UNESCO/IHA research project on the

GHG status of freshwater reservoirs

The GHG Reservoir Tool (G-res)

User guidelines for the Earth Engine functionality

iha
international hydropower association

United Nations
Educational, Scientific and
Cultural Organization

UNESCO Chair in
Global environmental
change

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CONTENTS

Introduction

In order to provide useful estimates of net GHG emissions from reservoirs, the G-res tool requires a lot of information concerning the physical, geographical, climatic, soil and land cover attributes of the reservoir itself as well as its catchment. However, this information needs to be extracted from the good and consistent sources. This process can be arduous and prone to error or inconsistencies. To facilitate this process, the G-res tool provides an additional functionality to help the user extract the information in a globally consistent manner to then enter the missing information manually within the G-res tool. This functionality was developed using Earth Engine platform of Google and it thus termed the Earth Engine (EE) functionality in the G-res tool. The information thus obtained can then be saved locally for future use.

The reservoir specific information that can be derived directly from the EE functionality are:

For the catchment:

- Catchment Area (in square kilometres)
- Catchment Annual Runoff (in millimeters per year)
- Population in the Catchment (person)
- Land Cover by Soil Type (in percentage)

For the reservoir:

- Dam Coordinates (in degrees, WGS84)
- Reservoir Area (in square kilometres)
- River length before impoundment (in meters)
- Maximum Depth (in meters)
- Mean Depth (in meters)
- Climate Zone
- Monthly Mean Temperature (in degree Celsius)
- Reservoir Mean Global Horizontal Radiance Annual (GHR) (in kilowatt hour per square meter per day)
- Reservoir Mean global horizontal Radiance (GHR) for the months of May to September (in kilowatt hour per square meter per day)
- Reservoir Mean Global Horizontal Radiance (GHR) for the months of November to March (in kilowatt hour per square meter per day)
- Soil Carbon Content in the Impounded Area (kilogram of carbon per square meters)
- Annual Wind Speed (meters per second)
- Land Cover by Soil Type (in percentage)

For the buffer surrounding the reservoir:

- Soil Carbon Content Buffer (kilogram of carbon per square meters)
- Land Cover by Soil Type (in percentage)

BEFORE TO START TO USE EARTH ENGINE

WARNINGS concerning data output:

Catchment Annual Runoff vs Annual Discharge from the reservoir

The catchment annual runoff (in mm/year) is given by Earth Engine and asked in the G-res tool. Although, if the Annual Discharge (m^3/s) is available, please provide this value.

Reservoir Mean Global Horizontal Radiance (GHR)

Please choose one of the options:

- If 40 > Latitude > -40:

  Mean GHR Annual (kWh/m2/day)

- If Latitude > 40

  Mean GHR May to September (kWh/m2/day)

- If Latitude < -40

  Mean GHR November to March (kWh/m2/day)

River Area Before Impoundment vs Reservoir Water Bodies from Land Coverage categories

If the natural water body present before the impoundment of the reservoir is a **river**, please provide the River Length before Impoundment. As you are adding new information, your total percent might become higher than 100%. Please check what land coverage is in the immediate area of your river and modify those percent land coverage to obtain a total of maximum 100% (or a No data greater or equal to 0).

If the natural water body present before the impoundment of the reservoir is a **lake**, please use Earth Engine Water Bodies from the land coverage of the reservoir area before impoundment percent.

Parameters name in the G-res tool compared to the Earth Engine tool

G-res parameters name	Earth Engine parameters name
Catchment Area (km²)	Catchment Area (km2)
Population in the Catchment (persons)	Population in the Catchment (persons)
Catchment Annual Runoff (mm/yr)	Catchment Annual Runoff (mm/year)
Land cover in the Catchment Area	Catchment Land Cover by Soil Type (%)
Croplands	Croplands - Mineral Soil + Croplands - Organic Soil
Bare Areas	Bare Areas - Mineral Soil + Bare Areas - Organic Soil
Wetlands	Wetlands - Mineral Soil + Wetlands - Organic Soil
Forest	Forest - Mineral Soil + Forest - Organic Soil
Grassland/Shrubland	Grassland/Shrubland - Mineral Soil + Grassland/Shrubland - Organic Soil
Permanent Snow/Ice	Permanent Snow/Ice - Mineral Soil + Permanent Snow/Ice - Organic Soil
Settlements	Settlements - Mineral Soil + Settlements - Organic Soil
Water Bodies	Water Bodies - Mineral Soil + Water Bodies - Organic Soil
Longitude of Dam (DD)	Dam longitude (°, WGS84)
Latitude of Dam (DD)	Dam latitude (°, WGS84)
Reservoir Area (km²)	Reservoir Area (km2)
River length before impoundment (m)	River length before impoundment (m)
Maximum Depth (m)	Reservoir Maximum Depth (m)
Mean Depth (m)	Reservoir Mean Depth (m)
Climate Zone (Reservoir Area)	Climate
Mean Temperature per Month (°C)	Reservoir mean temperature [Month] (°C)
Mean Global Horizontal Radiance (kWh/m²/d)	Mean Global Horizontal Radiance Annual (kWh/m2/day)
	Mean Global Horizontal Radiance May to September (kWh/m2/day)
	Mean Global Horizontal Radiance November to March (kWh/m2/day)
Pre-Impoundment Land cover at the Reservoir Area	Reservoir Land Cover by Soil Type (%)
Soil Carbon Content Under Impounded Area (kgC/m²)	Soil Carbon Content Under Impounded Area (kgC/m2)
Annual Wind Speed (m/s)	Annual Wind Speed (m/s)

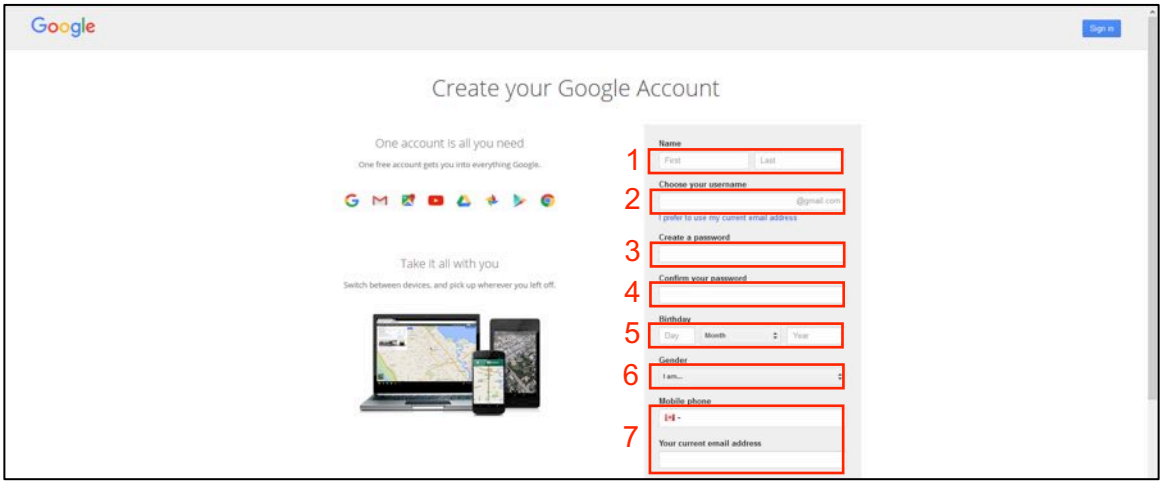
Below is a step-by-step guide describing how to use the EE functionality and how to link the information obtained with the appropriate fields of the G-res tool itself.

