

**Volume**

**1**

ACADEMIC CONSULTANCY TRAINING

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Wageningen University & Research

# Manual Google Earth Engine

# **Manual for GEE and Viwi for Wiertsema & Partners**

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## Chapter

# 1

### Context of the manual

Using Google Earth Engine (GEE) is a cloud-solution based application for processing large amounts of temporal satellite data. It provides cloud-computing, without the need for storing data on private servers. It scales easily, is flexible in choosing an ‘area-of-interest’, and when made into a web-application intuitively to use.

**GEE is used because** *“Earth Engine provides easy, web-based access to an extensive catalog of satellite imagery and other geospatial data in an analysis-ready format. The data catalog is paired with scalable compute power backed by Google data centers and flexible APIs that let you seamlessly implement your existing geospatial workflows. This enables cutting-edge, global scale analysis and visualization.”* (Source: Google)

The reader of this manual will learn to select and analyze areas of interest by focusing on temporal trend analysis of NDVI-values. Meaning: have vegetated areas gained productivity or has productivity been declining?

The skills the reader needs to use the application is common sense. The GUI in the GEE should be intuitively used by any person experienced in basic computer use and basic GIS knowledge.

The application provides a quick way to assess temporal trend analysis in vegetated areas. This result can further be used by Wiertsema & Partners in deciding potential measuring positions. As for the processing of data, GEE is especially useful in preventing the need for extensive importing of datasets on private servers.

This manual consists of two parts. The first part shows the quick guide, such that readers can quickly follow and run the application. The second part describes the details of the application and readers can better understand the advanced use of the application as well as the background and processes.

The solution requested by the company of Wiertsema & Partners should be **easy to learn, easy to use and easy to explore.**

## Chapter

# 2

### Quickstep manuals for NDVI slope and Viwi

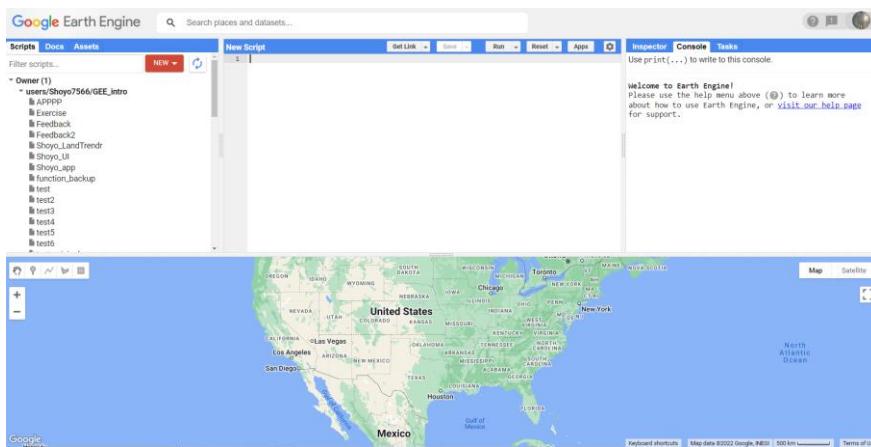
This provides a quick overview of the most basic and useful functions of the GEE application. Following these steps, one can easily achieve results in a few minutes. This GitHub repository containing the code, manual, and report can be found [here](#).

To quickly go to the NDVI Slope (greening-browning) application click [here](#). The application assumes assets are already loaded if results are to be exported. How to import an asset can be viewed on [page 21](#).

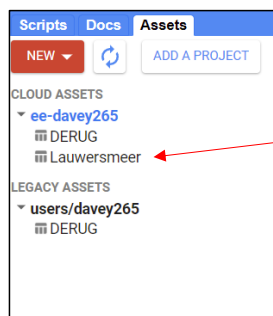
To quickly go to the LandTrendr Application, click [here](#). This goes the LandTrendr Quickstep manual, click [here](#).

