Processing Image to Geographical Information Systems (PI2GIS) – a learning tool in QGIS

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Outline

- Introduction
- Objective
- Methodology
- Results
- Discussion and conclusions
- Future work

Introduction

- In order to interpret the information presented in a satellite image, several processes must be performed:

  - i) image enhancement: histogram analysis, brightness and contrast, filters application;
  - ii) image processing: linear transformations, arithmetic transformations (such as environmental indices), texture analysis, segmentation and image fusion;
  - Iii) image classification in order to extract useful information.

Introduction

- Several open source software were developed to remote sensing applications: Orfeo Toolbox, Spring, SAGA, GRASS...
- QGIS software presents several advantages:
  - i) it integrates several external software such as SAGA, GRASS and Orfeo Toolbox;
  - ii) it presented new plugins daily;
  - iii) is intuitive and easy to use;
  - iv) the development of new plugins is supported by on-line support;
  - v) integrates the Semi-Automatic Classification Plugin (SCP) from Luca Congedo, a free and open source plugin for QGIS software which allows for the semi-automatic classification.

Introduction

- SCP allows:
  - supervised classification for remote sensed images;
  - the calculation of vegetation indices such as Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI);
  - automatic conversion to reflectance for different sensors;
  - definition of Region of Interest (ROI);
  - processes data from Landsat, Sentinel-2A, ASTER and MODIS.
- **BUT** it does not allows to:
  - the visualization of histograms;
  - the application of filters;
  - different image corrections;
  - applying an unsupervised classification;
  - and other several environmental indices computation.

Objective

- Creation of the Processing Image to Geographical Information Systems - **PI2GIS** - application inspired on SCP and including a new set of operations:

  - Inspired in the Semi-Automatic Classification Plugin (SCP) developed by Luca Congedo
  - Creation and vizualization of histograms for each band
  - Application of enhancement processes and filters
  - Calculation of different environmental indices
  - Unsupervised classification

Methodology - dataset

- Landsat 8 (OLI) images (datum WGS84 UTM Zone 29 coordinate system) - USGS Earth Exploration;
- CAOP (*Carta Administrativa Oficial de Portugal*) information: Vila Nova de Gaia municipality.

Methodology

- QGIS version 2.18.10
- Python programming language
- GDAL, SAGA, Orfeo, Matplotlib e Scipy libraries

- Some tools were used externally to the PI2GIS:
  - Different versions of *gdalwarp* from GDAL/OGR library performed clipping and coordinate systems transformations
  - Projections transformation;

Methodology – PI2GIS application

- Graphic interface - *QT Designer*
- Qt widgets: combo boxes, push buttons, spin boxes
- Three buttons: *Pre-Processing*, *Processing* and *Classification*

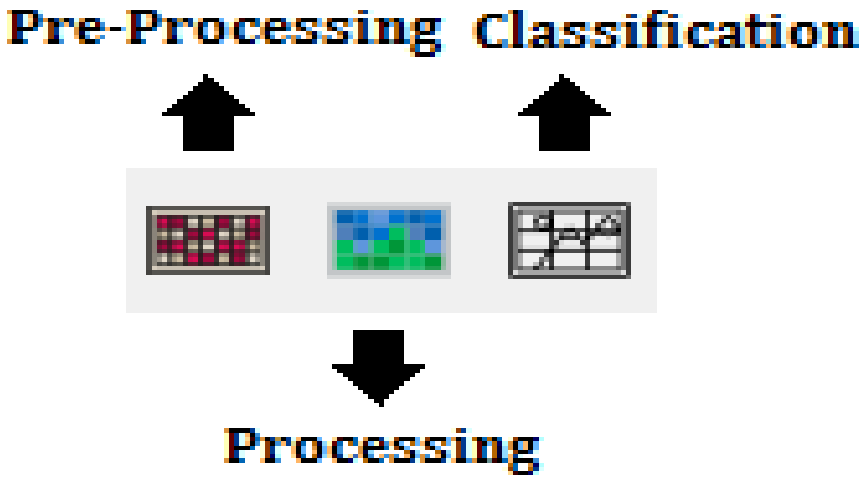
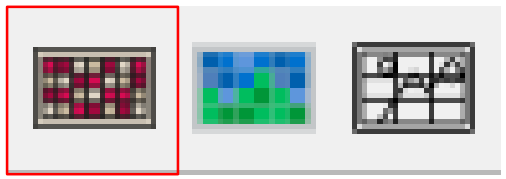


Figure 1 - PI2GIS toolbar

Pre-Processing



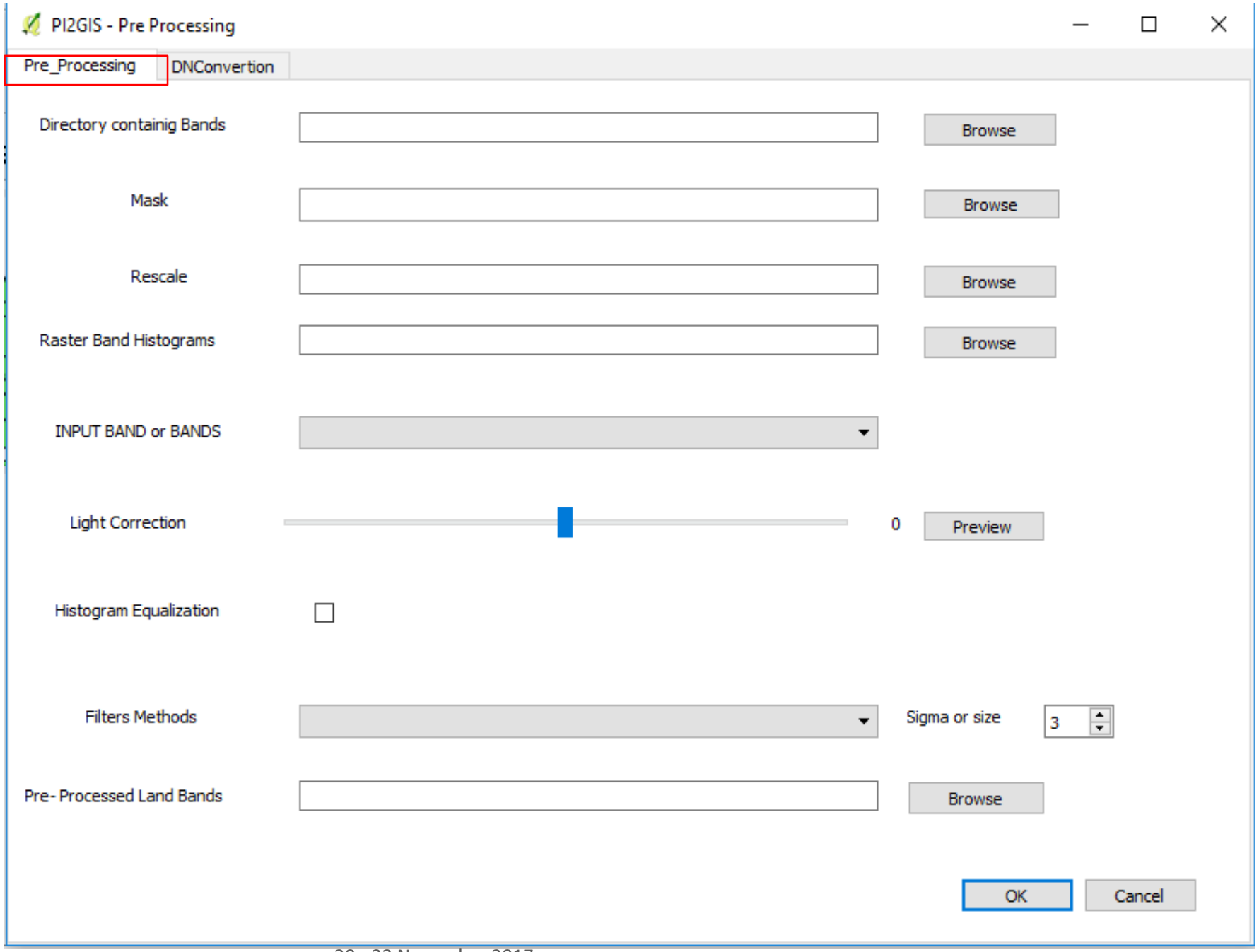


Figure 2 – Pre-Processing GUI.

Pre-Processing

- Format transformation of images from 16-bits to 8-bits using *gdal_translate* from GDAL/OGR;

- Histograms for each band of Landsat – 8 (OLI), using function *plt.hist* from *Matplotlib* library;

- Brightness corrections (from -200 to 200) automatically visualized in QGIS interface through *Preview* button;

Pre-Processing

- Histogram Equalization (contrast improvement), using *np.interp*, *np.flatten* from *Scipy* library*;*

- Filters (Low-Pass, High-Pass and Median Filter), using functions from the *scipy.ndimage* package:

    1. *filter.median* function (Median Filter)
    2. High and low pass filters used variations of *gaussian_filter*

