Identification and Delimitation of Natural Lentic Wetlands in the Department Valle Del Cauca with Satellite Imagery

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Key words: Inventory wetlands, images classification

SUMMARY

We developed the identification and mapping of natural lentic wetlands of the department through digital processing of Quickbird satellite images. We used the Normalized Difference Vegetation Index to differentiate water bodies from vegetation cover, and there were two types of classifications, supervised pixel-based and object-oriented. We compared the results obtained with both classifications and selected the best performing classification yielded to generate the mapping of wetland ecosystems at 1:10,000, which is identified with the water surface wetlands that count and differentiate among three types of aquatic vegetation predominant in these ecosystems. The application of remote sensing techniques to multitemporal monitoring of wetlands, allows deriving such crucial data as the decrease in the surface of a particular wetland, and the estimation of flood areas, periodic processes essential for the conservation of many of these ecosystems.

RESUMEN

Se elaboró la identificación y delimitación de los humedales lénticos naturales del departamento mediante el tratamiento digital de imágenes del satélite Quickbird. Se utilizó el Índice de Vegetación de Diferencia Normalizado para diferenciar los cuerpos de agua de la cubierta vegetal, y se realizaron dos tipos de clasificaciones, supervisada con base a píxeles y orientada a objetos. Se compararon los resultados obtenidos con ambas clasificaciones y se seleccionó la clasificación que mejores resultados arrojó para generar la cartografía de los ecosistemas de humedales a escala 1:10.000, donde se identifica el espejo de agua con el que cuentan los humedales y diferenciar entre tres tipos de vegetación acuática predominant en estos ecosistemas. La aplicación de las técnicas de teledetección al seguimiento multitemporal de los humedales, permite derivar datos tan cruciales como la disminución de la superficie de una zona húmeda concreta, así como la estimación de las superficies de inundación, procesos periódicos esenciales para la conservación de muchos de estos ecosistemas.
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1. INTRODUCTION

For the identification and delineation of wetlands, were used initially by traditional methods of mapping the field. The appearance of photo-interpretation techniques allowed for wetland maps more efficiently and accurately from aerial photographs, which have been the most widely used input wetland inventory, as reported by the work of Warner (1990), Ibrahim and Hashim (1990) and Tiner (1990). Later, several studies which used data from Landsat Multispectral Scanner (MSS) Thematic Mapper (TM) to distinguish water masses surrounding dry soil or vegetation, as quoted by Smith (1997).

Other sensors such as Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) the High Resolution Visible (HRV) Sensor for Earth Observation (SPOT) and the METEOSAT also been used to differentiate flooded areas within wetlands. The SAR (Synthetic Aperture Radar), with higher spatial resolution, allow the detection of flooded areas under a forest canopy. The most used are the ERS-1 and ERS-2 European Space Agency and the Japanese JERS-1 satellite. Ramsey, E.W. (1998) contains various experiences in the study of wetlands with SAR.

The presence of very small and ephemeral water bodies is difficult to map because their level, or even their existence, are highly variable depending on the distribution of rainfall and evaporation rates. Work and Gilmer (1976) showed how the spectral bands of 80 m resolution Landsat MSS were able to identify gaps less than 1.6 ha in Dakota. For its part, Ernst-Dottavio, Hoffer and Mroczynski (1981) identified small wetlands in northeast Indiana from Landsat MSS data. In Colorado, Eckhardt and Litke (1988) found gaps less than 0.5 and 0.1 ha using Landsat MSS and SPOT-HRV, respectively. It works Piaton and Puech (1992), who inventoried water bodies with satellite images SPOT_HRV under 0.25 ha, along with Harris and Mason (1989), who used AVHRR observations to obtain the area of Lough Neagh, a lake in Northern Ireland, formed the basis for the study by Verdin (1996) in the Sahel (Niger) where there are numerous areas of small and ephemeral water scattered throughout the region. A total of 21 lakes examined using NOAA-AVHRR six scenes with a resolution of 1-1km during the dry season the years 1988-1989. In Spain, the CEDEX obtained through the use of techniques based on digital analysis of Landsat-5 TM, location and location of existing water surfaces in the basins of the Duero, Guadiana, Júcar and Segura. Guadiana Basin images were used, and geometrically corrected, dated from 4 June 1994 and July 6 of that year, from the National Geographic Institute. The total number of water surfaces is detected 5581 ranging between 1788 extension has Orellana reservoir and the lower surface 625 m2 detected (Soriano, 1996).
In India, mapping of wetlands has been conducted using remote sensing data. Wetlands were mapped from 236 districts under the "Nationwide Wasteland Mapping". Different authors Khaziranga mapped areas, Bharatpur and Sundarbans, using data from the Indian Satellite IRS-IA and sensor LISS (Linear Imaging Self-Scanning Sensor). Also mapped coastal wetlands of the delta Sundara data from IRS-1B LISS-II combined with SAR data from ERS-1 (Dwivedi, 1999). Some studies to evaluate the potential of SAR systems for classification of flooded and unflooded areas were in the top of the wetlands of the Niger River as it passes through Mali. We used a temporal series of SAR images of ERS-1, from November 1992 through October 1993 (every 35 days), selecting the images of the dry season and maximum flooding. Also used additional data available from the NASA / DARA, radar images transported RADAR-C (SIR-C), X-SAR 994 e AVHRR images.

