NDVI to Variable Nitrogen Application Map – QGIS plugin

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(Version 0.5 for Education purposes)

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- Satellite images download – Copernicus Browser
    - Copernicus Data Space Ecosystem (CDSE), Modified Copernicus Sentinel data 2024 processed in Copernicus Browser. https://browser.dataspace.copernicus.eu/
- QGIS-based NDVI analysis and N prescription map processing
    - QGIS 2024. QGIS.org, Geographic Information System. QGIS Association. http://www.qgis.org

1. Conceptual framework (Precision Agriculture)

To enable site-specific variable management of nitrogen fertilizer (production input) site-specific variability hast to be ***quantifiable*** and ***manageable***. Quantifiable refers to specific means and methods for quantifying site-specific biomass variability (e.g. satellite image based NDVI and/or EVI etc.). Manageable in a sense being able practically via fertilizer spreader to reduce/increase fertilizer application amounts on a site-specific level.

With this open-source plugin the user can use NDVI (EVI) to identify in-field variability based on index value on site-specific level. There are two methods to utilize the index-based indication about site-specific level-based biomass variability. If its ***hypothesized*** that higher NDVI index value indicates better plant growth conditions a user can aim at: 1) agronomic yield maximizing or 2) agronomic yield equalizing site-specific variable nitrogen application.

In developed countries maximum nitrogen application amount per hectare in one season is limited due to environmental pollution concerns. This implies that if farmer wants to manage field nitrogen application on a site-specific level, it can be done only by reducing nitrogen applied in some areas of the field and increasing it in others.

Agronomic yield maximization would prescribe more fertilizer to be applied in the areas where plants “grow better” and less in the areas where index “indicates” less favourable conditions for plant growth.

Agronomic yield equalizing (homogenizing) variable N application would prescribe more fertilizer to be applied in the areas of the field with lower index values, under the assumption that plant need more nutrients in order to “catch up” with the rest of the field. It is assumed that this would lead to more equal biomass spread in the field at the end of season.

2. Required inputs

Two important geospatial input layers are required for running the plugin:

1) site-specific units delineating Input Layer (shape file delineating sub-field units – polygons) (***should be unzipped before adding to QGIS layer legend, in case if shape file is in zipped directory! This file should not be located on part of disk where QGIS plugin has no permission to access directory.***),

2) georeferenced NDVI input raster (.TIFF) that can be downloaded for specific dates via Copernicus Browser. In addition, via Copernicus Browser raw data (e.g. B02, B04 and B08) can be downloaded and NDVI can be calculated with QGIS Raster Calculator or experimental plugin “NDVI and EVI Index Calculator”. The index layer naming convention has to follow instructed in order for plugin to process the data:

- Input raster - Input layer of NDVI or EVI (file name has to end with date string e.g.: ...NDVI_03-24-2023) (layerName_M-D-Y) (add underscore before date!).

3. Running plugin

Sample files for testing QGIS plugin can be found in GitHub:

https://github.com/memicemir/ndvi_to_variable_N_application/tree/main/SampleImage-TestPlugin

