Determining Potential Dengue Hotspots using Sentinel-2 Satellite Data and QGIS

Scope: This document provides a step-by-step procedure on how to acquire and process Sentinel-2 band satellite data using QGIS 3.4 to determine stagnant water locations in the specified city. The generated output is a CSV file which contains the coordinates of these potential Dengue hotspots computed from the FAPAR and NDWI of the satellite image.

1. Creating the QGIS Project for the City

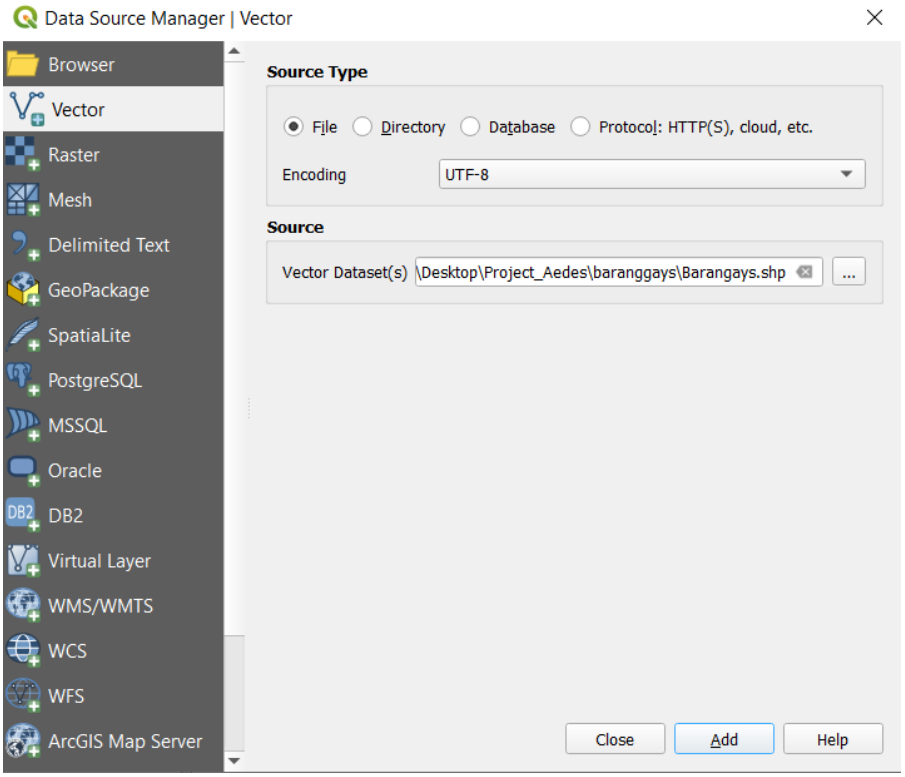
1.1. Create a new folder for the project in Windows Explorer (note: you can assign the CityName as folder name)

1.2. Open **QGIS 3.4** and click Project > New

1.3. Click Project > Save as, go to the new folder you've just created and type CityName.qgz (note: you now have a blank project for the city)

1.4. Import Barangays.shp (note: download this file from PhilGis.org if not yet available) by clicking on Layer > Data Source Manager > Vector. Fill out the fields as shown, then click ADD and CLOSE

QGIS Screenshot 1: Setting up the Philippine Barangays

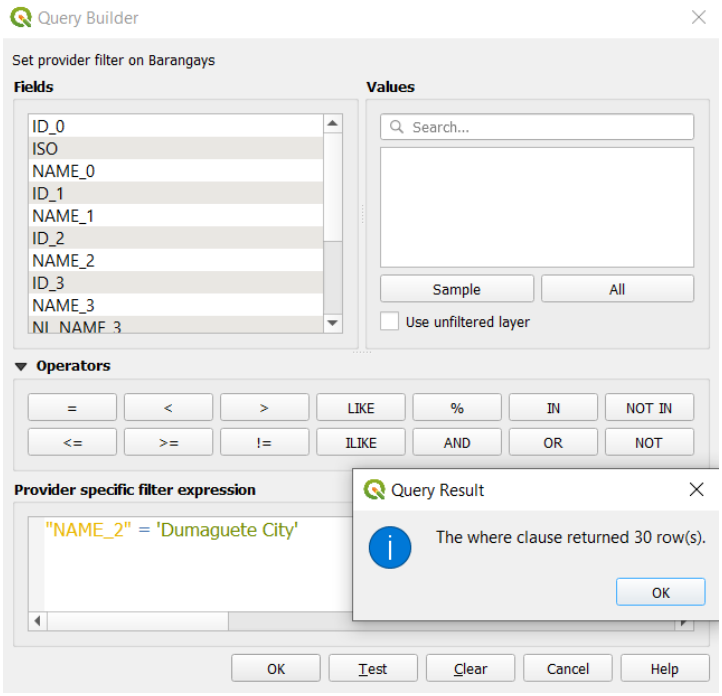


Expected Output: Philippine image in Map window and Layer named Barangay will appear in Layers window (see in QGIS window)

1.5. In the Layers window, right click on Barangays and choose Properties

1.6. Under Layer Properties > Source, click on Query Builder and fill out as shown (note: Name_2 field of Barangay corresponds to the city name). Click TEST and OK.

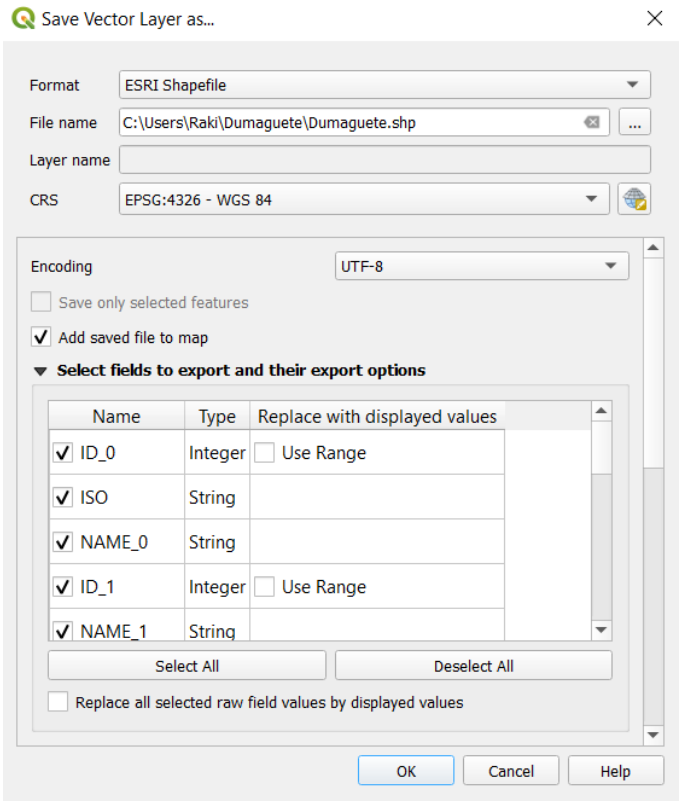
QGIS Screenshot 2: Setting up the City



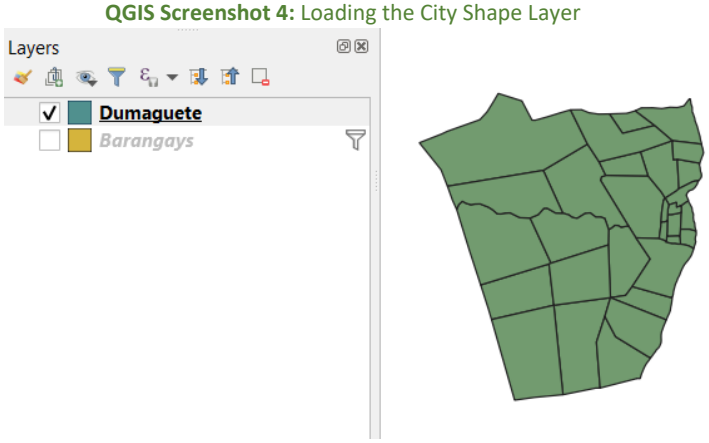
1.7. Under Layer Properties > Source again, click APPLY and OK.

1.8. In the Layers window again, right click on Barangays and choose Export > Save Features As. Fill out the fields as shown then click OK

QGIS Screenshot 3: Creating/Saving the City Shape File



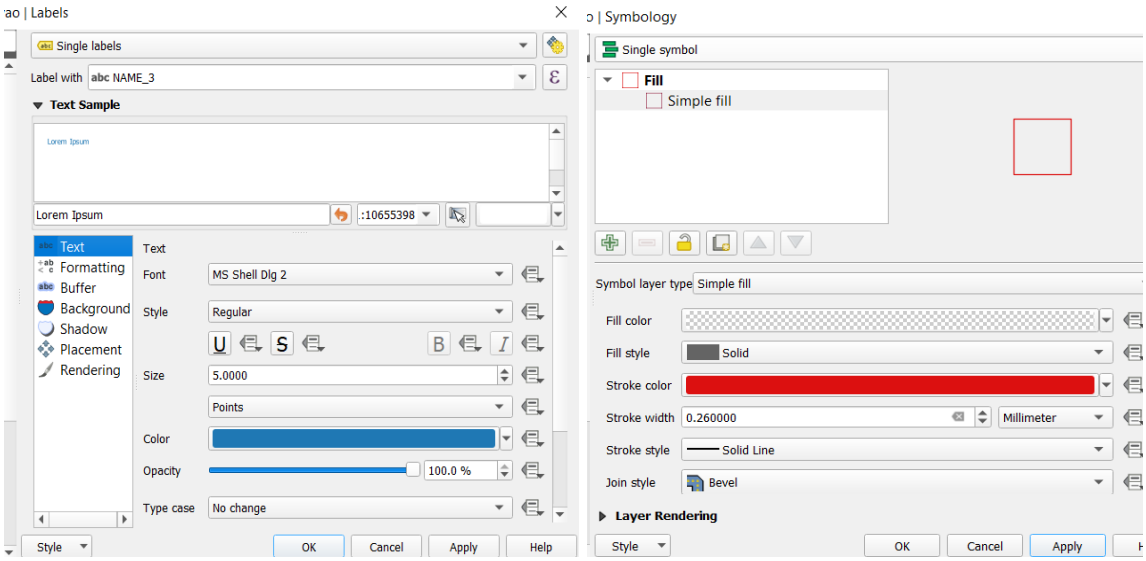
QGIS Screenshot 4: Loading the City Shape Layer



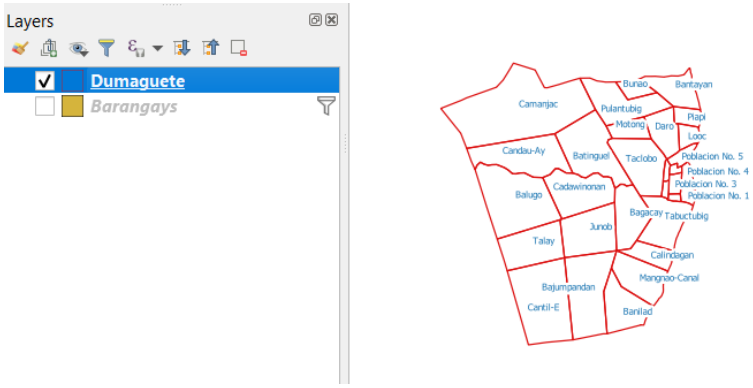
Expected Output: new file CityName.shp (see in project folder), CityName layer in the Layer window and city map (see in QGIS window)

1.9. In the Layers window again, right click on CityName and choose Properties. Set Labels as shown then click APPLY. Set Symbology as shown then click APPLY. Click OK

QGIS Screenshots 5 and 6: Modifying the Labels and Symbology of the City Shape File



QGIS Screenshot 7: City Map (sample output)



