyperion image showed accurate results, showing an important support tool for the management of the state's water resources in the spatialization of reservoirs, in addition to the diagnosis of reservoirs (dams) with the presence of macrophytes with a high degree of precision, where it can be affirmed that it is worth using this satellite in research aimed at evaluating land use and occupation.

The research recommends the use of hyperspectral images (Hyperion) due to the improved results of the separation of classes in the spatialization of water bodies, because it was much higher than the results of multispectral images (Landsat 8). However, the Hyperion satellite presented limitations for its use due to the small amount of available images and the low coverage area in the state of Ceará, limiting the development of research in strategic areas.

Hyperspectral data proved to be a good alternative for analyzing land use and occupation even on targets with similar spectral characteristics. Even using traditional classification methods, the data worked here achieved a good performance using the feature selection criteria of the different classes.

The results found using hyperspectral images have better performance than those found in multispectral analysis, which shows the importance of spectral image resolution, spatialization and separation of classes with different or similar characteristics. The classification of the Hyperion image using the Maximum Likelihood classifier showed a high degree of efficiency in the determination of soil uses.

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