Several methods were available inventory standard have been applied successfully in different circumstances, countries or regions. Notable examples are the inventory of the Mediterranean Wetlands Initiative (MedWet), the national inventory of wetlands from the U.S. Fish and Wildlife of the United States, the national inventory of wetlands in Uganda, the inventory of wetlands in Asia and the national inventory of wetlands in Ecuador.

In Colombia, wetlands have gradually lost or altered due to the deterioration of natural processes as a result of intensive agriculture, urbanization, pollution, drainage and other forms of intervention. The degradation of these systems and the loss of their productive capacity and aggressive actions merit priority at the national, regional and local levels. This situation is no stranger to the upper valley of the Cauca River. Floods and high water levels lead to a process of carving of the borders, where the river meanders in its own evolution and create gaps that make madreviejas natural storage areas for excess water, which exert a role important in regulating the flow to capture large volumes of water in the winter to release slowly in the summer.

In the 1950s there were over 160 madreviejas, of which the majority was associated with river. In 1955 the area of these was about 17,500 ha (CVC, 2007). In the 60's the population growth and socio-economic growth of Valle del Cauca involved urban expansion and agricultural frontier and thus the need for adaptation works to protect land against flooding. These changes influenced the decline of wetlands less than 3,000 ha in the late eighties.

In the department of Valle del Cauca, the inventory of existing wetlands as a priority has been kind to those of natural lentic, located in the Cauca river valley geographic mainly madreviejas River, swamps, floodplain lakes and areas of flooding human intervention such as rice crops. The study area is characterized by having a direct influence of the Cauca River, especially in the parts surrounding it, which are subjected to the action of rising and flooding in the rainy season. This makes the landscape that is dynamic and variable, as the annual flood of the river identified increased levels of all wetlands in the valley and the areas near these. On reaching the dry season the water level drops and the extent of these habitats is significantly reduced.
The work done to obtain existing information from wetland inventory in the Cauca river valley geographic are mainly due to the CVC studies (1956, 1986, 1997, 2002) that are based on Photogrammetric and fieldwork. The results of this work, we obtained similar maps showing the location of wetlands used in the formulation of comprehensive environmental management plans for some of the wetland inventory, in order to manage and plan the proper maintenance of them.

For an inventory, account was taken of the structured framework for wetland inventory planning established by the Ramsar Convention, and was carried out by digital analysis of three multispectral Quickbird satellite image of 2.4 m spatial resolution 2002 and 2004, also used existing information on wetlands such as Environmental Management Plans prepared by the CVC and a similar mapping of these ecosystems.

We applied the Index Normalized Difference Vegetation (NDVI, by its initials in English), in differentiating between the water bodies of other coverage. Subsequently applied to each image classification methods such as supervised classification based on pixel and object-oriented supervised classification, the latter method takes into account aspects such as shape and texture and not only the spectral information of each pixel. The results obtained with each method of classification were compared using confusion matrix and Kappa coefficient. Was generated digital mapping wetlands identified in the three images. The methodology allows the identification and delineation of wetlands lentic and coverage associated with these ecosystems efficiently and permanently and will support the development of plans of action to protect these ecosystems.