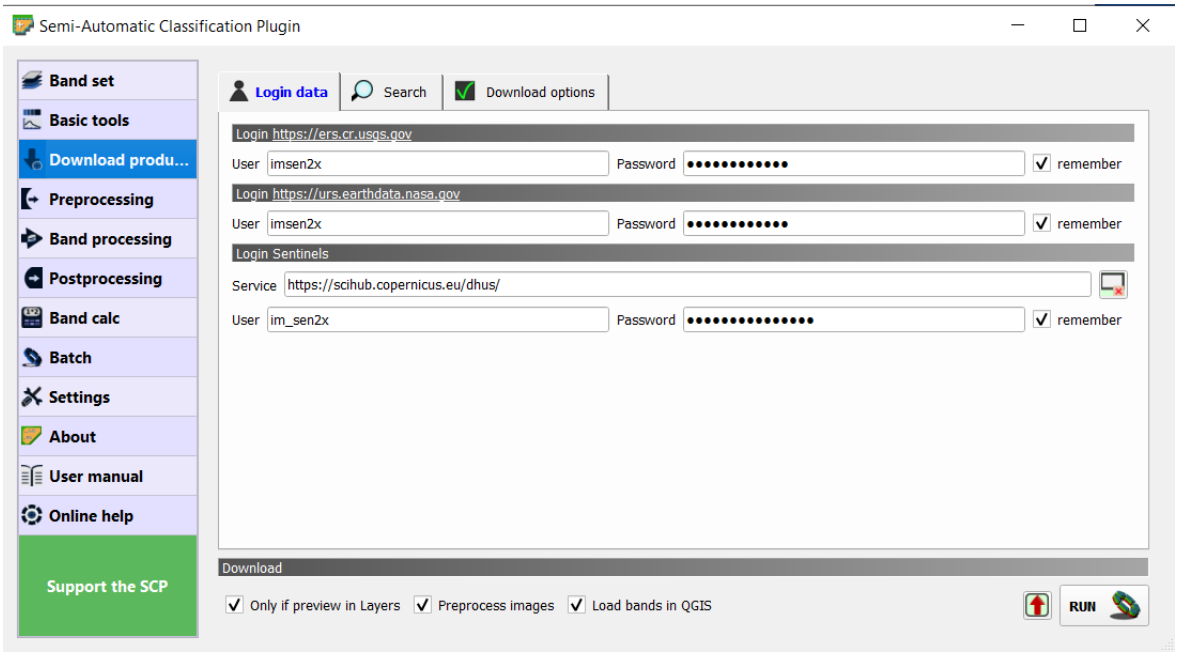
Expected Output: reformatted City map with barangay names (see in QGIS window)

1.10. Save the project by clicking Project > Save (note: you now have a project with city map and layer)

2. Downloading Satellite Images of the City

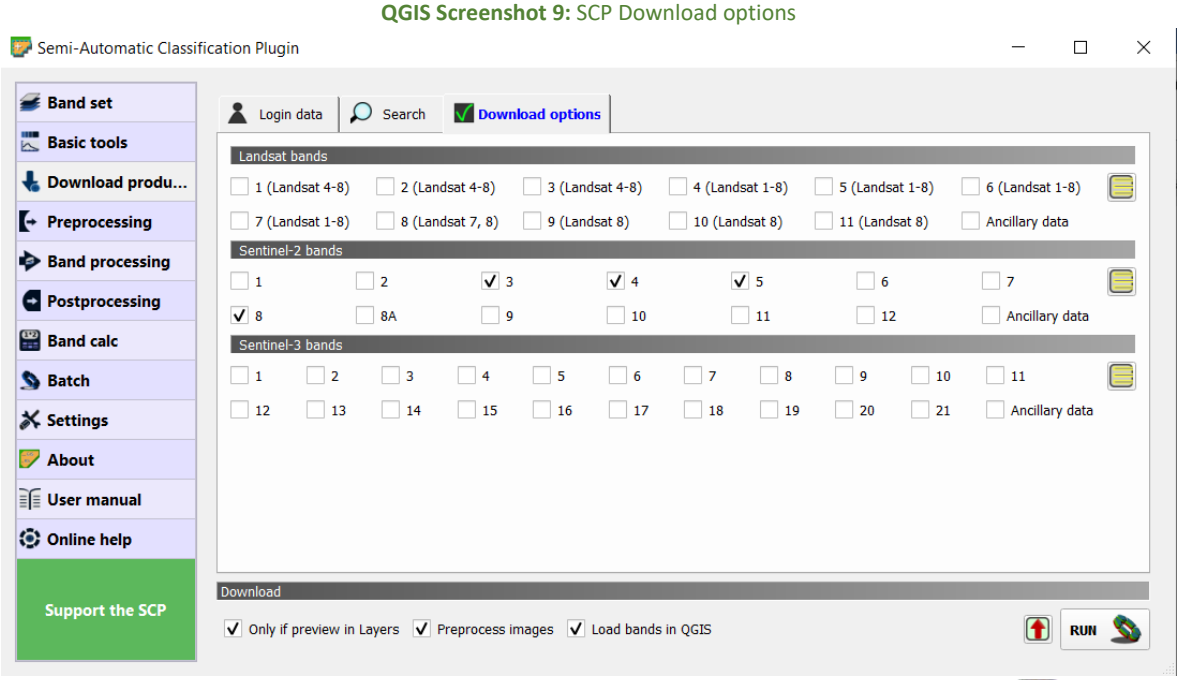
2.1. Click on SCP then Download Products and fill out Login data as shown (note: you should create your Sentinel account in scihub.copernicus.eu before this step). Do not click RUN yet.

QGIS Screenshot 8: SCP Login Data



2.2. Still under SCP > Download products, set Download options as shown (note: only Sentinel-2 bands 3, 4, 5 and 8 should be selected). Do not click RUN yet.

QGIS Screenshot 9: SCP Download options

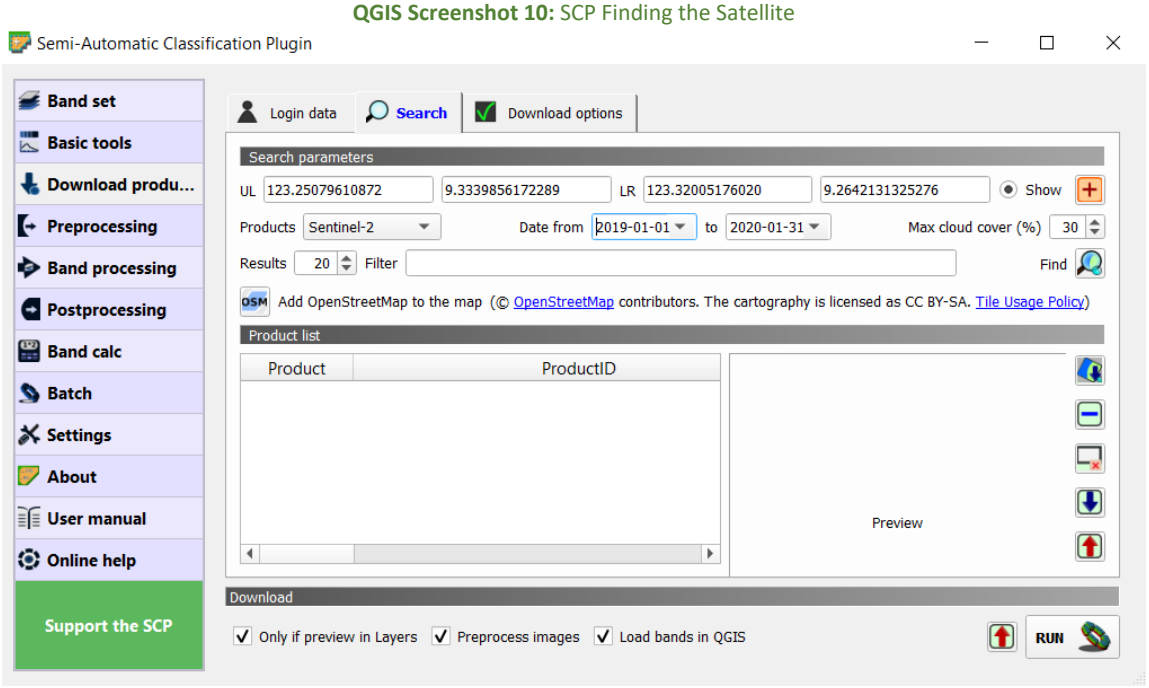


2.3. Still under SCP > Download products, fill out Search as shown and then click FIND . Do not click RUN yet.

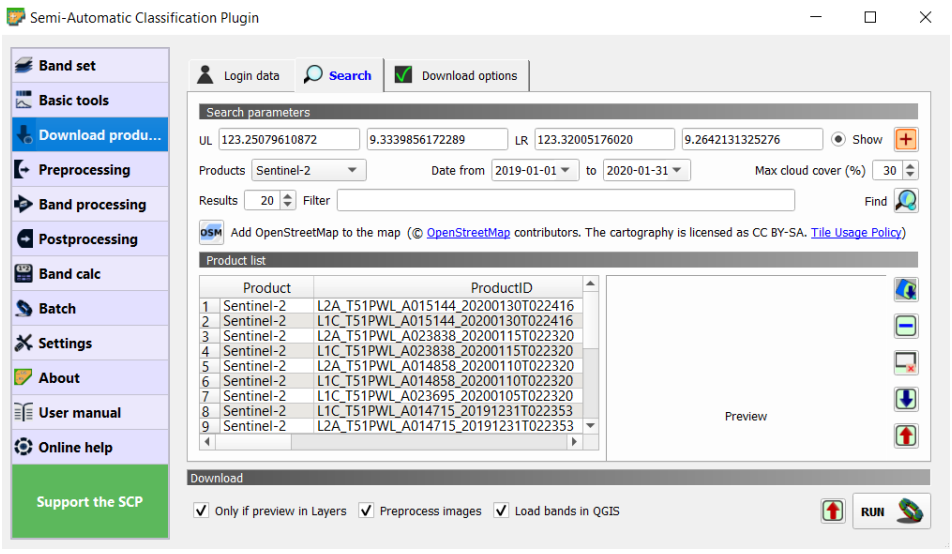
notes:

1. Max cloud cover may be set to 30% - 50% to acquire a good satellite image
2. Date from and To are randomly selected (you may set to start and end of a specific year)
3. UL and LR correspond to the Upper-Left and Lower-Right coordinates [Long, Lat] of the city which may be acquired from maps.google.com OR by clicking the button then clicking a rectangular area in the Map window

QGIS Screenshot 10: SCP Finding the Satellite



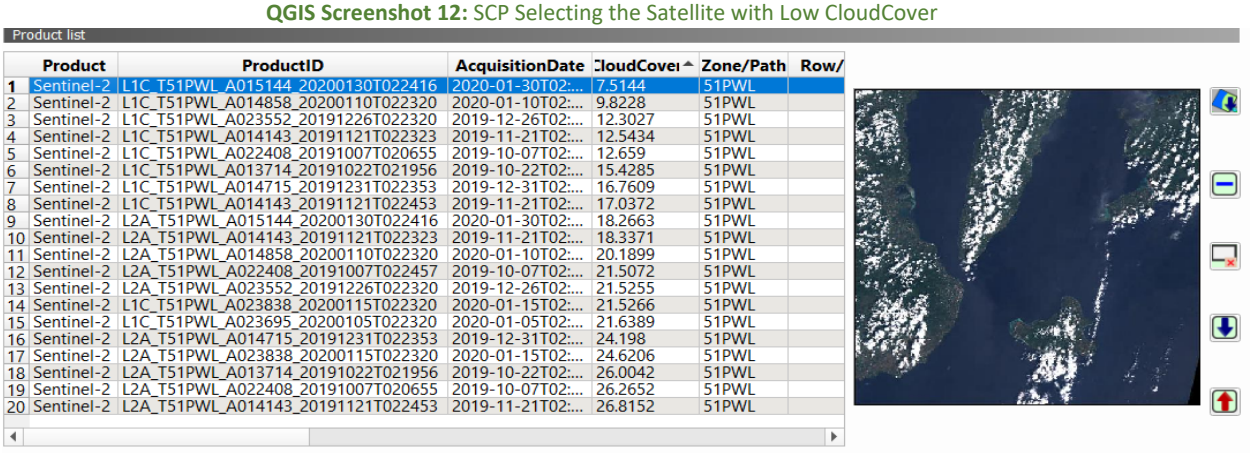
QGIS Screenshot 11: SCP Product List



Expected output: Product list will display satellite data for the specified city and dates

