

## GIS TUTORIAL 5: Agriculture and NDVI with GEE

In this tutorial we will use Google Earth Engine to explore agricultural landscapes over time using the Normalized Difference Vegetation Index (NDVI). The script that we will be using will highlight areas with dense vegetation by calculating new values from the red and near infrared bands of Sentinel-2 and Landsat-5 imagery.

### 1 A Simple Sentinel-2 NDVI Script (video tutorial playlist)

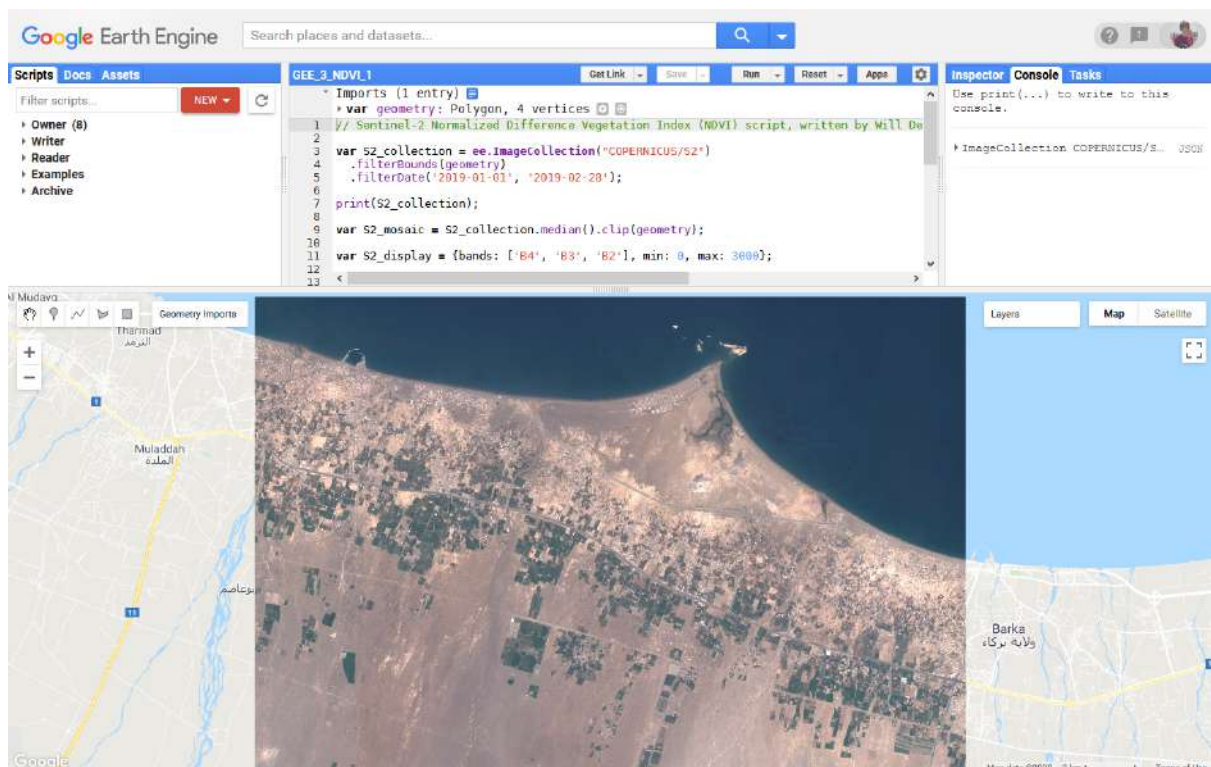
This section will introduce the concept of the Normalized Difference Vegetation Index (NDVI) and run through a simple NDVI script using Sentinel-2 imagery.

#### 1.1 Sentinel-2 bands and agriculture (video tutorial)

Agricultural areas, or any dense vegetation cover, appear very differently in satellite imagery depending on the band.

- Click here to open the simplest version of the script in your web browser <https://code.earthengine.google.com/3559a67f8075442893863334097fff35>

Some Sentinel-2 imagery of Oman will start to load.



Have a look at the script.

```

GEE_3_NDVI_1
Imports (1 entry)
  var geometry: Polygon, 4 vertices
1 // Sentinel-2 Normalized Difference Vegetation Index (NDVI) script, written by Will Deadman (william.m.deadman@gmail.com)
2
3 var S2_collection = ee.ImageCollection("COPERNICUS/S2")
4   .filterBounds(geometry)
5   .filterDate('2019-01-01', '2019-02-28');
6
7 print(S2_collection);
8
9 var S2_mosaic = S2_collection.median().clip(geometry);
10
11 var S2_display = {bands: ['B4', 'B3', 'B2'], min: 0, max: 3000};
12
13 Map.addLayer(S2_mosaic, S2_display, "S2_Imagery");
14
15 // selecting and displaying the composite's red band
16
17 var red = S2_mosaic.select('B4');
18
19 Map.addLayer(red, {min: 0, max: 3000}, "S2_Red", false);
20
21 // selecting and displaying the composite's infra-red band
22
23 var IR = S2_mosaic.select('B8');
24
25 Map.addLayer(IR, {min: 0, max: 3000}, "S2_IR", false);
26
27 Map.centerObject(geometry);
28

```

- Lines 3-5 add a Sentinel-2 based on the geometry of our study area and the given date range
- Line 13 adds a median-pixel composite to the Map Window.
- Lines 17 and 23 select just the red and near infra-red bands from this composite
- Lines 19 and 25 add them to the Map Window.

Turn on the “S2\_Red” imagery in the Layers Panel



You will notice that the agricultural areas are dark – this is because plants absorb red light during photosynthesis, so it is not reflected and picked up by the satellite. The sea also absorbs it.

- Turn on the “S2\_IR” imagery in the Layers Panel



You will see that the agricultural areas are very white, while in comparison the sea is very dark. This is because healthy plants reflect near-infrared light while water absorbs it.

- Turn on and delete the red rectangle, redraw it in your area of interest, and run the script to compare the two bands in agricultural and non-agricultural areas.

## 1.2 Simple NDVI script (video tutorial)

We can use the unique way in which vegetation reacts to different wavelengths of light to map agricultural areas. The Normalized Difference Vegetation Index is a great way of doing this. It is a simple equation:

$$NDVI = (NIR - Red) / (NIR + Red)$$

NDVI values range between 1 (very lush vegetation) to -1 (water), with values around 0 corresponding to rock or earth.