**Study Area**

The geographical coverage of the Cauca River valley, the entire flat strip which crosses this stream as it passes through the departments of Cauca and Valle del Cauca, the larger part of the valley is located in the vicinity of the Yumbo and the narrowest to the height the municipality of Buga, in the center of Valle del Cauca department (Figure 1). The study area is demarcated by the geographical coordinates: Latitude 3 ° 44 '11.82 "N, Longitude 76 ° 24' 46.02" W (top left) and latitude 3 ° 41 '56.85 "N, Longitude 76 ° 22' 14.30" O (bottom right).

From the standpoint of geological and geographical, the Cauca River in this area is located in a fertile Andean valley floor, the product of alluvial sediments deposited since the beginning of the Quaternary geological period on an area near the 214 km long and 20 km wide, with an area covering 440,000 ha, flat and level. This valley is situated between 900 and 1,000 meters, in a warm dry heat floor vegetation sub-Andean forest, temperatures above 24 ° C and an average rainfall of 1300 mm per year.

Physiographic features, climate and soil fertility to ensure use for economic development, focusing primarily on the agribusiness of sugarcane, with about 200,000 hectares under cultivation. Major tributaries in this sector, on its western edge are the rivers course, Timba, Jamundi and Risaralda, on the east bank where the valley is wider, the rivers Sheep, Palo
Amaima, Tulua, Guadalajara, Bugalagrande and La Old (CVC, 2007).

On their way through it north of Cauca and throughout the Department of Valle del Cauca, Cauca River is alluvial, is characterized by meandering shape and lies on a valley formed by sediment transported and deposited in million years by action of hydraulic and morphologic natural activity. In this installment of the Cauca River tributary receives an average flow of 260 m$^3$/s, the bankfull depth varies from a mean of 4.5 m to a maximum of 16 m, and its average width is 100 m. The materials that make up his bed are mainly medium sands, relatively uniform, poorly graded, ie a predominantly specific diameter of the particles. It is estimated that the river carries an average annual sediment load in suspension of 3.5 million tonnes, provided by the erosion that occurs in the basins themselves and their tributaries (CVC, 2007).

The wetlands in the region today are basically Ancient bed of Cauca River, swamps, lagoons and flood inundation areas generated by human intervention such as rice crops.

Currently there are 49 lentic wetlands, remnants of the complex hydrology of Upper Cauca River with approximately 4,000 ha, including 2000 in the lagoon has Sonso and 311 of the Cienaga El Conchal. (CVC, 2002 cited by Castillo).

![Figure 1. Geographic location of the Cauca River valley](image)

Some wetlands have preserved sample of native vegetation that should dominate the valley in centuries past, highlights some woody species such as wet soils Chambure (Erythrina glauca and E. edulis), the butter (Laetia americana), willow (Salix humboldtiana), the chiminangos (Pithecellobium dulce), saman (Samanea saman) and Guadua (Guadua angustifolia).

Within the predominant aquatic vegetation in permanent lagoon areas and those that are...
flooded frequently highlights the potbellied water (Eichornia crassipes), whose growth comes to completely hide the surface of some wetlands, the lettuce (Pistia stratiotes) also other plant forms large floating mats in shallow areas, as well as cattails (Typha angustifolia) and the strings (Piper sp). The satellite images acquired with sensors of high spatial and spectral resolution become the new alternative for periodic information to characterize these important ecosystems that are at high risk of extinction.

2. MATERIALS AND METHODS

The identification of wetlands is conducted through the digital processing of three multispectral Quickbird satellite images of 2002 and 2004, each image has 4 spectral bands (blue, 450-520 nm green 520-600 nm red, 630 -690 nm, near infrared, 760-900 nm). One image covers part of the Cauca River as it passes through the town of Yumbo and the other two cover the geographic area of the valley municipalities Guacari Vijes and also used information on wetlands as: Plans Environmental Management developed by the CVC and digital mapping of the study area.