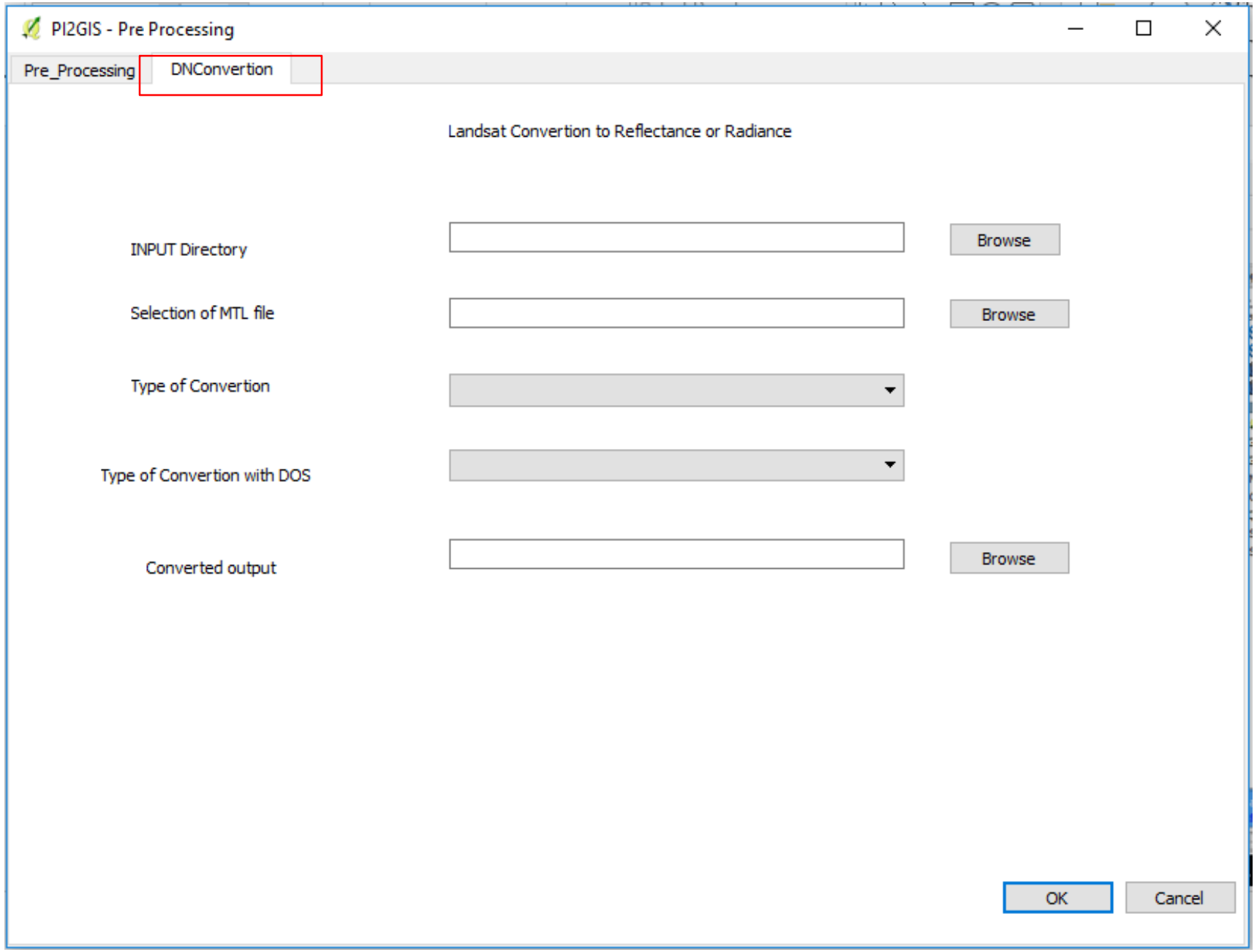
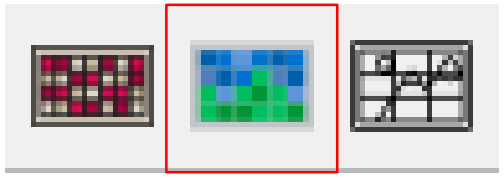


Figure 3 – Pre-Processing DN2reflectance tab GUI.

Pre-Processing – Radiance or reflectance

- Two fields: directory with images and MTL file;
- Landsat;
- Performs atmospheric correction DOS1 (Dark Object Subtraction);

Processing



PI2GIS - Processing

Color Composite and Vegetation Index

Operation

INPUT Dir — Browse

Mask — Browse

INPUT A

INPUT B

INPUT C

OUTPUT — Browse

Pan - sharpening with RCS algorithm

MS image — Browse

INPUT Panchromatic (B8) — Browse

Superimposition (MS) — Browse

OUTPUT Pan- sharpening — Browse

OK Cancel

Figure 4 – Processing GUI.

Processing

- Vegetation index calculation using *gdalrastercalculator* from GDAL/OGR library;

NDVI (Normalized Difference Vegetation Index)	$NDVI = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$
EVI (Enhanced Vegetation Index)	$EVI = G \frac{NIR - RED}{NIR + C1RED - C2BLUE + L}$
NDWI (Normalized Difference Water Index)	$NDWI = \frac{GREEN - NIR}{GREEN + NIR}$

Table 1 – Environmental indices.

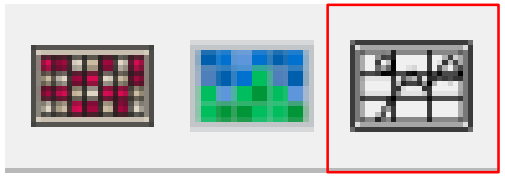
NIR – Near-infraRed reflectance band
RED – Red reflectance band
GREEN – Green reflectance band
L - canopy background adjustment (L=1)
G – gain or scale factor (G=2.5)
BLUE – blue reflectance (Band 2)
C1, C2 – coefficients of the aerosol resistance (C1=6, C2=7.5)

Processing

- Pan-sharpening allows increasing of spatial resolution of the multiespectral (MS) image by combining with the panchromatic band (PAN):

  - *Superimpose,* from *Orfeo Toolbox* – performs a projection of image into the geometry of another one;
  - *Pansharpening Ratio Component Substituition (RCS)*, from *Orfeo Toolbox* – merging the MS image (30 m) with PAN image (15 m);

Classification



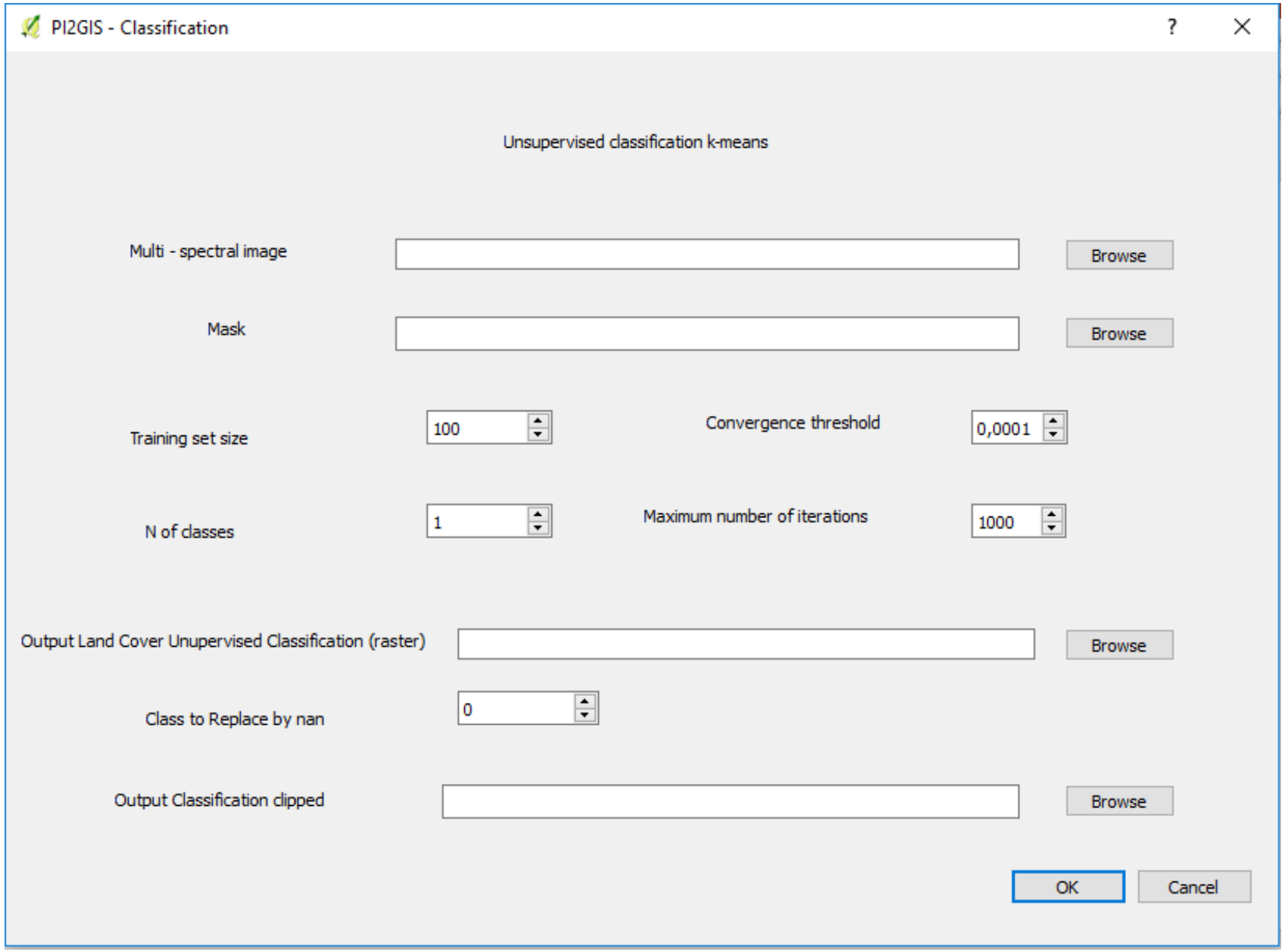


Figure 5 – Classification GUI.