- Open the next version of the script  
<https://code.earthengine.google.com/9c4fff2f64794ebd81009725afa36b26>

Sentinel-2 imagery of the same area of northern Oman will appear.

- In the Code Editor scroll down to line 25

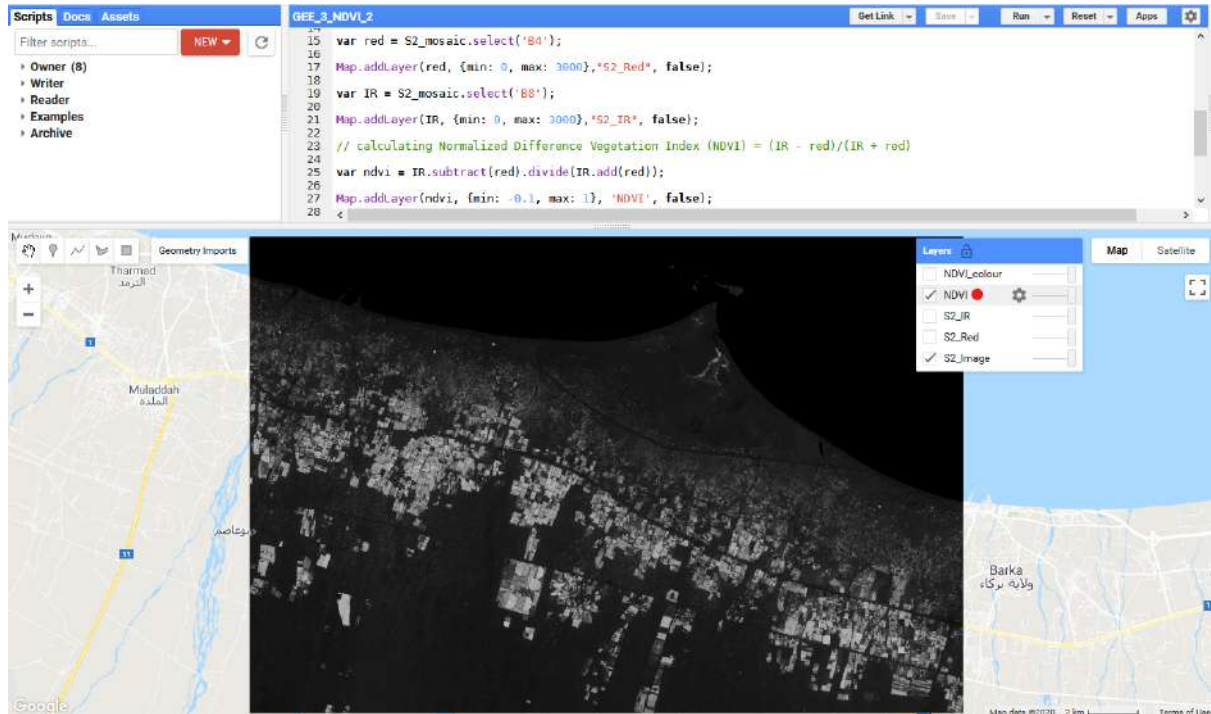
```

23 // calculating Normalized Difference Vegetation Index (NDVI) = (IR - red)/(IR + red)
24
25 var ndvi = IR.subtract(red).divide(IR.add(red));
26
27 Map.addLayer(ndvi, {min: -0.1, max: 1}, 'NDVI', false);
28

```

Here the script is carrying out the NDVI calculation using the red and near infrared bands and adding the result to the Map Window (line 27).

- Turn on “NDVI” in the Layers Panel



You will notice that arable farmland stands out in white, while bare earth and sea remain black or dark grey.

We want to show this in more suitable colours.

- Scroll down to line 31

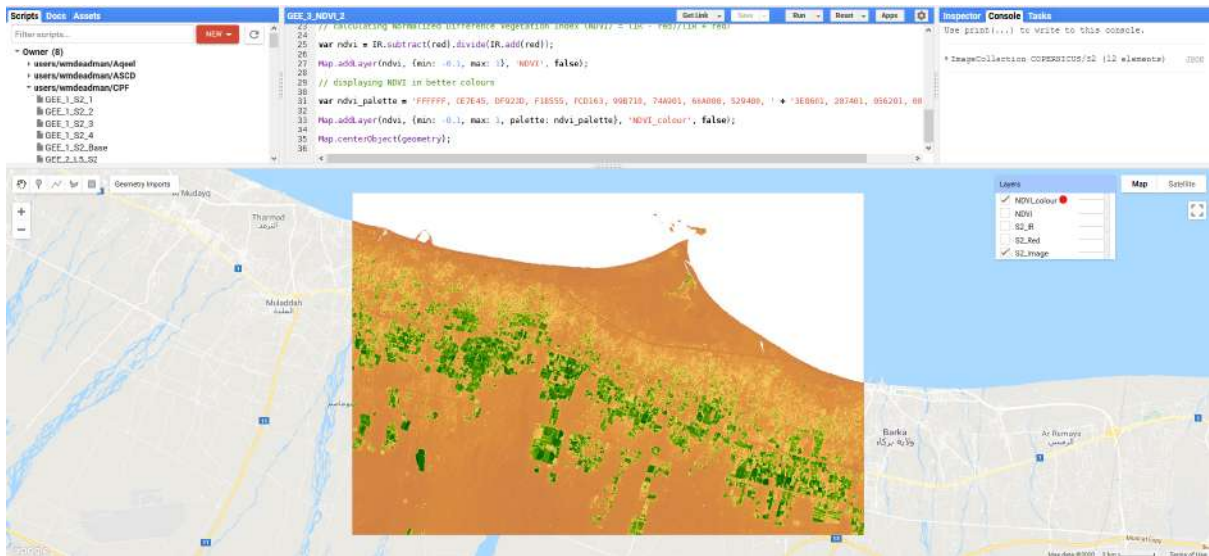
```

29 // displaying NDVI in better colours
30
31 var ndvi_palette = 'FFFFFF, CE7E45, DF923D, F1B555, FCD103, 998718, 74A901, 60A060, 529400, ' + '3E8601, 267401, 050201, 004C00, 023801, 012E01, 011D01, 011301';
32
33 Map.addLayer(ndvi, {min: -0.1, max: 1, palette: ndvi_palette}, 'NDVI_colour', false);
34

```

This is a simple list of colours that defines a suitable NDVI palette that distinguishes different areas (using hexadecimal codes, you can see examples here <https://www.color-hex.com/>).