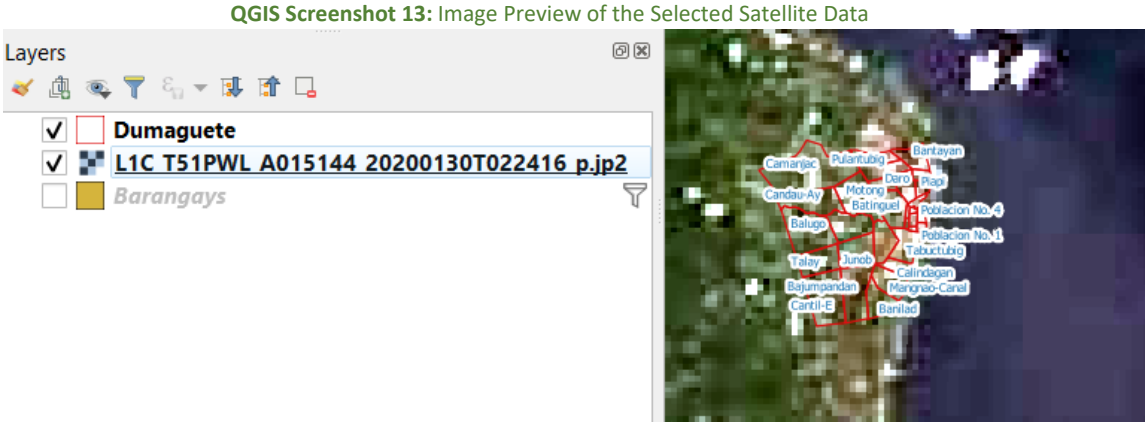
2.4. Look at the Product list, click on the Sentinel-2 Product with low CloudCover. This will load the preview image at the right. (note: you may need to try a few product no. before you can choose the one with the best image).

QGIS Screenshot 12: SCP Selecting the Satellite with Low CloudCover



2.5. Once the best Product has been chosen (highlighted in blue), click  to preview the image in the Main Window

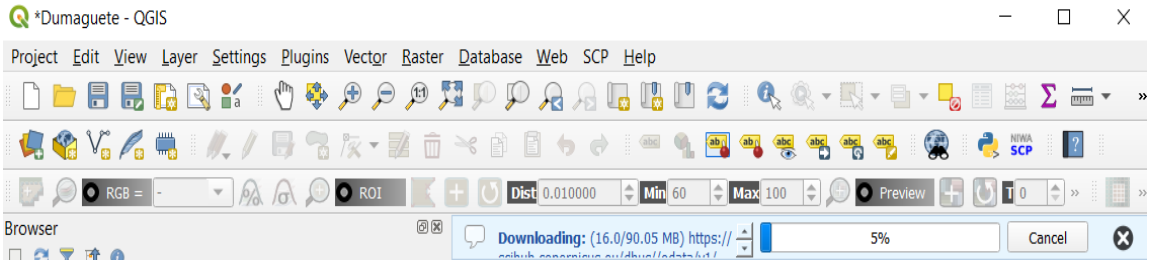
QGIS Screenshot 13: Image Preview of the Selected Satellite Data



Expected output: The blurred image of the city will appear in the Map and the corresponding JP2 will appear in the Layers window

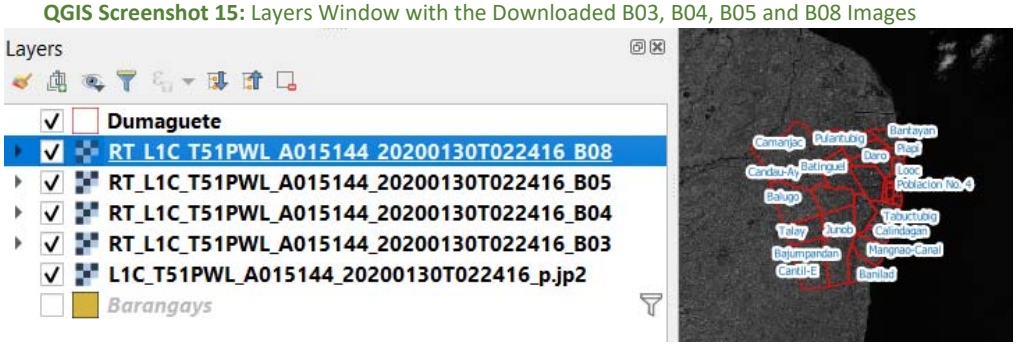
2.6. Go back to SCP > Download products > Search, with **only** the selected Sentinel-2 JP2 appearing in the main window (see previous screenshot), you may now click RUN (note: make sure to remove other image previews [JP2 layers] in the project, as all these data will also be downloaded). Select the Project Folder where to save the images. This will start downloading the satellite images. (note: downloading of satellite images takes around 1 to 2 hours). To check the status of Download, look at the QGIS Main window.

QGIS Screenshot 14: Downloading the Selected Satellite Data



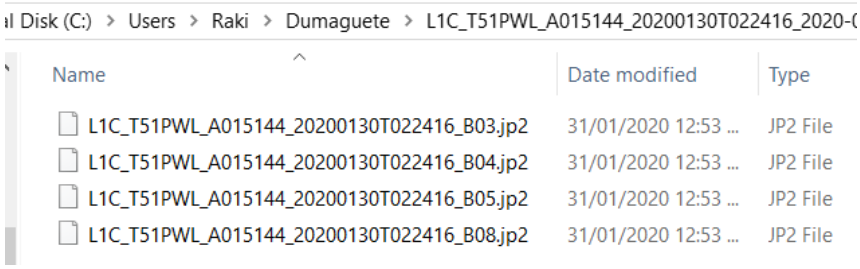
2.7. After completion of download, confirm by checking the Layers window and the Project Folder

QGIS Screenshot 15: Layers Window with the Downloaded B03, B04, B05 and B08 Images



Expected Output: The 4 Sentinel Band images (B03, B04, B05 and B08)

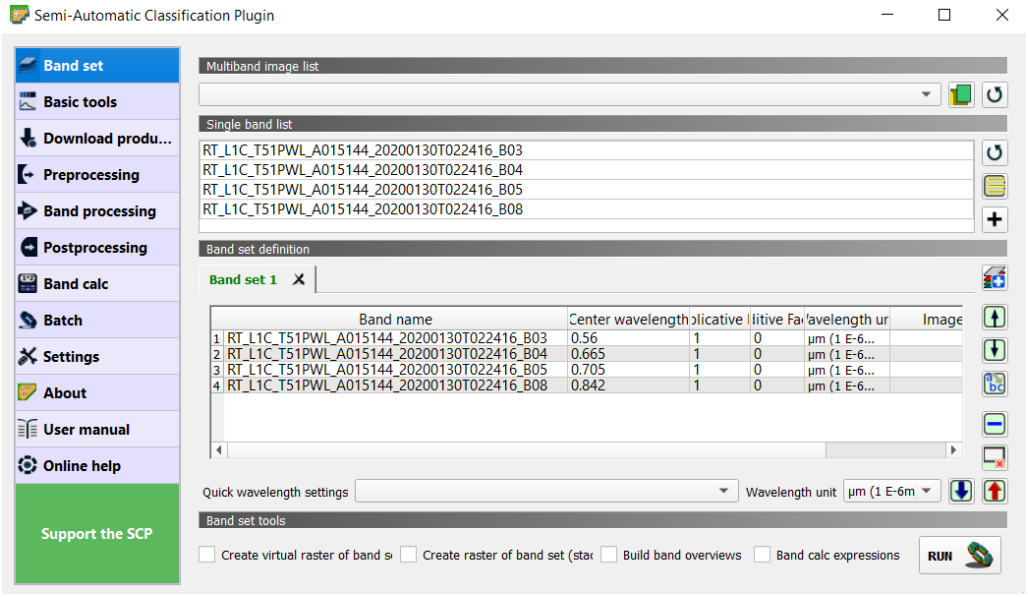
QGIS Screenshot 16: Project Folder with the Downloaded B03, B04, B05 and B08 jp2 Files



Expected Output: These 4 JP2 files are located inside the Project Folder

2.8. Under SCP > Band Set, check that the 4 Bandset images are available. Refresh the window by clicking the ↻ button under Single band list

QGIS Screenshot 17: Updated SCP Band Set



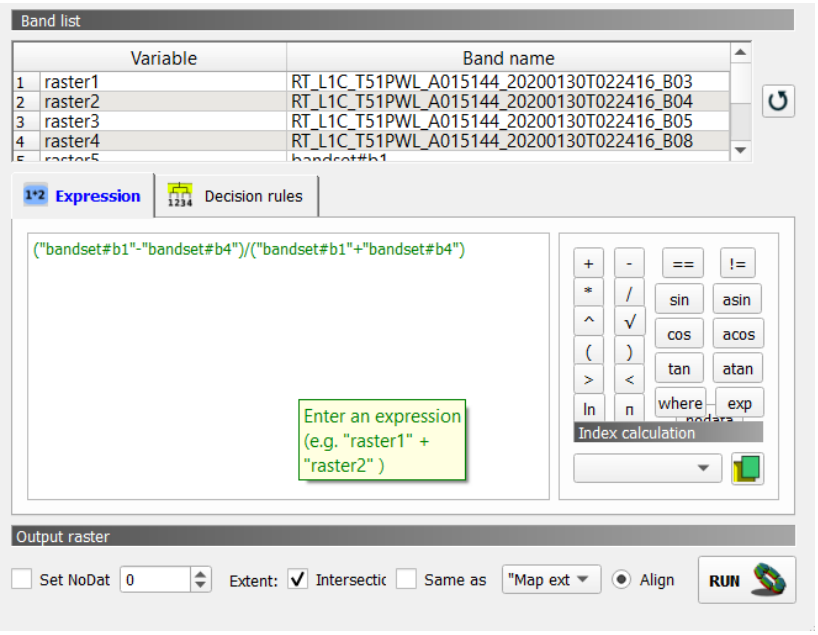
3. Processing the Satellite Images

3.1. Go to SCP > Band calc, click on the Refresh button to update the Band list

3.2. To calculate NDWI, paste the following formula in Expression

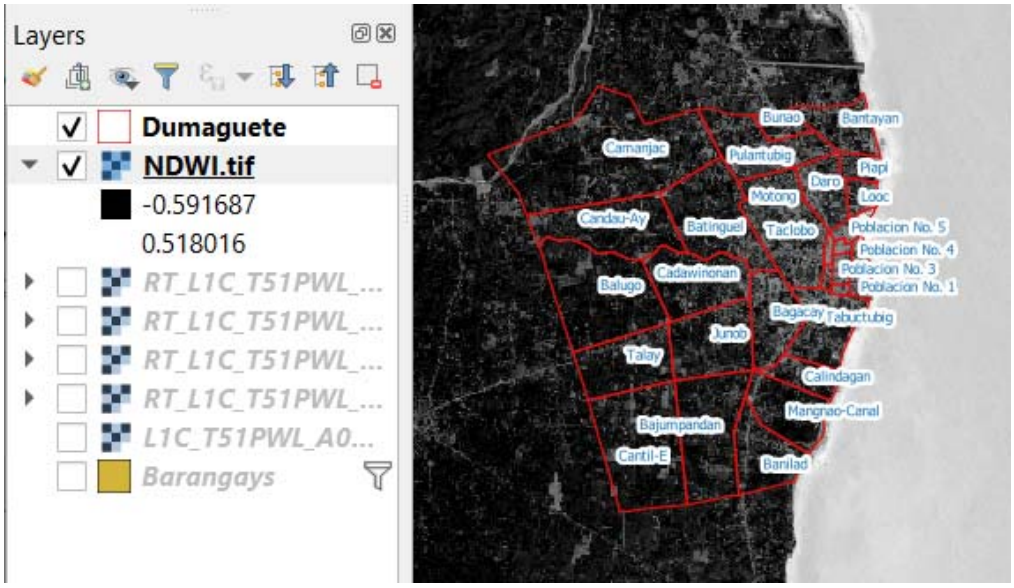
("bandset#b1"-"bandset#b4")/("bandset#b1"+"bandset#b4")