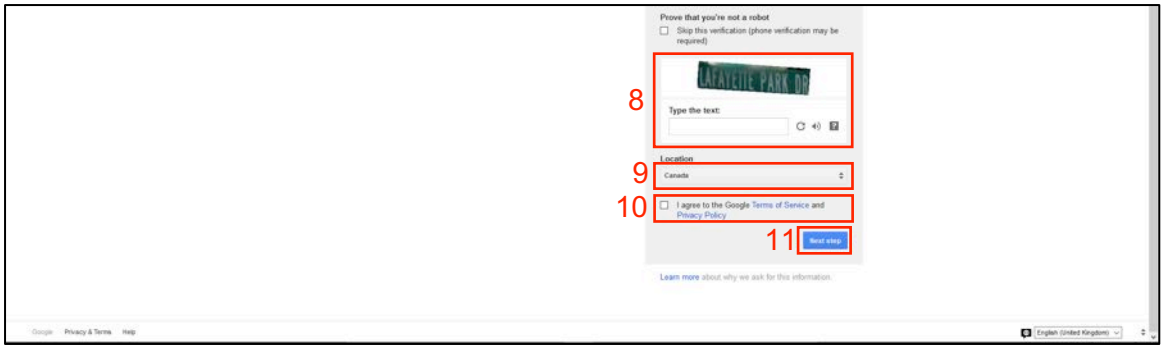
STEP 1: CREATING A GOOGLE ACCOUNT AND ENABLING THE ACCESS TO EARTH ENGINE

Step 1.1: Creating a Google account

If you already have a Google account, jump to **Step 1.2**. If you do not already have a Google account, you will have to create one. Go on https://accounts.google.com/signup and follow these steps to create your account.

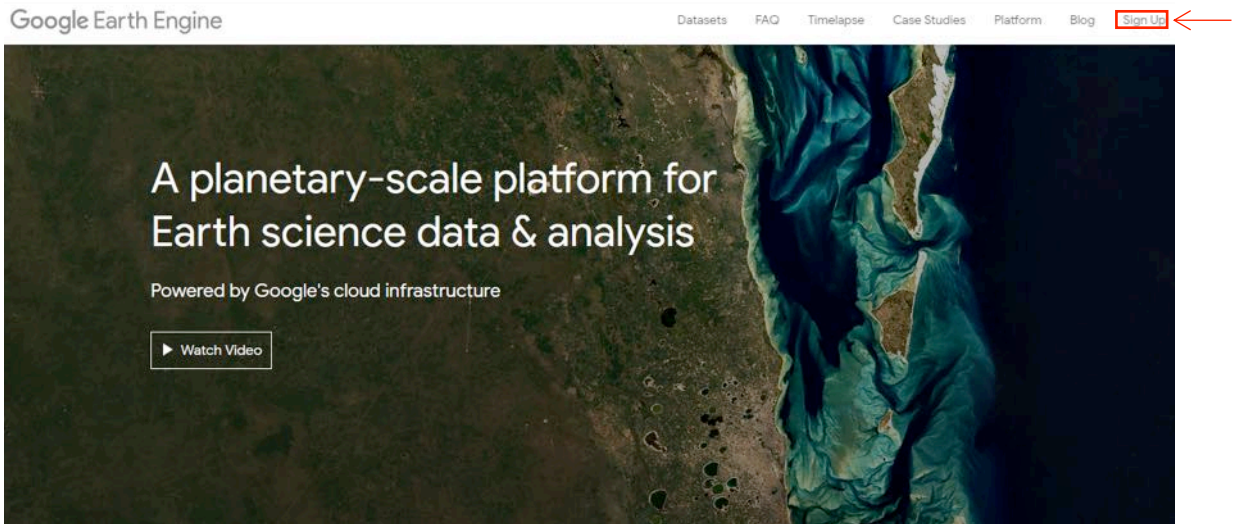
1) Enter your first and last names
2) Choose your username. This will be your Gmail address.
3) Create a password.
4) Confirm your password.
5) Enter your birthday.
6) Choose your gender (Female, Male, or Other).
7) This step is optional. Enter a mobile phone number or a current Email address to reset your password in case it is lost.
8) Type the text that appears in the image. It will be different each time. You may not have the same text as in this example.
9) Select your country.
10) Check the box "I agree to the Google Terms of Service and Privacy Policy" after reading them by clicking on the links.
11) Click on the "Next step" button to create your Google account.





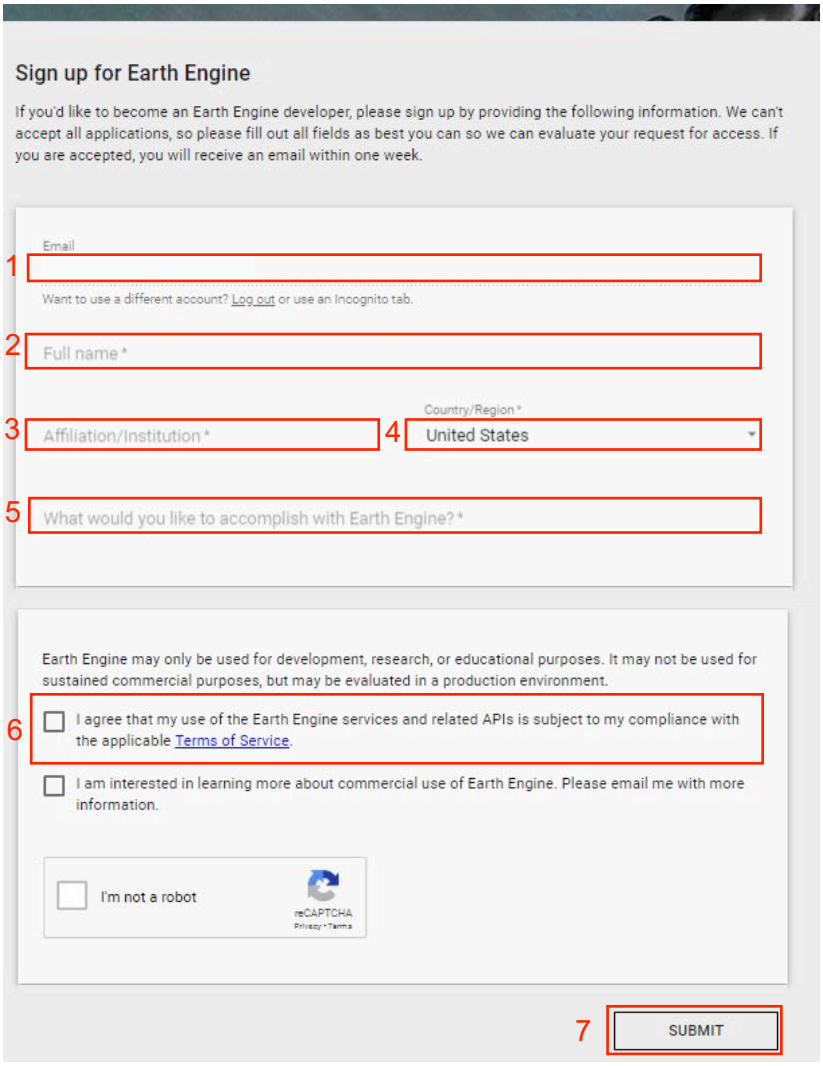
Step 1.2: Enabling the access to Earth Engine

Once you have your Google account, you will have to enable your access to Earth Engine. Go on https://earthengine.google.com/ and click on "SIGN UP" on the upper right corner.



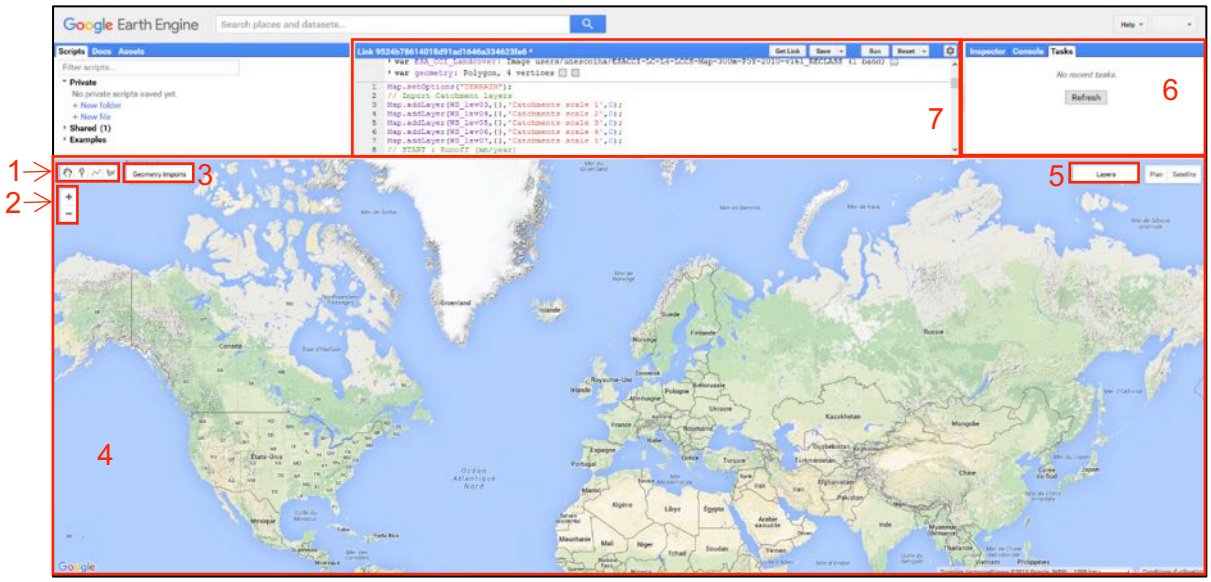
You will then be asked to fill the following form.

