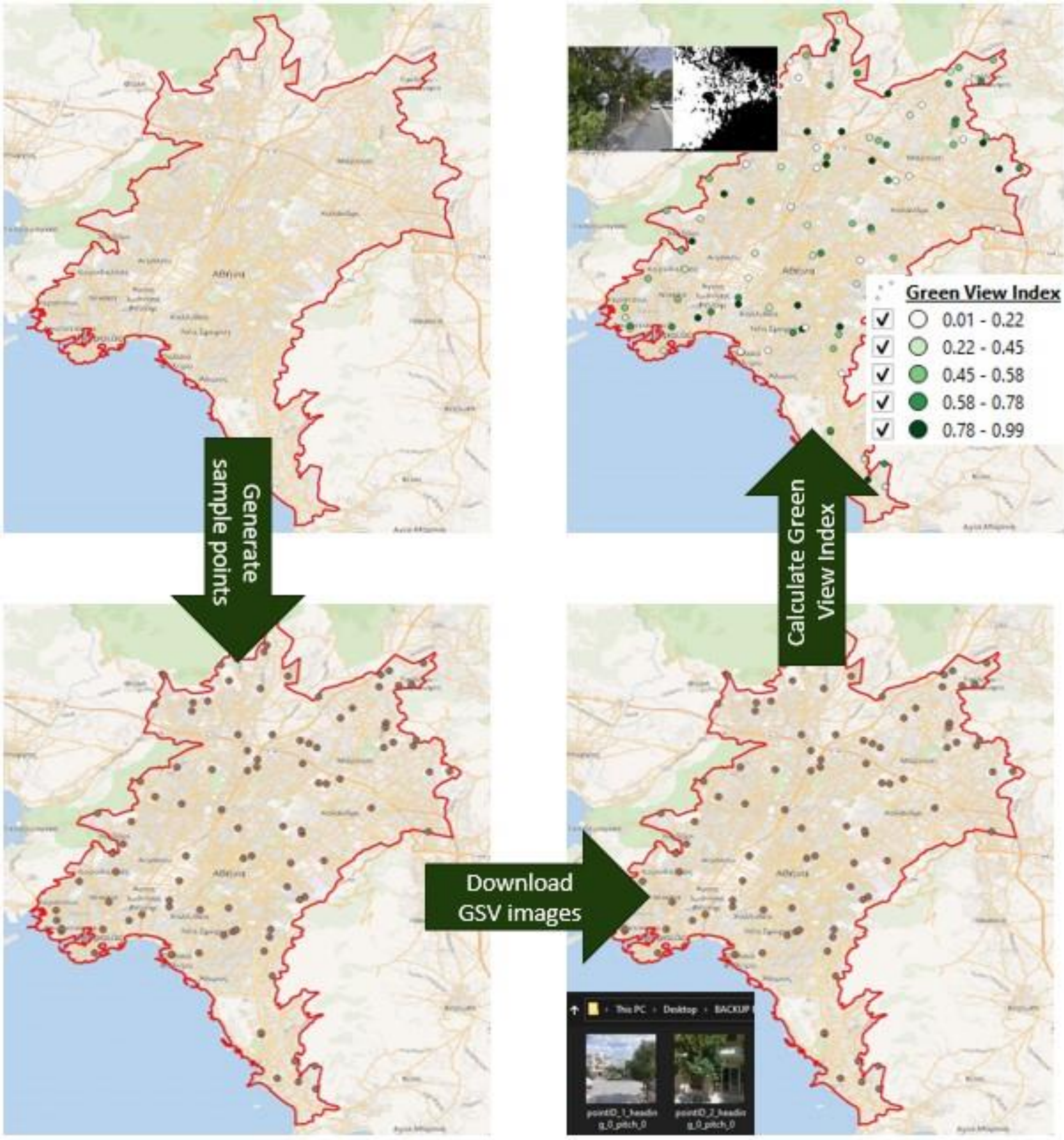
Green View Index for QGIS

v0.2

A QGIS plugin to easily calculate Green View Index through Google Street View images



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Introduction

The Green View Index (GVI) has emerged in the literature of the latest years as an objective measurement of urban green at the street level. Unlike satellite derived NDVI, which provides a mapping of vegetation from the top level, GVI utilizes street-level imagery to quantify the presence of vegetation from a human-eye point of view.

It was introduced as a concept in 2009 (Yang. et. al., 2009), but it has been popularized since 2015, with the introduction of an automatic method to extract the vegetation pixels in a Google Street View panorama (Li et. al., 2015a). As an index, it is now routinely used in literature to identify correlations with other variables, such as health (Wang et. al., 2019) or socioeconomic (Li et. al., 2015b). The Treepedia project by MIT's Senseable City lab has calculated GVIs for more than 25 cities worldwide and ranked them based on their average values (http://senseable.mit.edu/treepedia). This project has released two versions of their code.

However, no publication has been found to link GVI calculations with QGIS. This project aims to fill that gap and make the index more accessible to researchers and planners who are less comfortable with code. It is a high-level implementation, where the user sets input only through dialogue windows and there is no need to write code.

This document serves as documentation for the plugin. A brief literature review on the Green View Index is given in the first chapter. In the second chapter, the tool itself is overviewed and analyzed step by step.