Classification - unsupervised

- Used the *K-means* algorithm from *Orfeo Toolbox*;
- K-means splits the image into different clusters of pixels in the feature space;
- Not required the definition of training classes, just its number;

Study case

- ETRS89-PTTM06 coordinate system;

- Vila Nova de Gaia municipality
  - area of 168 km2
  - characterized by rugged terrain with 100.12 m as average height and 261 m of altitude as the highest point

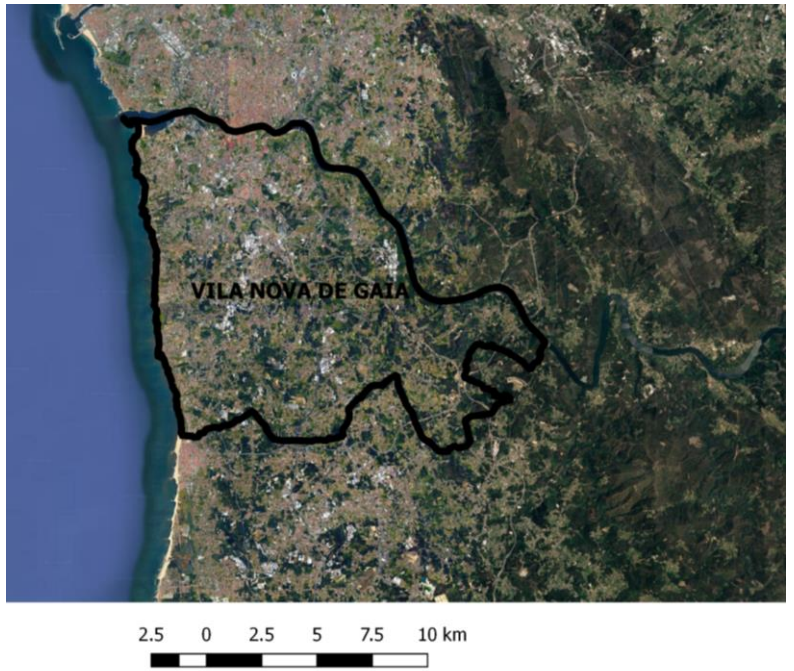
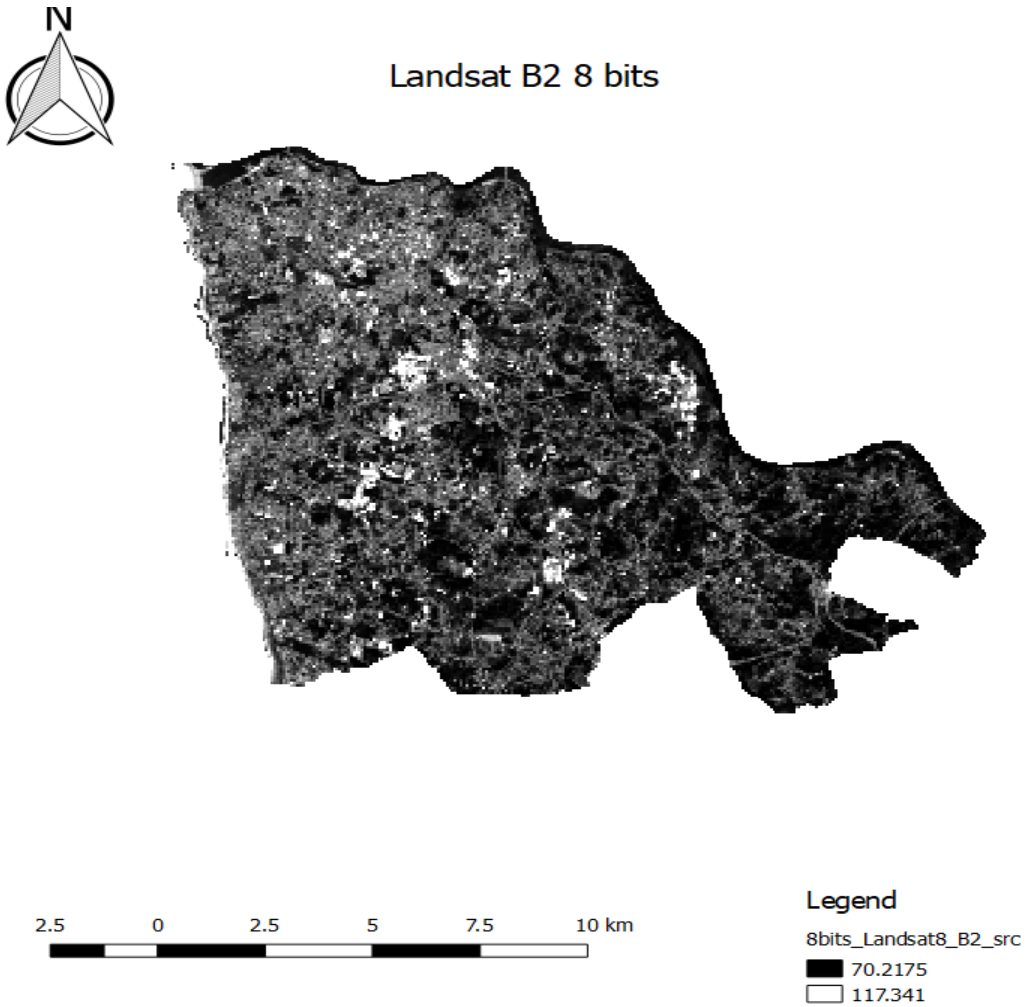


Figure 6 – Study case.

Results

- Pre – Processing results;
- Processing results;
- Unsupervised classification results compared with the supervised classification from SCP tool.

Histograms



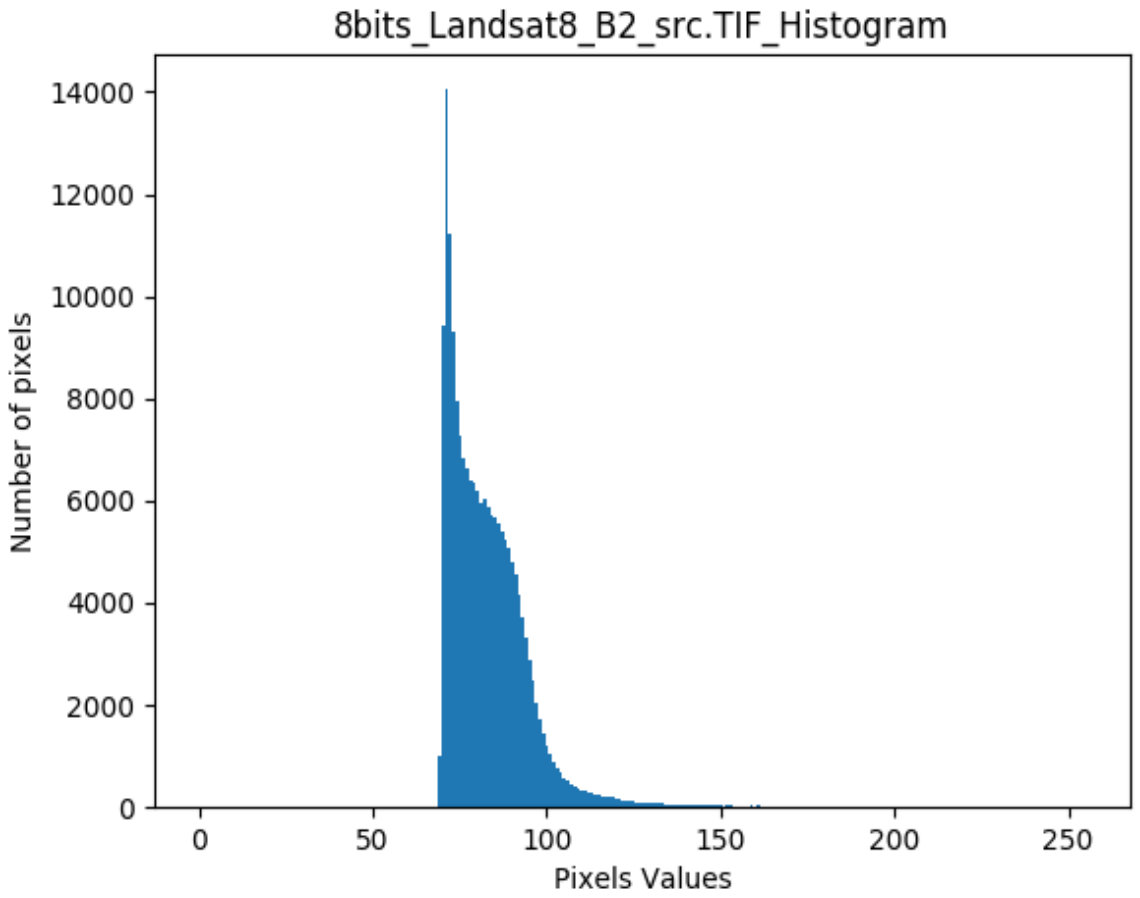
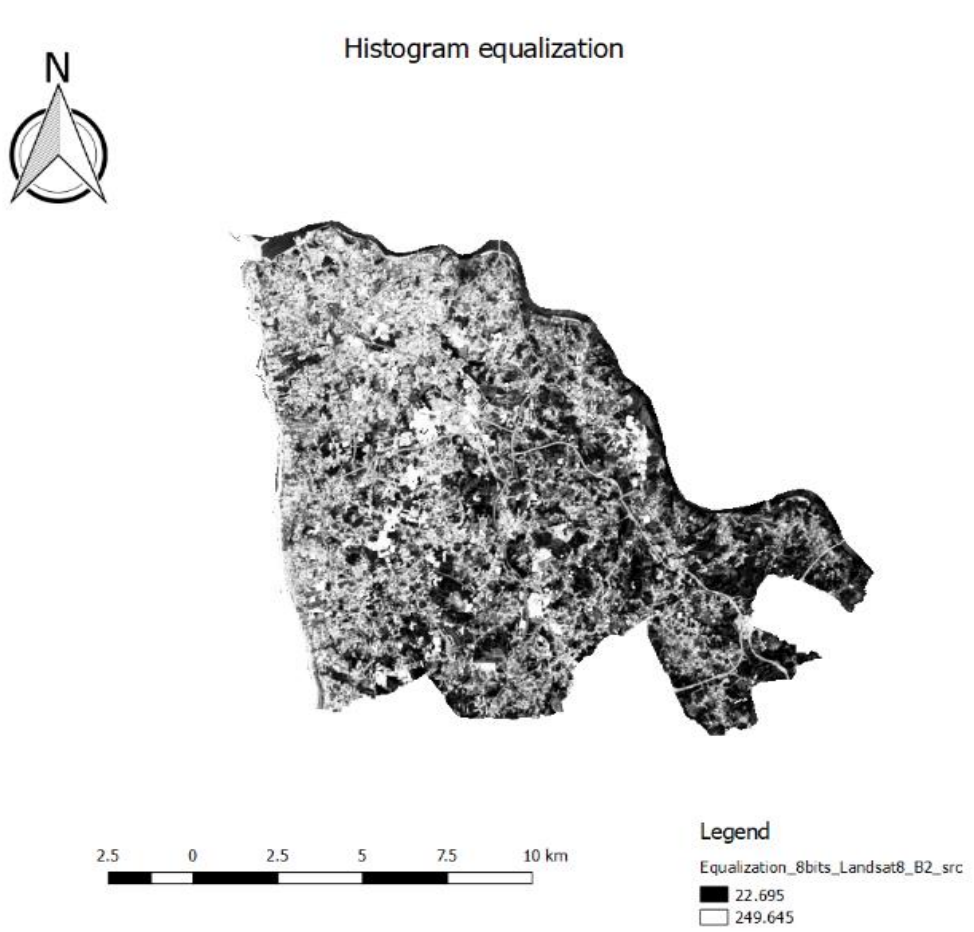