2.1 Pre-processing of images

All three images are from the satellite Quickbird Standard type, which means that it has corrected an approximate displacement produced by the relief with respect to the reference ellipsoid through a sufficiently coarse DEM. The degree of standardization is relatively small, and although each image corrections field has not considered orthorectified images.

The estimated accuracy of the product in "absolute geo-location" is 23 m for 90% of (CE90%), excluding travel by topography and displacement of the nadir angle of the shot, even on flat land can be reached at 14 m. The control is not done by ground control points but the information is extracted from the satellite ephemeris and altitude. To perform each step of the pre-processing of images, we used the program ERDAS v9.2

2.2 Correction of Atmospheric Effects

Electromagnetic radiation is greatly affected by the various components of the atmosphere. The presence of aerosols and water vapor selectively scattered radiation transmitted between the land surface and the sensor. The radiance finally detected by the sensor does not correspond exactly to which part of the land surface, but has an added percentage, as a result of the scattering effect of the atmosphere (Chuvieco, 1996).

Atmospheric gases and aerosols contribute to the absorption and scattering of direct sunlight and sunlight reflected from Earth's surface. The absorption reduces the amount of energy available at a particular wavelength, while the dispersion energy redistributes changing its direction. Although the dispersion does not change the properties of radiation other than its address, the result is a decrease in the contrast of the observed objects, resulting in degradation of the contours.
The scattering affects mainly the direction of the visible radiation, but can also alter the spectral distribution of wavelengths in the visible and near him. The main problem involving the scattering is its heterogeneity in space and time, in other words, atmospheric dispersion is not constant in the image but in certain areas may have been more affected than others, depending on the different presence of aerosols or water vapor. Furthermore, the effect is dependent on the wavelength and varies between images so difficult to predict. Unfortunately, it is very complex to address a severe correction of atmospheric dispersion, since a number of steps required for simultaneous image acquisition. (Chuvieco, 1996).

For the correction of atmospheric effects of each image, we used the histogram correction method for their minimum values (Chavez, 1996).

2.3 Georeferencing

Before the Georeferencing of each image, we proceeded to make a mosaic with the images corresponding to the municipalities and Guacari Vijes. The Georeferencing of each image is made from 1:10,000 scale digital map of the study area, which was provided by the CVC.

To carry out the process of georeferencing, were selected in each of the 3 images a total of 20 ground control points (GCP, by its initials in English). The georeferencing was conducted in three phases: (i) the location of ground control points in the image and digital mapping, (ii) calculation of the functions of transformation between image coordinates and mapping, and (iii) resampling or relocation of digital levels (ND) originals to the new position. For this last phase, we used the geocoding second-order polynomial and the criterion of nearest neighbor interpolation (nearest neighbor), because it involves less processing of original ND.

The mean square error (RMS, by its initials in English) should be less than one pixel. This work achieved a RMS lower than 0.25. The RMS is a measure of the accuracy of the GCP images expressed in the pixel size of the image. Values less than 1 provide high accuracy. A RMS = 1 is equivalent to having an error equivalent to the spatial resolution satellite image.

2.4 Subset images

Once the images were georeferencing, we proceeded to perform a subset of each image, both of the image corresponding to the Yumbo and the mosaic created with images and Guacari Vijes.

By identifying the bodies of water and type of vegetation found in wetlands, it was noted that there confusion because water bodies provided a spectral response similar to the shadows present in each image, the same situation appeared between some of clouds and vegetation types that are trying to classify each wetland, which was necessary to disguise the shadows and the clouds to clear them from the images. The experiment was conducted a supervised classification of each image, which was taken as a sample from each class areas of the images.
that were blended with clouds and shadows to achieve, through classification, clouds and shadows reflect correctly classified by avoiding confusion with other types of coverage.

Once classified the clouds and shadows, re-coded classification to obtain a new image without the presence of clouds and shadows. Classes for the clouds and shadows were coded with a value equal to zero and the remaining classes with a value of one. We Subsequently intercepted recoded geo-referenced images of the classification of clouds and shadows. The resulting image has the complete information of the four bands and the areas in which it was possible to observe the clouds and shadows appear black because the pixels have taken the value of zero.