For this first release, the basic features of a GVI calculation tool have been developed. More features are planned for future updates, such as more algorithms to extract green pixels. Contributions are welcome through the github repository.

The Green View Index

The Green View Index (GVI) is a measurement of urban green on a street level. Yang et al. (2009) introduced a “Green View” index to quantify the presence of urban green. Their GVI was defined as the ratio of the green pixels’ area from four pictures from an intersection to the total area of the four pictures. It was calculated according to following formula:

$$\text{Green View} = \frac{\sum_{i=1}^{4} Area_{g\_i}}{\sum_{i=1}^{4} Area_{t\_i}} \times 100\%$$

where $Area_{g\_i}$ corresponds to the total amount of green pixels in the picture taken in the i_{th} direction (among north, east, south and west) for one intersection, and $Area_{t\_i}$ corresponds to the total amount of pixels of the picture taken in the i_{th} direction.

There were mainly two problems with the work of Yang et. al (2009). The first was the manual delineation of the green pixels. The second was using only 4 directions, which is not enough to capture the full pedestrians’ view. With the availability of Google Street View images and automatic image processing methods, it is possible to use more direction angles and extract the green pixels automatically. Li et. al. (2015) proposed a total of 18 directions to consider, using 6 angles at 60° intervals in the horizontal plane (heading), and 3 angles at 45° intervals in the vertical plane (pitch).

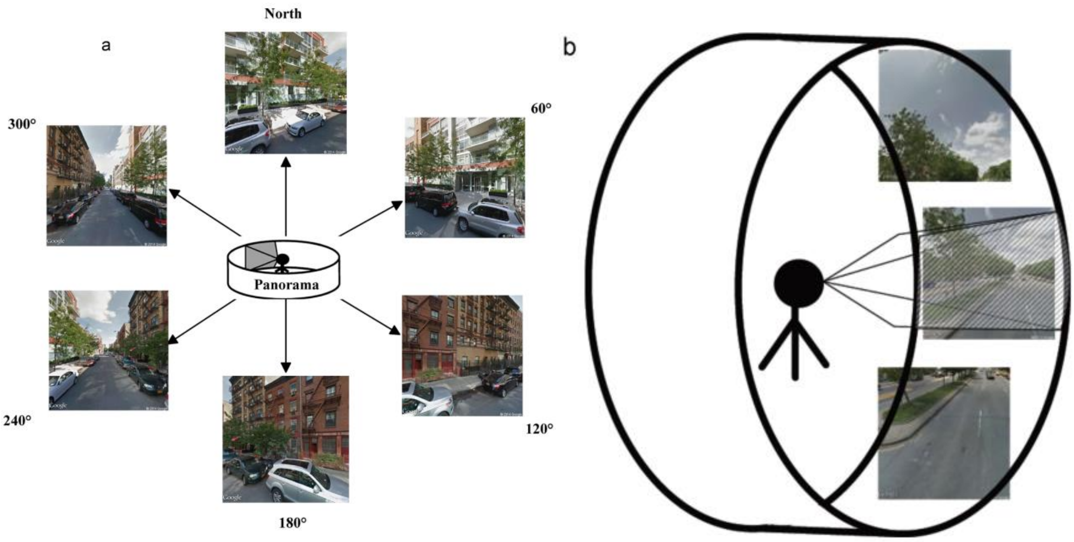


Figure 1: Street view panoramas at total of 18 angles capture the full pedestrian’s view

Therefore, the formula for the GVI is modified as follows:

$$\text{Green View} = \frac{\sum_{i=1}^{6}\sum_{j=1}^{3} Area_{g\_ij}}{\sum_{i=1}^{6}\sum_{j=1}^{3} Area_{t\_ij}} \times 100\%$$

It is possible to retrieve street view images by setting the appropriate values of heading, pitch (and field of view – ‘fov’) in the Street View static API request (Figure 2).

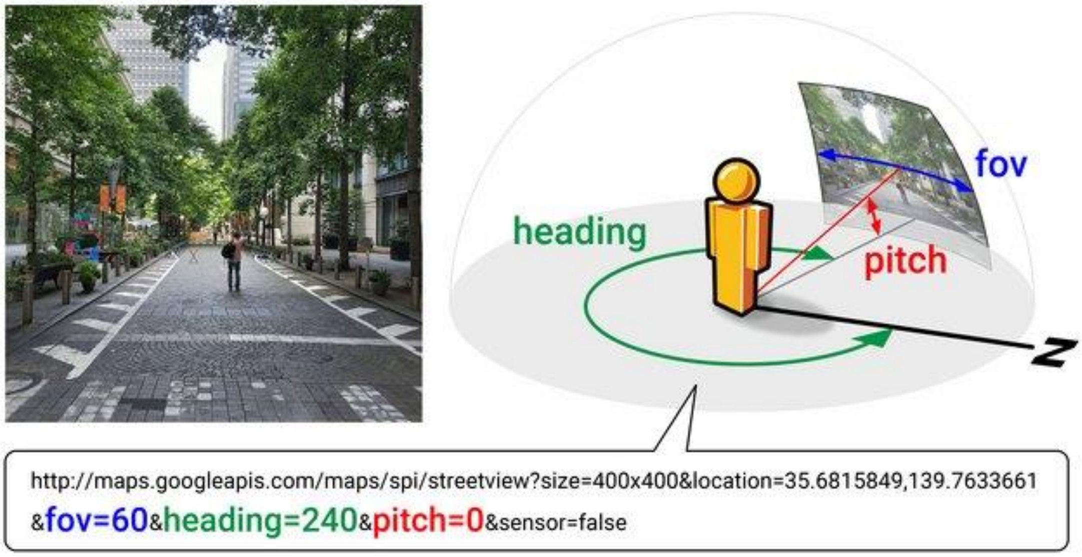


Figure 2: Heading, pitch and fov values for street view API (Kumakoshi et. al., 2020)

The same researchers proposed an algorithm for the automatic extraction of green pixels in the image, given in Figure 3.