- Turn on “NDVI\_colour” in the Layers Panel



You will see that using this palette water is white, land is orange-yellow and vegetation is green.

- Turn on and delete the red rectangle, redraw it in your area of interest, and run the script



### 1.3 Introducing a more advanced NDVI script (video tutorial)

- Click here to open the next version of the script  
<https://code.earthengine.google.com/5302e02fee1a1f9dc9346df0e544ca03>
- Have a look at lines 3-6 in the Code Editor

```

3 // display and colour settings:
4
5 var S2_display = {bands: ['B4', 'B3', 'B2'], min: 0, max: 3000};
6 var ndvi_palette = 'FFFFFF, CE7E45, DF923D, F1B555, FCD163, 99B718, 74A901, 66A000, 529400, ' + '3E8601,
7
  
```

We have moved the display and colour settings to the top of the script to make it less confusing.

- Scroll down to line 10

```

10 function addnd(input) {
11   var nd = input.normalizedDifference(['B8', 'B4']).rename('ndvi');
12   return input.addBands(nd);
13 }
14
15 var S2_collection = ee.ImageCollection("COPERNICUS/S2")
16   .filterBounds(geometry)
17   .filterDate('2019-06-01', '2019-09-30')
18   .filterMetadata('CLOUDY_PIXEL_PERCENTAGE', 'less_than', 10)
19   .map(addnd);
20

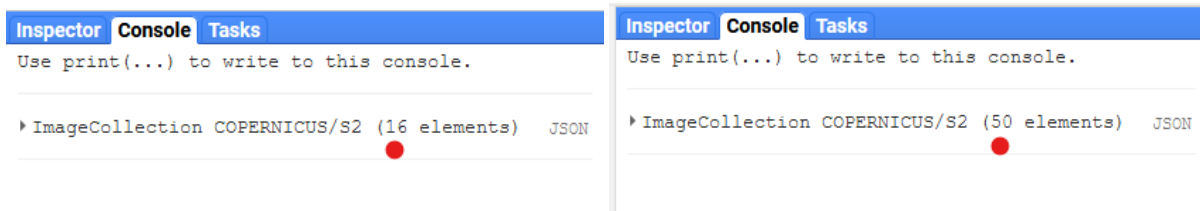
```

This is a function that automatically adds a NDVI band to a collection, we use it on our Sentinel-2 collection on line 19. You can see that rather than give GEE the full equation, as we did in the last script, we just use “normalizedDifference” and define the two bands – this is a common operation with satellite imagery in remote sensing and so it has a dedicated command.

- Have a look at line 17

This is where we define the date range of our collection.

- Change the date to include all of 2019 (i.e. from 1 January to 31 December), run the script and note what this does to the size of the ImageCollection in the console

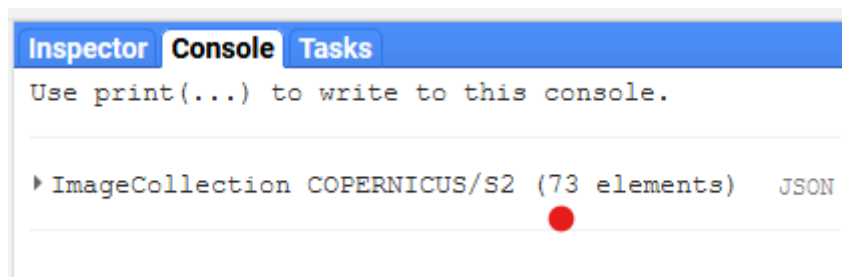


This greatly increases the number of images in the collection and therefore the time to perform the calculations – so you should keep the date range down if possible.

- Have a look at line 18

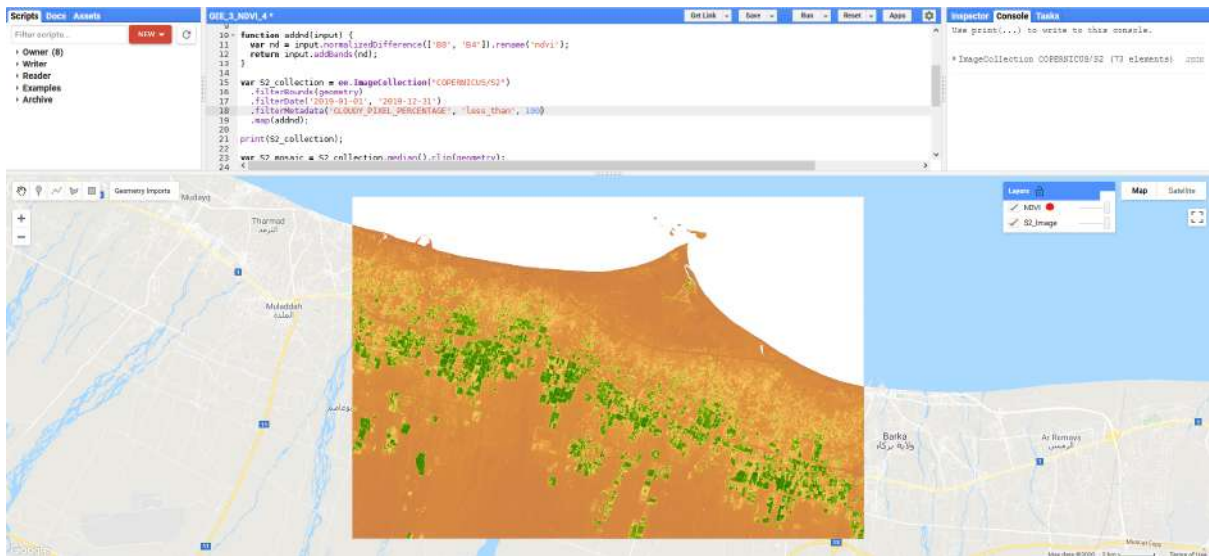
We have added an extra filter to our collection that excludes images that have more than 10% cloud cover.

- Change “10” to “100”, run the script and note what this does to the ImageCollection



By removing cloudy images we reduce the size of the collection and increase the overall quality by only keeping the clearest images, this also in turn speeds up the processing time. However, for some date ranges we may have to be less choosy as lots of clear imagery may not be available.

- Turn on “NDVI” in the Layers Panel.