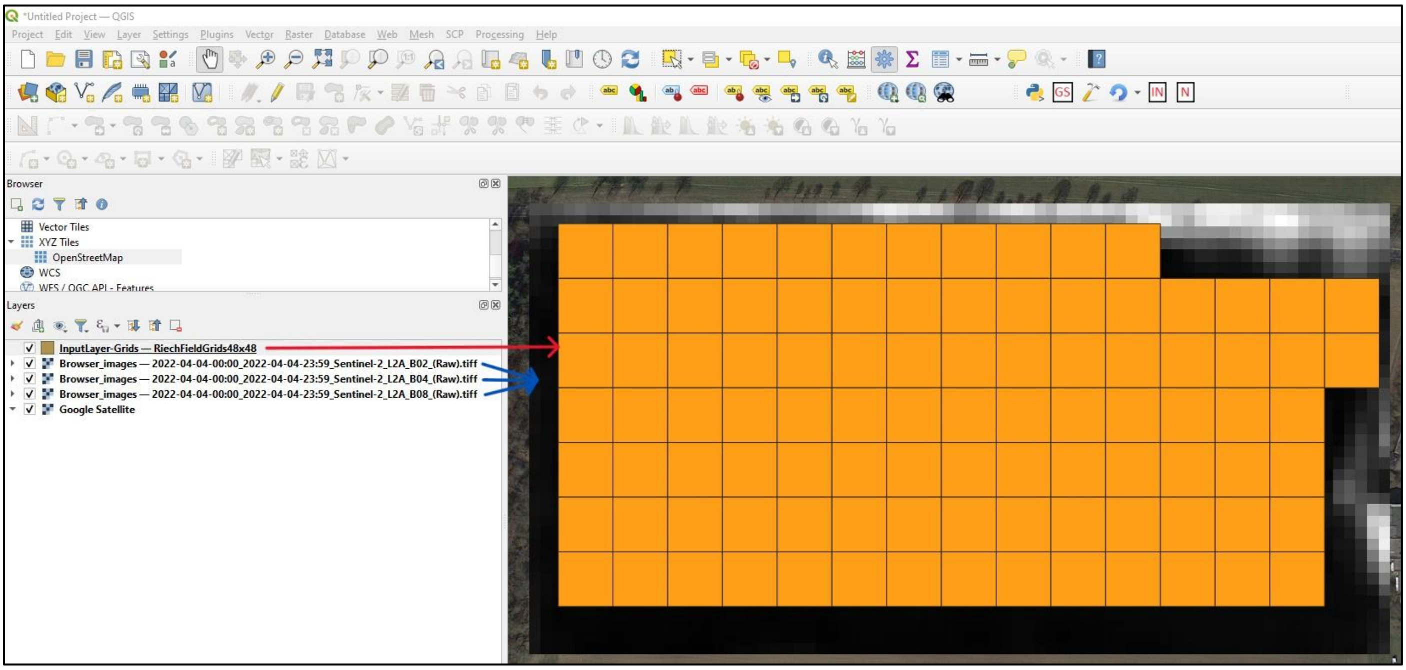

Figure 1. Input layers required for running plugin: geospatial grid (shape layer) and Sentinel 2 raw bands (in this case from Copernicus Browser). The shape file can be created in QGIS: Vector -> Research tools -> Create Grid

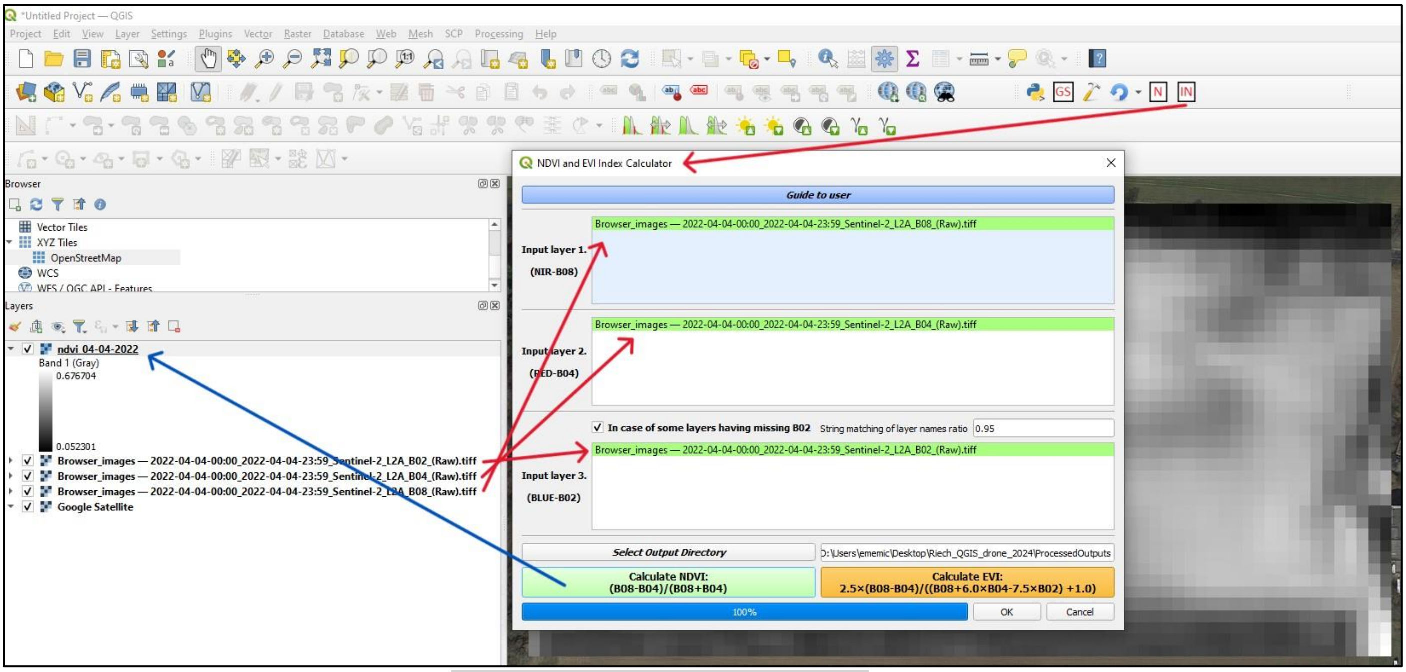

Figure 2. Using already published NDVI and EVI Index Calculator plugin a user can produce NDVI index layer from Red (B04) and Near infrared (B08) bands.