### Quickstep Manual for NDVI Slope

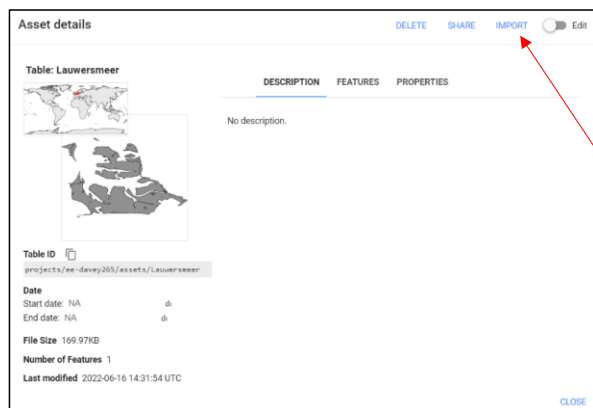
Step 0: Open the Google Earth Engine and log in.



Step 1: Add assets to imports. Click name of asset. All assets should be in EPSG:4326 (WGS 84). If not, reprojection is needed. For more information about uploading assets, click [here](#) or see chapter about importing assets in GEE on page 21.



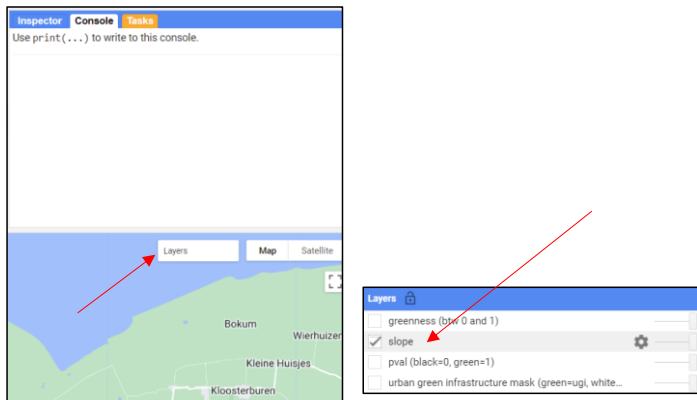
Step 2: Click import. Table will be imported and ready for use.



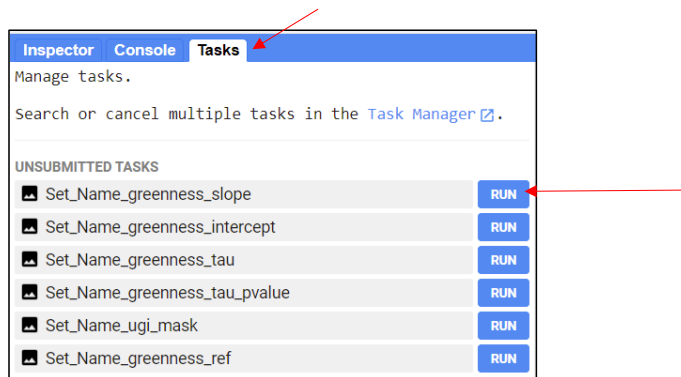
Step 3: Set startYear and/or endYear. Default startYear is 1985 (also minimal) and endYear 2021 (also maximal. Year should always be current year – 1).

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Step 5: Select slope in the layers button.



Step 6: Downloads will appear in 'Tasks'. Click Run.





Step 7: Export image to Google Drive. Settings then can be changed: Coordinate system, scale, Drive Folder, Filename and FileFormat.

Task: Initiate image export

Task name (no spaces) \*

Set\_Name\_greenness\_slope

Coordinate Reference System (CRS)

28992

Scale (m/px)

30

DRIVE

CLOUD STORAGE

EE ASSET

Drive folder

Drive folder name or blank for root

Filename \*

Set\_Name\_greenness\_slope

File format \*

GEO\_TIFF

CANCEL

RUN

Step 8: Change imagery (.tif) is situated after completion in Google Drive folder, ready for download for own usage.