Figure 7 - Landsat B2 8 bits; Histogram.

Histogram Equalization



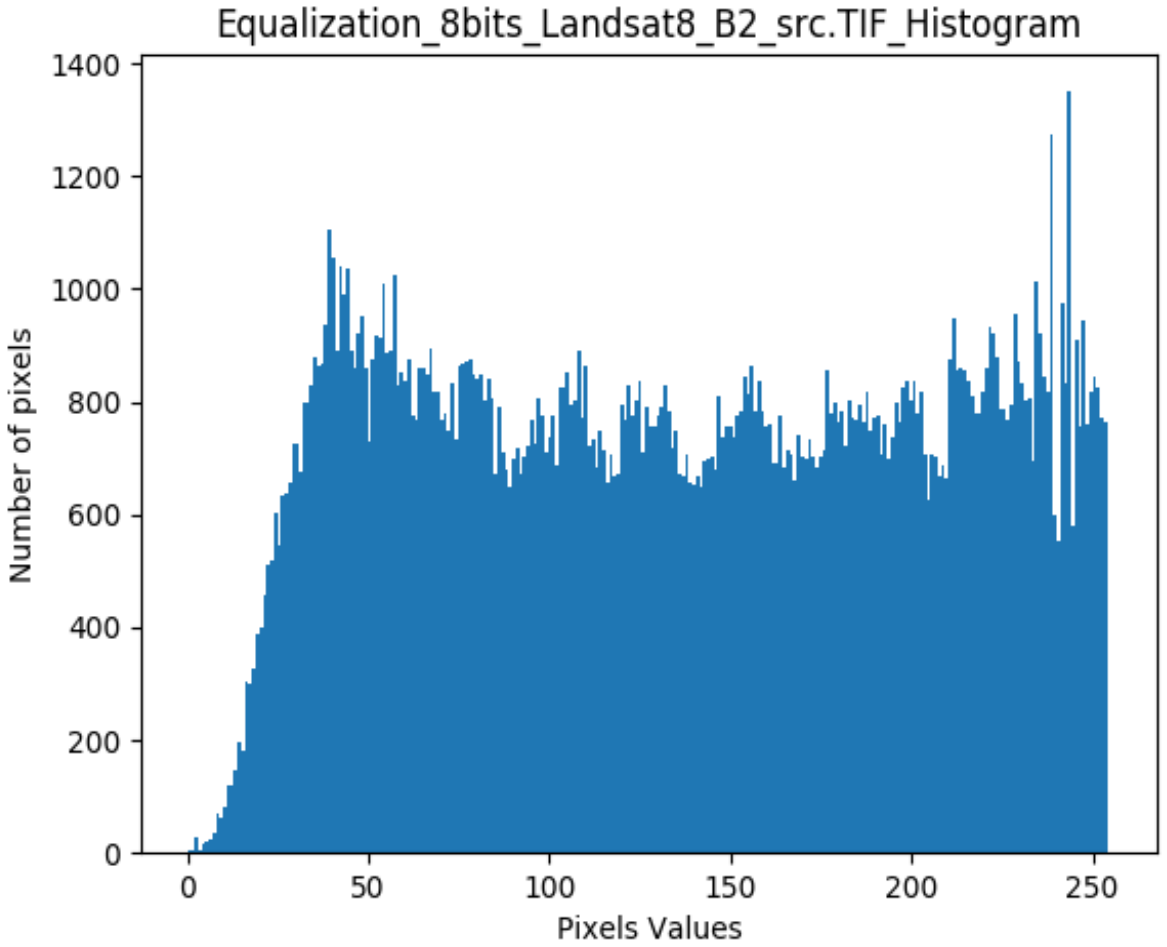
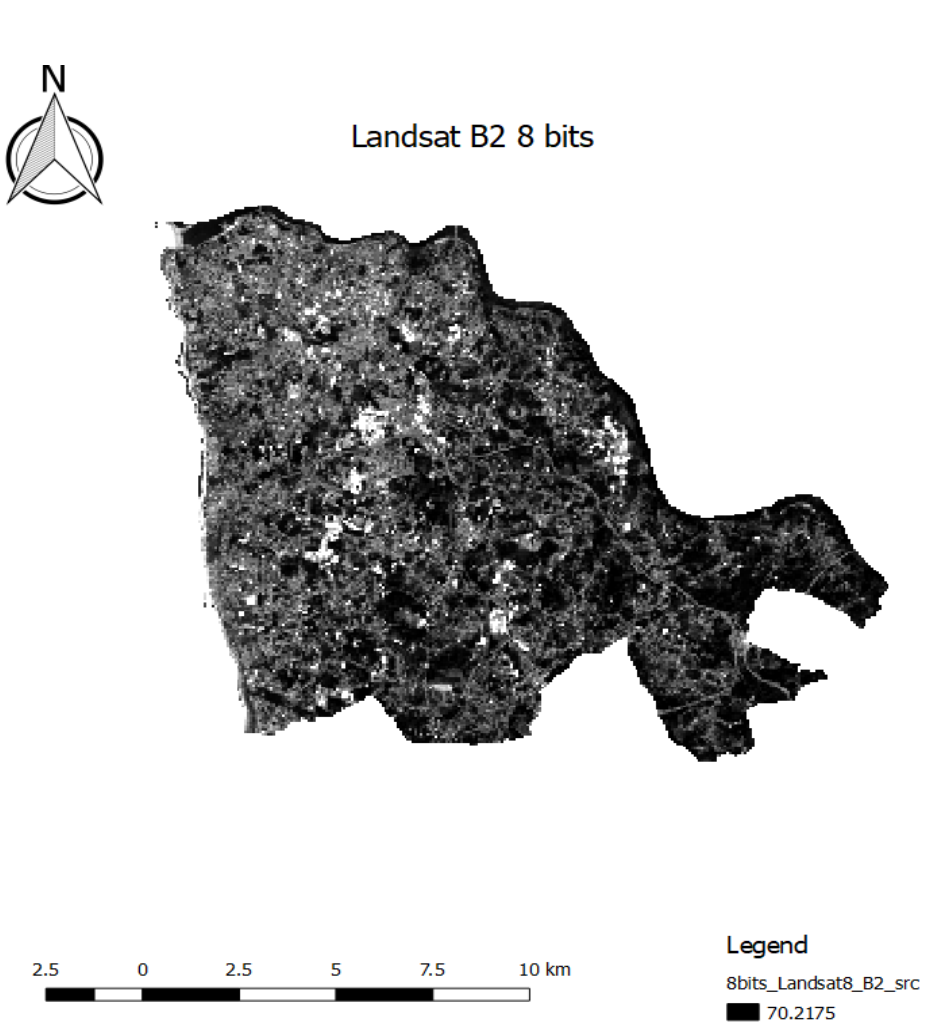


Figure 8 - Histogram equalization of Landsat B2 8 bits.