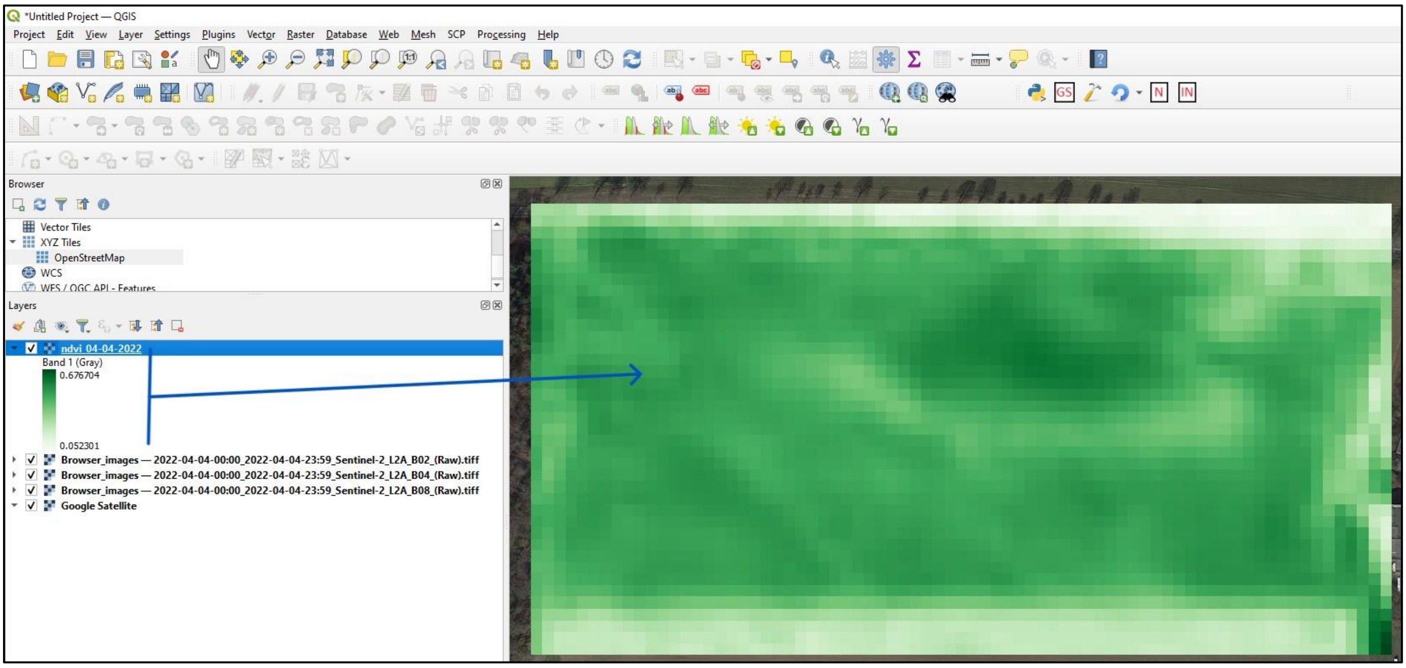

Figure 3. The NDVI index layer in QGIS (naming -> layername_M-D-Y e.g. ndvi_04-23-2022)