Commented [NS1]: Maybe add visualization shown by QGIS in step 9

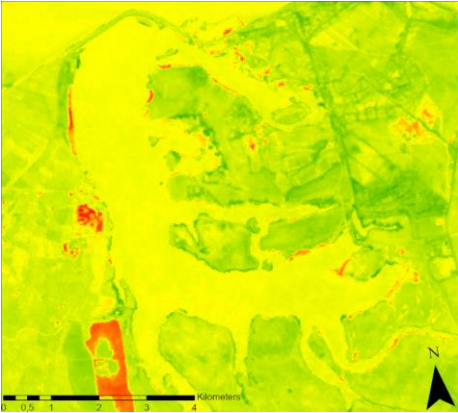
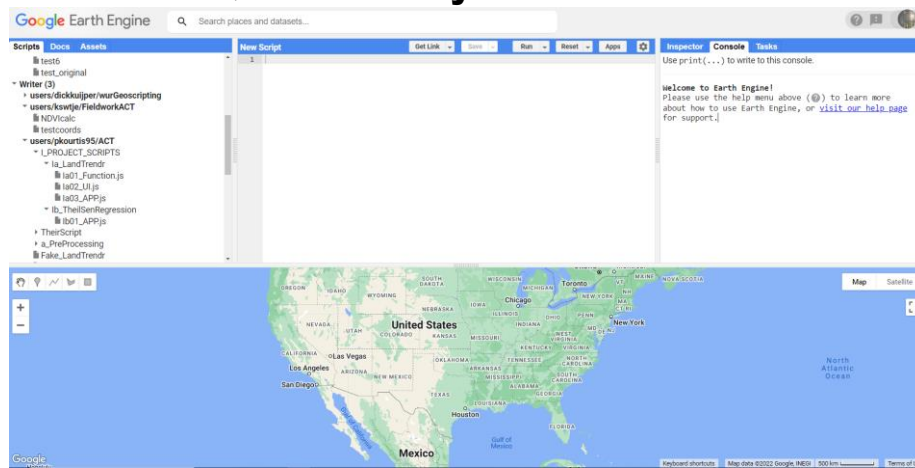


Figure 1: Example of NDVI Slope output

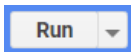
# LandTrendr Quick and Easy manual




## 1: Open repository and click APP

- users/pkourtis95/ACT
  - \_PROJECT\_SCRIPTS
    - la\_LandTrendr
      - la01\_Function.js
      - la02\_UI.js
      - la03\_APP.js
    - lb\_TheilSenRegression
      - lb01\_APP.js

## 2: Click



### 3: Click LandTrendr Options



LandTrendr Options >>

Asset Overlay Options >>

RGB Change Options >>

Pixel Time Series Options >>

Change Filter Options >>

Data Download Options >>

### 4: Define range of years (Default: 1985-2021)

LandTrendr Options <<

**Define Year Range (1985-2021)**

Start Year:  1985

End Year:  2021

**Define Date Range (month-day)**

Start Date:  05-01 End Date:  09-30

**Select Source Index**

NDVI

### 4: Click 'RGB Change Options'

LandTrendr Options >>

Asset Overlay Options >>

RGB Change Options >>

Pixel Time Series Options >>

Change Filter Options >>

Download Options >>

## 5: Draw polygon of research area

Select option below, then click point on map (optional)

☐ Draw Option: Click to create polygon(s) then select options below.

## 6: Click all four buttons to add imagery of change

Add RGB Imagery

Add Red To Green Delta Imagery

Add Green To Blue Delta Imagery

Add Full Time Series Imagery

## 7: Click Download Options

LandTrendr Options >>

Asset Overlay Options >>

RGB Change Options >>

Pixel Time Series Options >>

Change Filter Options >>

Download Options >>

## 8: Set EPSG code (Default: 28992)

### Define a EPSG projection code

EPSG:

## 9: Define file name and file folder

### Define a file name prefix

File Name Prefix:

### Define a folder name

Folder Name Prefix:

## 9: Check boxes for Download Change Imagery (CHANGE TO GREATEST LOSS)

### Download Selection

- ☐ Download RGB Imagery
- ☐ Download RG Delta Imagery
- ☐ Download GB Delta Imagery
- ☒ Download Change Imagery
- ☐ Download Full TimeSeries Imagery

## 10: Click download (Image .tiff exports to Drive)

### Download Selection

- ☐ Download RGB Imagery
- ☐ Download RG Delta Imagery
- ☐ Download GB Delta Imagery
- ☒ Download Change Imagery
- ☐ Download Full TimeSeries Imagery

[Download data](#)

### 11: Go to Tasks

Inspector Console **Tasks**

Manage tasks.

Search or cancel multiple tasks in the [Task Manager](#).