You will notice that while using a slightly different method, we produce a very similar output to the previous script.

- Click the Refresh button on your browser to reset the script to its original state, you may also have to click “Leave Page” or “Reload”.

**PRACTICE:** Move the processing area to your own area of interest and try changing the date range and cloud filter – a three-month period and 10% are good starting points.

## 2 Exploring Agricultural Areas Over Time with NDVI (video tutorial playlist)

In this section of the tutorial we are going to use NDVI to explore how agricultural practices have changed over time using Sentinel-2 and Landsat 5 imagery.

### 2.1 Two Sentinel-2 NDVI datasets (video tutorial)

We are going to create two different NDVI datasets using Sentinel-2 imagery. By doing this we can examine how the extent of agricultural areas, or other areas with dense vegetation cover, change over time.

- Click here to open the next version of the script:  
<https://code.earthengine.google.com/98dba3c5a3f8dd2374a3fcbcaafc349e>

Scroll down to line 10

```
10 // earlier S2 imagery
11
12 var S2_early = ee.ImageCollection("COPERNICUS/S2")
13   .filterBounds(geometry)
14   .filterDate('2018-06-01', '2018-09-30')
15   .filterMetadata('CLOUDY_PIXEL_PERCENTAGE', 'less_than', 10)
16   .map(addnd);
17
18 print(S2_early);
19
20 var S2_mosaic_early = S2_early.median().clip(geometry);
21
22 Map.addLayer(S2_mosaic_early, S2_display, "S2 Image earlier", false);
23
24 var ndvi_early = S2_early.select('ndvi').median().clip(geometry);
25
26 Map.addLayer(ndvi_early, {min: -0.1, max: 1, palette: ndvi_palette}, 'NDVI earlier');
27
```

Here you will see the code needed to add the first Sentinel-2 NDVI image.

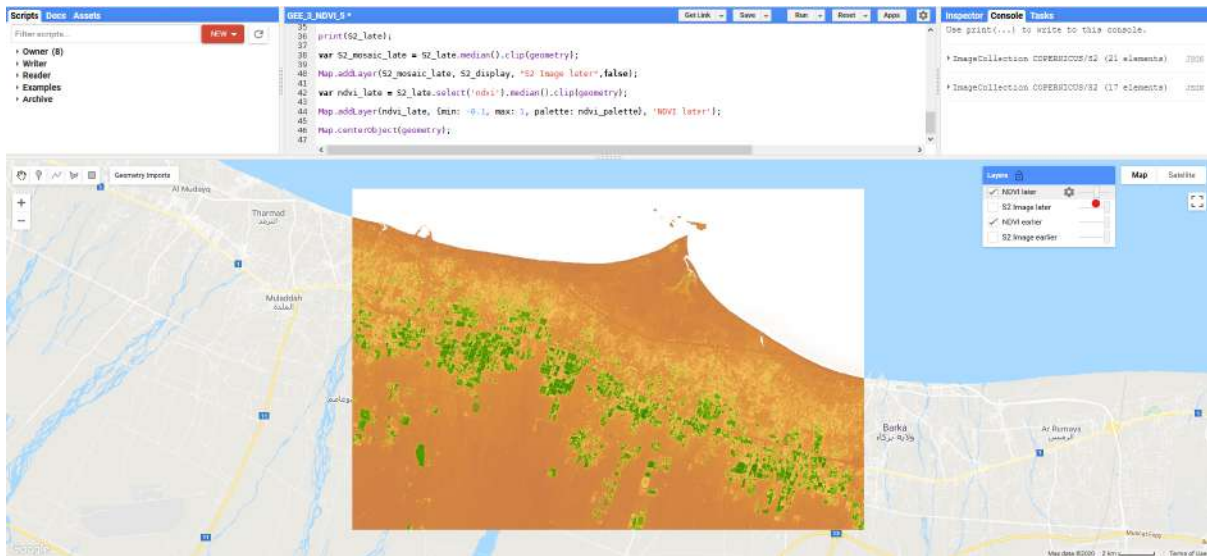
- The variables are labelled as “early” to indicate that they belong to the earlier of the two datasets.
- In line 14, you can see that the earlier period we want to look is between June to September 2018.

Scroll down to line 28.

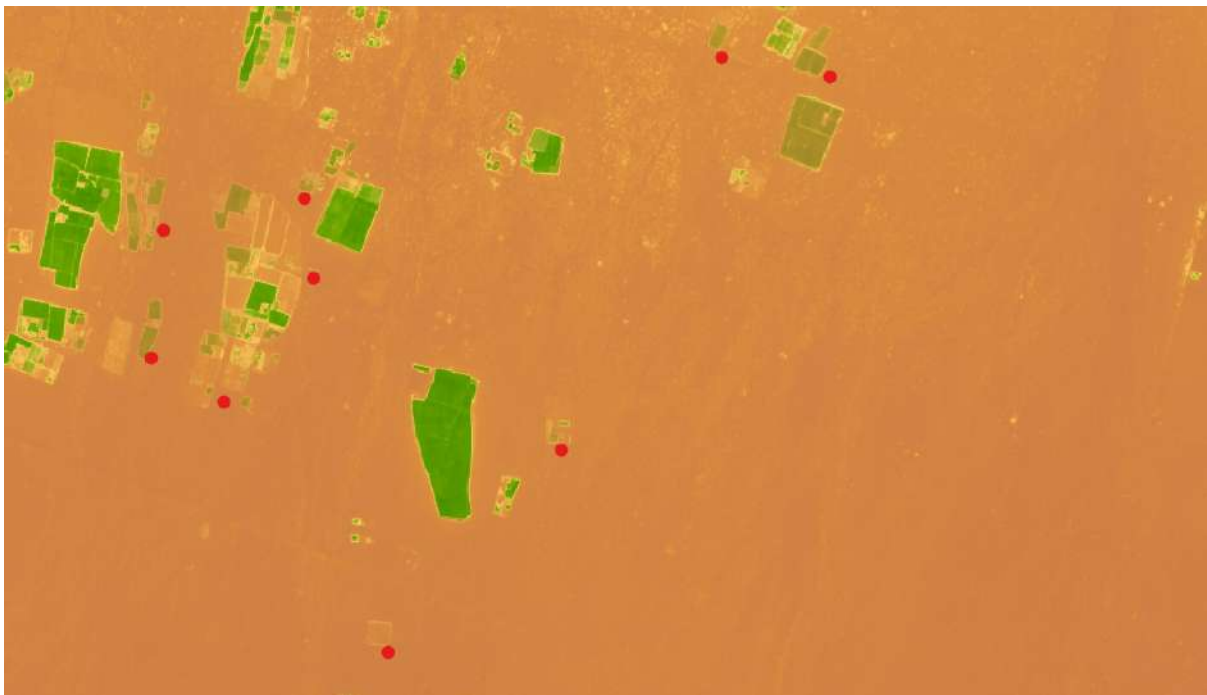
- You will see that this next block of code is almost identical, except the variables are labelled as “late” and the dates are filtered to include the period between June to September of 2020.