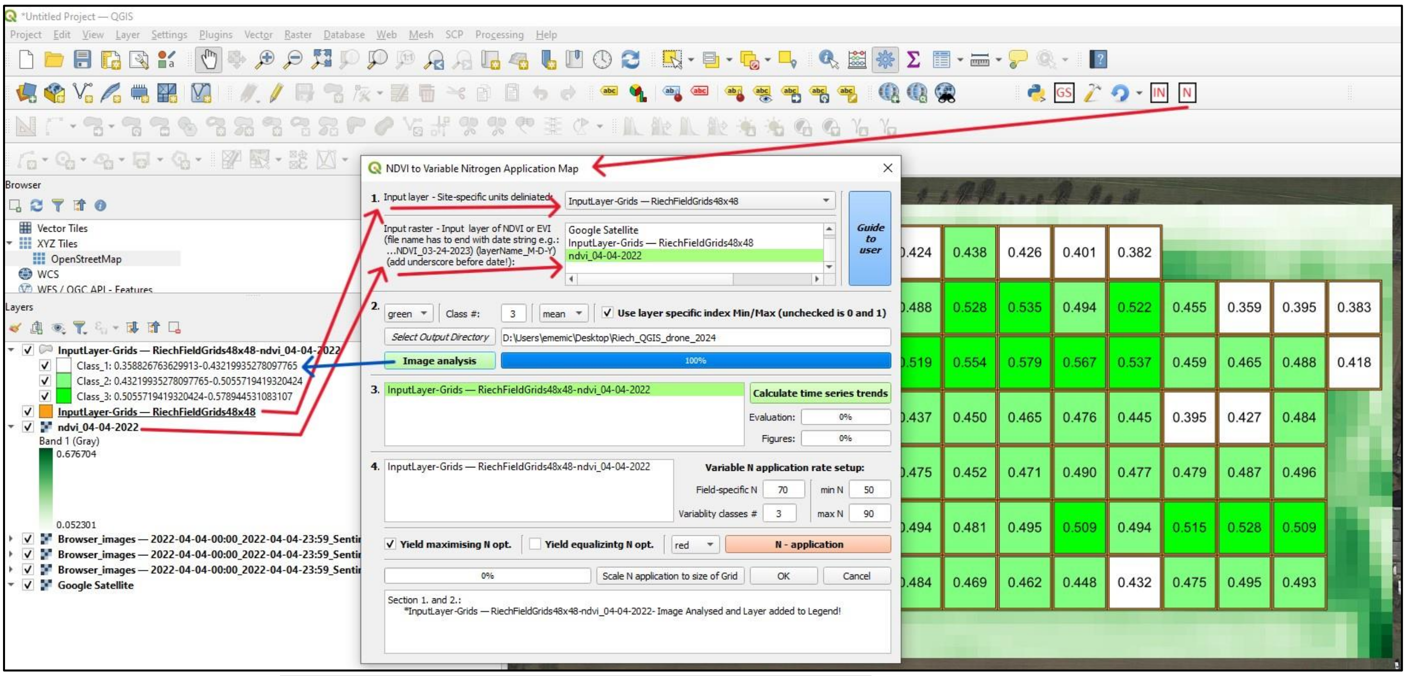

Figure 4. Initializing NDVI to Variable Nitrogen Application Maps plugin will open interface. In the interface section 1 in Input layer the user selects grid shape file and in Input raster the user selects NDVI index layer. Once Image analysis push button in section 2 in the interface is pressed, it will produce a new layer with grid (polygon) based index values. In Figure 5 the options from interface section 2 are described.

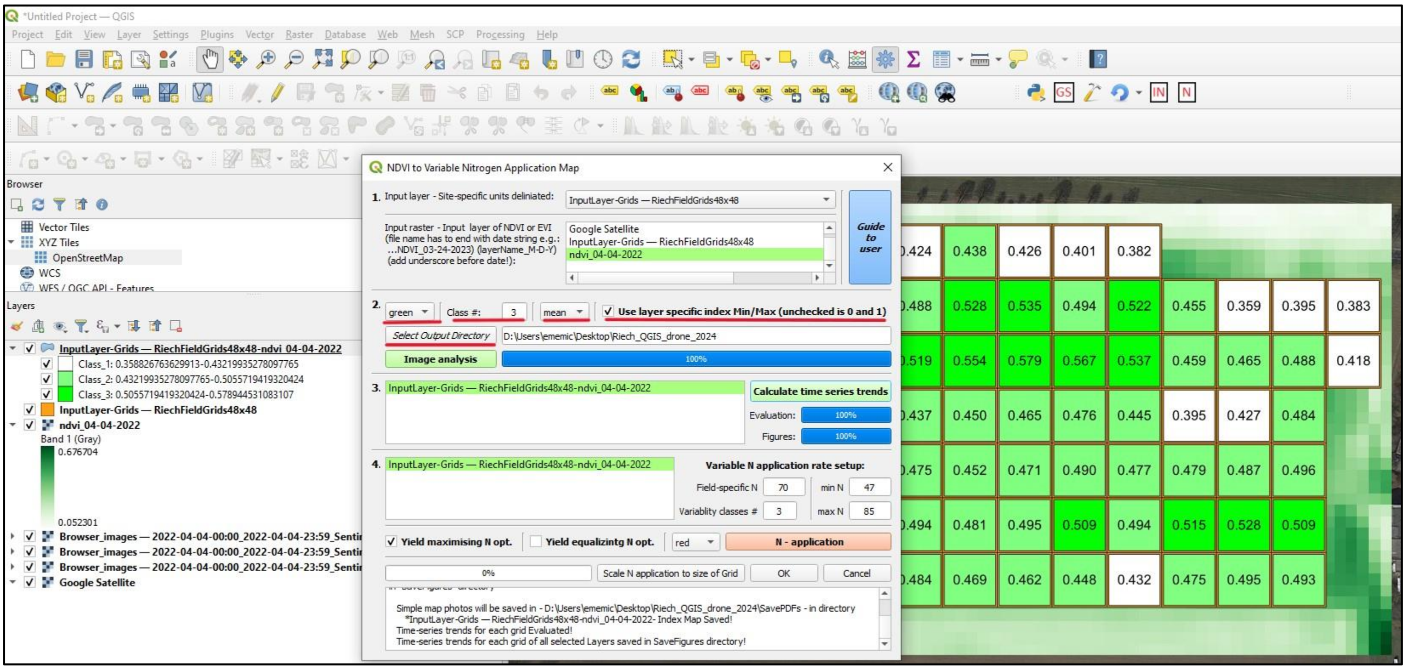

Figure 5. In section 2 in the interface the user can initialize the color of the heat map that will be used (e.g. red, green, blue) and number of index classes (categories). With in the interface Class #: 3 the plugin will assign all index values to three classes based on index min/max by splitting it in three equal interval categories. The option **mean** is the targeted field in the Attribute table used for analysis. Categories are based on the mean values from Attribute table. The user can also select processed files output directory, or continue using automatically generated (automatic is generated based on Input layer from section 1). Path should not contain zipped directories in it or be located at part of hard disk where QGIS plugin has no permission to access.