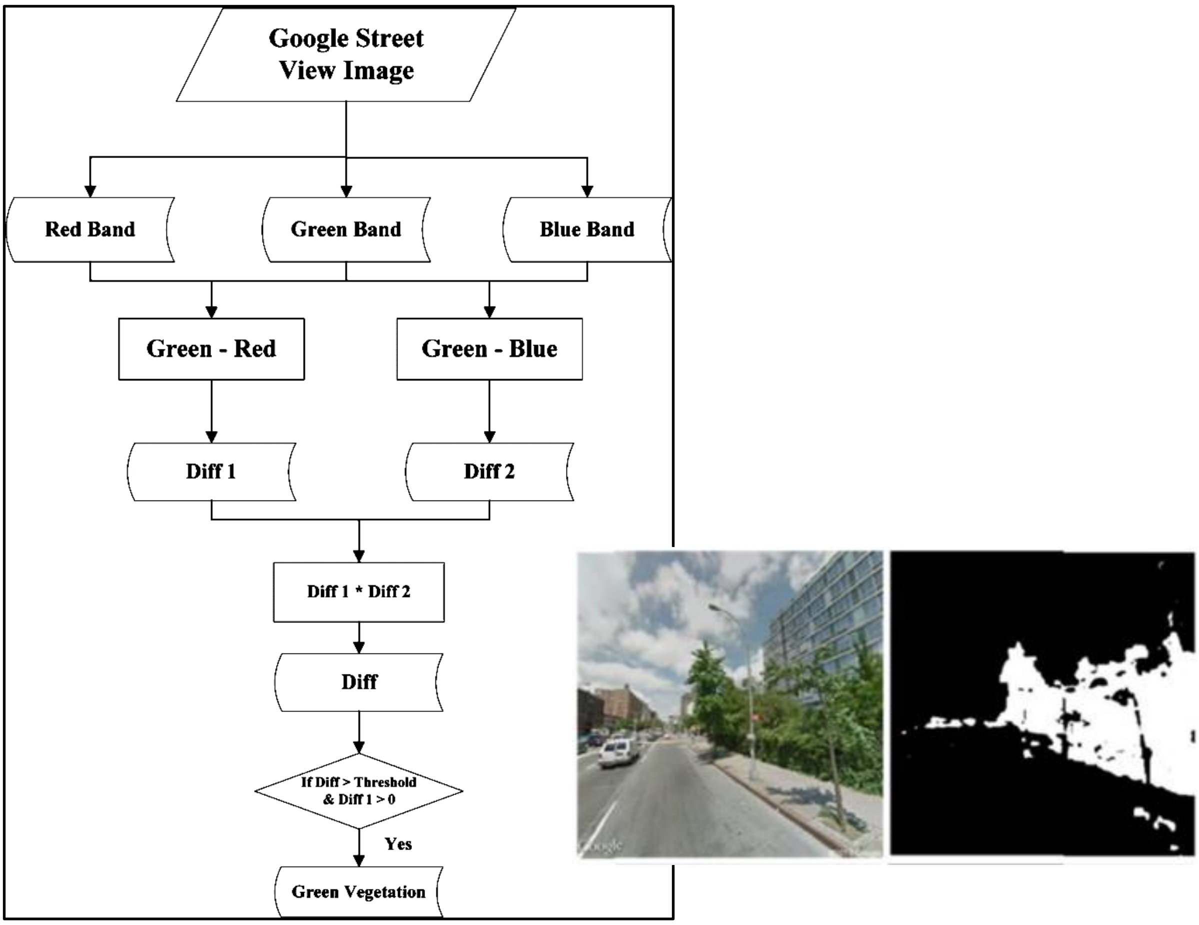


Figure 3: Workflow for calculation of green vegetation pixels by Li et. al., 2015a

This algorithm has been employed by numerous other researchers (Lu, 2017; Richards and Edwards, 2017) and yields sufficient accuracy. However, in the latest years, the extraction of green pixels has been routinely done through semantic segmentation and convolutional neural networks (Wang et. al., 2019; Helbich, 2019; Middel et. al., 2019; Gong et. al., 2018). This leads to all the pixels in the image being classified into a category (mainly green, sky and artificial services). A typical result is given in Figure 4.