QGIS Screenshot 18: SCP Band calc for NDWI



3.3. Click RUN and Save the Raster output as NDWI.tif

QGIS Screenshot 19: NDWI.tif in Main Window

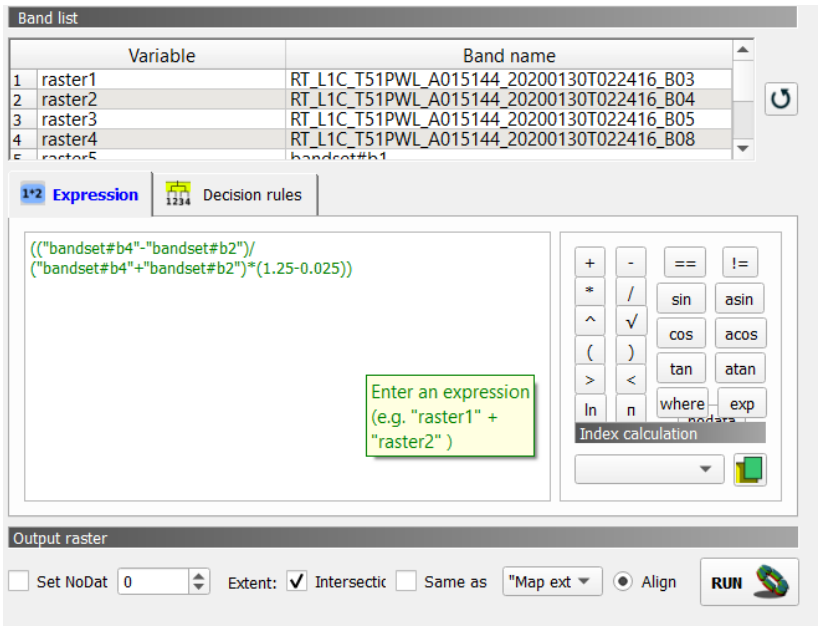


Expected Output: NDWI.tif in Project Folder and NDWI Layer and Image

3.4. After NDWI, calculate FAPAR by typing the following formula in Expression (still under SCP > Band calc)

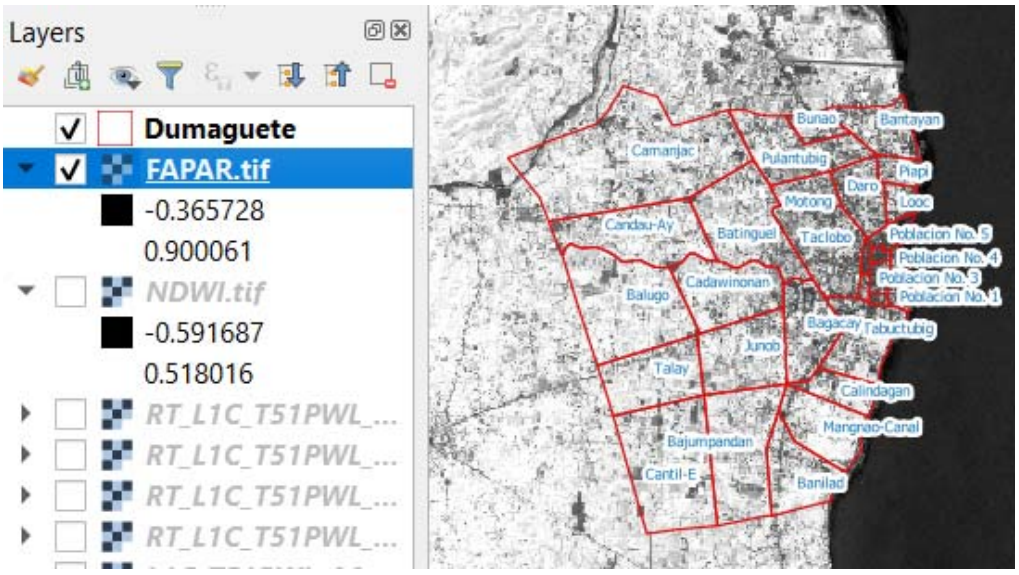
(("bandset#b4"-"bandset#b2")/("bandset#b4"+"bandset#b2")*(1.25-0.025))

QGIS Screenshot 20: SCP Band calc for FAPAR



3.5. Click RUN and Save the Raster output as FAPAR.tif

QGIS Screenshot 21: FAPAR.tif in Main Window

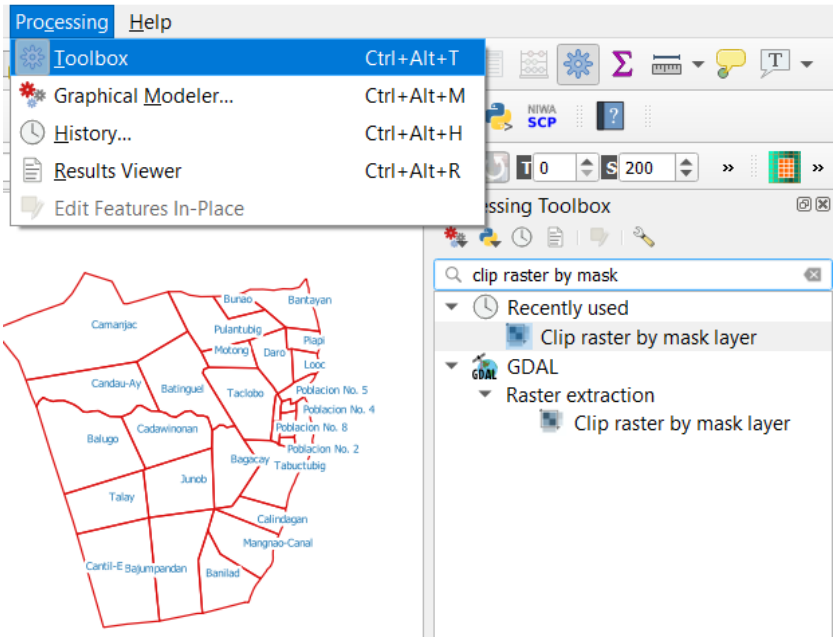


Expected Output: FAPAR.tif in Project Folder and FAPAR Layer and Image

3.6. Click on Project > Save. (note: it is advisable to save the project every time a new data or image is generated)

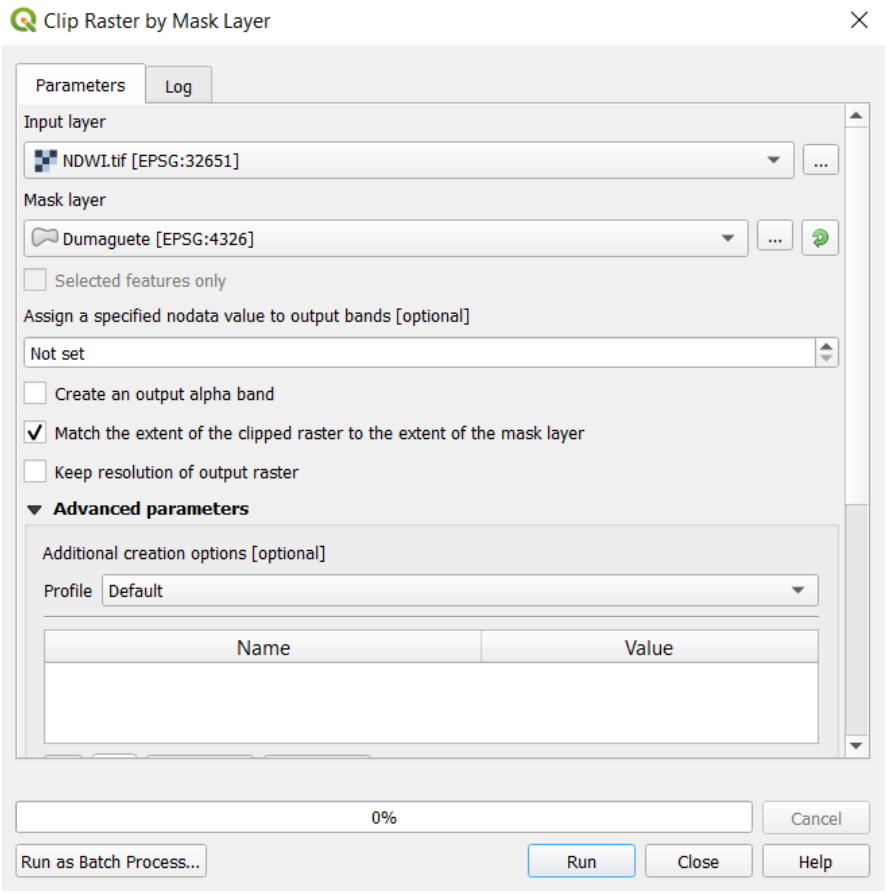
3.7. Click on Processing > Toolbox, search for and click "Clip raster by mask layer"

QGIS Screenshot 22: Searching for Clip Raster by Mask Layer



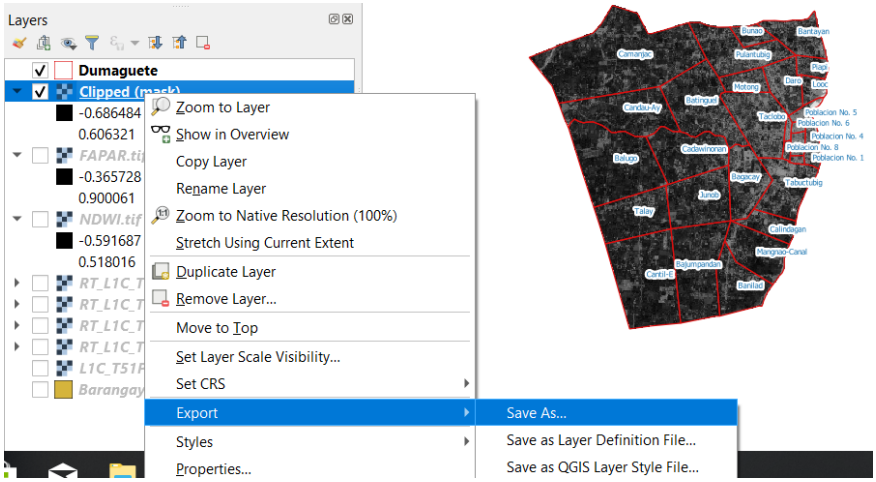
3.8. Under Clip Raster by Mask Layer, set the Parameters as shown and click RUN.