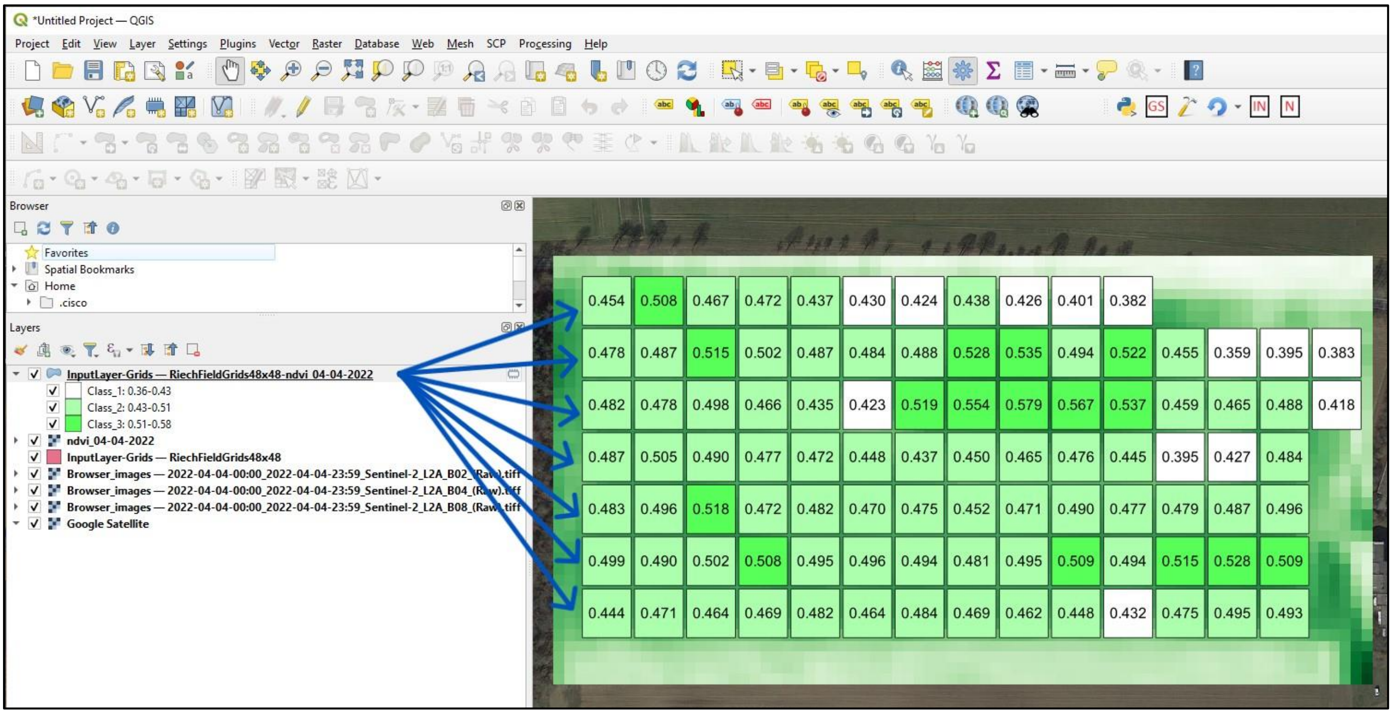

Figure 6. The output heat map is based on three categories of newly produced layer (in this example).