1) Your Gmail address should appear here automatically. If not, Sign in.
2) Enter your full name.
3) Enter your affiliation or the name of the institution that employs you.
4) Select your country or your region.
5) Write a brief description on what you would like to accomplish with Earth Engine e.g. "Evaluate the GHG emissions from a reservoir".
6) Click on "I agree that my use of the Earth Engine services and related APIs is subject to my compliance with the applicable Terms of Service" after reading the Terms and Service by clicking on the link. You can access the Terms of Service again at all time on https://earthengine.google.com/terms/.
7) Click on the "SUBMIT" button.



Soon, you will receive a confirmation email in the inbox of your Gmail account. Once you have the confirmation that you now have access to Earth Engine, you can continue to **Note 1**.

NOTE 1: UNDERSTANDING THE INTERFACE OF EARTH ENGINE

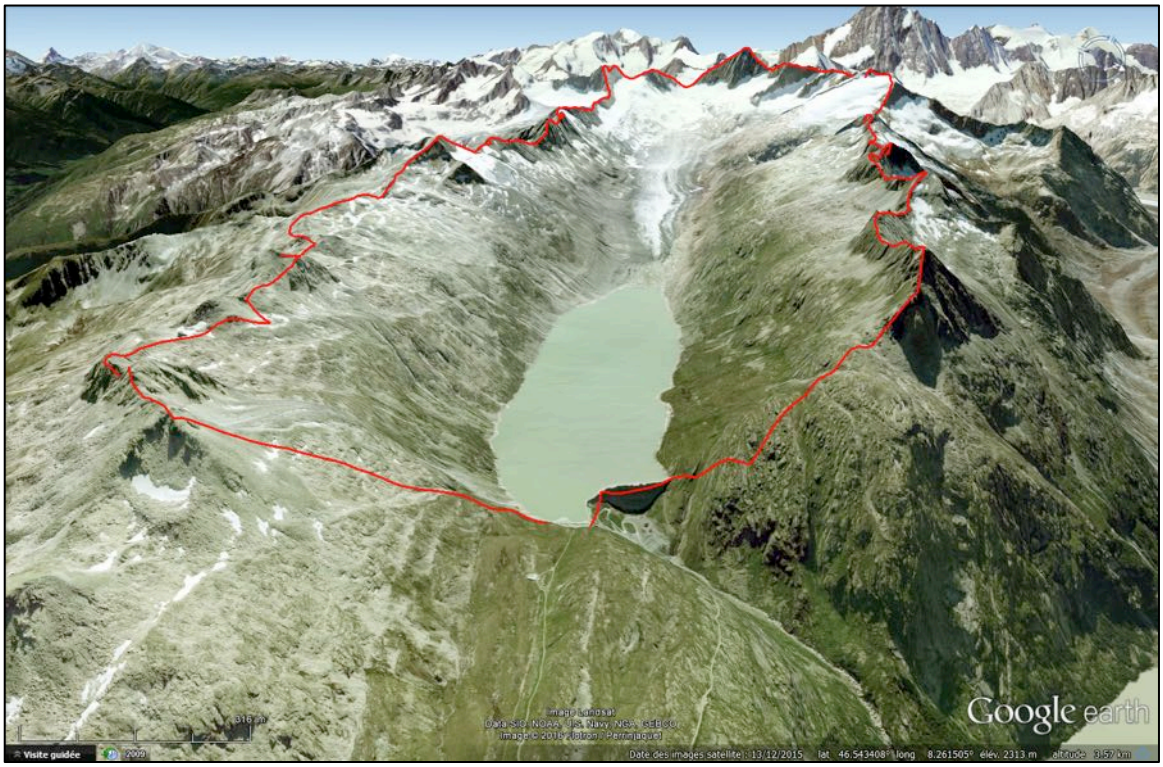


1) Geometry Tools: The shape drawing tool may be used to delineate catchment. The marker tool will be used to input the location of the dam. The line drawing tool may be used to draw and measure river length before impoundment. The hand tool is used to move or select elements.
2) Zoom: To zoom in and out the map. The wheel on the computer mouse can also be used.
3) Geometry Imports: List of the drawn point, polygon and line. Check the box to see them on the map, uncheck to hide. It will only appear once a geometry is drawn. Click on the lock once you are done to lock them in place and avoid moving them.
4) Map: Draw the point, polygon and line here. The land cover map and imported catchment will also appear on this map.
5) List of the layers used or created. Check the box to see them on the map, uncheck to hide. You may use the sliders to adjust the transparency of the layers.
6) Outputs: The data will appear in the “Console” tab. The “Tasks” tab is used to export the data to a CSV file.
7) Code window: Some information will be inputted in the code window.

NOTE 2: "CATCHMENT" DEFINITION

Before we begin the steps to get the catchment and reservoir data, we need to understand what a catchment is in order to delineate the zone accordingly.

A catchment, also called a watershed, "is the geographical area drained by a watercourse." (Food and Agriculture Organization of the United Nations 2016) It is delineated by the ridges of the surrounding topography.



In this Google Earth image, the catchment of the Oberrar reservoir (Switwerland) is delineated in red.

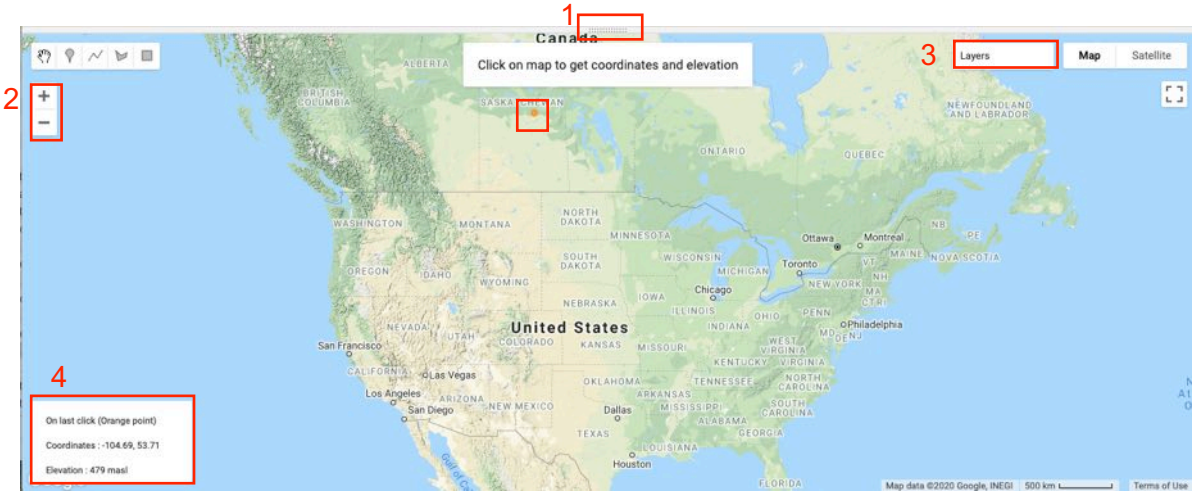
STEP 2: GET CATCHMENT AND RESERVOIR DATA

Step 2.1: From an Imported Catchment Vector File

In the G-res tool app, go in the Earth Engine tab and click on the "From an Imported Catchment Vector File" button to open the code in Earth Engine on your web browser.