Brightness



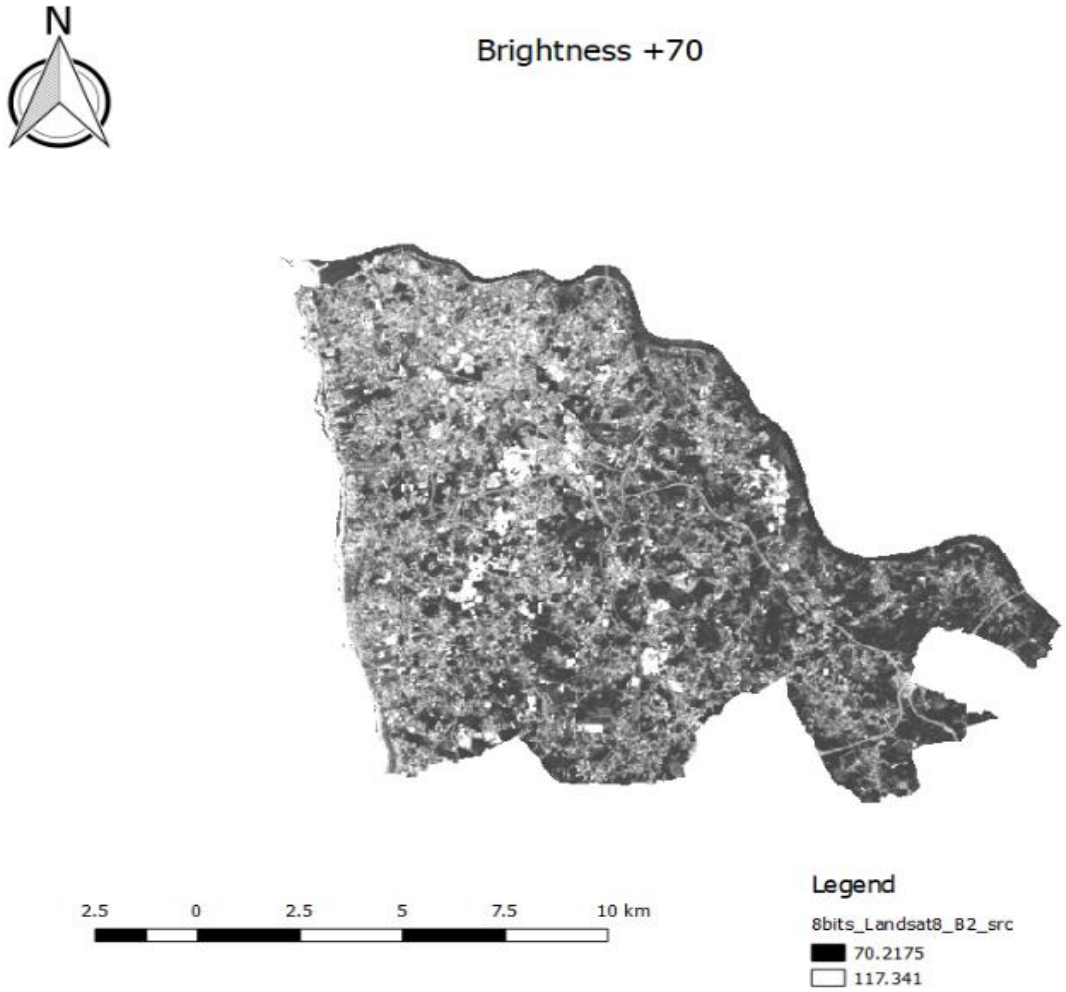


Figure 9 - Landsat B2 8 bits; Brightness applied.

Low-Pass filter

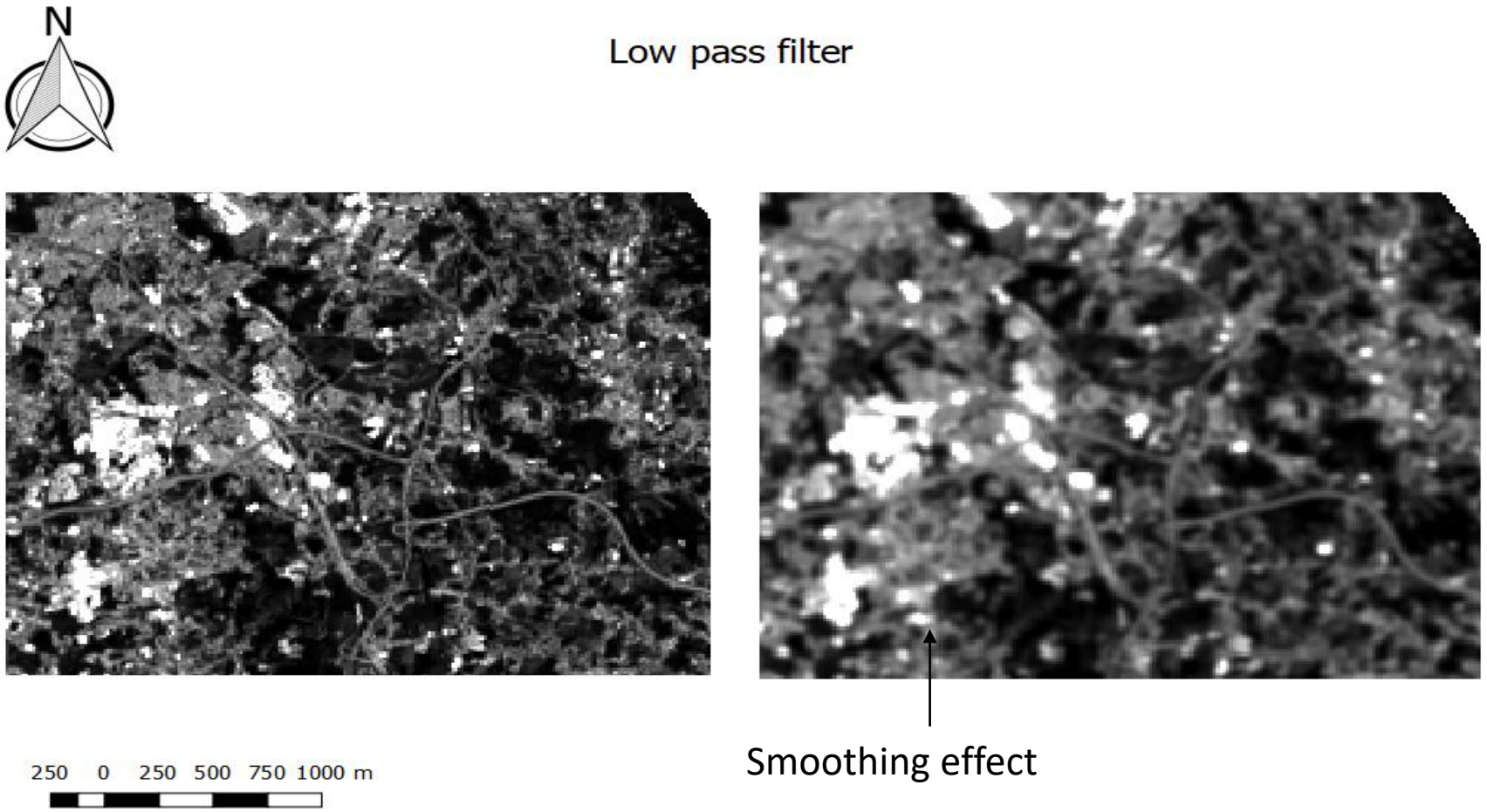


Figure 10 - Zoom in on the image before and after application Low pass filter.

Median filter

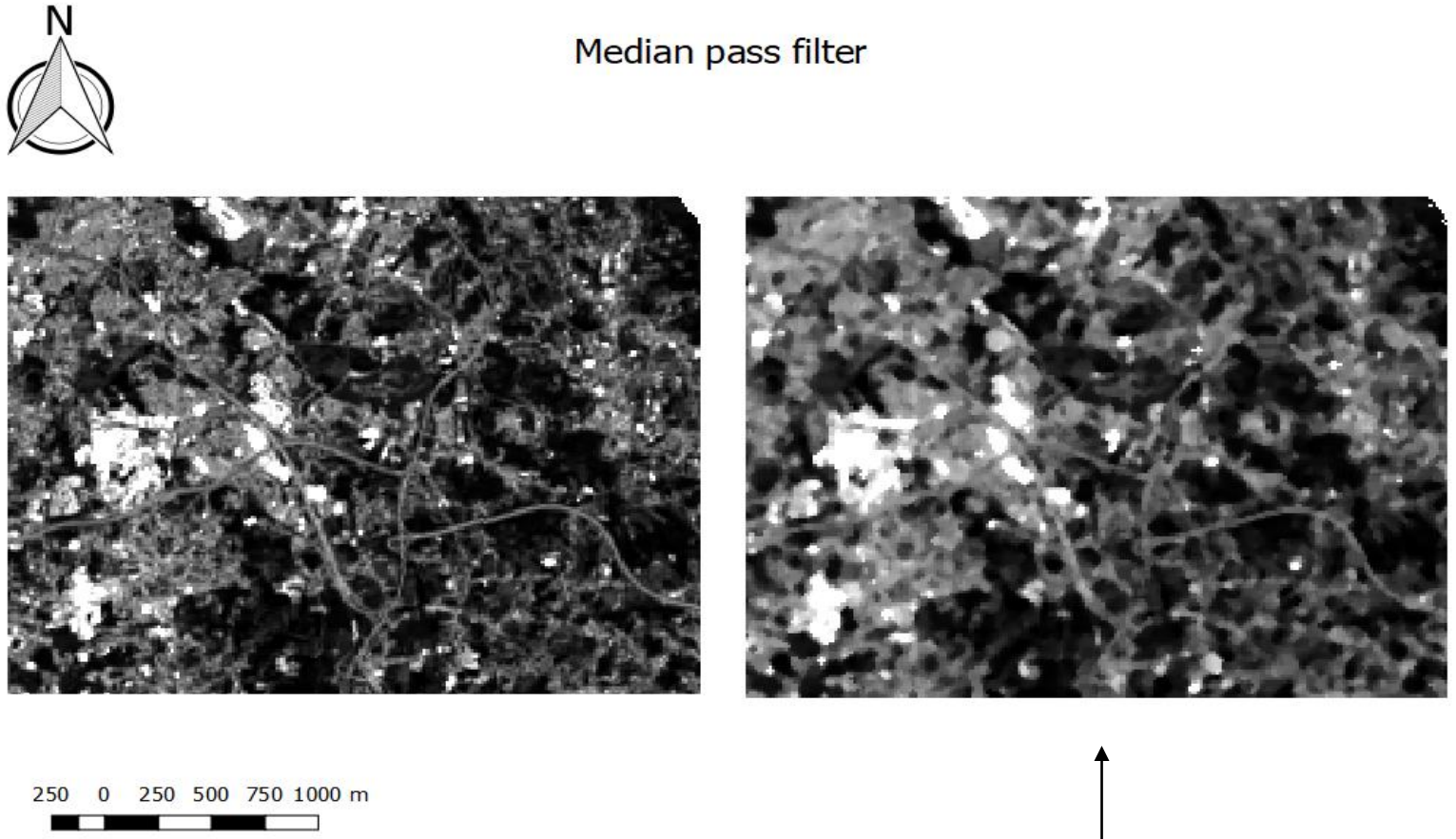


Figure 11 - Zoom in on the image before and after application Median filter.