QGIS Screenshot 23: Generating NDWI_clipped Image

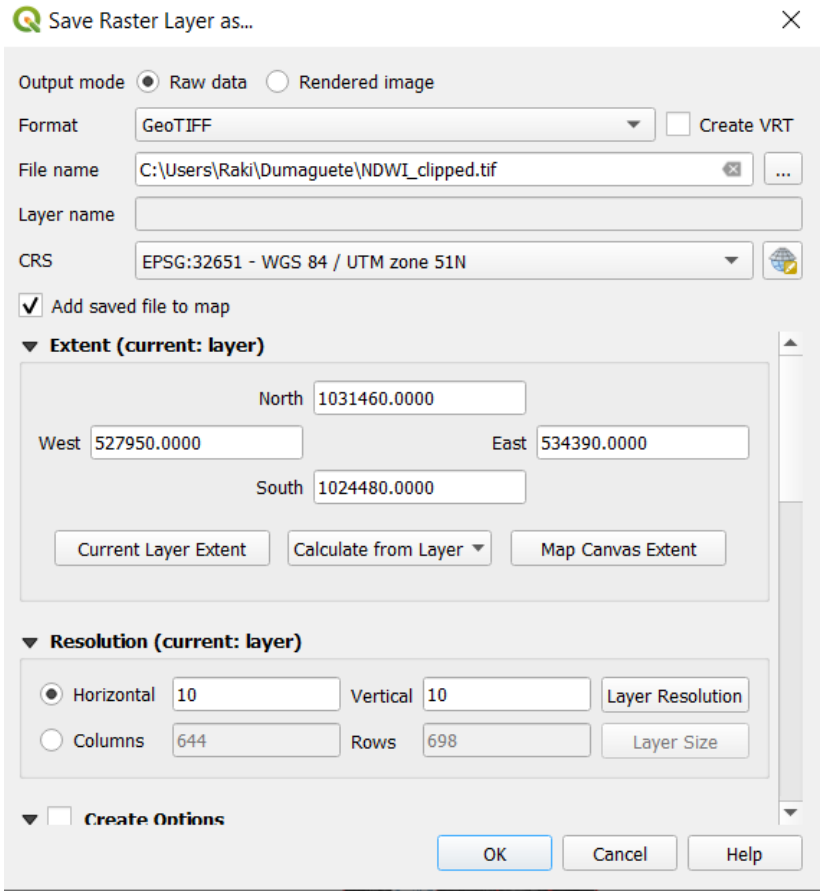


3.9. Check the Layers window, right click on Clipped (mask), then Export > Save As. This will open the Save Raster Layer window. Save as NDWI_clipped.tif, click OK.

QGIS Screenshot 24: Exporting the Clipped Mask

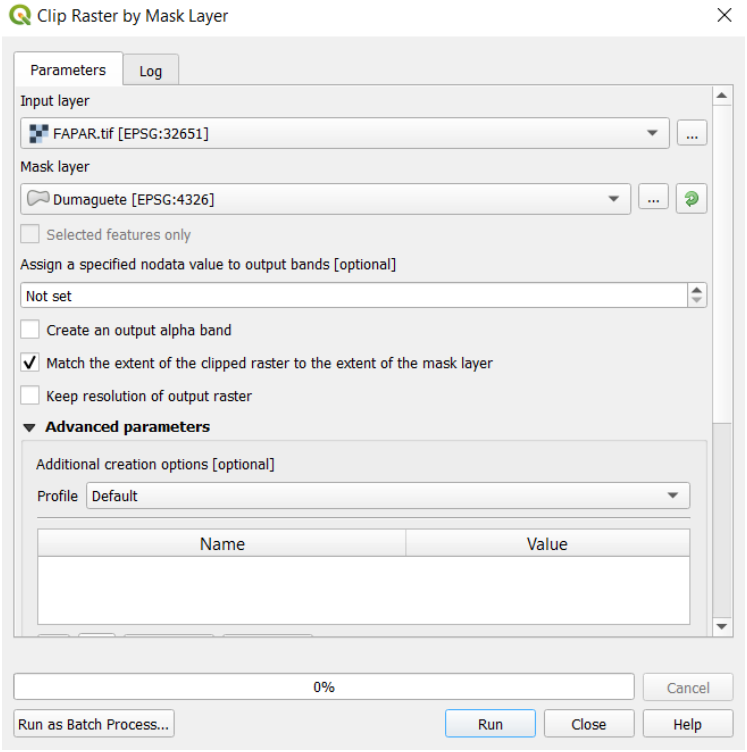


QGIS Screenshot 25: Saving the NDWI_clipped Image



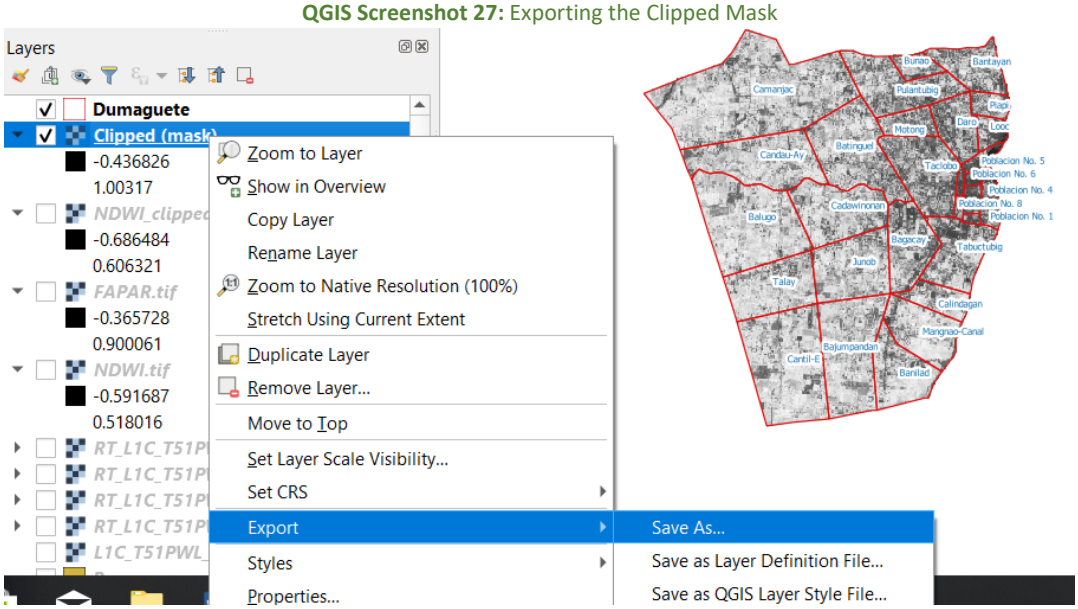
3.10. Do the same for FAPAR. Under Clip Raster by Mask Layer, set the Parameters as shown and click RUN.

QGIS Screenshot 26: Generating FAPAR_clipped Image

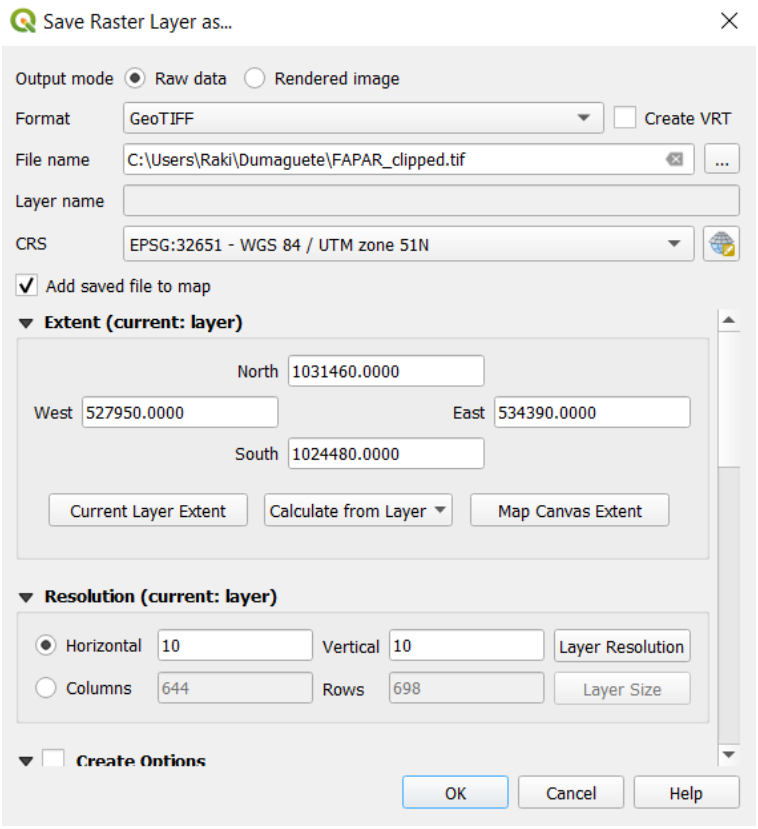


3.11. Check the Layers window, right click on Clipped (mask), then Export > Save As. This will open the Save Raster Layer window. Save as FAPAR_clipped.tif, click OK.

QGIS Screenshot 27: Exporting the Clipped Mask



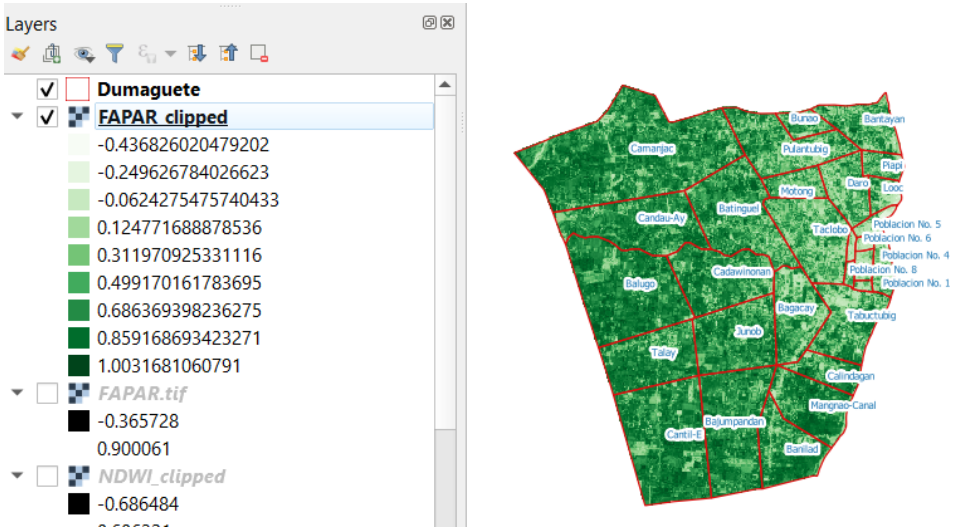
QGIS Screenshot 28: Saving the FAPAR_clipped Image



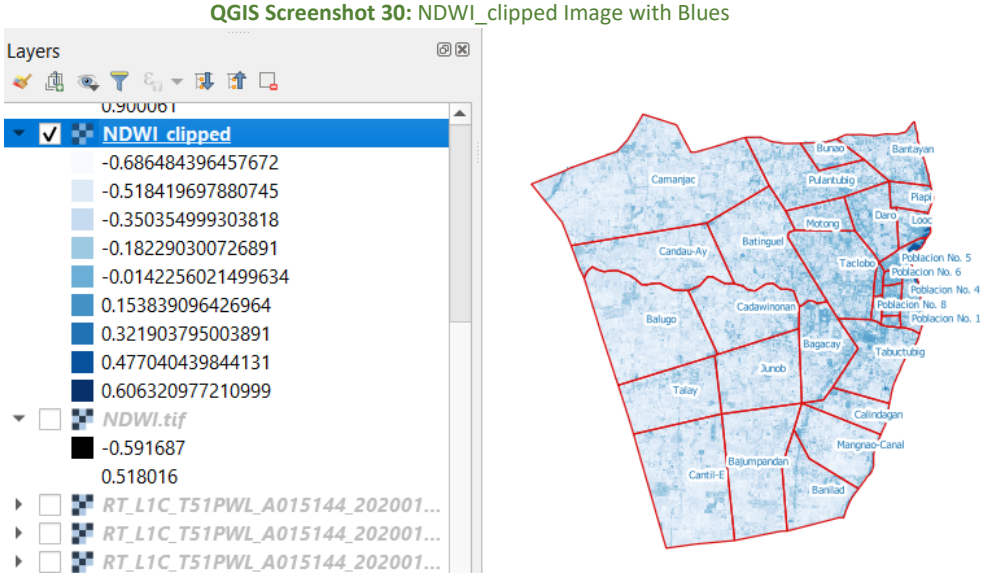
3.12. **Save** the project.