WARNING:
-Make sure to always import your vector file before to place the point at the dam site.
-The following red warnings are normal until you have added the catchment shape and dam point `"table" is not defined in this scope.` `"geometry" is not defined in this scope.`
-The following red warning means that your dam point is outside your catchment polygon `Line 302: List.get: List is empty (index is 0).`

1. Place the cursor on the dotted area at the top, click and bring down to open the code.
2. Zoom on your study site using the + and – zoom buttons or the wheel on the computer mouse. You can also type a location name or coordinate in the search bar at the top of the window and select a proposed location.
3. The layer bar allows you to view on the map any layers available. You may use the sliders to adjust the transparency of these layers.
4. At any time, you can click on the map with the hand cursor to get the coordinate and the elevation at this point (The location will show as an orange point).

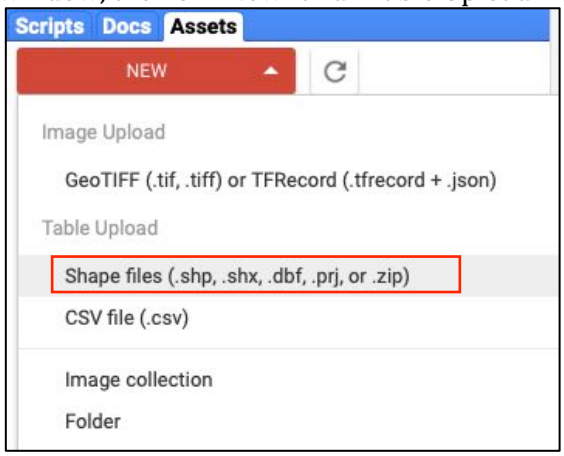


5. Once these preliminary steps are done, we need to import the vector file of the catchment into the code by adding the 5 following file formats from your vector file:

.shp
.dbf
.prj
.cpg
.shx

** Make sure your file name has no space and is saved as UTF 8 format.

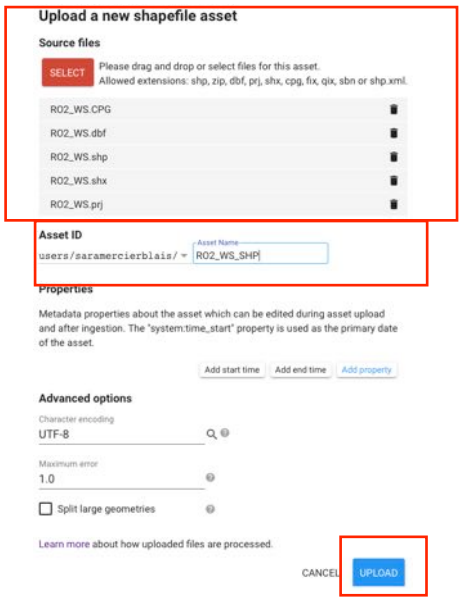
a. Click on the “Assets” tab in the upper left corner of the Google Earth Engine window, then on "New" and "Table Upload – Shape files".



5a

b. Click on "Select" to choose the 5 files needed, give an "Asset ID" to your asset and click on "Upload". This upload can take a few minutes (up to 30mins if the connection is slow or the vector file is complex). To view the upload progress, click on the "Tasks" tab.

**If you are using the “Asset” tab for the first time, you will need to create a root folder directly in the ‘Asset’ tab.



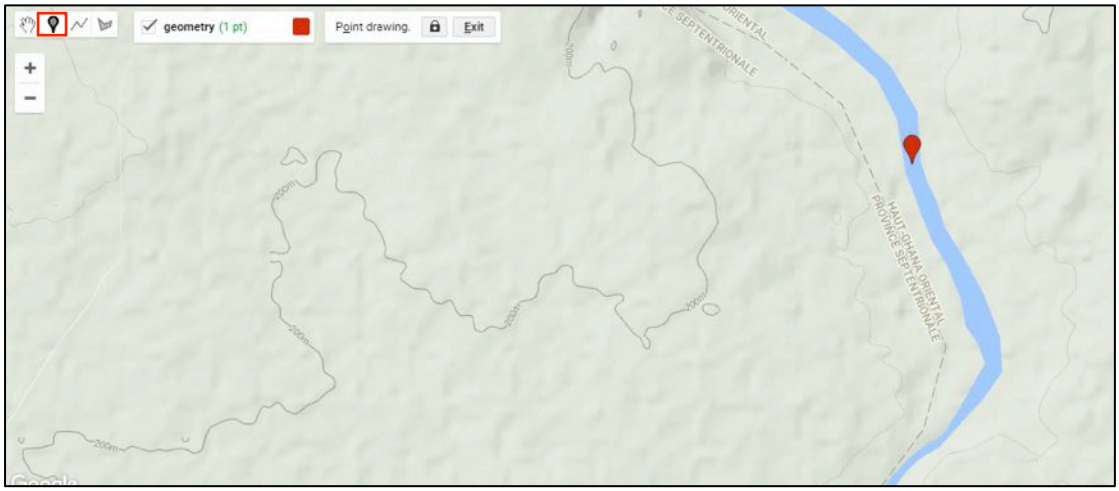
c. The new asset file will appear in the "Assets" Tab. (If it does not appear in the "Assets" tab, click on the Refresh button in the "Tasks" tab.) You can then click on the "arrow" on the left side of the Asset to Import it to the code. You can also import it by clicking on the shapefile name and then on the Import button.

5c

The shapefile is stored in your Google Drive and can be used again later by importing it each time the code is reopened (Redo step c. only). The shape will appear in black on the map, but the tool will not zoom automatically on it.

6. Click on run, locate and zoom manually on your study site using the + and – zoom buttons or the wheel on the computer mouse.
7. Place a point at the dam site location using the point tool. The dam point should be red. **Please make sure that the point of the dam site is in contact with (inside) the polygon of the catchment area.**

7



8. Write the water surface elevation in meters at the line 5 (replace the default "0" value).

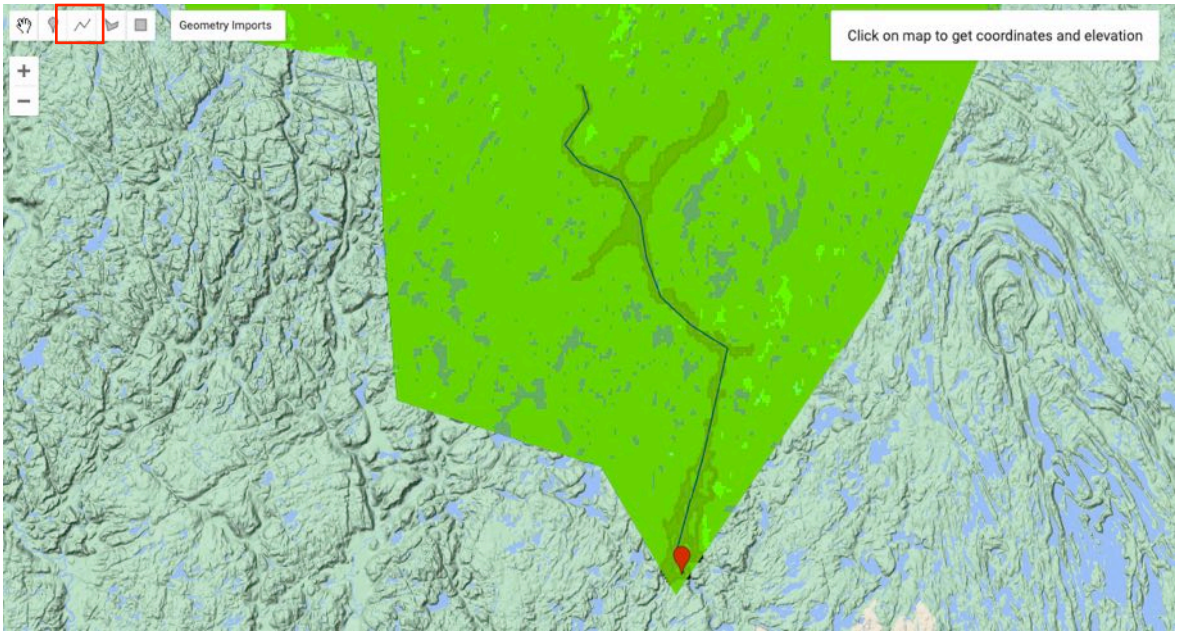
```
1
2
3  /////////   Please enter water surface elevation (masl)    ////////////
4
5  var riseLevel = 0;
6
7  //-------------------------------------------------------------------//
8
9  // G-res Tool Earth Engine Functionality using hand-dranw catchment.
10 // Developped by Sara Mercier-Blais and Roy Nahas, G-res Tool UQAM/IHA Research project.
11 // Last Update 09-05-2019.
12
13 // We would like to acknowledge the help of the Google Earth Engine Developers forum in the writing of this script.
14
15 //-------------------------------------------------------------------//
16
17
18 /////////   PLEASE DO NOT CHANGE THE CODE BELOW    ////////////
19
```