Smoothing effect less present than in Low Pass filter

High-Pass filter

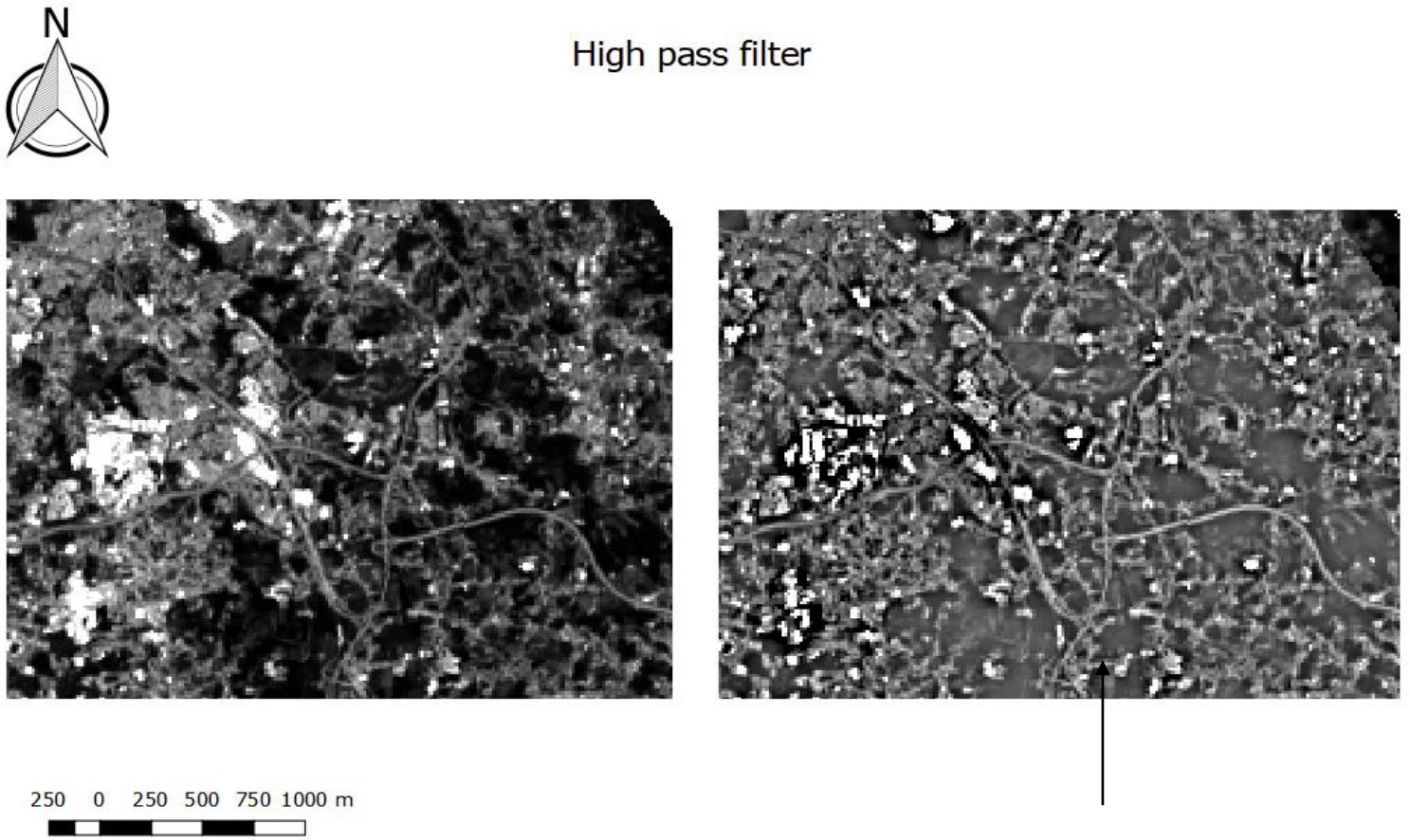


Figure 12 - Zoom in on the image before and after application High pass filter.

RGB combination

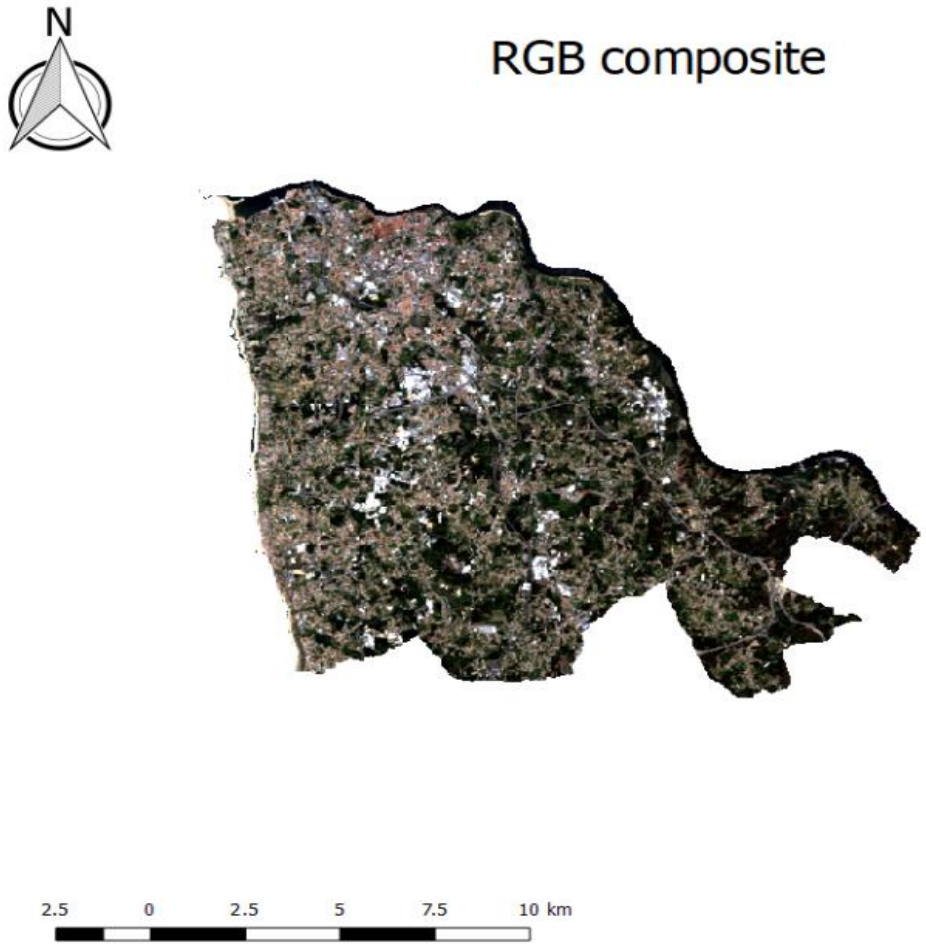
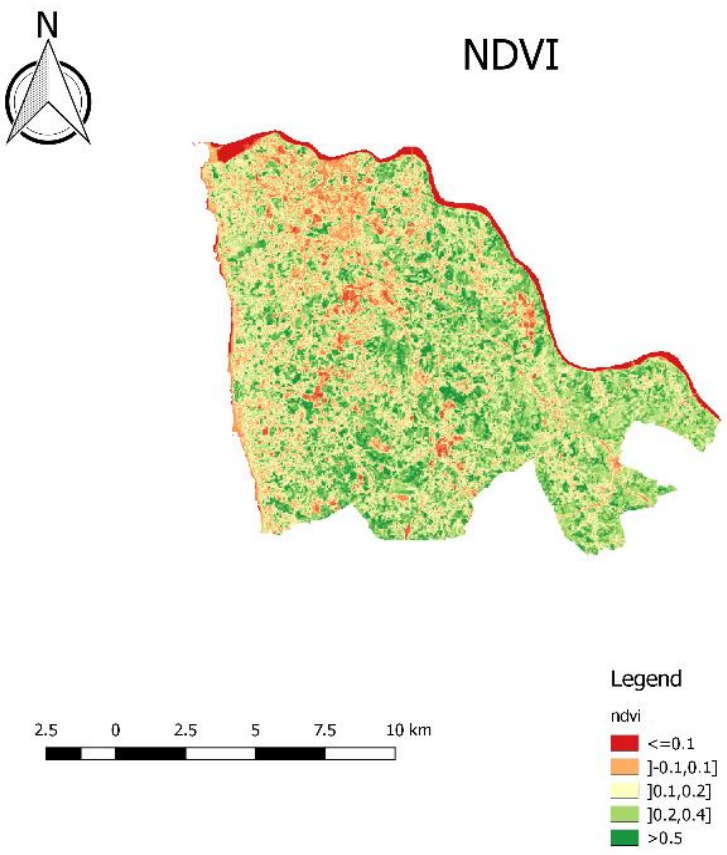
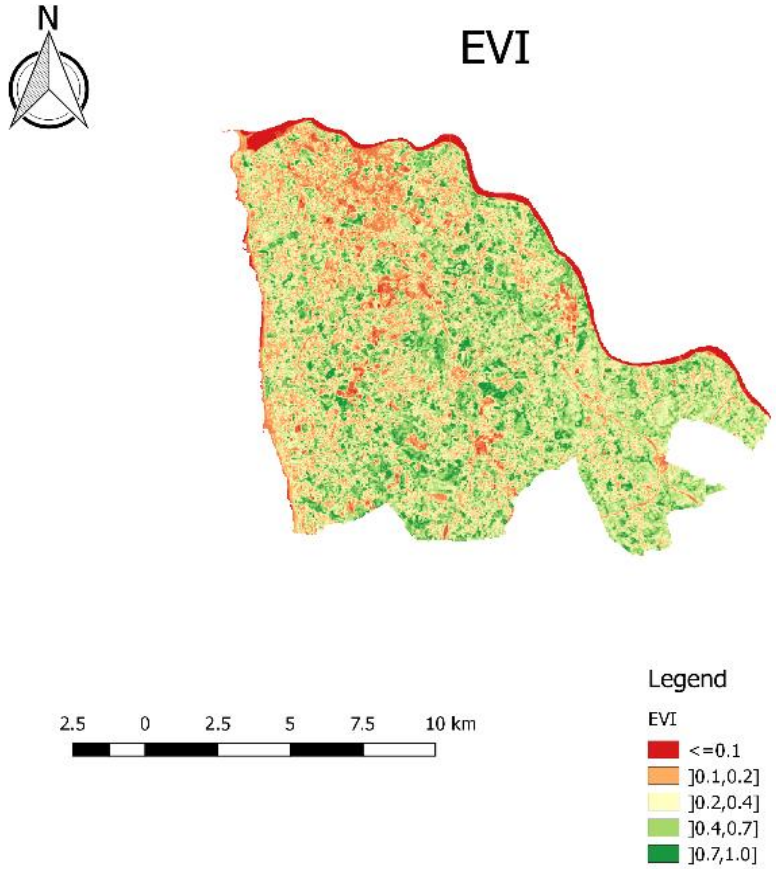


Figure 13 - RGB composite.