UNSUBMITTED TASKS

App-Data-File-Name-LT-Run-Info-Data	RUN
App-Data-File-Name-1985-2019-YOD-Mag-Dur	RUN
NDVI2015	✓ <1m
NDVI2015	✓ <1m
NDVI2015	✓ <1m

### 12: Click Run on the .tiff file (Upper file is .xlsx which provides metadata)

Inspector Console **Tasks**

Manage tasks.

Search or cancel multiple tasks in the [Task Manager](#).

UNSUBMITTED TASKS

App-Data-File-Name-LT-Run-Info-Data	RUN
App-Data-File-Name-1985-2019-YOD-Mag-Dur	RUN
NDVI2015	✓ <1m
NDVI2015	✓ <1m
NDVI2015	✓ <1m

**Task: Initiate image export**

Task name (no spaces) \*  
test-1985-ofFullFittedTimeSeries

Coordinate Reference System (CRS)  
EPSG:28992

Scale (m/px)  
30

**DRIVE**    CLOUD STORAGE    EE ASSET

Drive folder  
test-1985-ofFullFittedTimeSeries

Filename \*  
test-1985-ofFullFittedTimeSeries

File format \*  
GEO\_TIFF

CANCEL    RUN

13: In the new window it is possible to change coordinate systems, scale of pixels (m/px), saving folder, filename and file format (default GEOTiff).

14: Change imagery (.tif) is situated in Google Drive Folder, ready for download to own storage



Commented [NS2]: Wanna see the example visualization by QGIS

## LandTrendr options

**L**andTrendr has several options for optimizing the analysis. All functionalities will be explained in this chapter.

### Segmentation Parameters

#### Define Segmentation Parameters

Max Segments:	<input type="text" value="6"/>
Spike Threshold:	<input type="text" value="0.9"/>
Vertex Count Overshoot:	<input type="text" value="3"/>
Prevent One Year Recovery:	<input type="text" value="true"/>
Recovery Threshold:	<input type="text" value="0.25"/>
p-value Threshold:	<input type="text" value="0.05"/>
Best Model Proportion:	<input type="text" value="0.75"/>
Min Observations Needed:	<input type="text" value="6"/>

Explanation of segmentation parameters is found below (from <https://pro.arcgis.com/en/pro-app/latest/help/analysis/raster-functions/landtrendr-analysis.htm>)

PARAMETER	DESCRIPTION
SOURCE INDEX	The vegetation index name to use for segmenting the pixel value trajectories over time. Choose the index name that will best capture the changes in the feature you want to observe.
YEAR RANGE	The range of years used to define the change between two temporal dimensions.
DATE RANGE	The date range used to find the 95% percentile (used as maximum) NDVI value in a year.



<b>MAXIMUM NUMBERS OF SEGMENTS</b>	The maximum number of segments to be fitted to the time series for each pixel. The default is 6.
<b>SPIKE THRESHOLD</b>	The threshold to use for dampening spikes or anomalies in the pixel value trajectory. The value must range between 0 and 1 in which 1 means no dampening. The default is 0.9.
<b>VERTEX COUNT OVERSHOOT</b>	The number of additional vertices beyond <code>max_num_segments + 1</code> that can be used to fit the model during the initial stage of identifying vertices. Later in the modeling process, the number of additional vertices will be reduced to <code>max_num_segments + 1</code> . The default is 2.
<b>PREVENT ONE YEAR RECOVERY</b>	Specifies whether segments that exhibit a one year recovery will be excluded. <ul style="list-style-type: none"> <li>• Checked—Segments that exhibit a one year recovery will be excluded. This is the default.</li> <li>• Unchecked—Segments that exhibit a one year recovery will be not be excluded.</li> </ul>
<b>RECOVERY THRESHOLD</b>	The recovery threshold value in years. If a segment has a recovery rate that is faster than $1/\text{recovery threshold}$ , the segment is discarded and not included in the time series model. The value must range between 0 and 1. The default is 0.25.
<b>P-VALUE THRESHOLD</b>	The p-value threshold for a model to be selected. After the vertices are detected in the initial stage of the model fitting, the tool will fit each segment and calculate the p-value to determine the significance of the model. On the next iteration, the model will decrease the number of segments by one and recalculate the p-value. This will continue and, if the p-value is smaller than the value specified in this parameter, the model will be selected and the tool will stop searching for a better model. If no such model is selected, the tool will select a model with a p-value smaller than the lowest p-value $\times$ best model proportion value. The default is 0.01.
<b>BEST MODEL PROPORTION</b>	The best model proportion value. During the model selection process, the tool will calculate the p-value for each model and identify a model that

has the most vertices while maintaining the smallest (most significant) p-value based on this proportion value. A value of 1 means the model has the lowest p-value but may not have a high number of vertices. The default is 1.25.