3.13. View the generated NDWI and FAPAR clipped images. Right click on NDWI_clipped or FAPAR_clipped > Properties, go to Symbology. Change the Render type to Singleband Pseudocolor. Under color ramp, choose Blues for NDWI and Greens for FAPAR. Click APPLY and OK. See sample images below.

QGIS Screenshot 29: FAPAR_clipped Image with Greens



QGIS Screenshot 30: NDWI_clipped Image with Blues

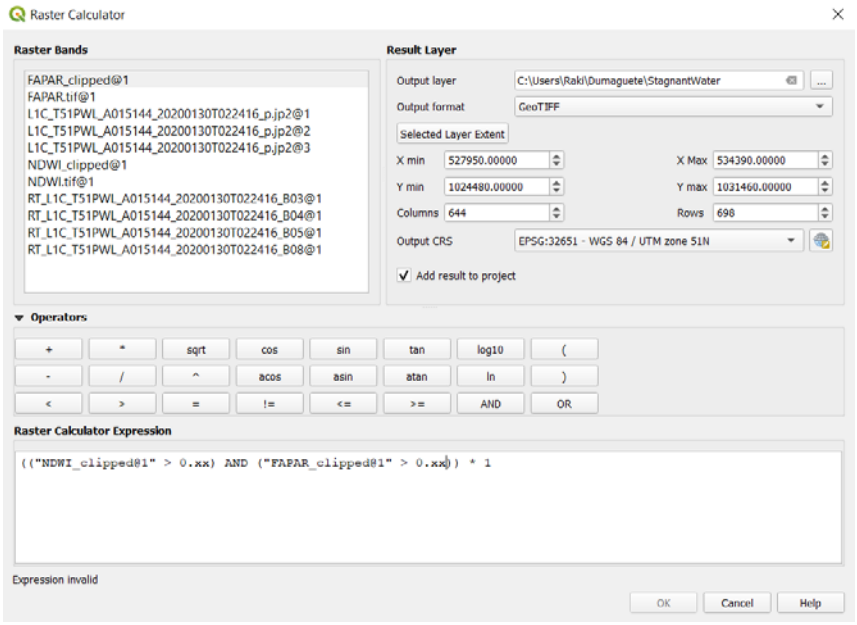


3.14. Compute for the Stagnant Water. Click on Raster then Raster Calculator. Type the following formula in the Raster Calculator Expression (click OK and save the file as StagnantWater.tif):

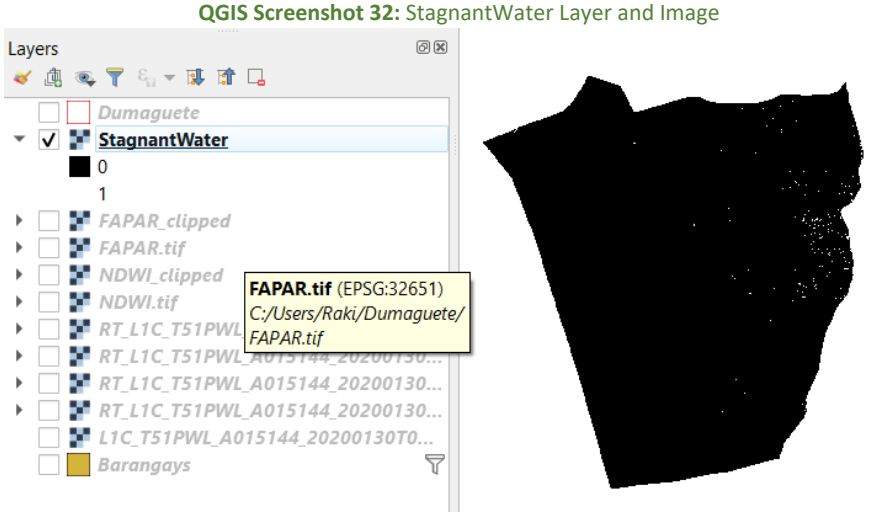
(("NDWI_clipped@1" > 0.xx) AND ("FAPAR_clipped@1" > 0.xx)) * 1

where 0.xx is variable depending on the FAPAR/NDWI values (note: you may set to 0.10 by default)

QGIS Screenshot 31: Computing and Generating StagnantWater Image



QGIS Screenshot 32: StagnantWater Layer and Image

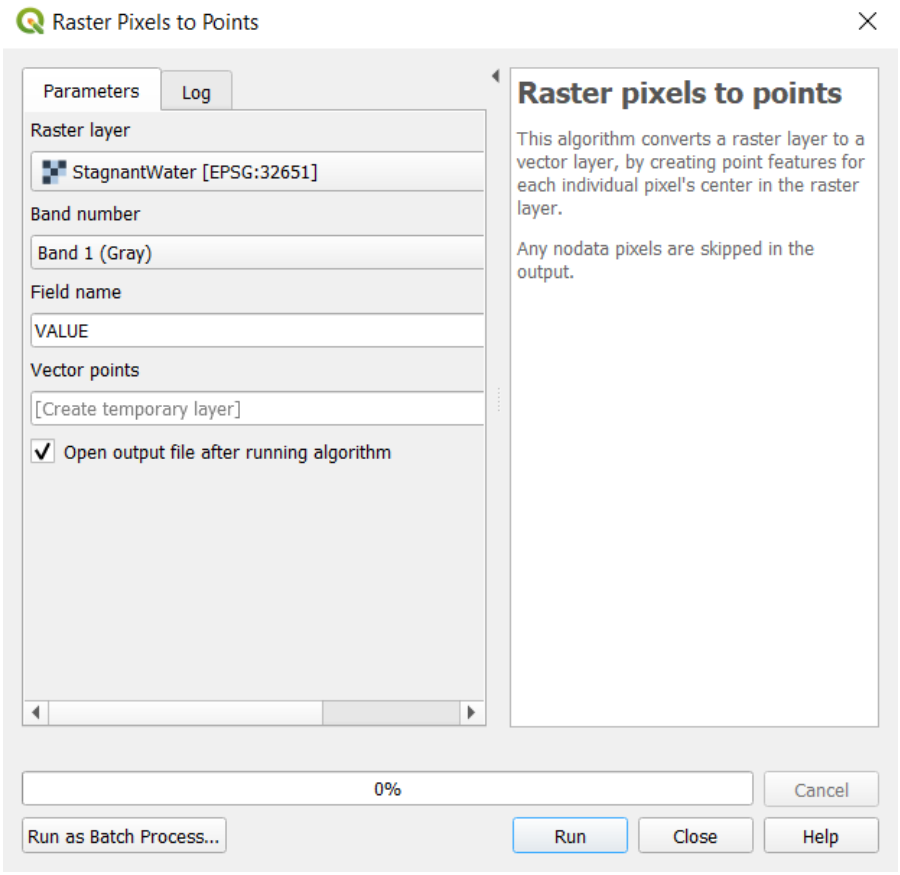


Expected Output: StagnantWater.tif in Project Folder and StagnantWater Layer and Image

4. Generating the Output Table

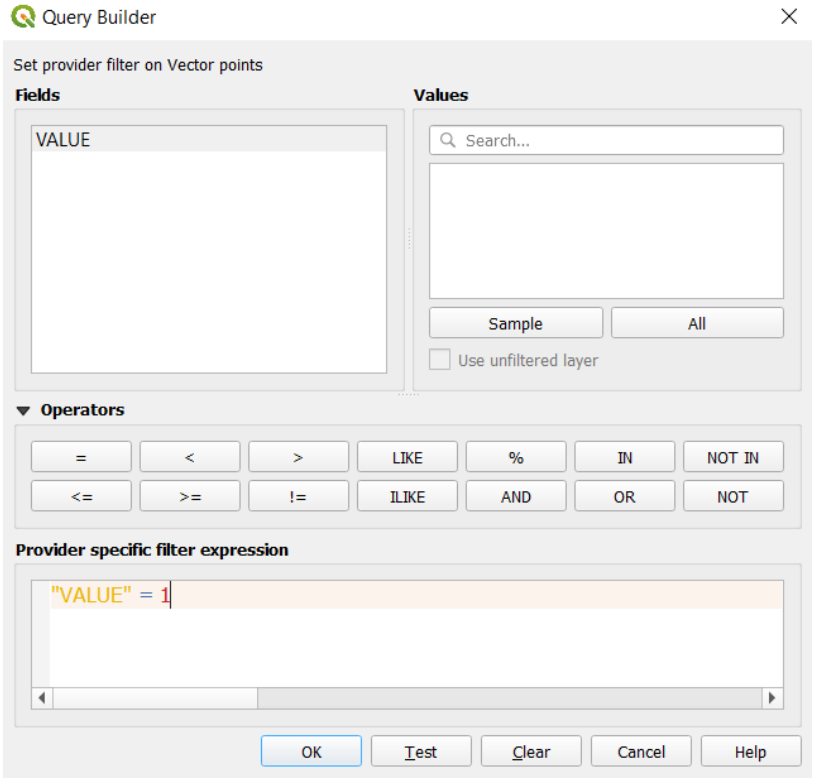
4.1. Under Processing > Toolbox, click Raster pixels to points to convert StagnantWater.tif to Vector points. Click RUN

QGIS Screenshot 33: Converting StagnantWater Image to Vector Points



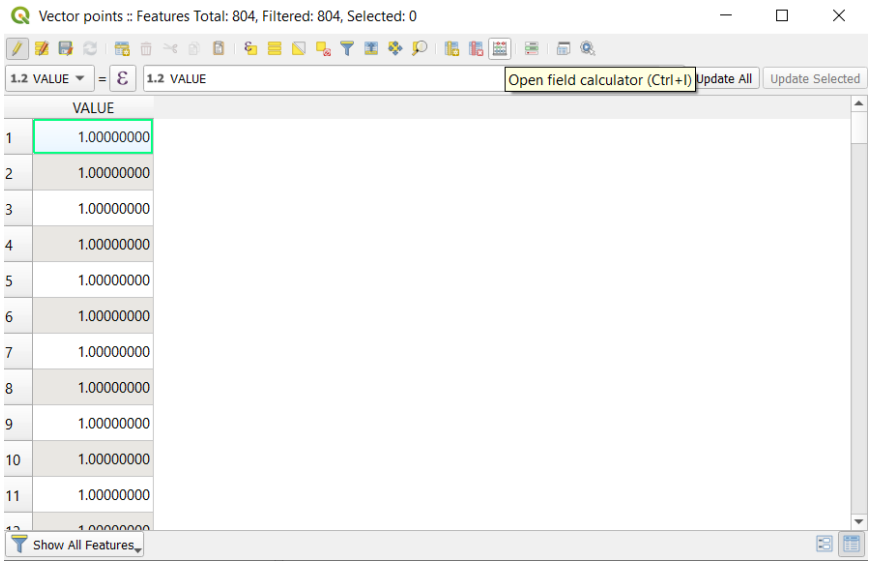
4.2. In the Layer window, right click on the generated Vector points, select Properties > Source. Click Query Builder and set as shown ("VALUE" = 1). This will filter the Stagnant Water points when generating the table (note: without filtering, the output table will include even the zero values which will make the processing very slow). Click TEST and OK.