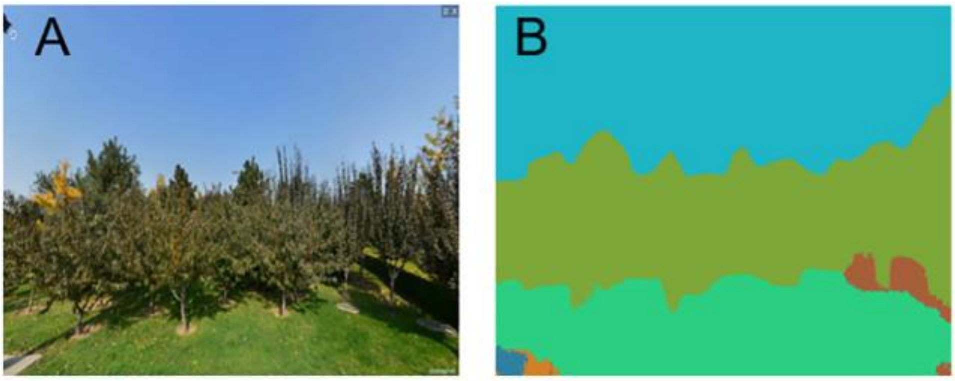


Figure 4: Output of semantic segmentation with Convolutional Neural Network

In the present plugin, the algorithm of Li et. al. (2015a) is used to extract the green pixels, given that it is simple and accurate enough for most applications. However, more algorithms are planned for future updates

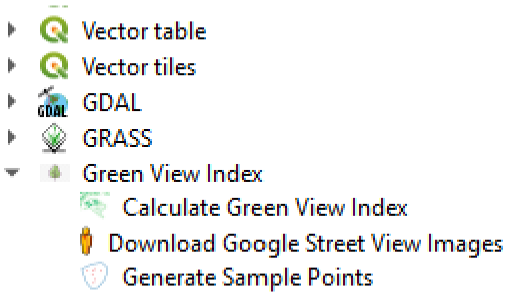
The Green View Index for QGIS

Overview

The Green View Index for QGIS is a plugin that perform the three main procedures required to calculate GVI for a given area:

- Generation of random points within an area
- Downloading of Google Street View images for the coordinates of those points
- Calculation of Green View Index

It is a processing plugin, so after installation, it will appear under Processing Toolbox



A graphic overview of the scripts is given in Figure 5.

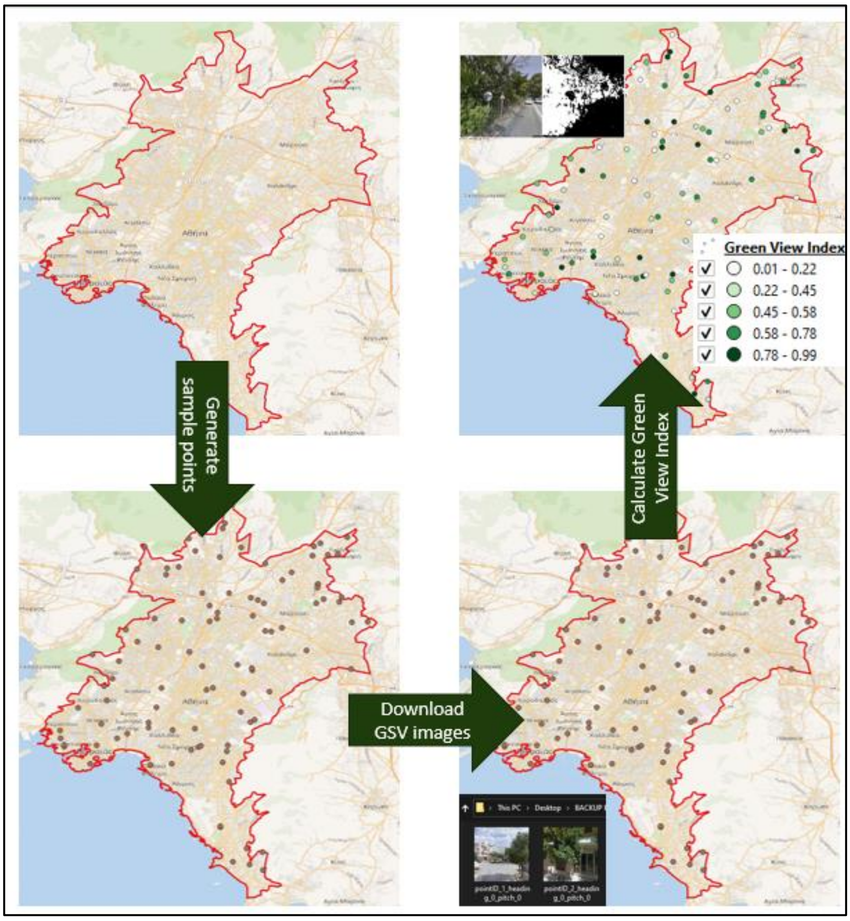
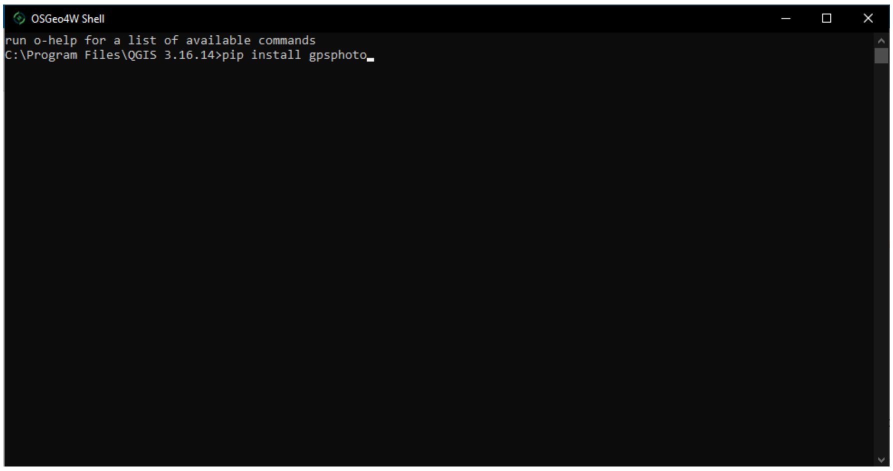