8

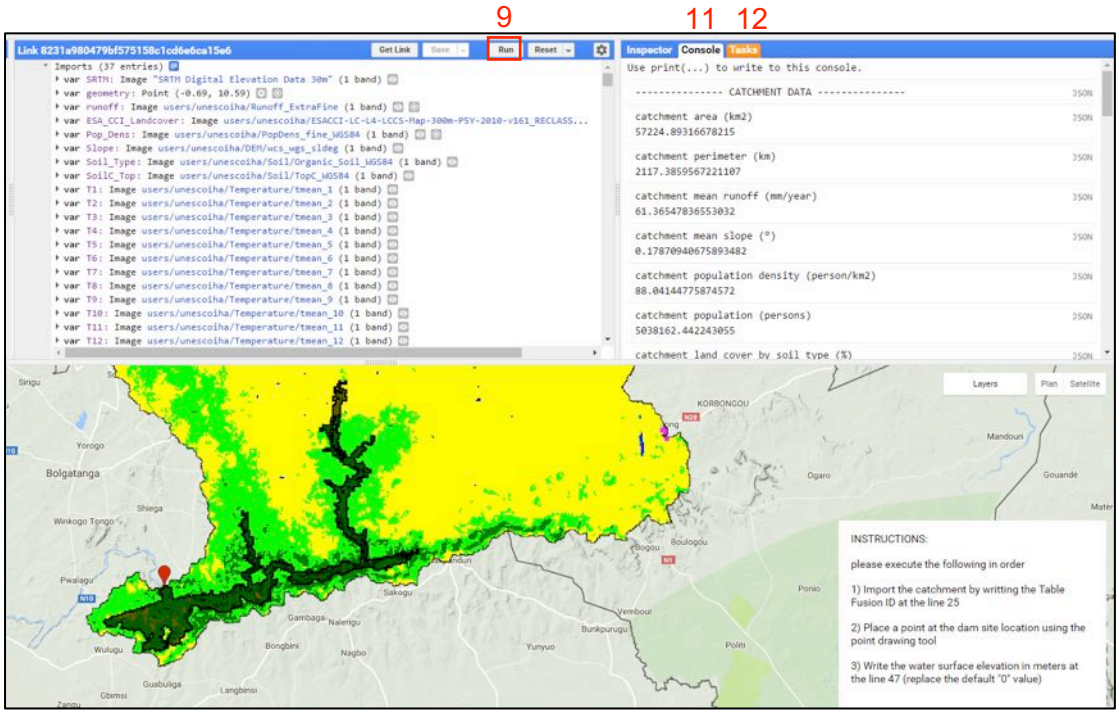
```
1
2
3  /////////   Please enter water surface elevation (masl)    ////////////
4
5  var riseLevel = 170;
6
7  //-------------------------------------------------------------------//
8
9  // G-res Tool Earth Engine Functionality using hand-dranw catchment.
10 // Developped by Sara Mercier-Blais and Roy Nahas, G-res Tool UQAM/IHA Research project.
11 // Last Update 09-05-2019.
12
13 // We would like to acknowledge the help of the Google Earth Engine Developers forum in the writing of this script.
14
15 //-------------------------------------------------------------------//
16
17
18 /////////   PLEASE DO NOT CHANGE THE CODE BELOW    ////////////
19
```

9. Click on the “Run” button to see the land cover inside the catchment and the flooded area.
10. Draw a line following the river using the line tool and click on the “Run” button” again

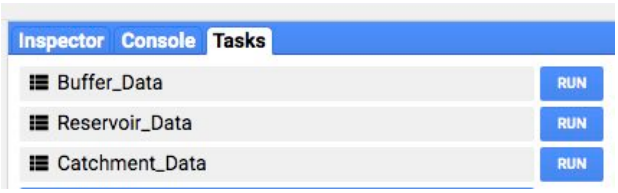
10



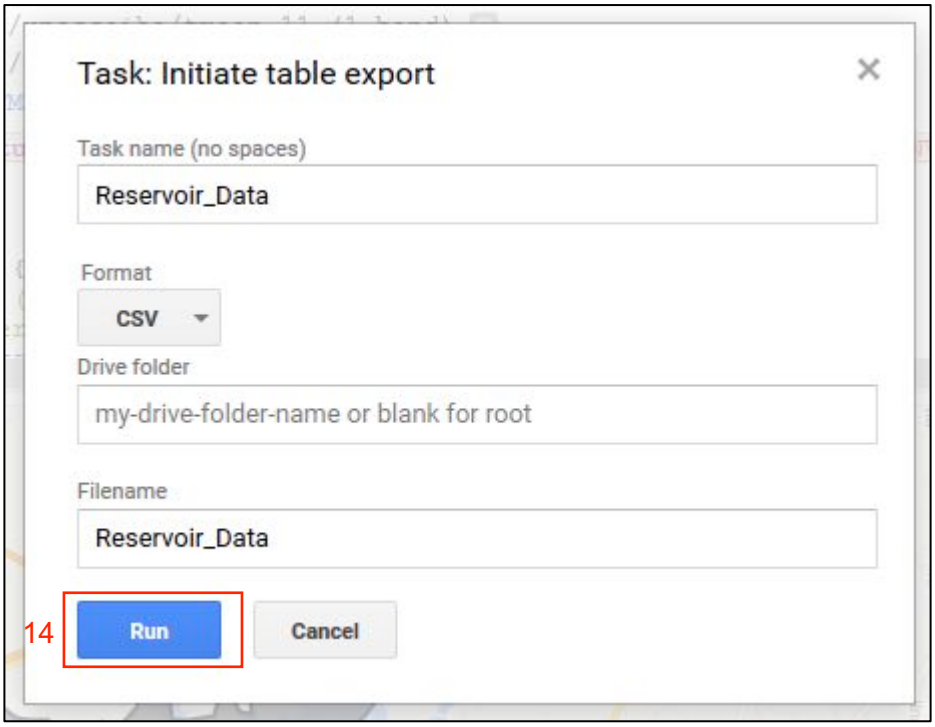
11. The data needed to run the G-res tool also appear in the “Console” tab.
12. To save the data, you can copy-paste the full content of the console in a Word/Excel document or go to the “Tasks” tab to export the data in a CSV text file.



13. In the “Task” tab, click on “RUN” (for each file)



14. In the new window that appears, click on “RUN” once again to export the data to your Google Drive (https://www.google.com/drive/) in CSV text format (for each file). You can connect to Google Drive with your Google account.


Task: Initiate table export
Task name (no spaces)
Reservoir_Data
Format
CSV
Drive folder
my-drive-folder-name or blank for root
Filename
Reservoir_Data
14
Run
Cancel

Step 2.2: From a Hand-Drawn Catchment

In the G-res tool app, go in the Earth Engine tab and click on the "From a Hand-Drawn Catchment" button to open the code in Earth Engine on your web browser.