QGIS Screenshot 34: Filtering the StagnantWater Points



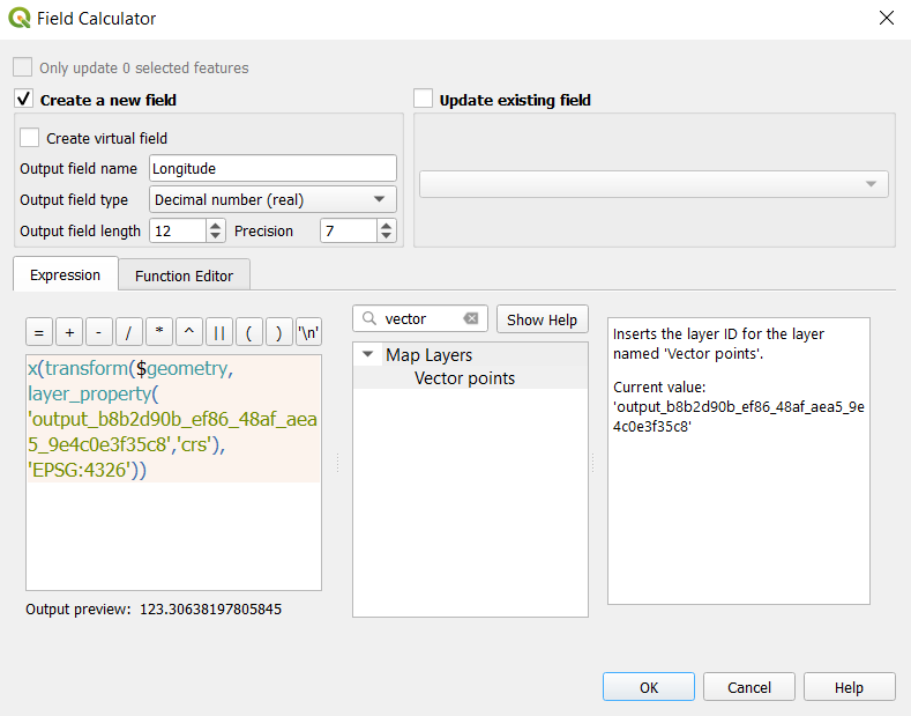
4.3. Back in the Layer window, right click on the Vector points, select Toggle Editing. Right click on the Vector points again, select Open Attribute Table. Click the Open Field Calculator button 

QGIS Screenshot 35: Vector points Attribute Table



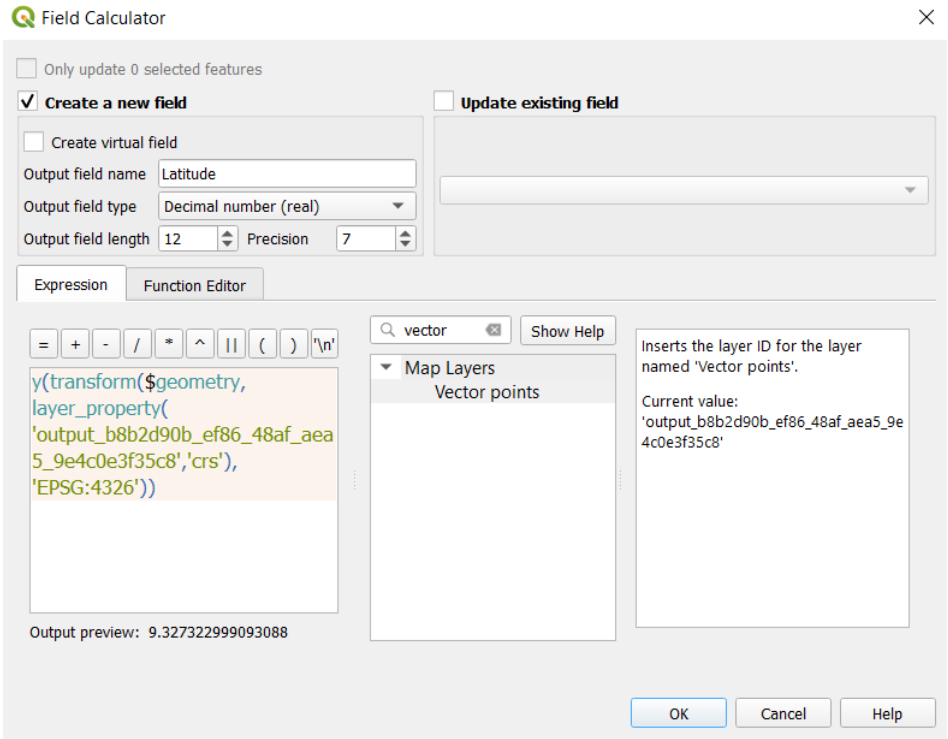
4.4. Fill out the Field Calculator as shown to add the Longitude field. Click OK.

QGIS Screenshot 36: Adding the Longitude Field to the Vector Points



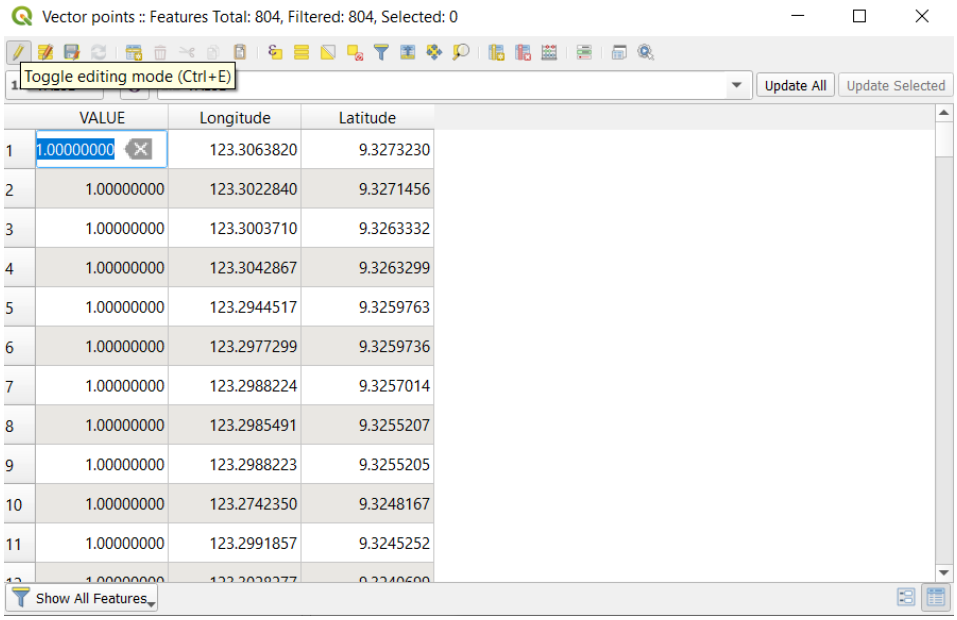
4.5. Repeat for the Latitude field. Fill out the Field Calculator as shown then click OK.

QGIS Screenshot 37: Adding the Latitude Field to the Vector Points



4.6. View the updated Vector points table and click the Toggle editing mode. Click SAVE.

QGIS Screenshot 38: Updated Vector points Attribute Table

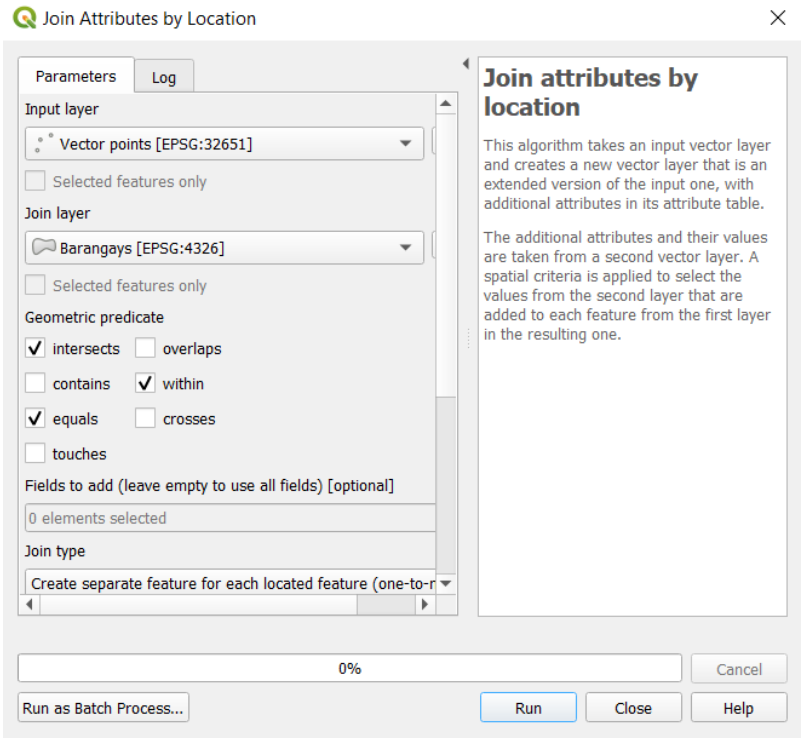


	VALUE	Longitude	Latitude
1	1.00000000	123.3063820	9.3273230
2	1.00000000	123.3022840	9.3271456
3	1.00000000	123.3003710	9.3263332
4	1.00000000	123.3042867	9.3263299
5	1.00000000	123.2944517	9.3259763
6	1.00000000	123.2977299	9.3259736
7	1.00000000	123.2988224	9.3257014
8	1.00000000	123.2985491	9.3255207
9	1.00000000	123.2988223	9.3255205
10	1.00000000	123.2742350	9.3248167
11	1.00000000	123.2991857	9.3245252

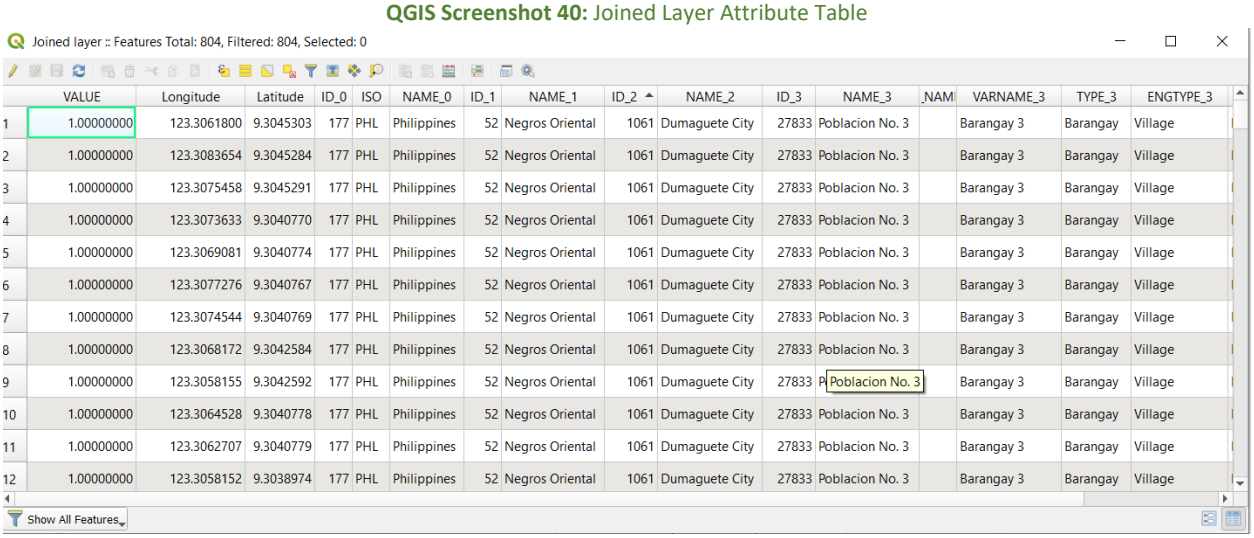
Expected Output: Vector Points with Longitude and Latitude Fields (GPS Coordinates)

4.7. Under Processing > Toolbox, click Join attributes by location and set as shown. Click RUN. This will generate the Joined layer (in the Layer window, right click on Joined Layer > Open Attribute Table – see below).