Figure 5: Graphic overview of the scripts of Green View Index for QGIS

The scripts provide some additional capabilities, such as the option to geotag the downloaded images. All the capabilities and the exact workflow are summarized in the next chapters.

Prerequisites

The plugin has dependency on two libraries: scikit-image and gpsphoto. They can easily be installed with pip through OSGeo4W Shell, simply run *pip install gpsphoto* and then *pip install scikit-image*.



The tool requires a Google Street View Static API key. Complete instructions can be found in this video. Overall, in order to generate a key, the following steps must be taken:

1. Create a Google account
2. Create a new project at Google Maps Platform
3. Enable billing for that project (a valid credit or debit card is required, but no charge is made)
4. From the Credentials page, create an API key

Generate sample points

The first step is to create sample points in your area. If you already have such a dataset, there is no need to run this script, but make sure that the dataset has an ID field, with a unique integer value for each feature.

As input, you need to set what defines your area of interest (AOI). The first option is a polygon layer to directly define the AOI. In this case, random points will be generated inside the AOI, regardless of the road network underneath (Figure 6). The second option is to set a road network as input, and random points will be generated along the lines of that network (they will be snapped to the line features, Figure 7). The third option is to set both AOI and road network as input. In this case, first the road network will be clipped to the boundaries of the AOI, and then the points will be generated along the lines of the remaining network (Figure 8).