2.5 Radiometric Correction

The radiometric correction of images was performed to convert the digital levels of each pixel in spectral radianc values using calibration coefficients and the effective bandwidth obtained from the header images.

Table 1. Calibration coefficients and effective bandwidths. (DigitalGlobe, Inc)

<table>
<thead>
<tr>
<th>Spectral Band</th>
<th>Calibration Coefficient</th>
<th>Effective Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (blue)</td>
<td>0,01604120</td>
<td>0,068</td>
</tr>
<tr>
<td>2 (green)</td>
<td>0,01438470</td>
<td>0,099</td>
</tr>
<tr>
<td>3 (red)</td>
<td>0,01267350</td>
<td>0,071</td>
</tr>
<tr>
<td>4 (near infrared)</td>
<td>0,01542420</td>
<td>0,114</td>
</tr>
</tbody>
</table>

The radiometric calibration process was divided into 2 stages (Digital Globe, 2003): The first step was to multiply the values of digital accounts for each of the bands of the original pixel \((q_{\text{pixel, band}})\) for the calibration coefficients \((K_{\text{banda}})\), giving the integrated radiance for each band as shown in Equation 1

\[
L_{\text{Pixel,Banda}} = K_{\text{Banda}} * q_{\text{Pixel,Banda}} \quad (1)
\]

The second step was to divide the integrated radiance of each band \((L_{\text{pixel, band}})\) for the bandwidth \((\lambda_{\text{band}})\), gaining half spectral radiance for band.

\[
L_{\lambda_{\text{Pixel,Banda}}} = \frac{L_{\text{Pixel,Banda}}}{\Delta\lambda_{\text{Banda}}} \quad (2)
\]

We assume that the radiance detected by the sensor \((L_{\lambda \text{ pixel, band}})\) depends on several
factors. Mainly, is a function of incident solar radiation, the response of land cover such radiation and the contribution of radiance due to the atmosphere. In sum, expressed as Mather (1987) as:

\[ L_{\lambda_{Pixel, Banda(k)}} = L_{su(k)} * \rho_{(k)} * \tau_{(k)} + La_{(k)} \]  \hspace{1cm} (3)

From this expression one can obtain the reflectivity:

\[ \rho_{(k)} = \frac{L_{\lambda_{Pixel, Banda(k)}} - L_{su(k)}}{L_{su(k)} * \tau_{(k)}} \]  \hspace{1cm} (4)

Assuming that the surface has lambertian behavior, we can estimate the radiance that reaches the ground (LSU (k)), on the specified date of acquisition of the image from the following parameters:

\[ L_{su(k)} = \frac{E_{o(k)} * \cos \theta}{K * \pi} \]  \hspace{1cm} (5)

Where: EO (k) is the extraterrestrial solar irradiance (in that spectrum band), \( \theta \) is the zenith angle and K is the correction factor of the distance Earth - Sun calculated as:

\[ K = 1 + 0,0167 \cdot 2\pi(n - 93,5) / 365 \]  \hspace{1cm} (6)

Where: n is the Julian day of the year.

To avoid variation of the radiance over the annual variation of solar irradiance, should be performed by standard solar irradiance by converting spectral radiance to planetary reflectance. This variable combines the reflectivity of the earth surface with the atmospheric effects and can be obtained by the following expression:

\[ \rho_{(k)} = \frac{L_{\lambda_{Pixel, Banda(k)}} * K * \pi}{E_{o(k)} * \cos \theta} \]  \hspace{1cm} (7)

In the next chart you can see the values of solar irradiance for each band, which have been used to calculate the reflectivity and are taken from the documentation published by NASA for the Landsat program.

Table 2. Extraterrestrial solar irradiance values for the Landsat program. (NASA)
<table>
<thead>
<tr>
<th>Spectral Band</th>
<th>Extraterrestrial Solar Irradiance (E$_0$) (W / m$^2$ * m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1969,00</td>
</tr>
<tr>
<td>2</td>
<td>1840,00</td>
</tr>
<tr>
<td>3</td>
<td>1551,00</td>
</tr>
<tr>
<td>4</td>
<td>1044,00</td>
</tr>
<tr>
<td>5</td>
<td>225,70</td>
</tr>
<tr>
<td>6</td>
<td>82,07</td>
</tr>
<tr>
<td>7</td>
<td>1368,00</td>
</tr>
</tbody>
</table>

### 2.6 Image processing

To improve the discrimination of some thematic features present in the images, specifically to differentiate between soils and vegetation, we used the Index Normalized Difference Vegetation (NDVI, by its initials in English).