#### MIN OBSERVATIONS NEEDED

The minimum number of valid observations required to perform fitting. The number of years in the input multidimensional dataset must be equal to or greater than this value. The default is 6.

### Asset overlay options

This is used for importing an area of interest, instead of drawing your own polygon, and using this for analysis. Three areas of interest can be used at the same time.

Define the file path to an asset.

File Path:

users/Wiertsema/DERUG

file/path/to/asset

Define Layer Name

Name:

aol

Name of layer

Name of layer

Define the Layer's color

Color:

green

red

blue

Use first file path as AOI

☒ Use the first file path to process imagery as area of interest.

Add Asset to Map

#### FILE FORMATS

Shapefiles (.shx, .shp, .dbx, .prj)

or zip

csv

TIF

TPRecord (+ json)

1) **Define the path to an asset.** This asset will be loaded into the map view as a layer. The asset path can be found by clicking on an asset (go to the assets tab) and recording the path under "Table ID".

2) Optional, define a name to call the loaded asset.

3) Optional, define the color of the asset.

4. **Check box to use first file** as area of interest in analysis. Add asset to map.

## RGB Change Options

RGB Change Options <<

Define Years for Red, Green, Blue

Red Year:  1985

Green Year:  2005

Blue Year:  2021

Define Mask Elements

☐ Clouds
☒ Shadows
☒ Snow
☐ Water

Click a point on the map, or enter pixel coordinates. (optional)

Longitude:  6.173

Latitude:  53.3744

Define an image buffer around coordinates (km)

Buffer:  10

Select option below, then click point on map (optional)

☐ Draw Option: Click to create polygon(s) then select options below.

Add RGB Imagery

Add Red To Green Delta Imagery

Add Green To Blue Delta Imagery

Add Full Time Series Imagery

Imagery can found [here](#).

1) **Define years to represent red, green, and blue** color in the final RGB composite. The Red Year value is the year value for the Full Time Series Display image. Detailed explanation for Delta Imagery can found [here](#).

2) **Define Masking options.** Each item selected will be masked out as NoData to the best of its ability

3) **Optionally** define a pixel coordinate set to view the time series of, alternatively you'll simply click on the map. Note that the coordinates are in units of latitude and longitude formatted as decimal degrees (WGS 84 EPSG:4326). Also note that when you click a point on the map, the coordinates of the point will populate these entry boxes.

4) Define a buffer around the center point defined by a map click or provided in the longitude and latitude coordinate. The units are in kilometers. It will draw and clip the map to the bounds of the square region created by the buffer around the point of interest.

5) **Draw a polygon by clicking the check box.** Then click on the map to draw a polygon that will be the extent of the imagery displayed. To remove the polygon and us the point buffer extent simply uncheck the draw box.

6) **Click the Add RGB Imagery button to add red year, green year, and blue year composite to the map view.** The extent of the imagery displayed is define by a point buffer or drawn polygon. Detailed explanation for Delta

7) **Click the Add RED to Green Delta button** to add an image of magnitude and direction from the red year to the green year to the map view. The extent of the imagery displayed is define by a point buffer or drawn polygon.

8) **Click the Add Green to Blue Delta button** to add an image of magnitude and direction from the green year to the blue year to the map view. The extent of the imagery displayed is define by a point buffer or drawn polygon.

9) **Click the Add Full Time Series Imagery** to add an image of the whole time series

## Pixel Time Series Options

Pixel Time Series Options <<

Select Indices

☒ NDVI

Define a pixel size for time series (m)

Size: 30

Click a point on the map, or enter pixel coordinates.  
(optional)

Longitude: 6.228197 Latitude: 53.374121

Submit Pixel

Sometimes one wants to analyze a single pixel (30x30m). This is the tool to use.

