**Supplementary material 1**

**RapidEye satellite imagery catalog from the Ministry of the Environment -MMA**

Type: Image

Geometry: Draw on the map

Image coverage: First - Reference year 2011, with additional images from 2012

Download: Add to download tab

Download Coverage – Global options

Geometry: Whole image

Output SRS: SRS of the original image

Projection system: WGS 84 Zone 22 S EPGS: 32722

**Table S1:** Identification of the exact images (Satellite of Belém - PA, Brazil) used in the study.

|  |  |
| --- | --- |
| **1 Title** | **2238627\_2015-08-22\_RE3\_3A\_318555** |
| Tile ID | 2238627 |
| Cat. ID | 23046153 |
| Roof | Fourth |
| Image type | RapidEye - 3A |
| Key words | RapidEye, 3A, 2238627, 23046153 |
| Access | WMS, WCS |
| Date of acquisition | 22-ago-2015 |
| SRS | EPSG:32722 |
| Extension | 787500, 9879500, 812500, 9904500 |
| **1.2 Title** | **2238627\_2015-06-28\_RE5\_3A\_318555\_CR.tif** |
| Tile ID | 2238627 |
| Cat. ID | 23046148 |
| **2 Title** | **2238626\_2014-08-18\_RE5\_3A\_318228\_CR.tif** |
| Tile ID | 2238626 |
| Cat. ID | 22933127 |
| **3 Title** | **2238527\_2015-08-22\_RE3\_3A\_318555\_CR.tif** |
| Tile ID | 2238527 |
| Cat. ID | 23045269 |
| **3.1 Title** | **2238527\_2015-06-28\_RE5\_3A\_318555\_CR.tif** |
| Tile ID | 2238527 |
| Cat. ID | 23046109 |
| **4 Title** | **2238526\_2015-06-28\_RE5\_3A\_318555\_CR.tif** |
| Tile ID | 2238526 |
| Cat. ID | 23045435 |
| **5 Title** | **2238427\_2015-08-22\_RE3\_3A\_318555\_CR.tif** |
| Tile ID | 2238427 |
| Cat. ID | 23045032 |
| **6 Title** | **2238426\_2015-06-28\_RE5\_3A\_318555\_CR.tif** |
| Tile ID | 2238426 |
| Cat. ID | 23044866 |

|  |  |
| --- | --- |
| ID – BELÉM | Quantity. Image |
| 2238626 | 1 |
| 2238627 | 2 |
| 2238526 | 1 |
| 2238527 | 2 |
| 2238426 | 1 |
| 2238427 | 1 |

**Source:** Search in the rapideye satellite image catalog of the Ministry of the Environment-MMA (<http://geocatalogo.mma.gov.br/>)

The satellite images were provided by the Ministry of the Environment (MMA), from which the brief characteristics of the RapidEye satellite images are described (Table S2). The REIS sensors were installed on the five RapidEye satellites and obtain images of the Earth in five spectral bands, and their spatial resolution offered by the sensor is 6.5 meters and 5 meters in orthoimages.

**Table S2:** General characteristics of RapidEye satellites.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sensor** | **Spectral**  **Bands** | **Spectral Resolution** | **Spatial Resolution** | **Temporal Resolution** | **Imaged Track** | **Radiometric Resolution** |
| REIS (RapidEye Earth Imaging System) | Blue | 440 - 510 nm | 6,5 m (nadir) it is  5 m for orthoimages | 24 hours (off-nadir) and 5.5 days (nadir) | 77,25 km | 12 bits |
| Green | 520 - 590 nm |
| Red | 630 - 690 nm |
| Red-Edge | 690 - 730 nm |
| Near infrared | 760 - 880 nm |

**Source:** Monitoring Satellites, EMBRAPA website (<https://www.embrapa.br/satelites-de-monitoramento/missoes/rapideye>).

**Complementary explanations of the methodological paths**

To be used in mapping, satellite images underwent pre-processing, with the main corrections being geometric (georeferencing and orthorectification of images) and radiometric (noise elimination and atmospheric correction). RapidEye 3A images are already supplied orthorectified, that is, corrected for relief displacements. Thus, the image's atmospheric correction and orthorectification evaluation were carried out using the QGis Semi-Automatic Classification Plugin (SCP), in the pre-processing tab.

The following vector data of the study area were integrated into GIS QGIS 3.22.11: hydrography, federation boundaries, state, municipality and Human Development Units (HDU). Furthermore, the tabular data referring to socioeconomic variables based on information from the IBGE demographic census (2010) were joined to the attribute table of the selected HDUs, using the QGIS unions tool, through the column of codes common between the files.

The polygons representing green areas were obtained through photointerpretation of satellite images and later validation in Google Earth Pro, Google Maps and OpenStreetMap software, the green area polygons were interpreted and vectorized. Then, in QGIS, the vegetation polygons were compared with the RapidEye satellite image, making it possible to verify the georeferencing and make vectorization adjustments to the polygons.

All cartographic data used were integrated and standardized for the WGS 84 Zone 22 S EPGS: 32722 coordinate system. Subsequently, the indices were estimated and thematic maps were created that supported the quantitative and qualitative analysis of the work.

In summary:

1 - Download spatial layers of the study area in greater detail;

**Pre-processing:** reproject the satellite images to WGS 84 Zone 22M EPGS: 32722. Make the necessary clips.

2- Image mosaic;

3 - Buffer in QGis;

We buffered 1000k (thousand kilometers). Applied to not lose image edge information.

4 - Fishnet shapefile (1000k);

Within the definition of the area of interest, several equally spaced points were distributed, in the form of a grid or randomly. The specific study area was subdivided into 371 1k grids.

5 - Image Classification (OTB);

**Processing:** in the Orfeo Toolbox -OTB plugin, we perform the classification

Supervised in TrainVectorClassifier algorithm BAYES - Maximum Likelihood – MAXVER.

OTB provided tools to train a supervised classifier from different feature sets and to use the generated classifier for classifying vector data. The model's performance is estimated from the statistics generated by the modeling, with a confusion matrix, a table that compares the real classes with the classes predicted by the image classification. This allows you to calculate metrics such as global accuracy, precision, recall and F1-score. And the Kappa coefficient as a statistical measure that takes into account the agreement beyond chance between actual rankings and predicted rankings. It is often used to adjust overall accuracy.

6 - Quality control + high resolution images;

**Post-processing:** visual evaluation of the polygon by photo interpretation.

7 - Final layer of green áreas.