QGIS Screenshot 39: Join Attributes by Location



QGIS Screenshot 40: Joined Layer Attribute Table

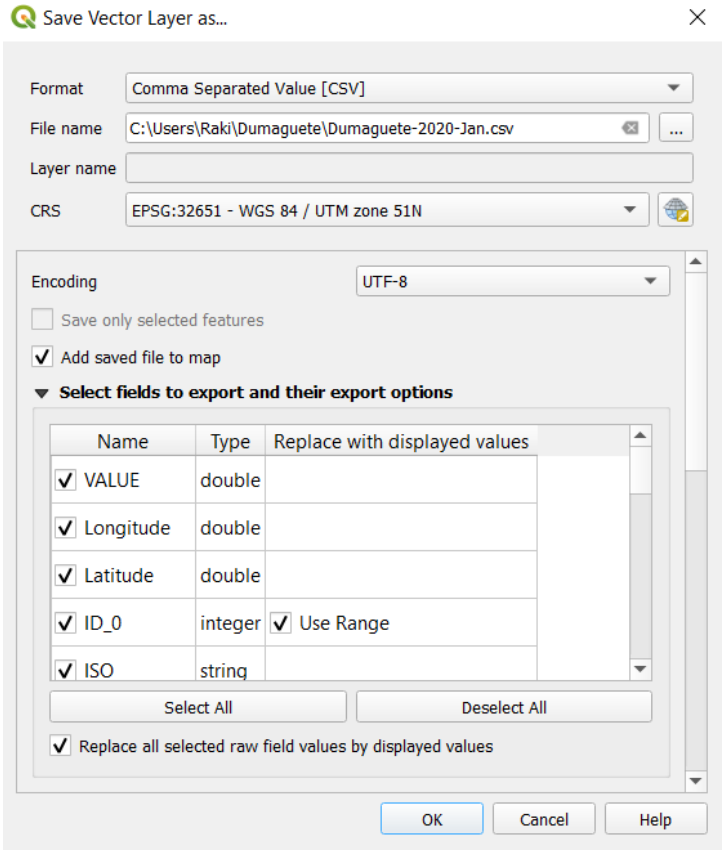


	VALUE	Longitude	Latitude	ID_0	ISO	NAME_0	ID_1	NAME_1	ID_2	NAME_2	ID_3	NAME_3	NAM	VARNAME_3	TYPE_3	ENGTYPE_3
1	1.00000000	123.3061800	9.3045303	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
2	1.00000000	123.3083654	9.3045284	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
3	1.00000000	123.3075458	9.3045291	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
4	1.00000000	123.3073633	9.3040770	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
5	1.00000000	123.3069081	9.3040774	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
6	1.00000000	123.3077276	9.3040767	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
7	1.00000000	123.3074544	9.3040769	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
8	1.00000000	123.3068172	9.3042584	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
9	1.00000000	123.3058155	9.3042592	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
10	1.00000000	123.3064528	9.3040778	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
11	1.00000000	123.3062707	9.3040779	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village
12	1.00000000	123.3058152	9.3038974	177	PHL	Philippines	52	Negros Oriental	1061	Dumaguete City	27833	Poblacion No. 3		Barangay 3	Barangay	Village

Expected Output: Joined Layer with GPS Coordinates and Barangay Fields

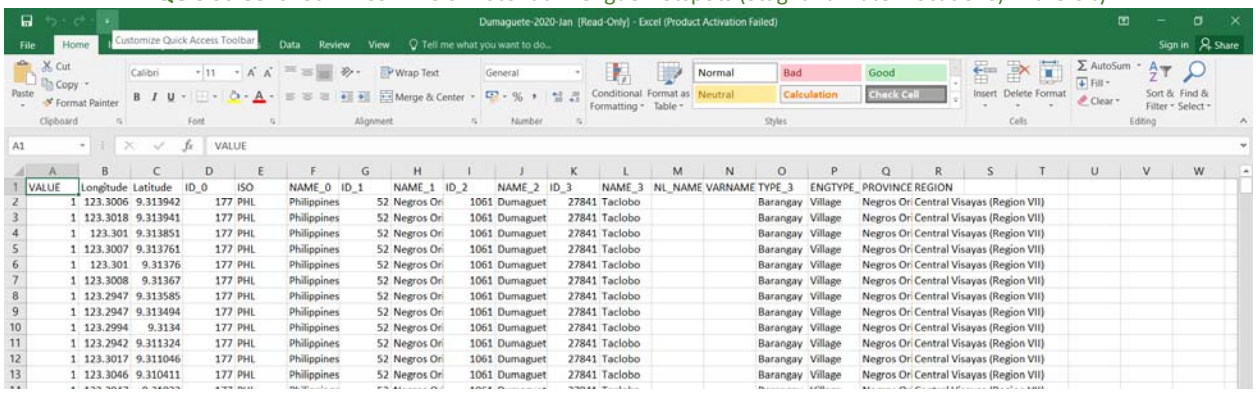
4.8. In the Layer window, right click on the generated Joined layer. Select Export > Save Features As and fill out as shown to save the Joined layer as CSV File. Click OK.

QGIS Screenshot 41: Saving/Exporting the Joined Layer as CSV File



4.9. The generated CSV file can be opened using Excel

QGIS Screenshot 42: CSV File of Potential Dengue Hotspots (Stagnant Water Locations) in the City

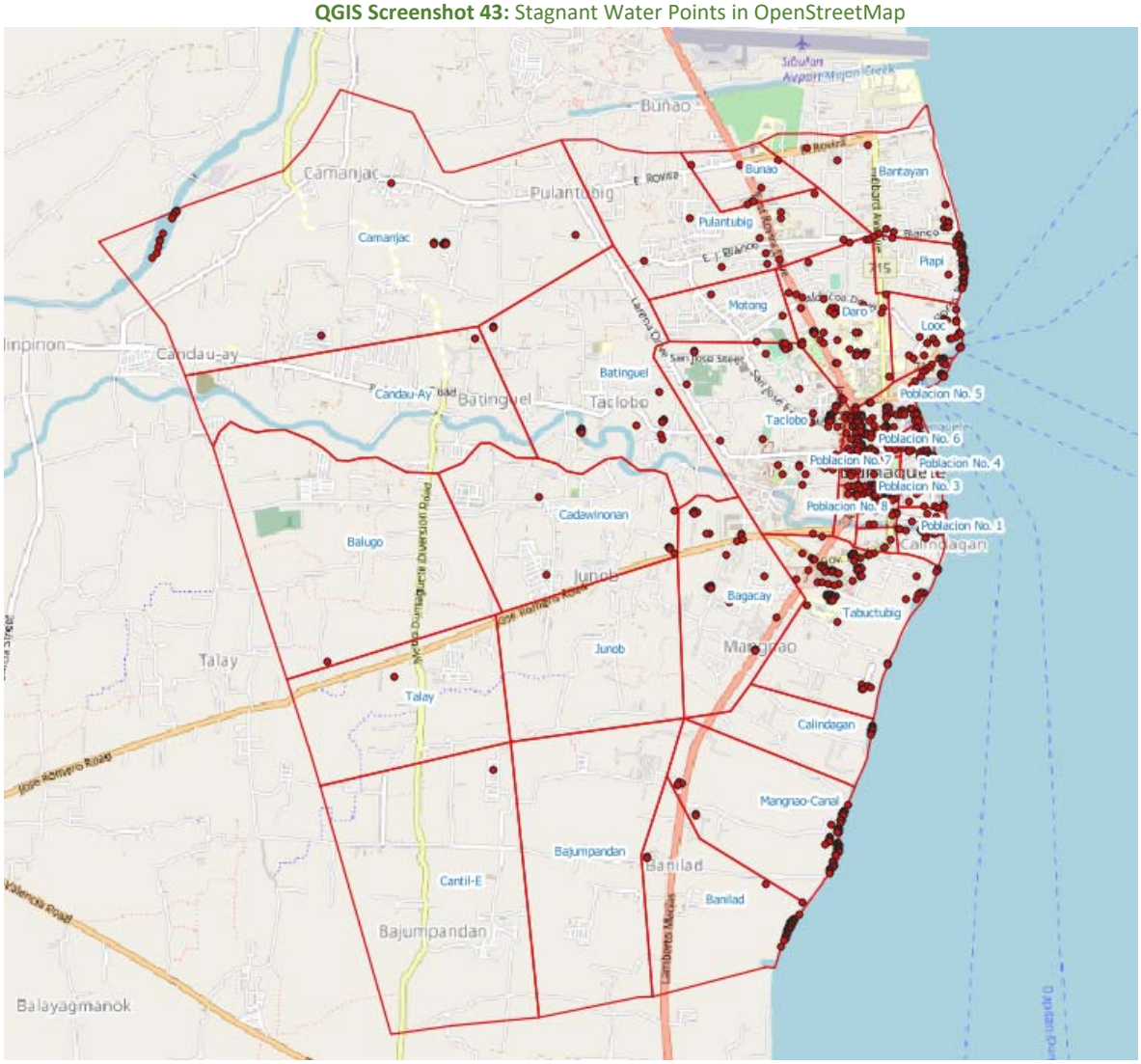


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	VALUE	Longitude	Latitude	ID_0	ISO	NAME_0	ID_1	NAME_1	ID_2	NAME_2	ID_3	NAME_3	NL_NAME	VARNAME	TYPE_3	ENGTYPE_	PROVINCE	REGION
2	1	123.3006	9.313942	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
3	1	123.3018	9.313941	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
4	1	123.301	9.313851	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
5	1	123.3007	9.313761	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
6	1	123.301	9.31376	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
7	1	123.3008	9.31367	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
8	1	123.2947	9.313585	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
9	1	123.2947	9.313494	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
10	1	123.2994	9.3134	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
11	1	123.2942	9.311324	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
12	1	123.3017	9.311046	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)
13	1	123.3046	9.310411	177	PHL	Philippines	52	Negros Ori	1061	Dumaguet	27841	Taclobo			Barangay	Village	Negros Or	Central Visayas (Region VII)

Expected Output: CSV File with Long, Lat and Barangay Fields

4.10. The CSV File output corresponds to the stagnant water locations (or potential Dengue hotspots) as shown below. These are the red dots when viewed using the OpenStreetMap.

QGIS Screenshot 43: Stagnant Water Points in OpenStreetMap



Common issues encountered:

- City requires more than 1 satellite image to cover the whole area (ex. Davao) – download all relevant images to cover the entire city then use Merge Layers; update bandset 1 with the merged B03, B04, B05 and B08 to use in computing FAPAR and NDWI
- Clicking FIND in SCP won't initiate the search for new satellite – make sure that product list is empty prior to clicking FIND by clicking on button to delete/reset the list
- Clicking RUN in SCP won't initiate the download – make sure to preview the selected satellite before clicking RUN by clicking to preview the image and add the JP2 layer to the project
- Stagnant water results to all zero values – decrease threshold values (0.xx in the formula) of FAPAR and NDWI for stagnant water computation (with the lowest possible threshold as 0.0 for both)
- Too many stagnant water locations detected - increase threshold values (0.xx in the formula) of FAPAR and NDWI for stagnant water computation
- StagnantWater.tif takes a very long time to generate and results to a big file (same size as NDWI and FAPAR) – make sure that NDWI_clipped and FAPAR_clipped are chosen in the expression; delete old StagnantWater.tif prior to re-computing

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Revision History

- **Ver1.0: 01.31.2020** – Dumaguete used as sample city for Jan 30, 2020 satellite image (rdgarcia)
- **Ver2.0: 02.02.2020** – Added issue re: downloading due to multiple image previews; added common issues (rdgarcia)