- Once both NDVI images have loaded, use the transparency slider next to the “NDVI later” image in the Layers Panel to see if you can spot any new fields or farms.



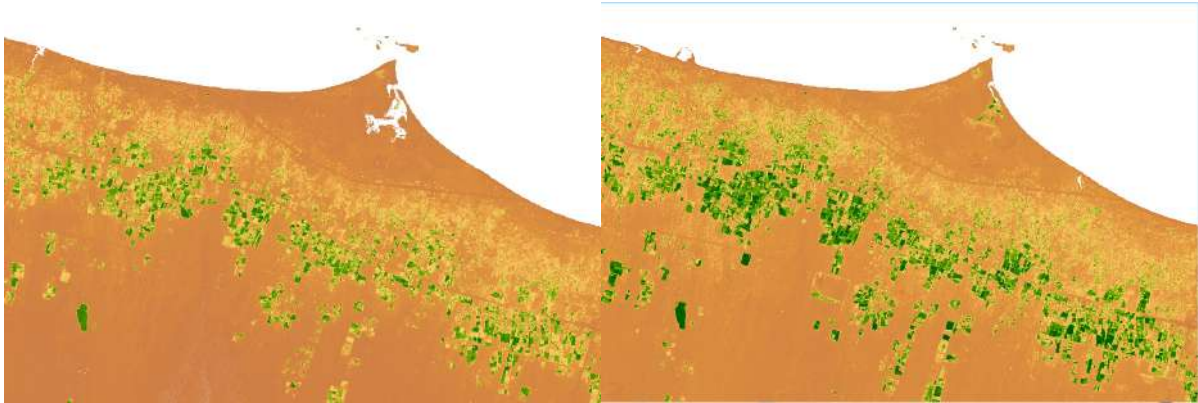
These are particularly common as you move further south, away from the coast.



- Change the “early” imagery to 2016 and run the script to see how agricultural areas have changed over a longer period.

Sentinel-2 imagery only started to be collected in 2015 – so data from this year provides the widest possible comparison.

- Change the earlier imagery to August 2015 and the later imagery to October 2020 and run the script



- Practice looking at agricultural change in your area over different periods.
- You may have to try several different date combinations to find the most appropriate imagery.

## 2.2 Sentinel-2 and Landsat 5 NDVI datasets (video tutorial)

Sentinel-2 data only goes back to 2015, so if we want to make longer comparisons, we need to use a different dataset.

We are going to use Landsat 5 to explore how agricultural practices have changed over several decades.

- Click here to open the next version of the script:  
<https://code.earthengine.google.com/8c0d6dd5fbbf892c8675cb92c53f09fa>
- Scroll down to line 5.

```

5 //Landsat 5 (1984-2012)
6
7 var L5_display = {bands: ["B3", "B2", "B1"], min: 0, max: 0.5};
8
9 function addndl5(input) {
10   var nd = input.normalizedDifference(['B4', 'B3']).rename('ndvi');
11   return input.addBands(nd);
12 }
13
14 var L5_collection = ee.ImageCollection("LANDSAT/LT05/C01/T1_TOA")
15   .filterBounds(geometry)
16   .filterDate('1990-01-01', '1990-12-31')
17   .filter(ee.Filter.lt("CLOUD_COVER", 0.1))
18   .map(addndl5);
19
20 print(L5_collection);
21
22 var L5_mosaic = L5_collection.median().clip(geometry);
23
24 Map.addLayer(L5_mosaic, L5_display, "Landsat 5");
25
26 var ndvi_L5 = L5_collection.select('ndvi').median().clip(geometry);
27
28 Map.addLayer(ndvi_L5, {min: -0.1, max: 1, palette: ndvi_palette}, 'NDVI L5', false);
29

```

This is new code where we create a new Landsat 5 layer. Notice that the bands are different to the Sentinel-2, because the satellite used different instruments that number the bands differently.

- In line 16 we can see that the Landsat 5 imagery has been set to a composite of data from the whole of 1990.

Scroll down to line 30.

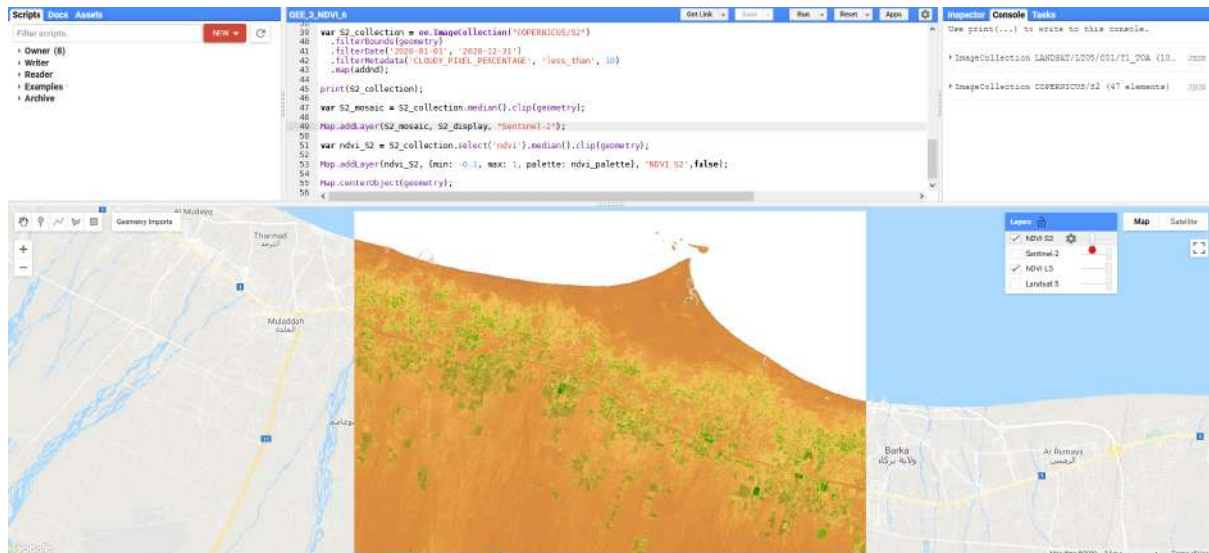
- This is where our familiar Sentinel-2 imagery is created. Unlike in the last code, only one collection is used in this script.
- In Line 41, we see that the Sentinel-2 imagery has been set to look at images from 2020.