1) **Select spectral indices** and bands to view. You can select one or two.

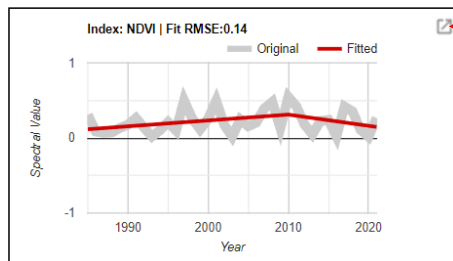
2) **Define pixel size** for time series (m)

3) **Identify location** with one of two options:

a) **Click on the map.** The coordinates of the point will populate the latitude and longitude (coordinates are in units of latitude and longitude formatted as decimal degrees (WGS 84 EPSG:4326).

b) Or **enter pixel coordinates** in decimal degrees.

4) If you want to change anything about the run, but keep the pixel coordinate, make the changes and then hit the ReSubmit Pixel button.



5. Create and view full size graph. Graph can be exported in the new window opened by clicking the button and be downloaded to csv.

# Change Filter options

Change Filter Options <<

Select Vegetation Change Type: Loss

Select Vegetation Change Sort: Greatest

☒ Filter by Year:  
Start Year: 1985  
End Year: 2021

☒ Filter by Magnitude (0-1000):  
Value: 100 Operator: >

☒ Filter by Duration:  
Value: 9 Operator: >

☒ Filter by MMU: 6

Add Filtered Disturbance Imagery

- 1) **Define the vegetation change type** you are interested in - either vegetation **gain** or **loss**.
- 2) **Define the vegetation change sort** - should the change be the greatest, least, longest, etc. This applies only if there are multiple vegetation changes of a given type in a pixel time series. It is a relative qualifier for a pixel time series.
- 3) Optionally filter changes by the year of detection. Adjust the sliders to constrain the results to a given range of years. The filter is only applied if the Filter by Year box is checked.
- 4) Optionally filter changes by magnitude. Enter a threshold value and select a conditional operator. For example, if you selected the change type as vegetation loss defined by NDVI and wanted only high magnitude losses shown, you would maybe want to keep only those pixels that had greater than 0.1 NDVI units' loss - you would set value as 1000 and select the > operator. The filter is only applied if the Filter by Magnitude box is checked.
- 5) Optionally filter by change event duration. Enter a threshold value and select a conditional operator. For example, if you only want to display change events that occurred rapidly, you would maybe set the value as 2 (years) and the operator as < to retain only those changes that completed within a single year. The filter is only applied if the Filter by Duration box is checked.
- 6) Optionally filter by a minimum disturbance patch size, as defined by 8-neighbor connectivity of pixels having the same year of change detection. The value is the minimum number of pixel in a patch. The filter is only applied if the Filter by MMU box is checked. **As pixels are 30x30m, filter should be off to look at specific patches.**
- 7) Click the **Add Filtered Disturbance Imagery** to the map viewer.

Commented [NS3]: Wanna see example output

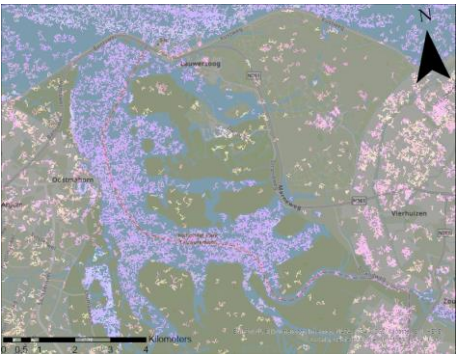


Figure 2: example of filtered disturbance imagery in QGIS

## Download options

**Define a EPSG projection code**  
EPSG:

**Define a file name prefix**  
File Name Prefix:

**Define a folder name**  
Folder Name Prefix:

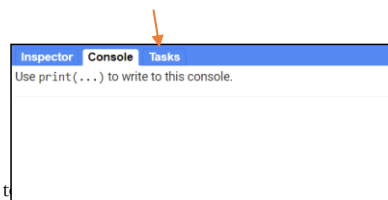
**Download Selection**  
☒ Download RGB Imagery  
☐ Download RG Delta Imagery  
☐ Download GB Delta Imagery  
☐ Download Change Imagery  
☐ Download Full TimeSeries Imagery

- 1) **Define the output imagery projection** in the form of a EPSG code.
- 2) **Define a file name prefix.** Image information such as selected years and other info will be appended the file name prefix.
- 3) **Define a folder name prefix** to store the imagery in your Google Drive. Image information such as selected years and other info will be appended the folder name prefix. Also, each image represented by a checked box will be downloaded into its own folder. This will help manage mergers of image chunks if necessary.
- 4) **Select the checkboxes** for the data you wish to download.
- 5) Click the **Download Data** button to start tasks.