Environmental indices





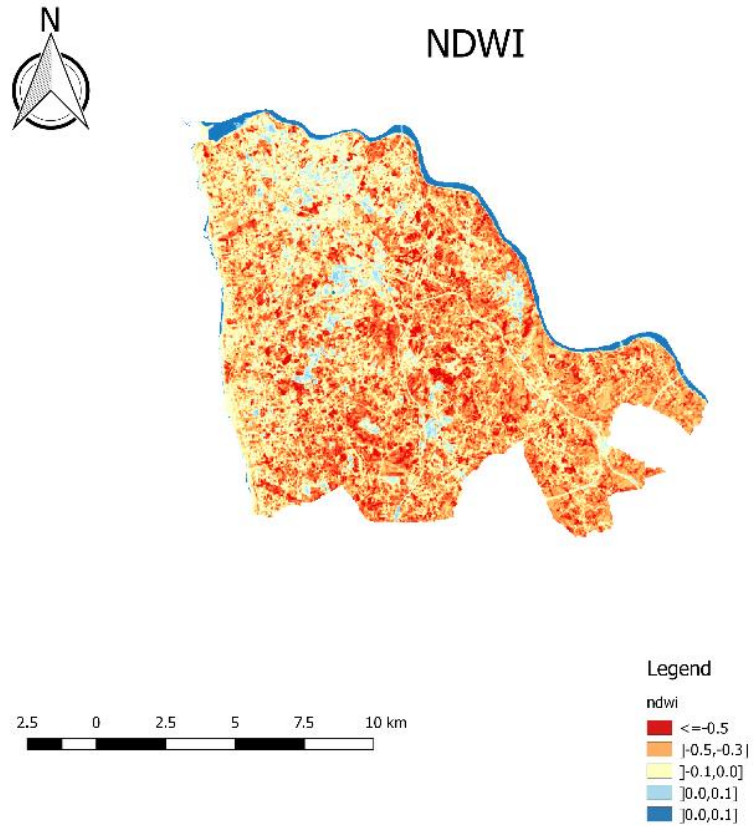


Figure 14 - NDVI map; EVI map; NDWI map.

Pan-sharpening

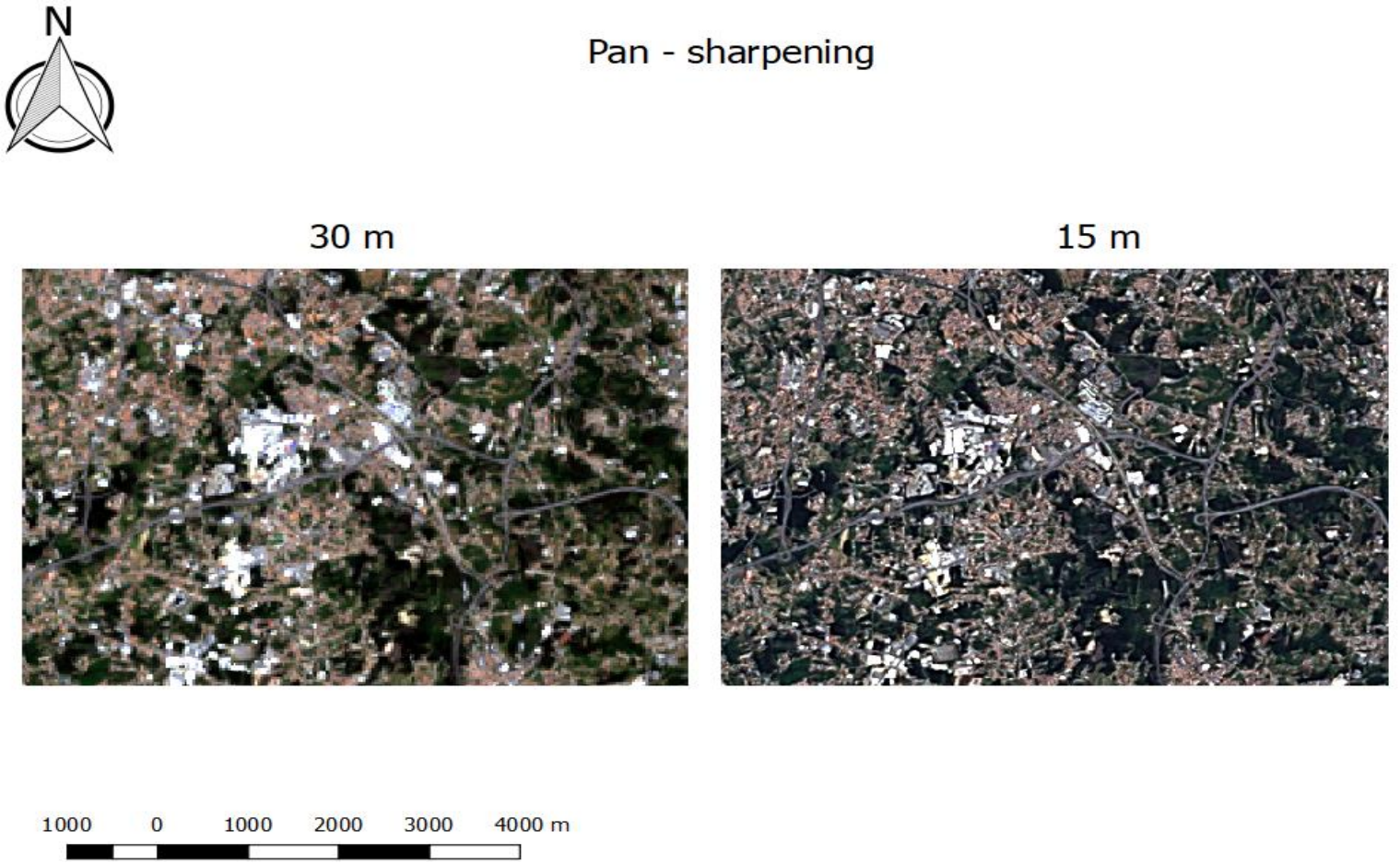


Figure 15 - Pan-sharpening example.

Supervised classification

- Applied a False Colour combination (RGB = 5,4,3)
- Used to enhance the high pics of vegetation reflectance
- Input for supervised (SCP tool) and unsupervised classification