Turn off the 2020 Sentinel-2 layer in the 'Layers' menu to compare it with the 1990 Landsat 5 underneath

- The area has transformed completely in 30 years, and a lot of this relates to agriculture.

Turn on the NDVI layers and turn off the others in the Layers Panel.

- Use the "NDVI S2" slider to compare the two datasets.



**PRACTICE:** Move the processing area to your own area of interest, change the date range of the Sentinel-2 and Landsat 5 imagery and run the script.

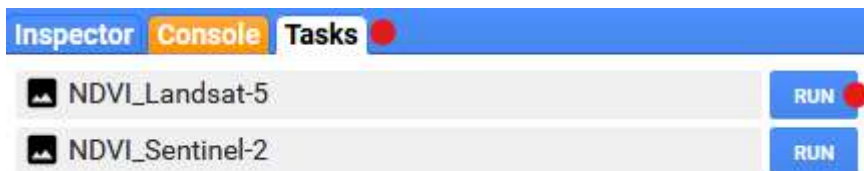
### 3 Exporting NDVI Data into QGIS (video tutorial playlist)

Having explored NDVI using different scripts and datasets, we are now going to export this data to QGIS and display it there.

- Click here to open the final version of the NDVI script  
<https://code.earthengine.google.com/ef8ba96c3329f23f067863b0ef127039>

Scroll down to line 57.

- This is the only new part of the script – it exports the Sentinel-2 and Landsat 5 NDVI data to Google Drive. You should be familiar with this from previous tutorials.
- Change the processing area to your area of interest.
- Change the dates to periods that you are interested in, do not worry if you want to create more than two NDVI datasets, just choose two for now.
- Run the script and make sure you are happy with the results.
- Click on the Tasks Tab.
- Click the blue Run button next to “NDVI\_Landsat-5”.



- Everything in the new Export window can stay the same, except it is a good idea to add the date of the imagery you are exporting at the end of the filename.
- Then click Run.

**Task: Initiate image export** ✕

Task name (no spaces) \*

Resolution \*

Scale (m/px) ▾ 30

Drive
  Cloud Storage
  EE Asset

Drive folder

Filename \*

- Repeat for “NDVI\_Sentinel-2”

- If you want to export more than one Sentinel-2 or Landsat 5 NDVI dataset, then change the dates in the code, rerun the script and repeat the export process.
  - You can start the second batch before the first batch has been completed.
- Wait for the export process to complete.
- When complete, open your Google Drive folder by clicking the “?” next to the exported data and clicking “Open in Drive”.

Task details: NDVI\_Sentinel-2 ✕

State: **Completed**

Started: **20m ago** (2020-11-05 10:44:29 +0000)

Runtime: **8m**

Attempts: **1**

Id: **NXLIO2QBV6I5W5YRQIPLWONU**

[Source script](#) | [Open in Drive](#) ●

[OK](#) ●

- In your Google Drive folder, right-click each image and click “Download”.

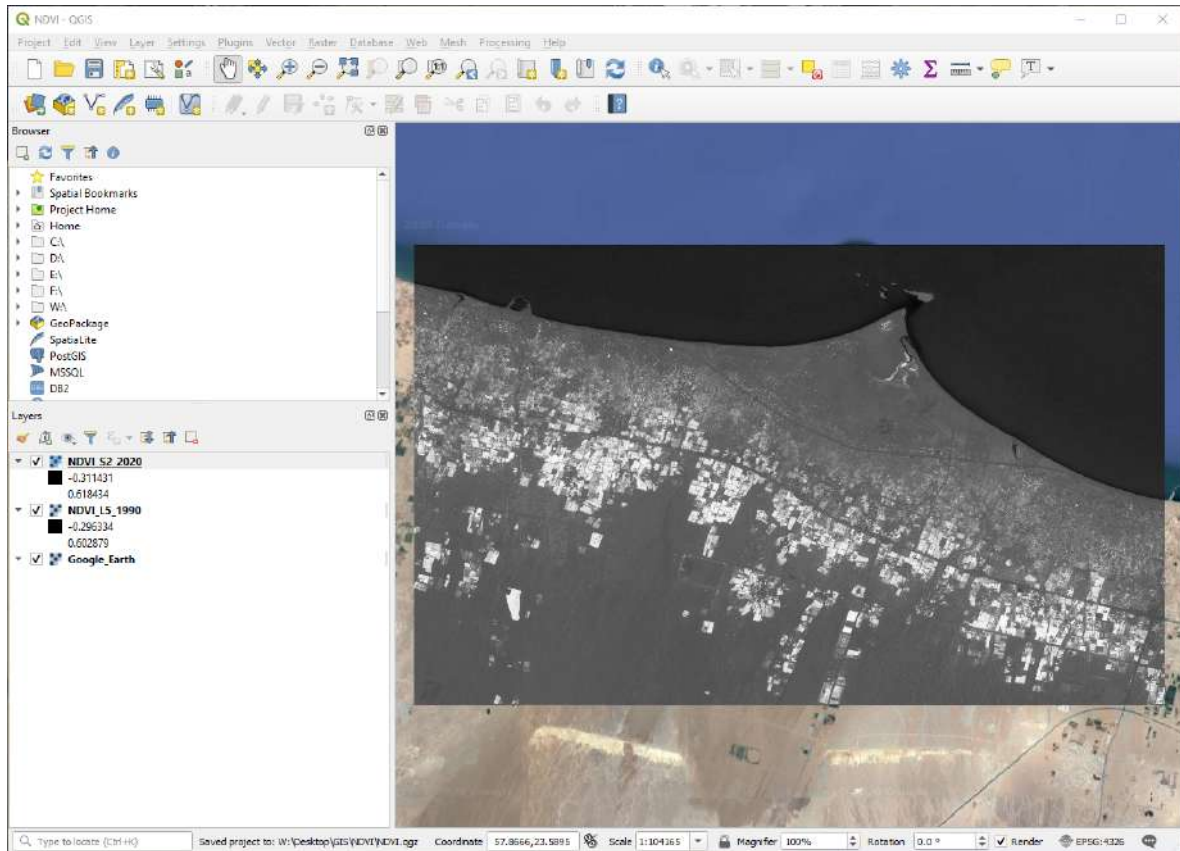
My Drive > GEE\_NDVI ▾

Name ↑	Owner	Last modified	File size
NDVI_L5_1990	me	10:45 me	2 MB
NDVI_S2_2020	me	10:52 me	24 MB