The NDVI reflects the state of vegetation density and photosynthetic activity. It is related to biomass and correlated to evapotranspiration (Nemani and Running, (1989); Sawamoto and Shin, (1997) cited by CONABIO). The NDVI integrates two key aspects of the spectral behavior of photosynthetic tissues: the low reflectance at wavelengths corresponding to red (due to absorption by chlorophyll) and high reflectance in the near infrared portion (due to the structure the mesophyll of the leaves). The NDVI is calculated as (Rouse et al., (1973) cited by CONABIO):

\[
NDVI = \frac{IRc - R}{IRc + R} \tag{8}
\]

Where: R & IRC correspond to the reflectance in the red and near-infrared portion of the electromagnetic spectrum, respectively.

One advantage is that NDVI is between -1 and 1 which facilitates its interpretation. It may be noted as a critical threshold for ground cover NDVI value of 0,1 and 0,5 dense vegetation. Any negative value implies the absence of vegetation.

In identifying wetlands NDVI image was used as an auxiliary to discriminate water from land and other types of covers (bare soil, other vegetation) with the aim of identifying the wetland ecosystems.

### 2.7 Classification of images
At first there was a non-supervised classification in each image where the number of classes varied between 10 and 20, that in order to determine more clearly the number of classes that are classified in each image. We used the ISODATA algorithm (Iterative Self-Organizing Data Analysis Technique), which uses the minimum spectral distance to assign a pixel to a group (ERDAS, 1997).

From the pictures obtained with non-supervised classifications, we proceeded to perform supervised classification rate based on pixel and object-based.

2.7.1 Supervised classification based on pixel

To perform classification, we selected samples of pixels for each class in each image was defined according to the results of such classifications and unsupervised algorithm chosen to assign each pixel to a class was to minimum distance. The result was a thematic image classification, 9 and 12 classes for the image of Yumbo and mosaic-Guacari Vijes respectively.

2.7.2 Supervised classification based object

To make this classification was used Ecognition v4.0. The first step in object-oriented analysis is to group pixels (considering the initial regions) in homogeneous groups, ie to perform the image segmentation to classify objects subsequently extracted. The size and shape of the resulting objects were determined empirically. The degree of similarity varies according to the maximum allowed heterogeneity for an object in the image defined by the parameter "scale factor (scale factor).

The result was a thematic image classification of 6 classes for the image of Yumbo and 7 classes for the mosaic-Guacari Vijes respectively (Figure 2).
3. RESULTS AND ANALYSIS

The results of the classifications of the images obtained with both methods were evaluated using the confusion matrix that is generated for each classification and with whom it is possible to determine the reliability of each classification. Also we calculated the kappa coefficient, which measures the degree of adjustment simply because of the accuracy of classification, apart from that caused by random factors.

In the confusion matrix generated for supervised classification based on pixels, it was observed that in general the reliability of the classification made in both images is good with a value of 75% for the image of Yumbo and 72% for the mosaic Vijes-Guacari. The Kappa index reached 72% and 70% for each image. This means that the classification is 70% better than if done randomly.

Speaking specifically of wetland ecosystems aim of this project, the classification of water surface is very high: 100% for the accuracy of the producer and 90% for the accuracy of the user. Now, examining the classification results for the three vegetation types (buchón, cattail and lettuce) that were different for each wetland, one can notice that the results are very encouraging. This situation stems from the similarity of the spectral response of buchón and other crops, as with the rush to be confused with the ground.

In an attempt to improve the result obtained with this first classification method, each image was calculated to Adjusted Vegetation Index Soil (SAVI, by its initials in English), but even so the result did not change significantly. The vegetation of the wetland continues to confuse with crops and soil.