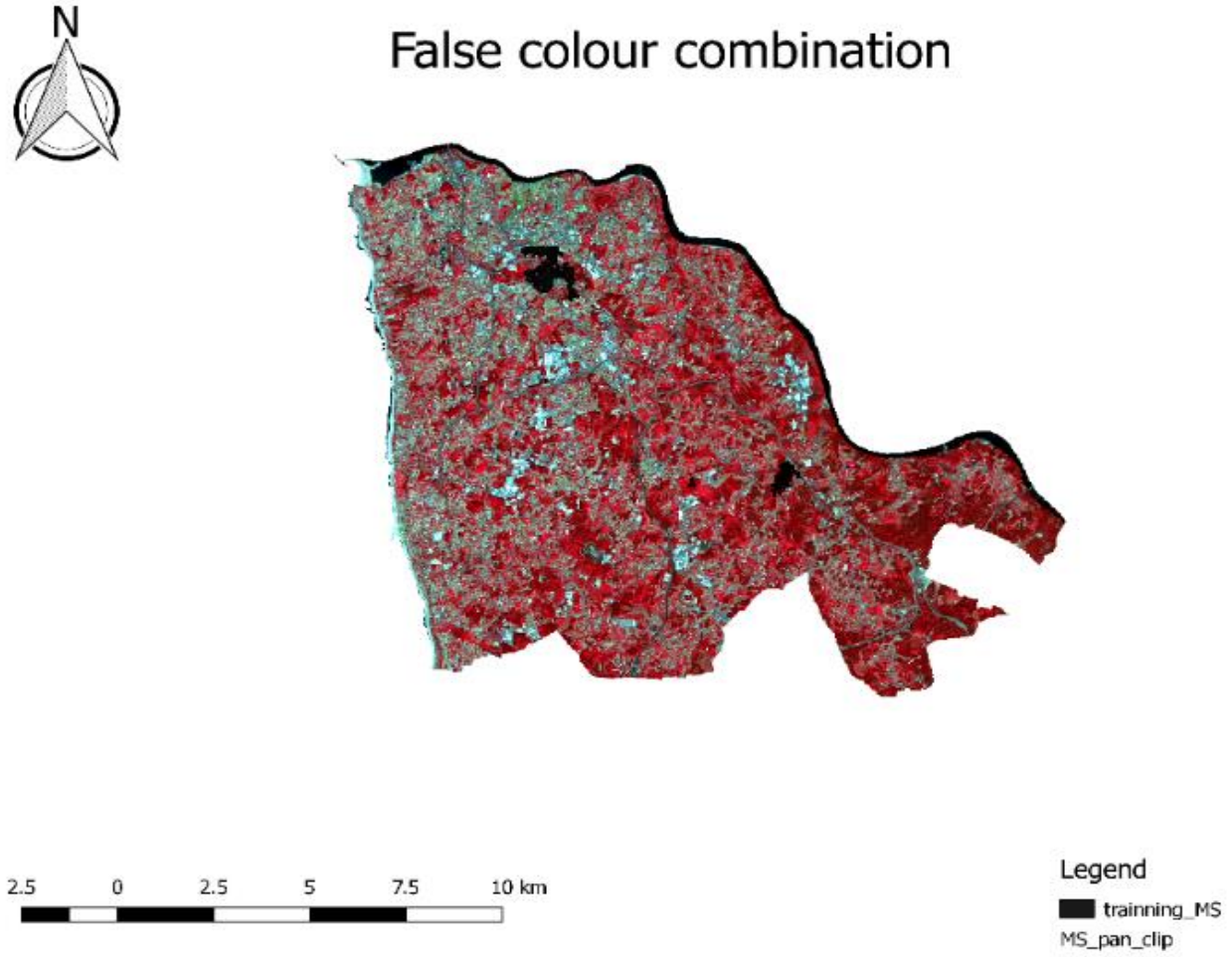
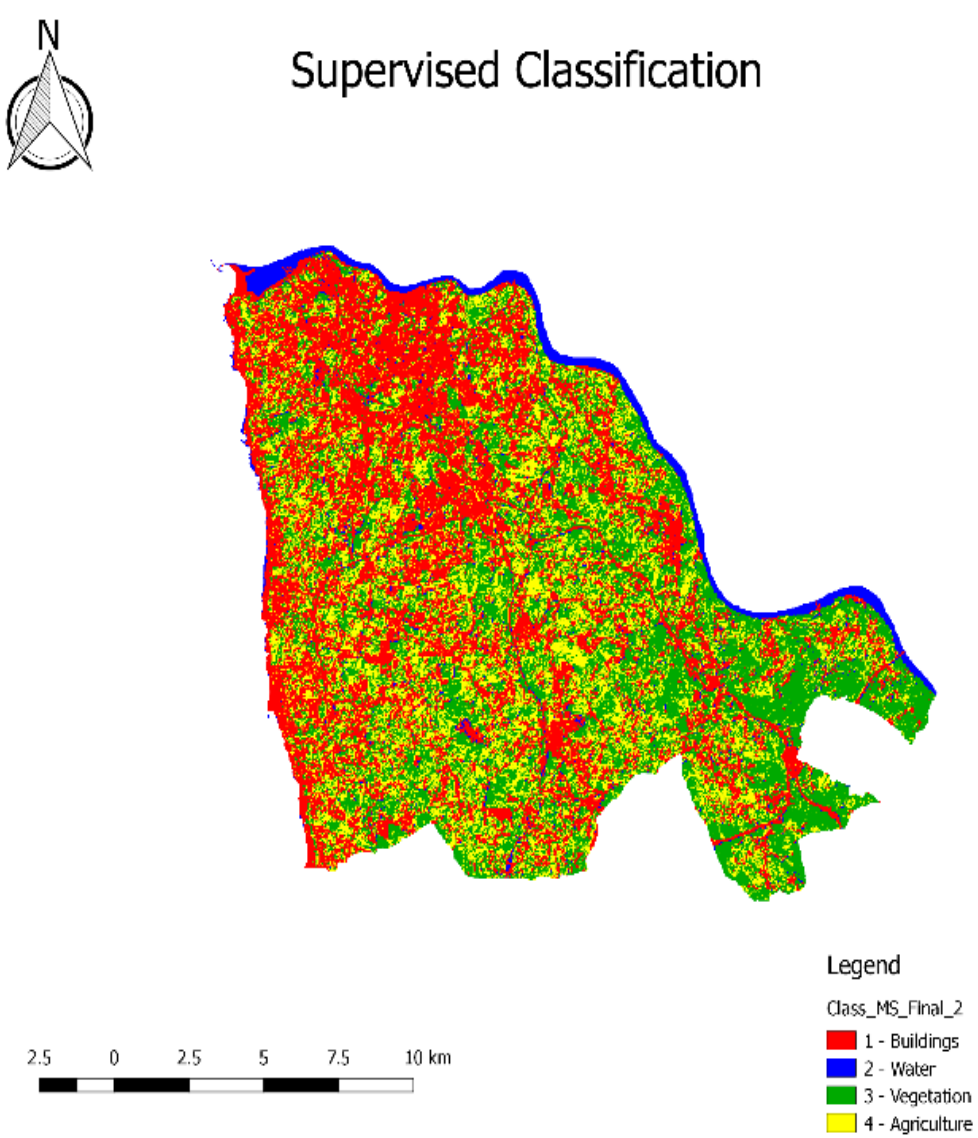


Figure 16 - False colour combination .



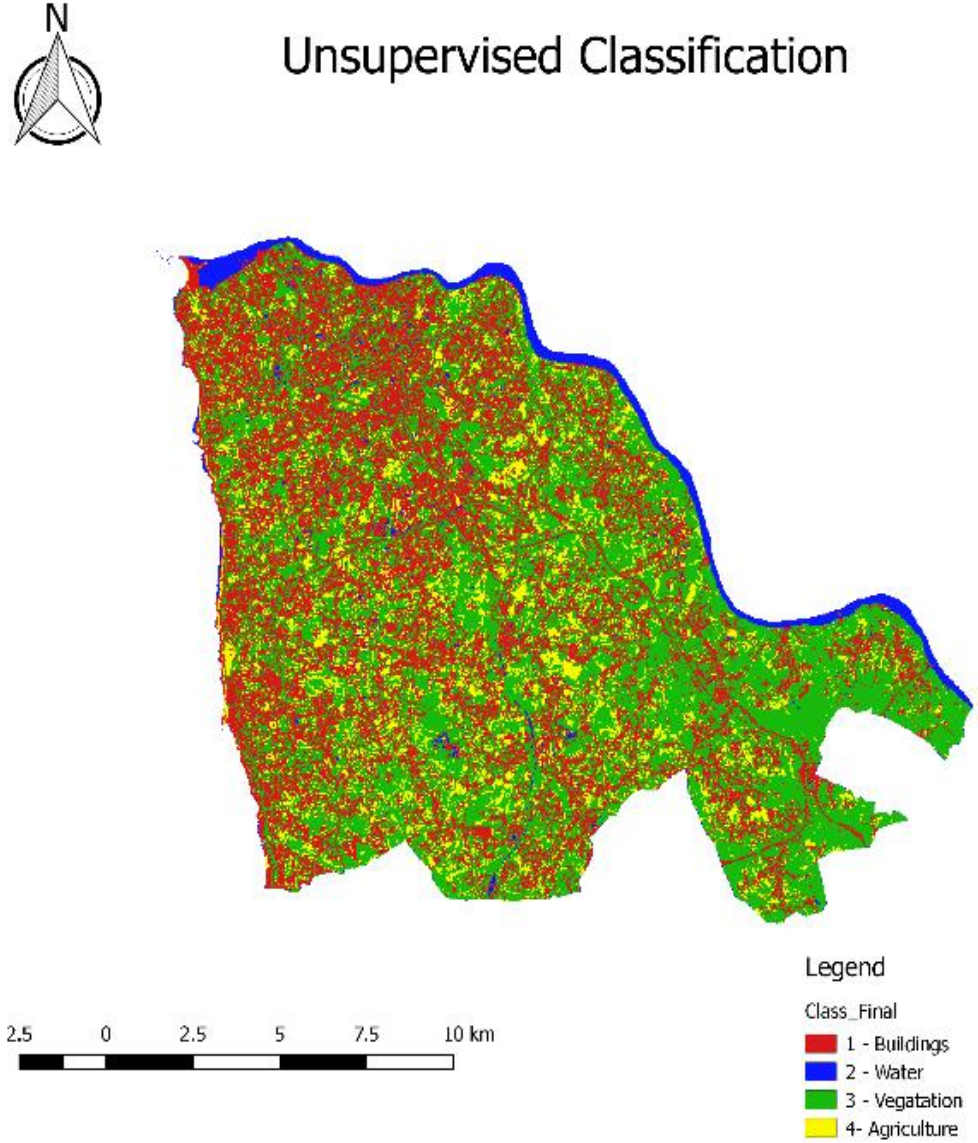


Figure 17 -Supervised classification with SCP; Unsupervised classification with PI2GIS

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Classification report

K = 0,97

Overall accuracy = 98,5%

	Supervised Classification			
Classes	Buildings	Water	Vegetation	Agriculture
Pixel percentage	36.819 %	4.261 %	33.478 %	25.441 %

	Unsupervised classification			
Classes	Buildings	Water	Vegetation	Agriculture
Pixel percentage	35.948 %	3.494 %	47.564 %	12.994 %

Table 2 - Statistics obtained with SCP plugin and the unsupervised classification image obtained with PI2GIS.

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Discussion and conclusions

- **Histograms**, **filters**, **image corrections**, **NDWI** and **unsupervised classification** were tools not implemented in SCP were developed in PI2GIS;

- Results proved that PI2GIS could be used to remote sensing teaching classes;

- Once this plugin is free and open source further improvements in tools/functionalities can be implemented.

In the future

- Add more enhancement methods to improve contrast such as Optimal Linear Transformation or Gama Correction;
- Automate projection transformations;
- Include all external tools in the plugin so it becomes more automatic;
- Rescale to radiance or reflectance for Sentinel-2A images also;
- Calculation of Soil Moisture Index (SMI) and other vegetation index;
- Implement ISODATA unsupervised classification method.

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Thanks for the attemption!

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