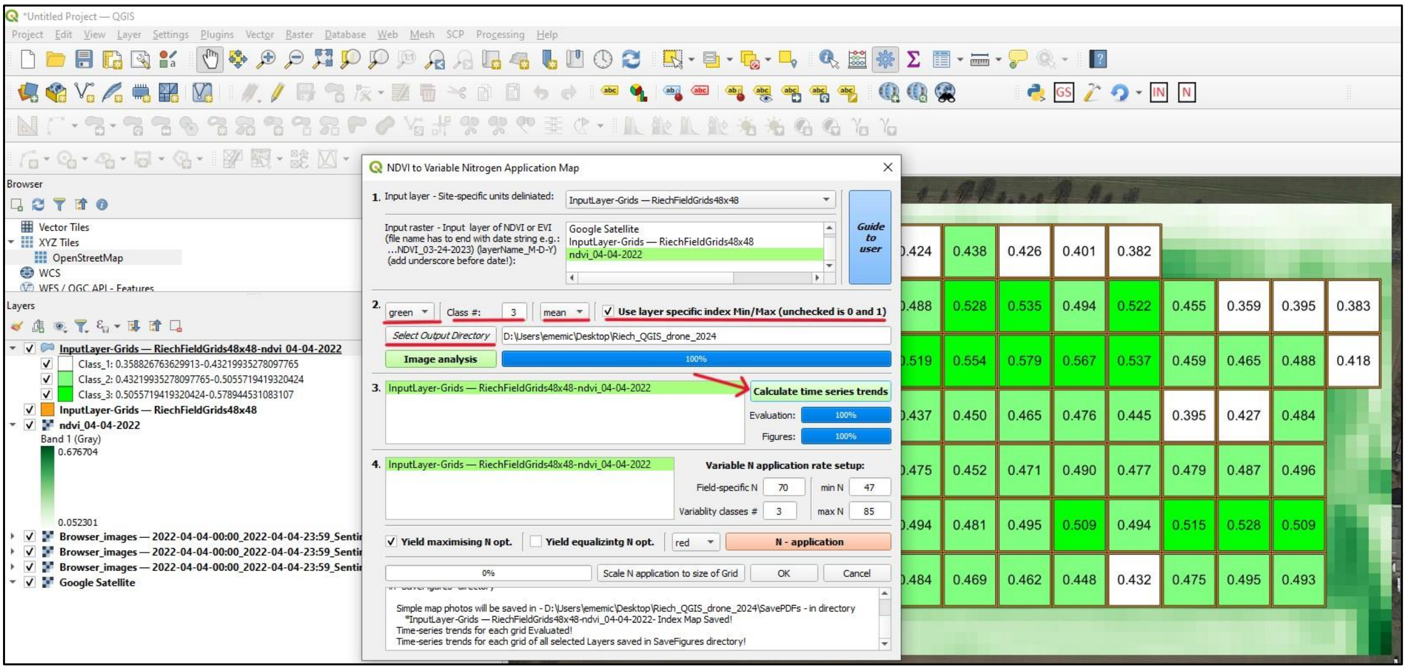

Figure 7. In the interface section 3 newly produced layer is added to the list widget window and is used for calculating time-series trends of all available indices. Output values are saved in the SaveFigures directory, which is located in directory defined in section 2 of interface. Layer map of index distribution is saved automatically as photos (.png) of the layers in SavePDFs directory.

In the section 4 of the plugin interface "**Variable N application rate setup**" there are multiple options that have to be considered before clicking N-application push button to create site-specific N application map.

The user can enter Field-specific N application amount. The filed-specific N refers to N application on field scale if user would apply uniform N throughout all field. Variability classes # refers to how many N variability classes user wants to create (if its 3, as in example the plugin will create three N application rates such as: low yielding, medium yielding and high yielding N application zones). Classes number will classify index values in three groups based on field specific index minimum and maximum with equal interval ranges, as can be seen in layer legend.

min and max N bounds are created based on percentile difference of index mean. Percentile difference between field index mean and lowest index value in the field is multiplied with Field-specific N value and min N is populated with that relative difference. Same is the case for max N. If the user change Field-specific N min and max N bound are automatically modified based on percentage difference between index mean and min/max. If the user is not satisfied with the automatically generated min and max N bounds the user can modify the bounds manually.

Yield maximizing and equalizing N optimization options were described at the beginning of this document.