- Preview
- Open with >
- Share
- Get link
- Add a shortcut to Drive ?
- Move to
- Add to Starred
- Rename
- Manage versions
- Make a copy
- Report abuse
- Download** ●
- Remove

- Save to a new NDVI folder in your GIS folder, or move it from Downloads to this folder.

- Open QGIS and add all your NDVI rasters to the project.

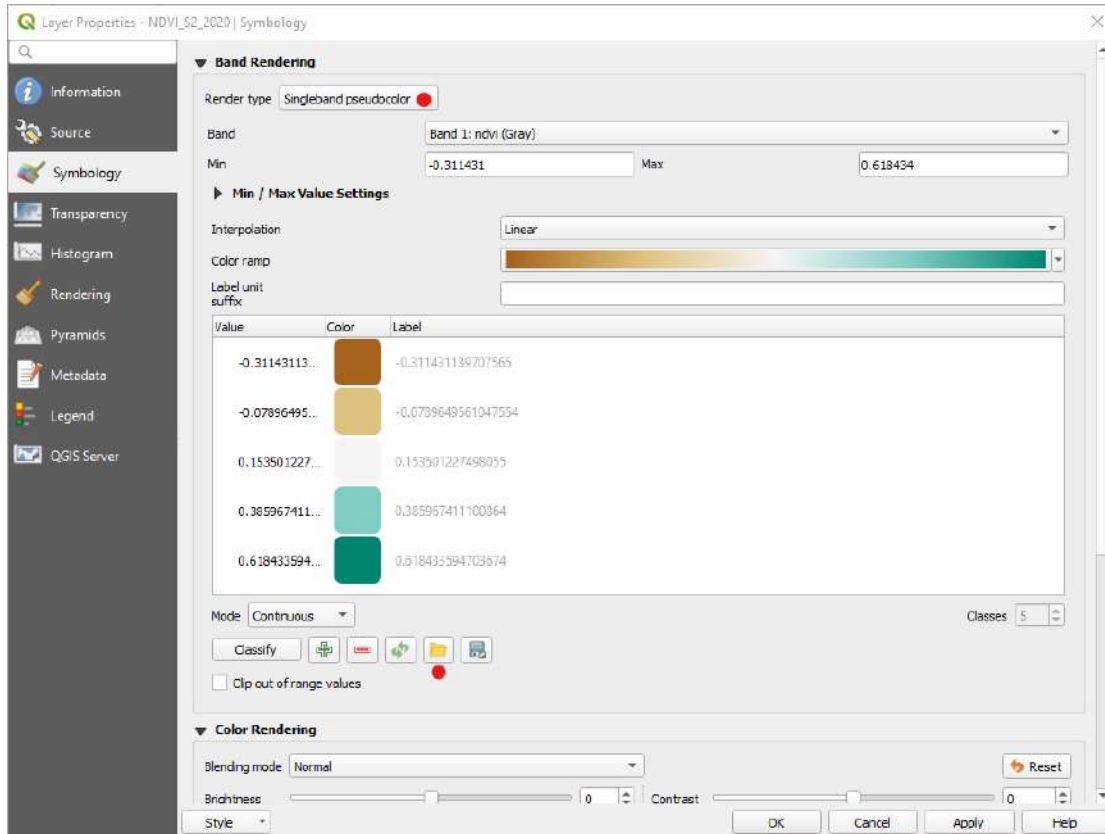


They will be displayed in black and white.

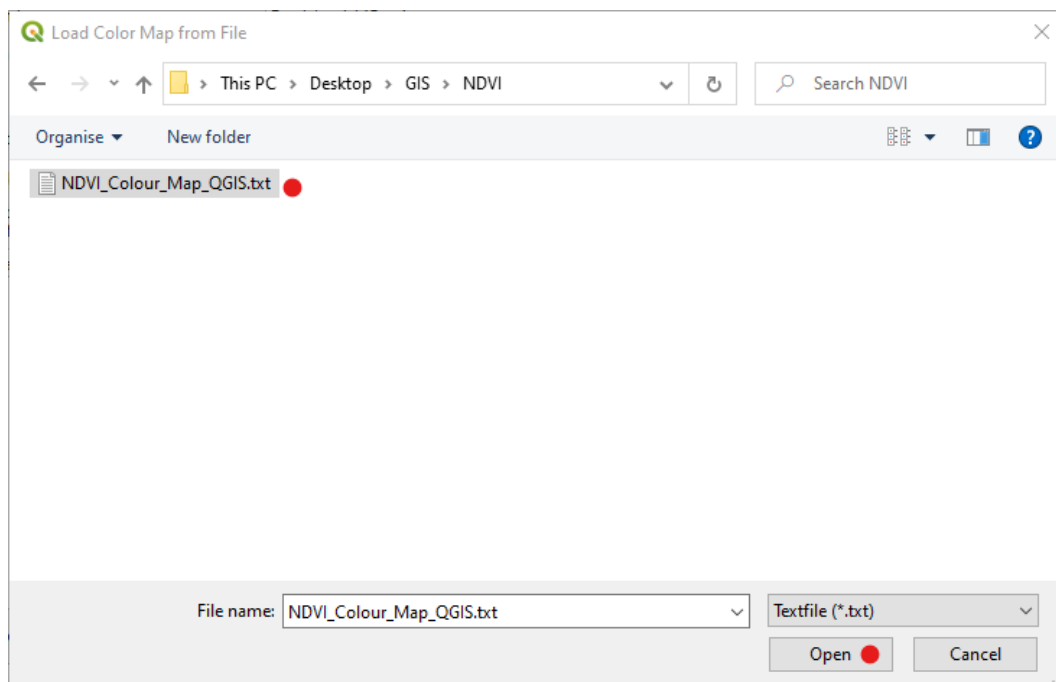
We want to use the same colours we used in GEE:

- Switch to your web browser and download the “NDVI\_Colour\_Map\_QGIS.txt” file from the EAMENA-CPF training website (<https://eamena.web.ox.ac.uk/cpf-training>) and save it in your NDVI folder.