WARNING:

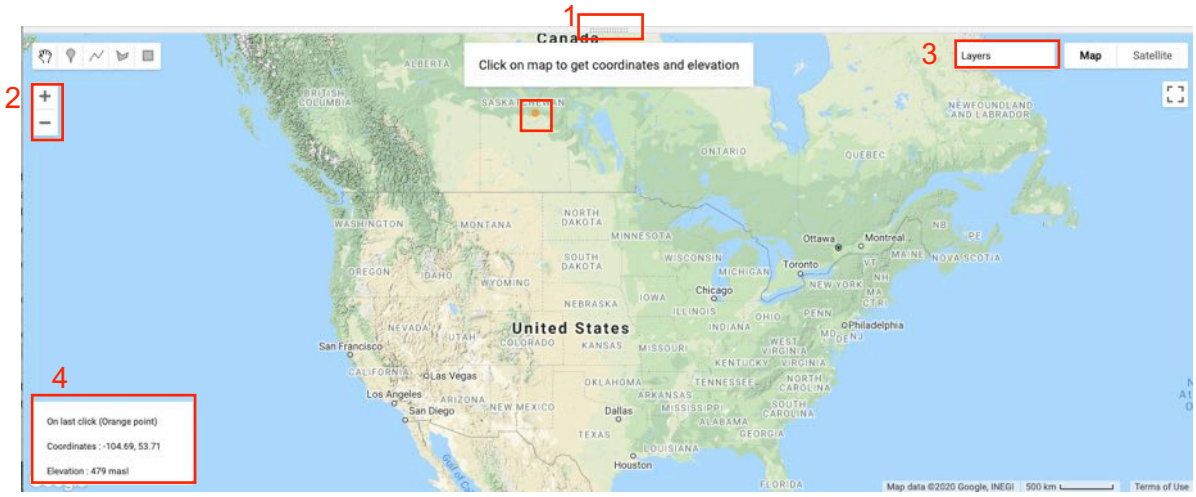
- Make sure to always place the point at the dam site before to draw the catchment polygon.

-The following red warnings are normal until you have added the catchment shape and dam point: `"geometry" is not defined in this scope.` `"geometry2" is not defined in this scope.`

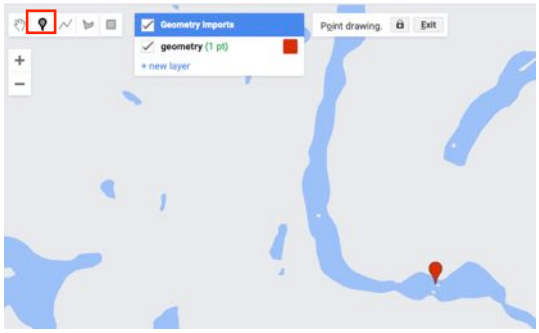
-The following red warning means that your dam point is outside your catchment polygon `Line 302: List.get: List is empty (index is 0).`

-Your dam point needs to be red and your catchment polygon needs to be green.

1) Place the cursor on the dotted area at the top, click and bring down to open the code.
2) Zoom on your study site using the + and – zoom buttons or the wheel on the computer mouse.
3) Using the terrain map (it appears on the map automatically), the different catchment layers (different scales), and the "Hillshade" and the "Landsat" layers in the "Layers" toolbar, delineate the catchment of the future reservoir (see step 4). You may use the sliders to adjust the transparency of these layers.
4) At any time, you can click on the map with the hand cursor to get the coordinate and the elevation at this point (The location will show as an orange point).

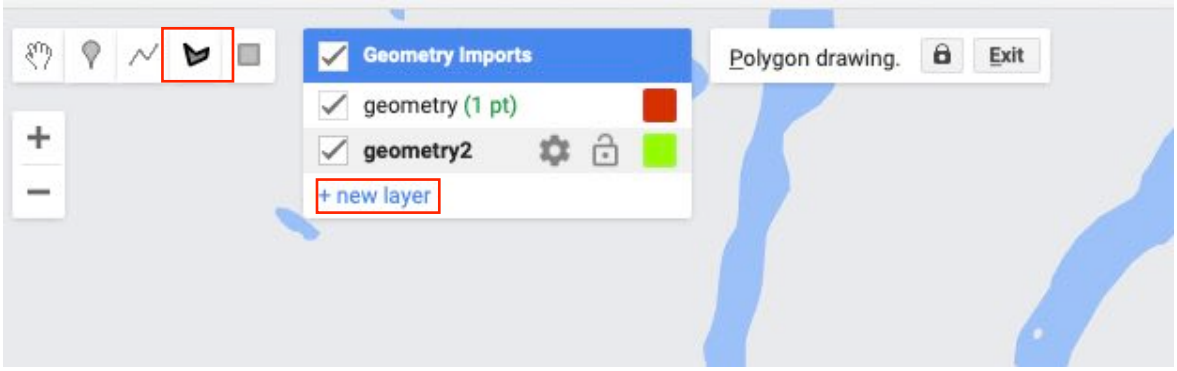


5) Use the marker drawing tool (upper right in the Geometry Tools toolbox) to place a point at the dam site.

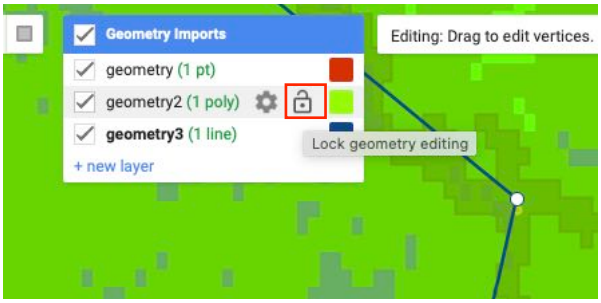


6) Geometry Imports will appear with only one item listed: “geometry (1 pt)”. Click on “Exit” to exit the Marker drawing mode. If you want to erase the drawn marker, click on the “Delete” button “appearing when the “geometry (1 pt)” is selected.

7) Click on “+ new layer” under “Geometry Imports” and select the shape tool. Draw on the map the catchment of the future reservoir following the different guide provided in the Layers dropdown menu. To draw, click on the map to input each vertex of the polygon. Connect with the first point or double-click on the last one to finish the drawing. **Please make sure that the point of the dam site is in contact with (inside) the polygon of the catchment area.**

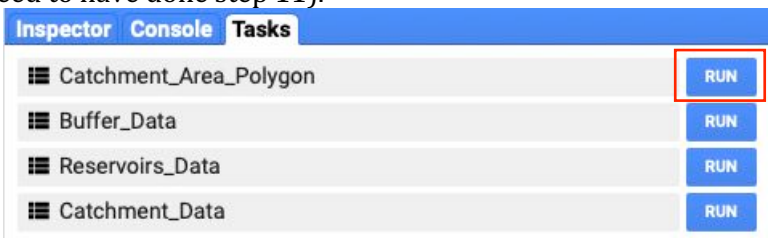


8) Once you are happy with the shape of your catchment polygon, make sure to “lock geometry editing” by clicking on the lock symbol beside your polygon geometry. This makes sure that you do not move your catchment or modify it by error.

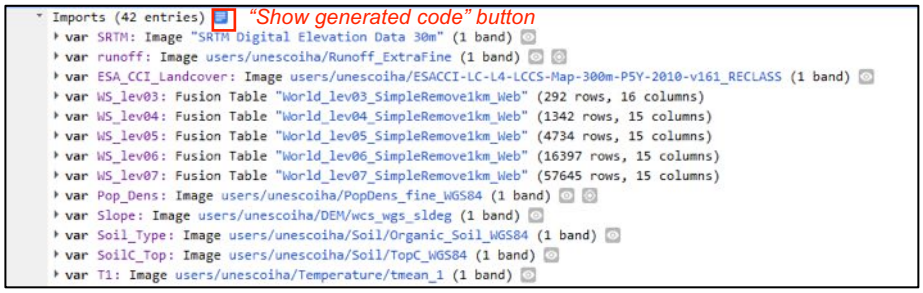


9) You can also save your shape in two different ways:

9a) **Save a final version of your polygon.** You have the option to save this polygon as a final shape (not possible to modify) once you are done in the Tasks tab (You need to have done step 11).