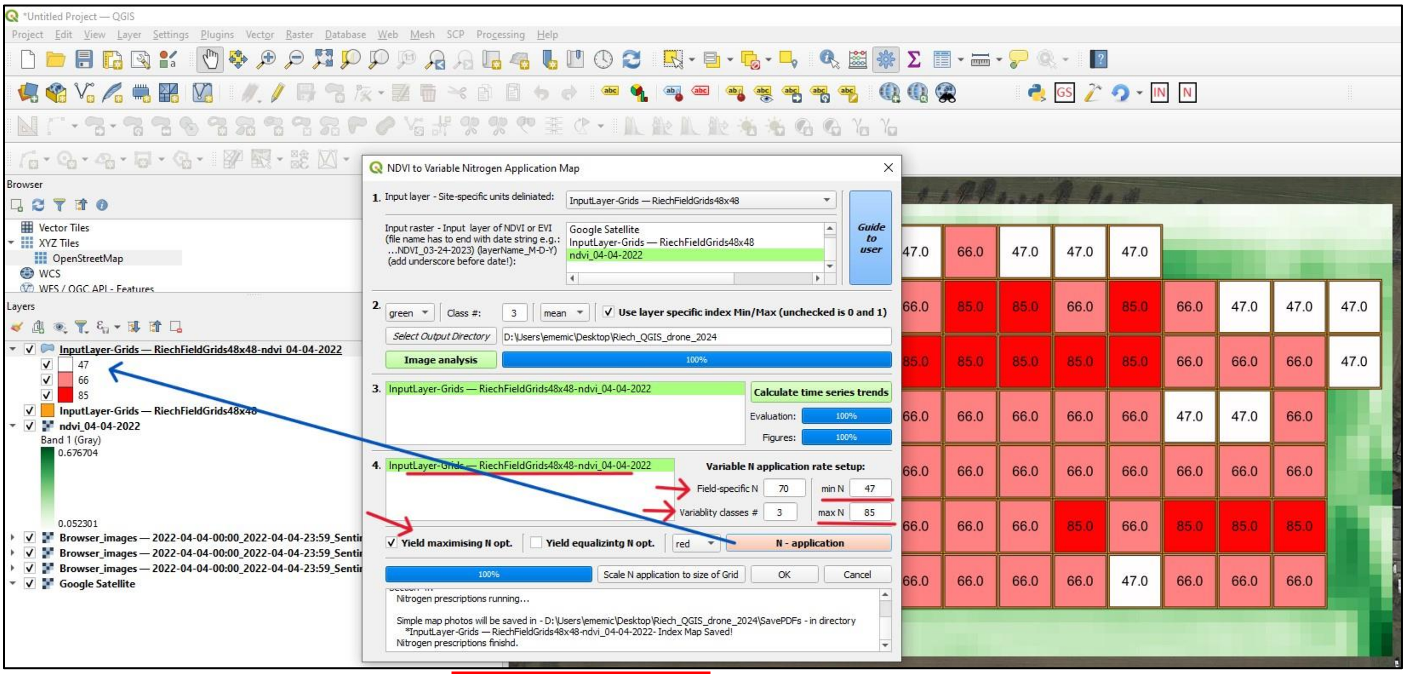

Figure 8. In section 4 site-specific N recommendations are created and layer is saved as image (.png) in SavePDFs automatically. The N recommendations push button will produce information about distribution (Figure 9) of the N application values, in the SavePDFs directory.

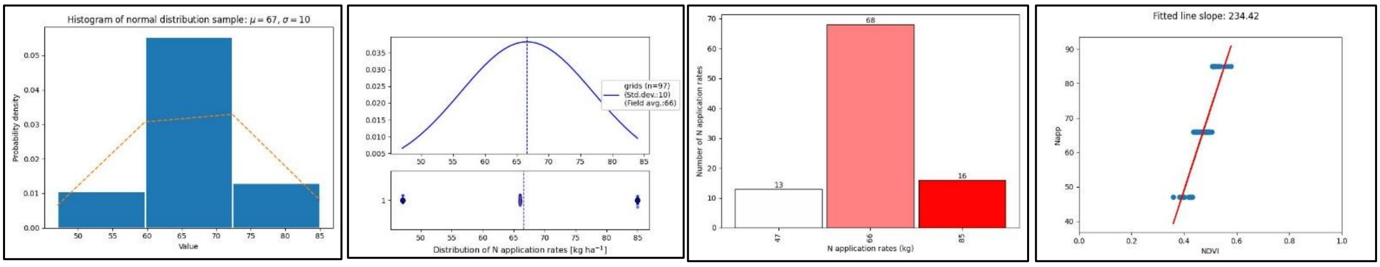

Figure 9. This information will give a user a better idea of how many grids belong to which category.