6) Look under the **Tasks tab** for the export processes.

7) Click the **RUN** button to start the downloading process to the console.

8) In the new window it is possible to change coordinate systems, scale of pixels (m/px), saving folder, filename and file format (default GEOTiff).



Task: Initiate image export

Task name (no spaces) \*

test-1985-ofFullFittedTimeSeries

Coordinate Reference System (CRS)

EPSG:28992

Scale (m/px)

30

DRIVE
CLOUD STORAGE
EE ASSET

Drive folder

test-1985-ofFullFittedTimeSeries

Filename \*

test-1985-ofFullFittedTimeSeries

File format \*

GEO\_TIFF

CANCEL
RUN

## Google Earth Engine Settings

### Creating a polygon in Google Earth Engine using the application

1: Check the 'Draw Option' box. The cursor will automatically into a polygon draw tool.

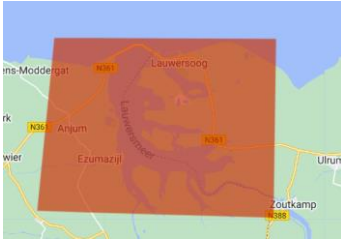
Select option below, then click point on map (optional)

☒ Draw Option: Click to create polygon(s) then select options below.

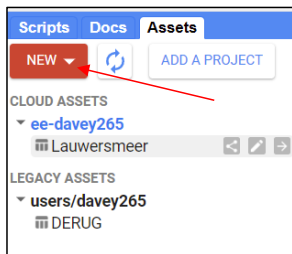
2. Click on a point to start drawing the polygon.



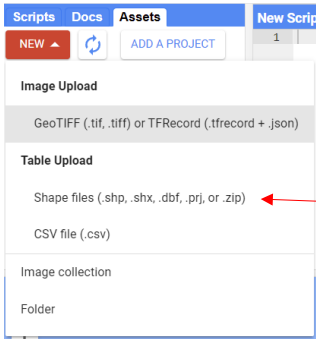
3. Repeat clicks until ideal shape of polygon is created.
4. Polygon is created.



## Importing assets into Google Earth Engine



- 1: Go to Assets
- 2: Click NEW



- 3: Select Shape files or what you want



**Upload a new shapefile asset**

**Source files**  
 SELECT

Please drag and drop or select files for this asset.  
 Allowed extensions: shp, zip, dbf, prj, shx, cpq, fix, qix, sbn or shp.xml.

**Asset ID**  
 projects/ee-davey265/assets/ Asset Name

**Properties**  
 Metadata properties about the asset which can be edited during asset upload and after ingestion. The "system:time\_start" property is used as the primary date of the asset.

Add start time Add end time Add property

**Advanced options**  
 Character encoding  
 UTF-8  
 Maximum error  
 1.0

CANCEL UPLOAD

- 4: Select source files (important to add all other files)  
 5: Select where to save asset and file name  
 6: Click upload to upload file as an asset

7: Asset is now in the assets folder

Scripts Docs **Assets**

NEW ADD A PROJECT

CLOUD ASSETS  
 ee-davey265  
 Lauwersmeer

LEGACY ASSETS  
 users/davey265  
 DERUG

## Detailed NDVI Slope Application explanation

This table is intended for interpreting the results of the trend slope map

Class	Description
$\leq -0.015 \rightarrow$ major browning	Downward trend (Browning) due to housing policies, development of industrial and commercial areas, new grey infrastructures
$-0.015 < x \leq -0.0001 \rightarrow$ slight browning	
$-0.0001 < x \leq 0.0001 \rightarrow$ no changes	
$0.0001 \leq x \leq 0.007 \rightarrow$ slight greening	Upward trend (Greening) due to green infrastructure management; vegetation growth, climate change
$> 0.007 \rightarrow$ major greening	

## How to interpret the results of Viwi

The goal of LandTrendr is to detect vegetation change. It does this by producing three products. These are: the year of change detection, the magnitude of change and the duration of change. These are explained below. For a more detailed and in-depth explanation, click [here](#).