- In QGIS, right-click the top NDVI raster and select “Properties”.
- Select the Symbology Tab.
- Change “Render type” to “Singleband pseudocolour”.
- Underneath the different colours click the “Load Color Map” button.

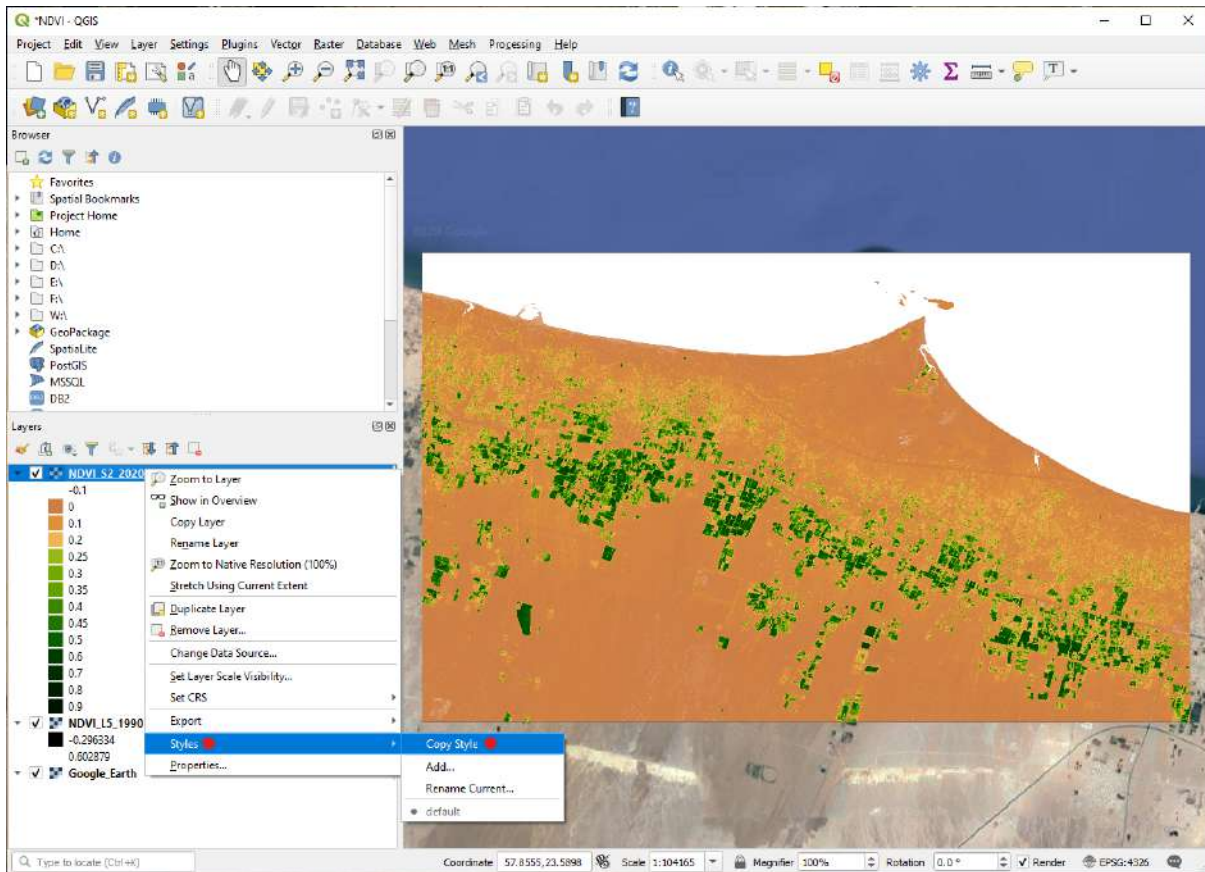


- In QGIS find the ‘NDVI\_Colour\_Map\_QGIS’ file you downloaded above and select this file and click “Open”.

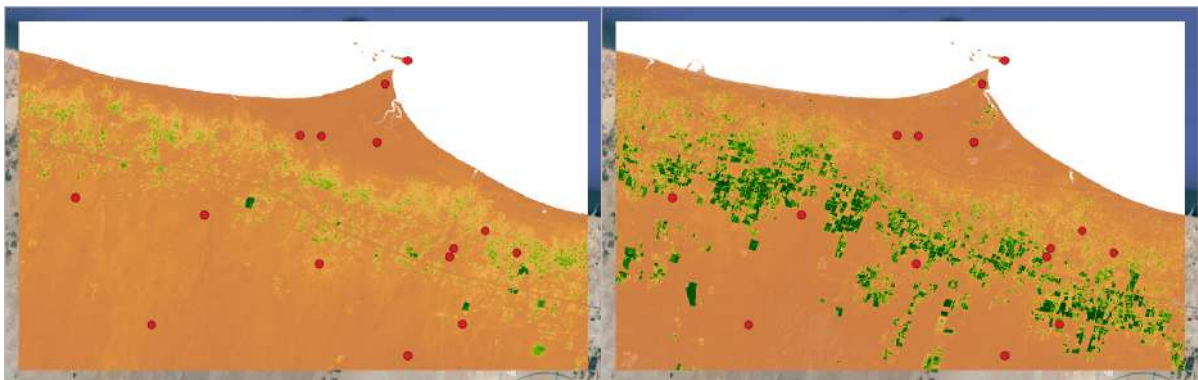


The same NDVI colour scheme that appeared in GEE will be loaded for your raster

- Click Apply and OK.
- Right-click the coloured NDVI raster and select “Styles” > “Copy Styles”.



- Right-click the next black and white NDVI raster and select “Styles” > “Paste Styles”.
- Repeat for each remaining black and white NDVI raster.
- Add any other relevant data, such as sites, to your map and save your project.



- If you want to keep your version of the GEE script, do not forget to click “Save As” and to save it in your own GEE folder in Google Earth Engine.

**ACTIVITY:** create multiple maps in QGIS using NDVI data from GEE showing changes in agricultural practices or vegetation coverage over time in your area of interest.