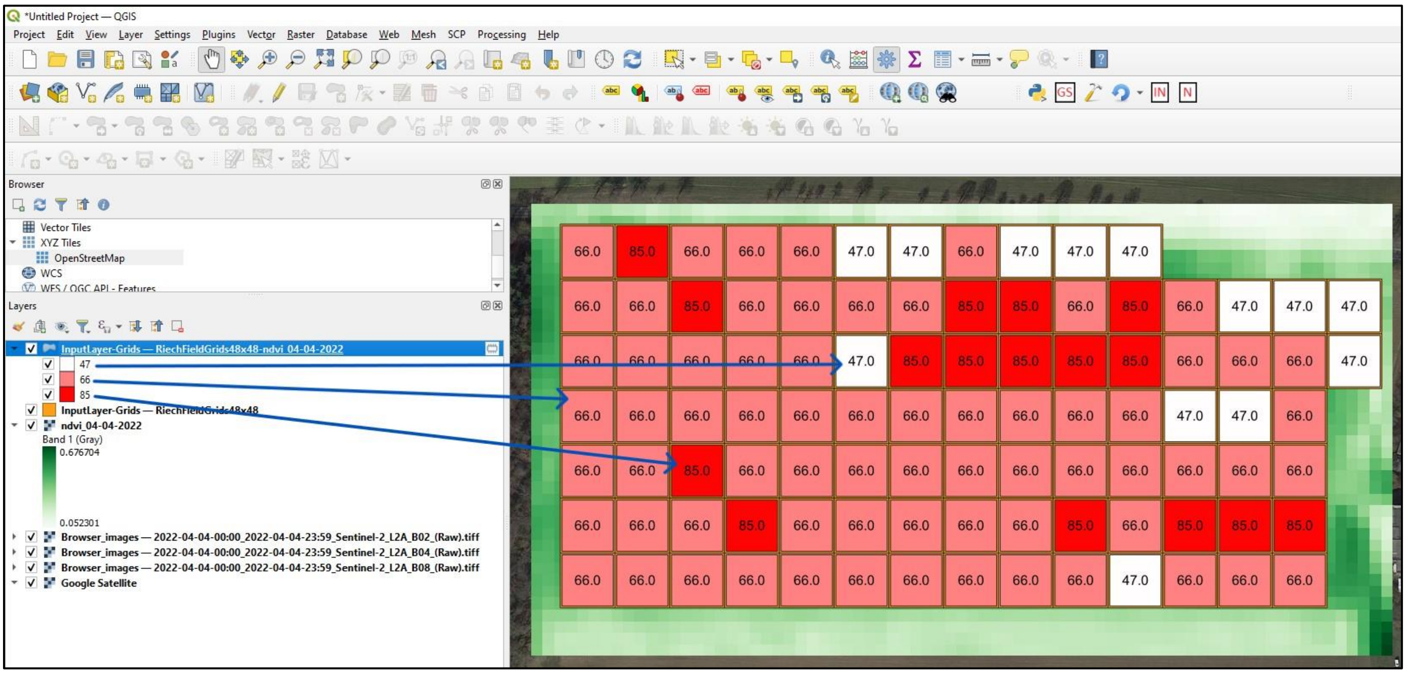

Figure 10. Output heat map of site-specific N recommendations. This is hectare scale recommendation.

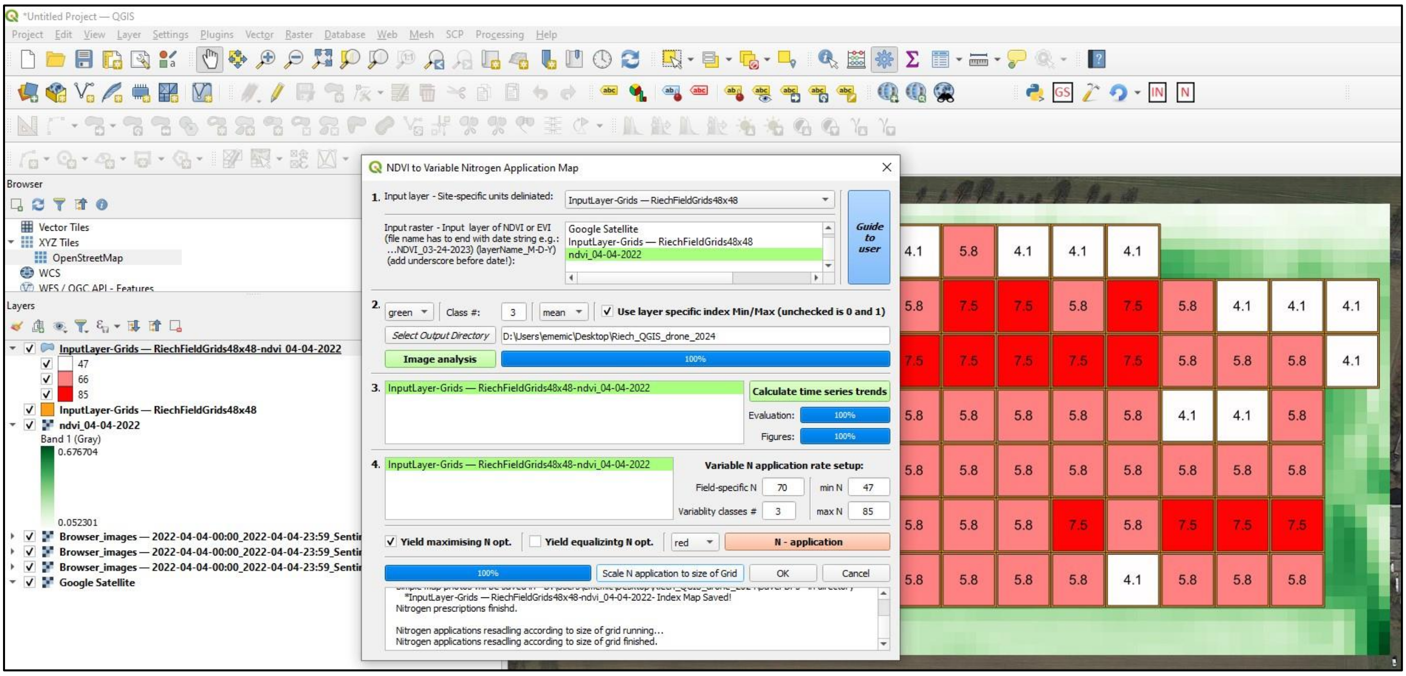

Figure 11. If the user wants to see what nitrogen recommendation would be depending on the size of the grid (rescaled according to size of site-specific unit) user can achieve that by pressing the push button Scale N application to size of grid. This push button will create an additional field in the Attribute table named "actualNkg".