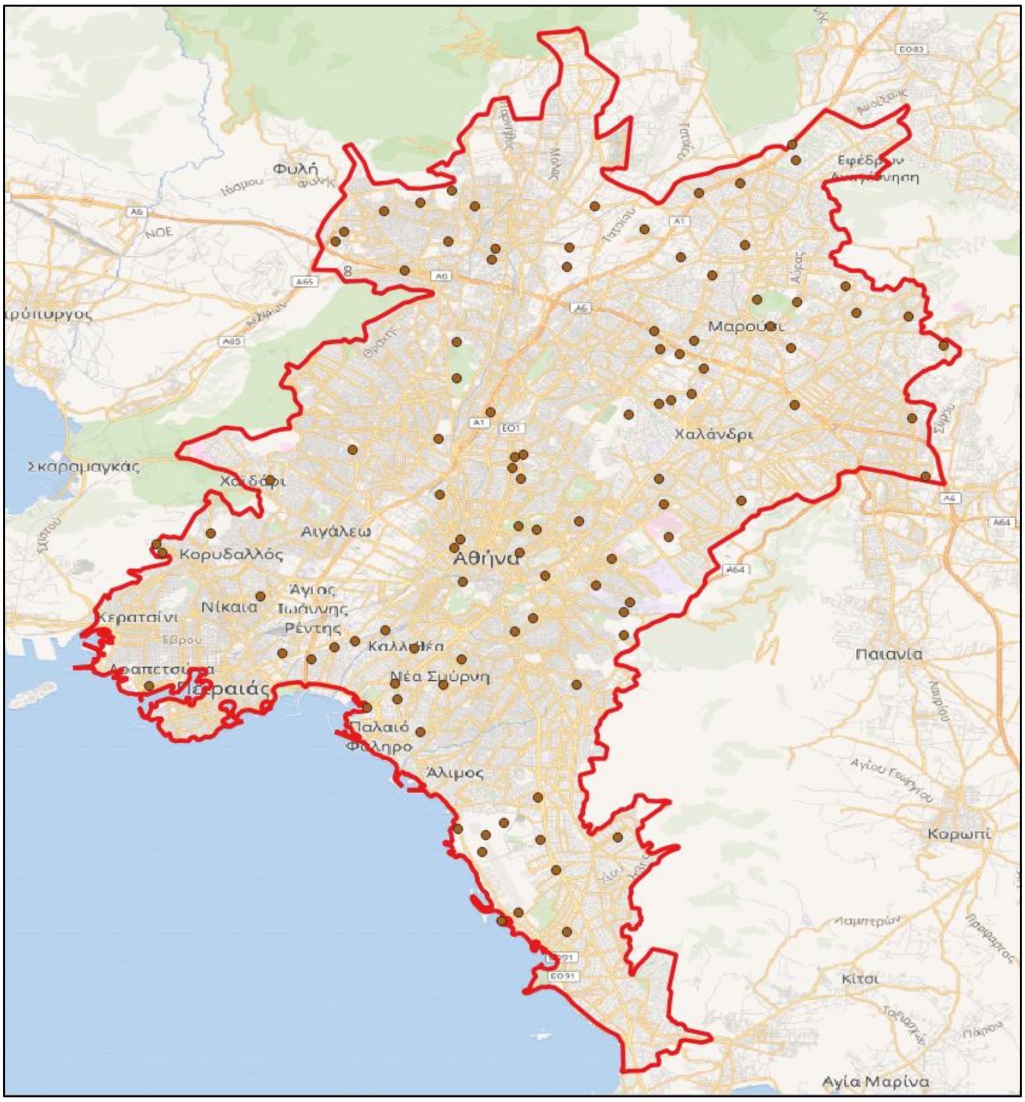


Figure 6: Random points inside polygon AOI, ignoring underneath road network

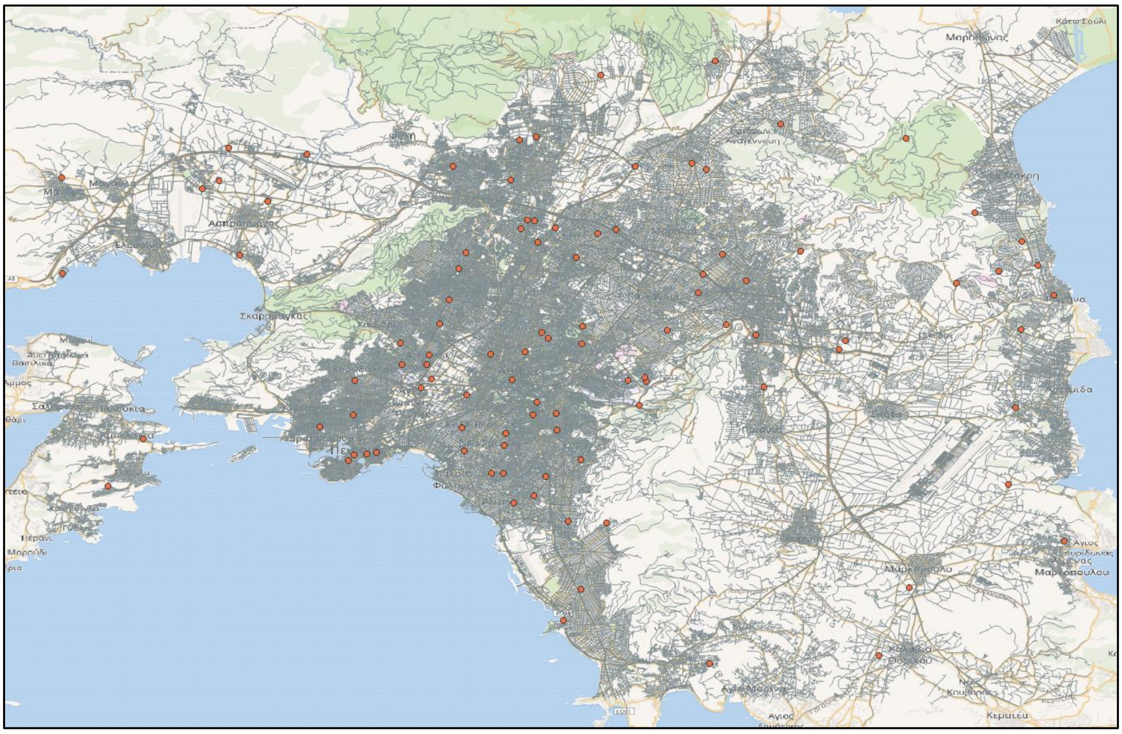


Figure 7: Random points along a road network, on the total extent of it.