### Year of Detection

The LandTrendr detects the year in which the significant change starts to occur. In the figure below this is indicated as “Start year”.

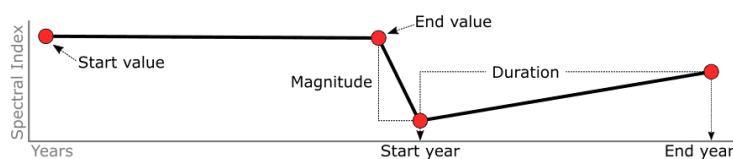


Figure 3: Source <https://emapr.github.io/LT-GEE/lt-gee-outputs.html>

### Magnitude

Magnitude refers to the change in the quantity of the spectral properties. The more the NDVI is changed, the more likely there is a change in the spectral properties and hence in magnitude of change over time. This scale goes from 0-1000.

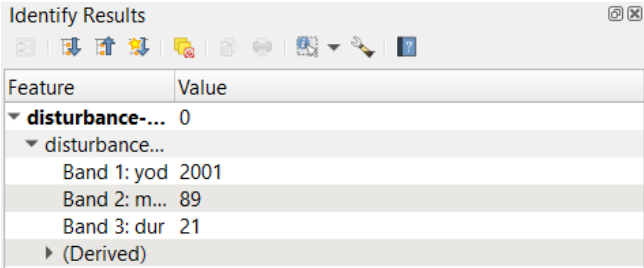
### Duration

Duration means the time when a consistent change is occurring, i.e., vegetation is recovering or decreasing (stress). The duration goes from Start year to End year.

Output file will be a raster. Pixels with detected change contain information on three bands.

Band	Description
1	Year of detection
2	Magnitude of change
3	Duration of change

Import the raster in QGIS. Using the Inspection tool in QGIS each pixel can be inspected. Results appear in the top right corner. Selecting only specific bands is also possible.



One can easily just inspect the magnitude of change, as can be seen in figure 2.

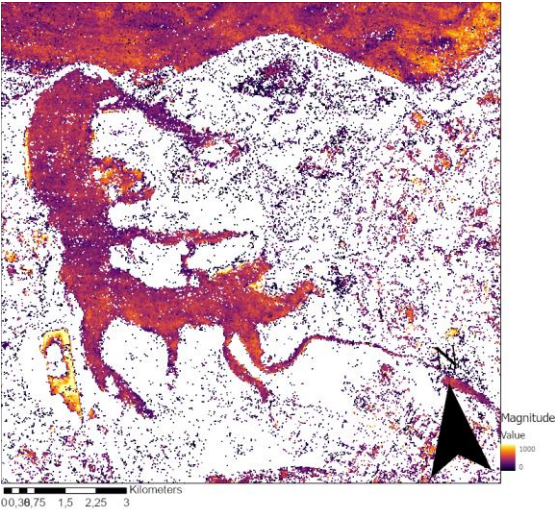


Figure 4: Magnitude of change map

## FAQ

### **How do I sign up to Google Earth Engine?**

Visit [signup.earthengine.google.com](https://signup.earthengine.google.com) to sign up for the platform.

### **Where can I find more information about GEE?**

You can find more, such as scripts, API's and datasets on <https://developers.google.com/earth-engine/>

### **Is Google Earth Engine free to use by for-profit companies?**

Earth Engine's terms allow for use in development, research, and education environments. It *may also be used for evaluation in a commercial* or operational environment, but sustained production use without a commercial license is not allowed. Additionally, under these terms, data products generated by Earth Engine may not be sold.

### **Who owns the algorithms I write in Earth Engine and the results of my analyses?**

You do. The results of all analyses you perform are yours. All algorithms that you write with our API are yours.

### **My Google Drive storage is running out. What do I do?**

If storage is running out, move the .tif-files to your own private storage to create room for new files.