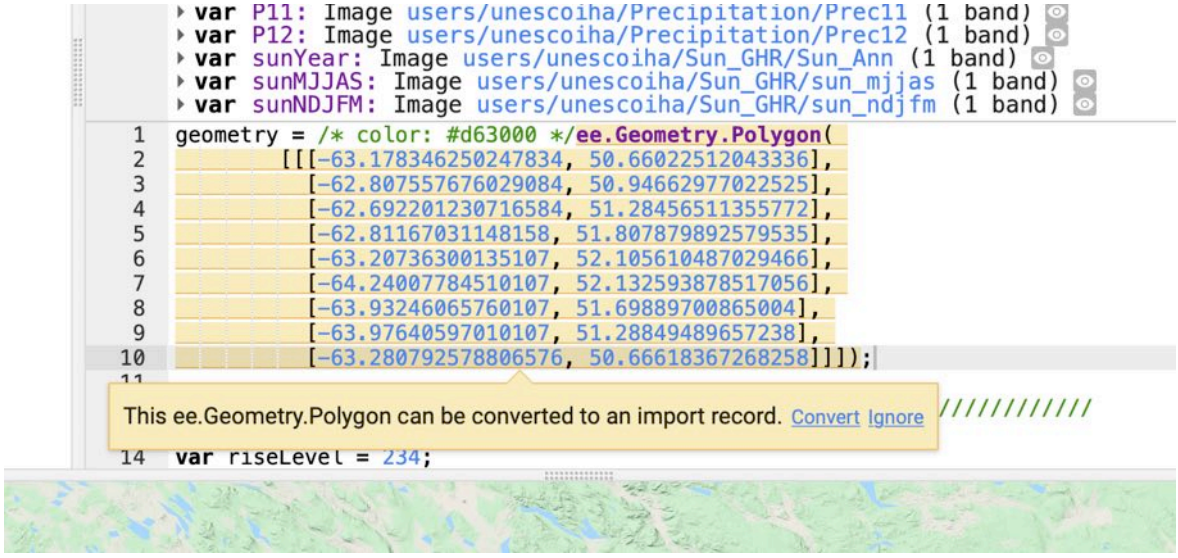


9b) **Save your polygon to modify later**. To keep a copy of the drawn polygon to continue to modify it later, click on the "Show generated code" button in the top section of the script and copy the code of the variable called "geometry". If you want to reuse this polygon in another code, simply paste this part at the beginning of a new script (Line 1, Hand drawn catchment empty code) and click on the convert button in the yellow suggestion tooltip appearing when you bring the mouse on the code.



Below is the JavaScript code representing the current imports. To transfer them to another script, paste this code into the editor and click "Convert" in the suggestion tooltip.

```
    sunYear = ee.Image("users/unescoiha/Sun_GHR/Sun_Ann"),
    sunMJJAS = ee.Image("users/unescoiha/Sun_GHR/sun_mjjas"),
    sunNDJFM = ee.Image("users/unescoiha/Sun_GHR/sun_ndjfm"),
    geometry = /* color: #d63000 */ee.Geometry.Polygon(
        [[[-63.178346250247834, 50.66022512043336],
          [-62.807557676029084, 50.94662977022525],
          [-62.692201230716584, 51.28456511355772],
          [-62.81167031148158, 51.807879892579535],
          [-63.20736300135107, 52.105610487029466],
          [-64.24007784510107, 52.132593878517056],
          [-63.93246065760107, 51.69889700865004],
          [-63.97640597010107, 51.28849489657238],
          [-63.280792578806576, 50.66618367268258]]]),
    geometry2 = /* color: #98ff00
*/ee.Geometry.Point([-63.22132404935048, 50.66301273209795]);
```



10) Write the water surface elevation in meters at the line 5 (replace the default "0" value). In the case of this example, we used 170 meters above mean sea level (amsl).

10

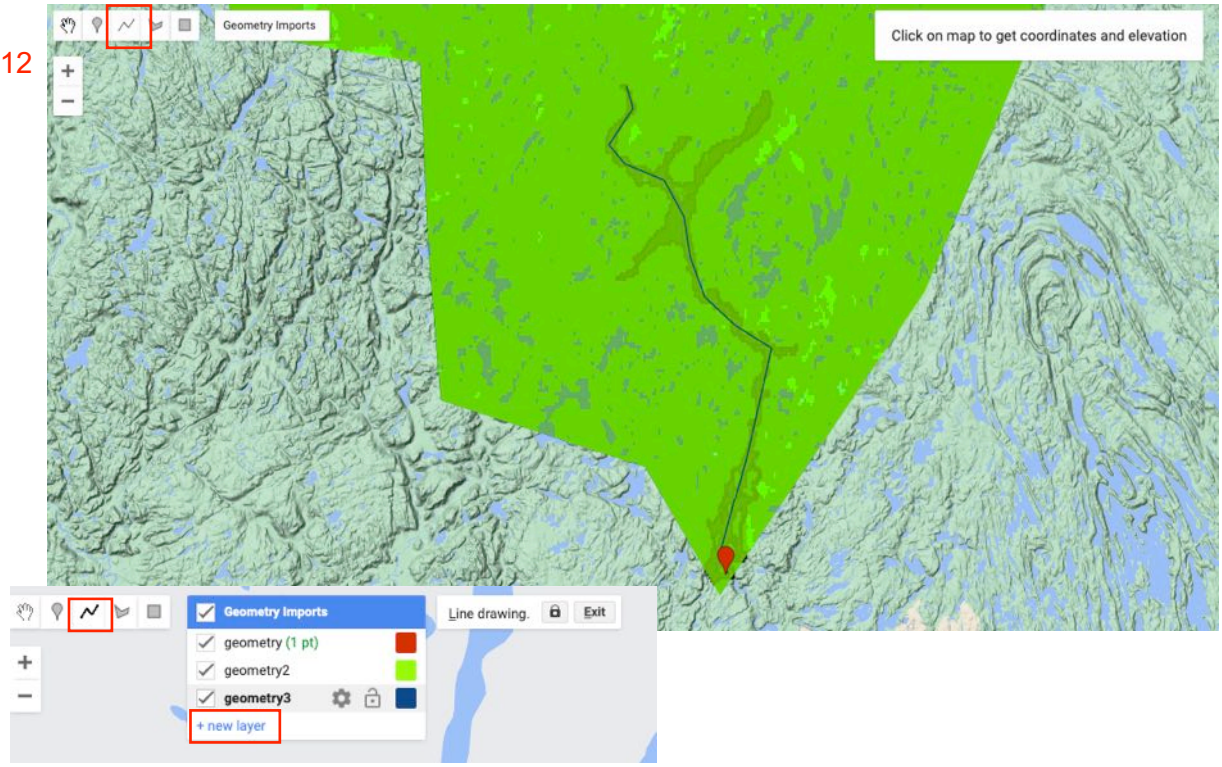
```
1
2
3  ////////   Please enter water surface elevation (masl)    ////////////
4
5  var riseLevel = 0;
6
7  //-------------------------------------------------------------------//
8
9  // G-res Tool Earth Engine Functionality using hand-drawn catchment.
10 // Developped by Sara Mercier-Blais and Roy Nahas, G-res Tool UQAM/IHA Research project.
11 // Last Update 09-09-2022.
12
13 // We would like to acknowledge the help of the Google Earth Engine Developers forum in the writing of this script.
14
15 //-------------------------------------------------------------------//
16
17
18 ////////   PLEASE DO NOT CHANGE THE CODE BELOW    ////////////
19
```

10

```
1
2
3  ////////   Please enter water surface elevation (masl)    ////////////
4
5  var riseLevel = 170;
6
7  //-------------------------------------------------------------------//
8
9  // G-res Tool Earth Engine Functionality using hand-drawn catchment.
10 // Developped by Sara Mercier-Blais and Roy Nahas, G-res Tool UQAM/IHA Research project.
11 // Last Update 09-09-2022.
12
13 // We would like to acknowledge the help of the Google Earth Engine Developers forum in the writing of this script.
14
15 //-------------------------------------------------------------------//
16
17
18 ////////   PLEASE DO NOT CHANGE THE CODE BELOW    ////////////
19
```