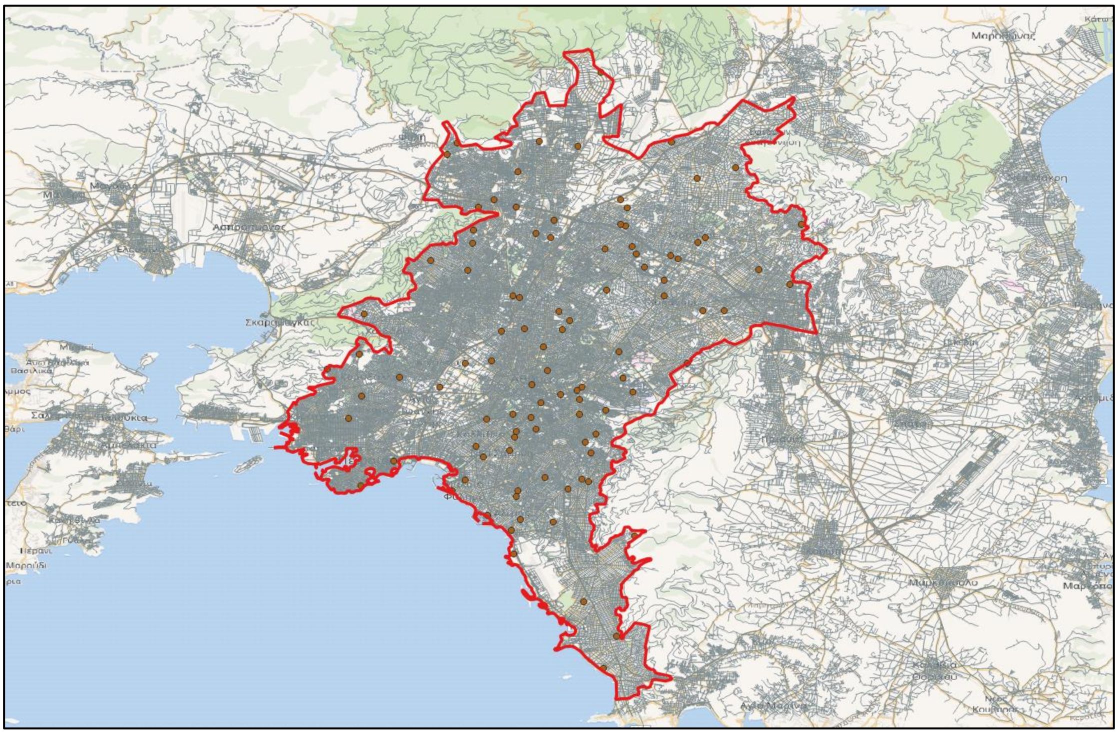
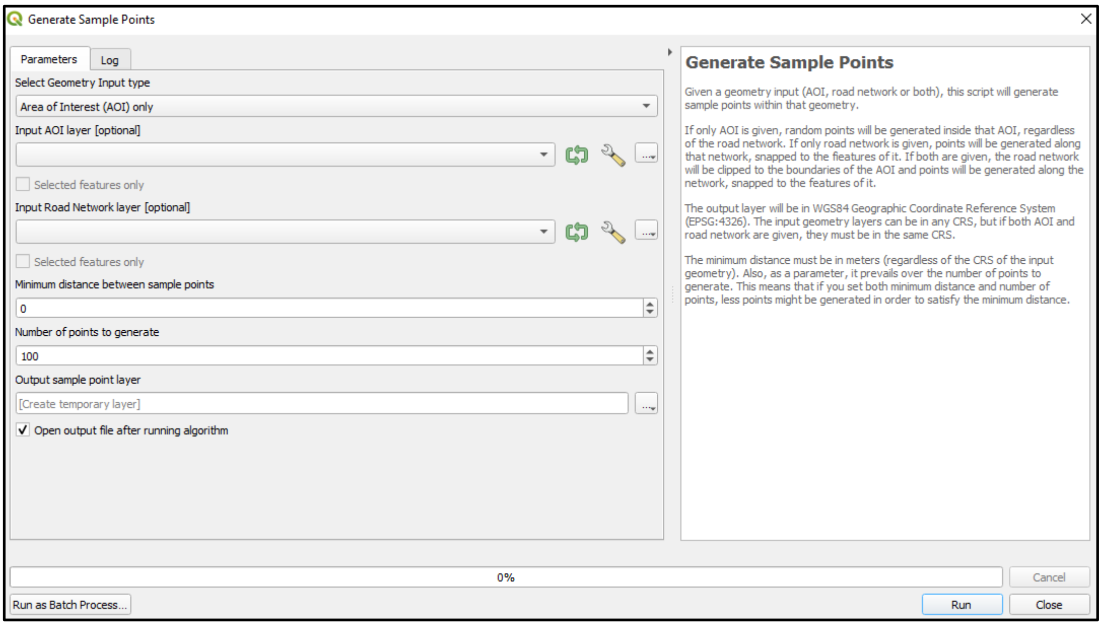


Figure 8: Round points along a road network, clipped to an AOI.

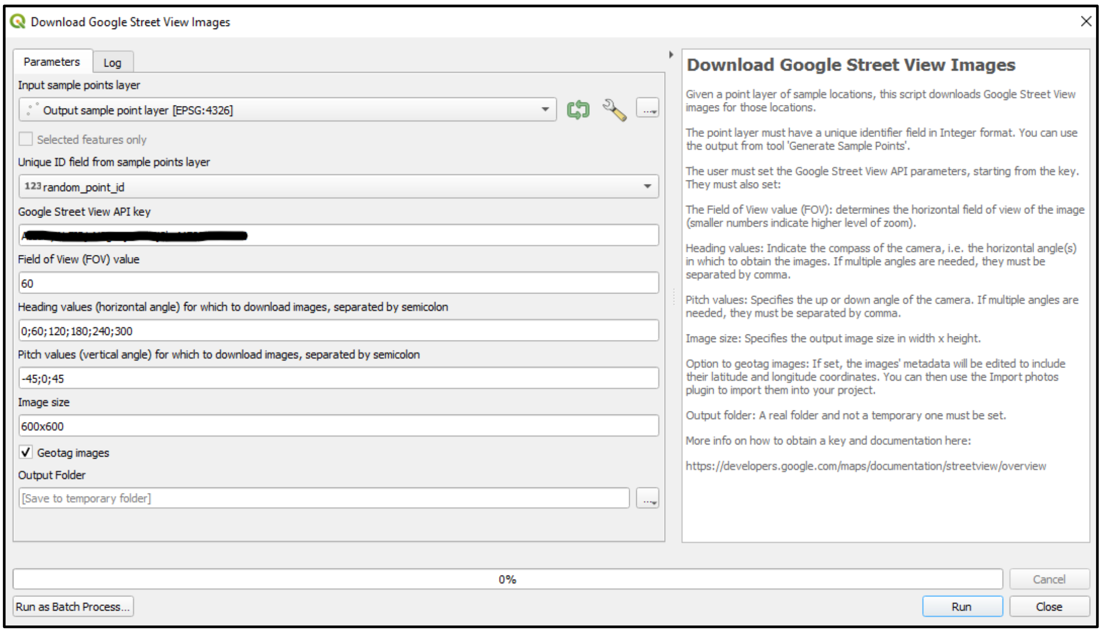
The script needs two additional parameters to run. The minimum distance between points and the number of points to be generated. The minimum distance must be in meters (regardless of the CRS of the input geometry). Also, as a parameter, it prevails over the number of points to generate. This means that if you set both minimum distance and number of points, less points might be generated in order to satisfy the minimum distance.