Using the method of object-oriented classification, the results were better than expected. For both images were obtained at 100% reliability in the classification. The same value was obtained for the Kappa coefficient. Referring strictly to wetland ecosystems, the classification of water surface coverage and wetland vegetation was very high, both for the accuracy of the producer to the user, the value was almost 100% in both images.

Moreover, to validate the use of satellite imagery in the identification and delineation of wetlands, there was a classified wetland overlay on existing maps of these ecosystems aerial photographs dating from 1998. By overlaying the classification that achieved the best results on the reference maps, one can notice that the mirror of water with the wetlands that had, over a period of four years (the period between the aerial photographs and satellite imagery) has changed considerably as shown in Table 3.
Table 3. Comparison of water surface wetland.

<table>
<thead>
<tr>
<th>Wetland</th>
<th>Area Water Mirror (Ha)</th>
<th>Aerial Photographs</th>
<th>Quickbird Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higueroncito</td>
<td>8.062</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Carambola</td>
<td>15.130</td>
<td>1.122</td>
<td></td>
</tr>
<tr>
<td>Videles</td>
<td>9.257</td>
<td>4.700</td>
<td></td>
</tr>
<tr>
<td>Román</td>
<td>4.511</td>
<td>2.713</td>
<td></td>
</tr>
<tr>
<td>Maizena</td>
<td>4.560</td>
<td>7.678</td>
<td></td>
</tr>
<tr>
<td>El Cocal</td>
<td>6.750</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

To be sure, the extent of the wetland itself has not decreased, what happened is that over the years the water surface has undergone a transformation has been covered by aquatic vegetation.

4. CONCLUSIONS

The main objective of this study was to identify and delineate wetlands natural lentic Valle del Cauca with satellite imagery, for which, QuickBird images used were appropriate because of its good spatial resolution and spectral characteristics, making them suitable for these studies.

Index Normalized Difference Vegetation (NDVI) computed for each image was of great help as a first step towards the identification of bodies of water, specifically water surface wetland objective of this work.

Regarding the classification methods used, it was noted that the method of pixel based supervised relatively painless in terms of differentiation of the three main vegetation types in wetland ecosystems studied were classified in each image. It may be noted in the confusion matrices for the potbellied, bulrushes and wild lettuce, both the accuracy of the user and the Kappa index for each class does not exceed 20%. However, with the object-oriented approach the classification obtained was very high in terms of classification accuracy of both producer and user, this is because this method greatly reduces the problems associated with using high resolution images, significantly improving levels of accuracy in classification. Furthermore, the accuracy of the user and the Kappa index for each type of vegetation in wetlands classified reach a value of 100%.

Looking at the comparison was made with the results of object-oriented classification and
mapping of wetlands existing in the year 98, you can see that the satellite images are a useful tool for the identification of bodies of water of wetlands. It is also possible to notice how the water mirror of the six wetlands identified has decreased considerably and the majority has suffered a decrease of 50%, two of them have no water body and only in the ancient bed of river opposite has occurred, the glass of water instead of decreasing, increased.

Looking for an explanation of these changes in the mirrors of water from wetlands, the classification made in each image shows how the mirror area of each wetland has been covered by hydrophilic vegetation: floating as the potbellied and lettuce, and emerging as the cattail.

In Higueroncito wetlands and El Cocal is very noticeable how they have begun the process of change from a state lake (initial state which is a wetland) to a swamp-type state (state in which the fund is not consolidated).

Given the above, one can conclude that wetlands are more easily identified and permanently flooded areas the degree of difficulty to detect increases as each wetland is moving from a wet state (lake) to dry state (forest).

The Histogram Correction method for their minimum values used for the correction of atmospheric effects of each image is a simple method that depends on the existence of dark objects in the image, such objects should in theory be black. In the radiometric correction is not only took into account the calibration coefficients, but also the effective bandwidths contained in the header of each image and followed the dictates of Digital Globe to ensure efficient conversion of digital values of each pixel in spectral radiance values.

It is necessary to do field work using existing images that allow verification of the results. It should also be severability analysis to assess the degree to which the categories can be distinguished spectrally. It is also useful to evaluate the season taking pictures with climate records to determine if the image was taken on a rainy or dry season.

5. REFERENCES


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