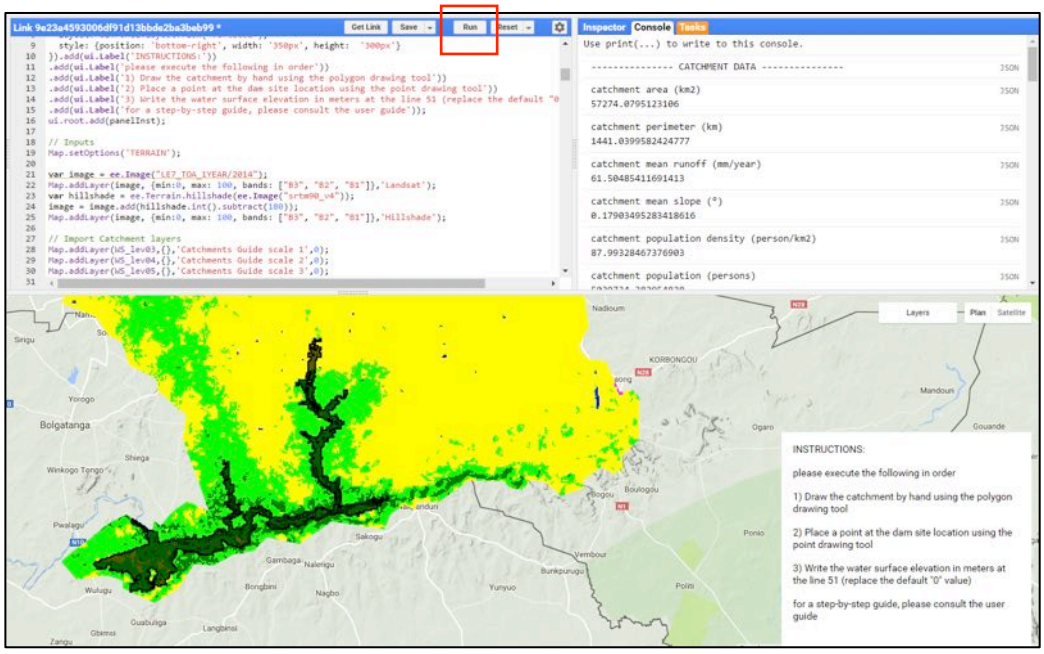
11) Click on the “Run” button to see the land cover inside the catchment and the flooded area.
12) Click on “+ new layer” under “Geometry Imports” and select the line tool. Draw a line following the river using the Line tool (your line must be blue) and click on the “Run” button again

12

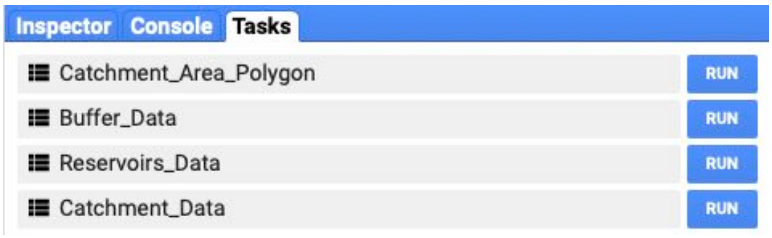


13) The data needed to run the G-res tool also appear in the “Console” tab.
14) To save the data, copy-paste the data from the console to a Word/Excel document or export the data as a CSV text files by clicking on the “Tasks” tab

10 13 14

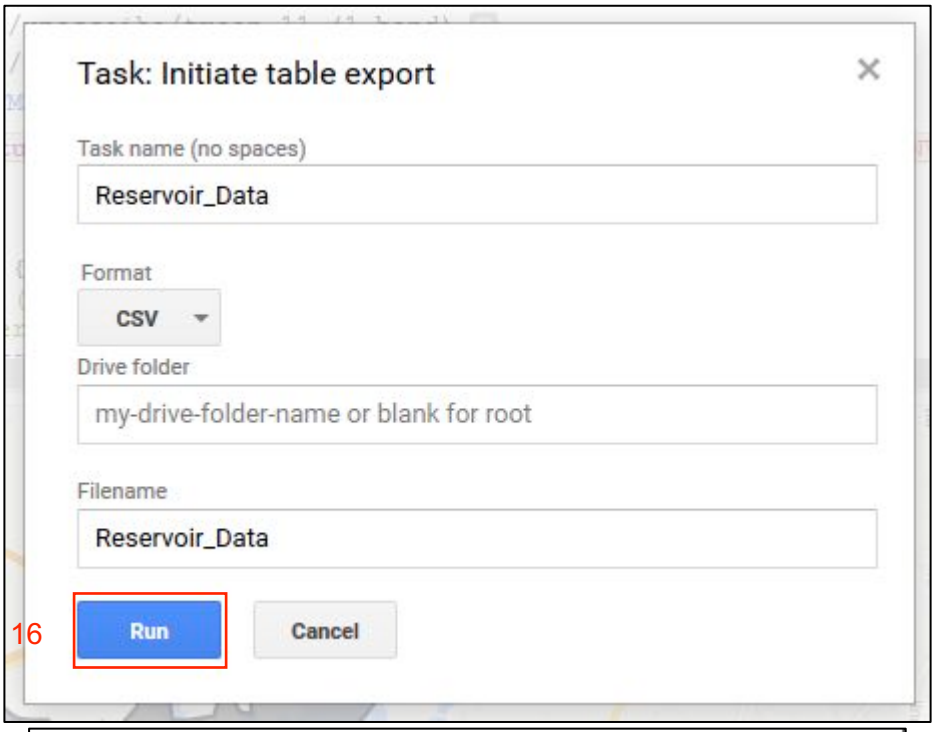


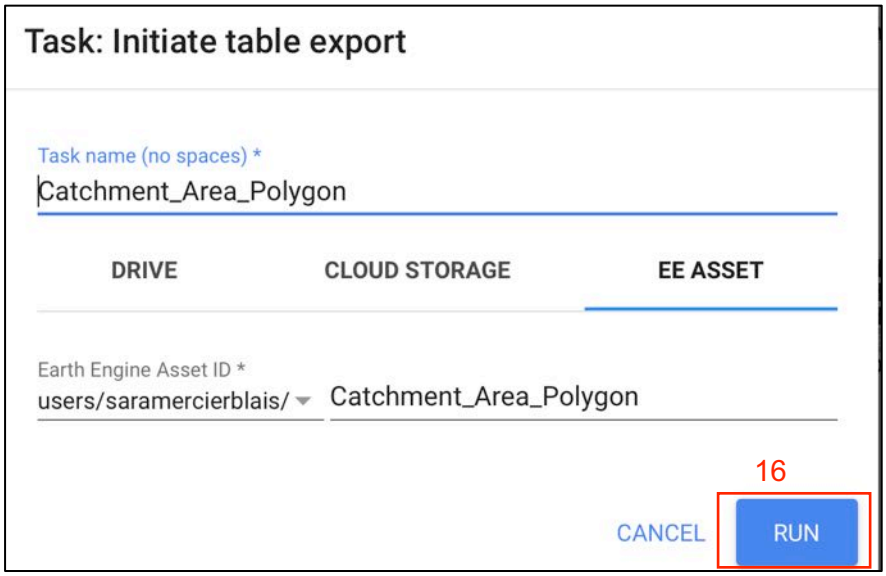
15) In the “Task” tab, click on “RUN” (for each file)



15

16) In the new window that appears, click on "RUN" once again to export the data to your Google Drive (https://www.google.com/drive/) in CSV text format (for each data file) or in kml file (Catchment shape). You can connect to Google Drive with your Google account. For the Catchment shape, use the EE Asset option to save it directly in Earth Engine (Saved in the Assets tab) (see step 5a).





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REFERENCES

Food and Agriculture Organization of the United Nations. (2016). Sustainable Forest Management (SFM) Toolbox. Available at http://www.fao.org/sustainable-forest-management/toolbox/modules/watershed-management/basic-knowledge/en/ (consulted on 2016-04-25)