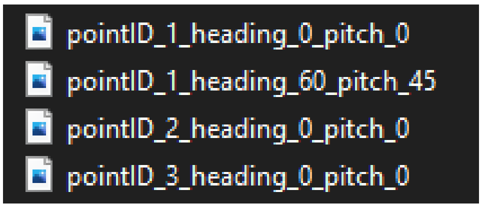
The output layer will be in WGS84 Geographic Coordinate Reference System (EPSG:4326). The input geometry layers can be in any CRS, but if both AOI and road network are given, they must be in the same CRS.

Download Google Street View Images

The next step is to download GSV Images at the sample point locations. The input for this script can be either the layer produced by the previous script, or a dataset of your own, as long as it includes an Integer unique ID field. This field needs to be set as input, so that when the images are saved on the drive, their ID is part of their name.



The user must also set the Street view API parameters to run the tool and they have the option to geotag the images that will be downloaded. The output folder, where the images will be downloaded must NOT be a temporary directory. In that folder, the images will be named according to the point's ID and the heading and pitch value of the scene. In the following example, the second image corresponds to the point with ID 1, heading 60° and pitch 45°. The third image corresponds to the point with ID 2, heading 0° and pitch 0°etc.



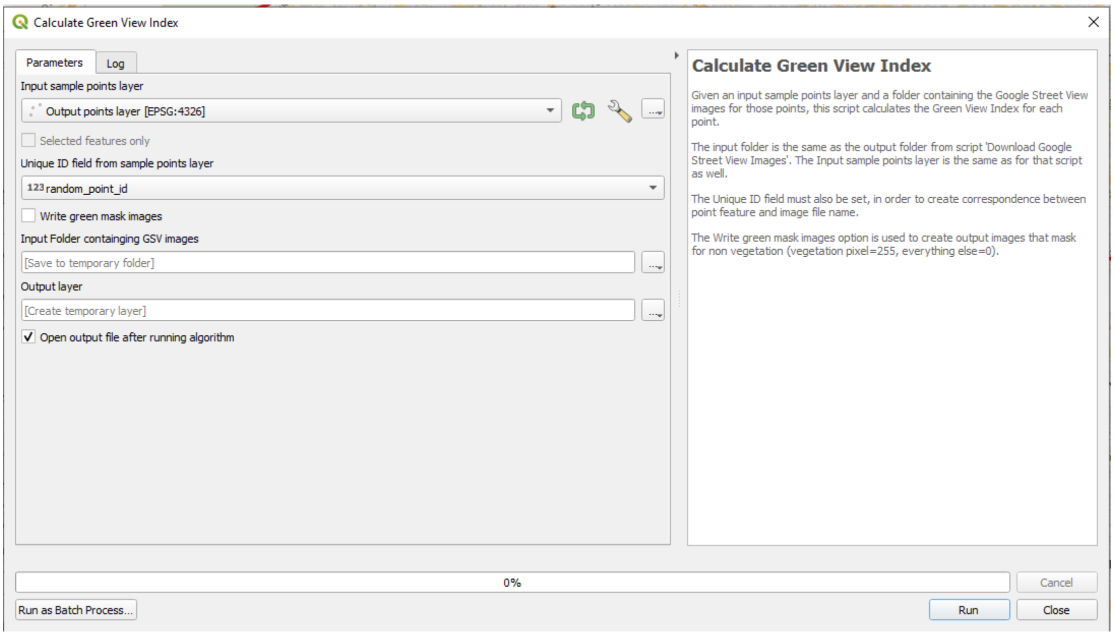
<u>IMPORTANT NOTES</u>: Make sure that the folder where the images will be downloaded will be a dedicated folder for that, with no other files. This will make the next script run smoother. Also, by default, 18 angle combinations are set as input (6 horizontal x 3 vertical). You can set less angles if you want, but the calculation of GVI does not yet work well if you set to download only 1 angle combination (e.g. only 0º heading and 0º pitch).

If the Geotag images option is ticked, the images will be written with latitude and longitude coordinates, so they can be imported with the Import Photos plugin on the map.

The script also produces a csv file with the status of the request and the date of the image.

Calculate Green View Index

The final script performs the calculation of the Green View Index for the panoramas downloaded by the previous script. The user must set as input the sample points layer, the unique ID field and the folder where the images were downloaded. The images have been named according to the ID, so in this way the results of the GVI calculation can be joined with the point layer.



The green pixels are extracted for each panorama of each point, and they are summed by point ID. They are divided by the total number of pixels to yield the Green View Index.

If the option 'Write green mask images' is ticked, the script will also produce green mask images in the same folder as the panoramas.

Contact – Contribution

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https://github.com/kowalski93/Green-View-Index-for-QGIS

Buy me a coffee!

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