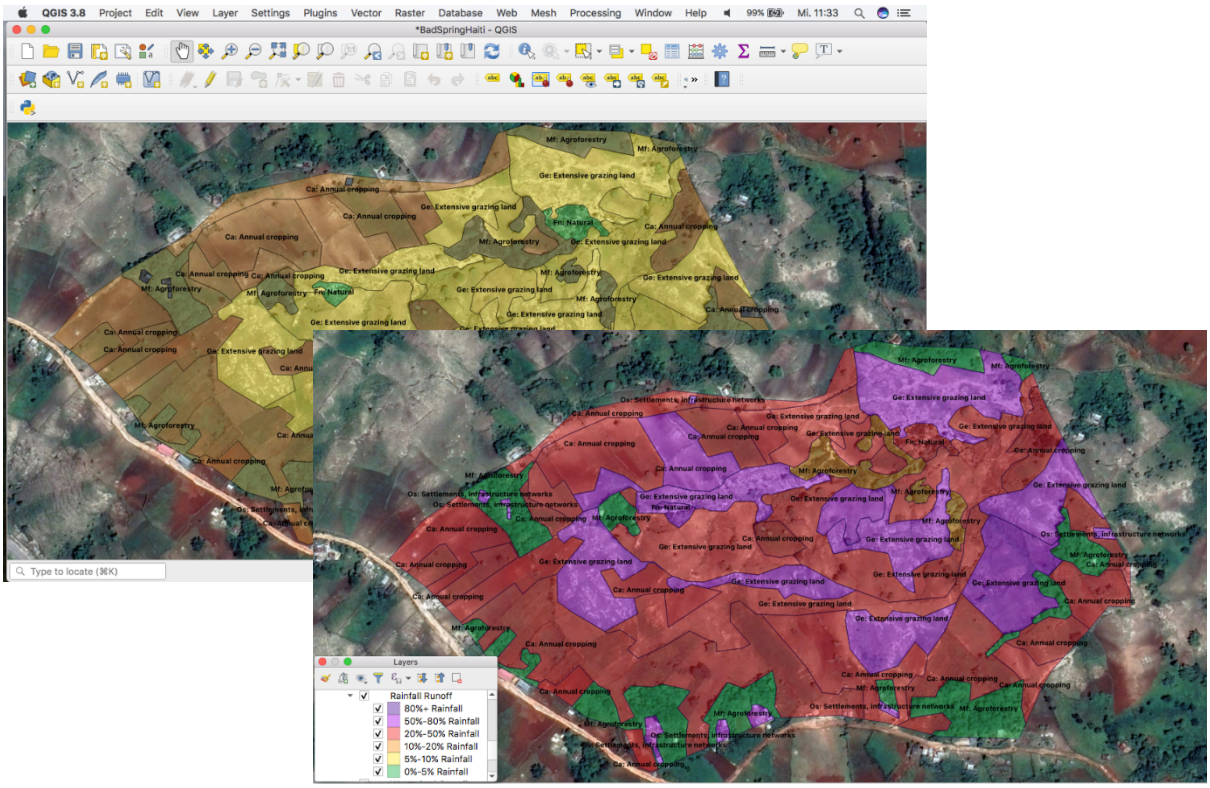
User Manual for the WOCAT SLM Watershed Tool

Beta Version: 13/06/2020 Windows/Mac © WOCAT 2020



Hanspeter Liniger, Lorenz Joss, Joana Eichenberger, Matthias Fries, Jürg Krauer

Introduction to the WOCAT SLM Watershed Tool (Beta Version: Mac and Windows)

The Watershed Tool helps to categorize and map different land use/land management types, calculate their runoff rates, and determine their contribution to the total watershed runoff from daily rainfall events. Using Google satellite images and QGIS (a free, open source Geographic Information System), users can delineate small to medium sized watersheds (<100 km^2) and understand how current land use and land management, soil types and slope conditions contribute to surface runoff. The Watershed Tool further allows users to analyse different land use scenarios and assess how changes in land management - such as spreading SLM practices - affect runoff contributions within the watershed, as well as quantify the total outflow from the watershed (e.g. to understand flood risks).

The tool can be used in rural areas facing land degradation, high runoff and frequent damage caused by floods. It has been developed for regions with data scarcity on information about land use/land management, rainfall, river flows and soil conditions. The Watershed Tool is made to support local/regional planners, project implementers and researchers by improving participatory assessments and intervention planning in a watershed with local land and water users. The current version of the tool requires basic GIS skills, however a more user-friendly version requiring no GIS knowledge is planned to be developed in the future (based on demand and available resources).

The tool uses a slope-corrected SCS runoff curve number (developed by USDA), which has been continuously applied and improved upon for application in watersheds worldwide. For the WOCAT Watershed Tool, the USDA land use classification was merged with the WOCAT classification. The steps consist of delineating a watershed and subdividing into different Hydrologic Response Units (HRUs) according to the following variables: land use, slope, hydrologic condition and hydrologic soil group. Users can draw polygons by hand or load shapefiles with land use classifications based on satellite images. In the next step, users assign a daily rainfall and the tool calculates (a) runoff in % of rainfall and volume for each HRU (b) the contribution of each land use/ land management practice to the total runoff at the outlet of the watershed.

With such information, the impact of land use/management changes can be further assessed. The current land use/management can be compared with scenarios of improved land management e.g. the spreading of SLM Technologies documented in the WOCAT database (https://qcat.wocat.net/en/wocat/). This allows project planers and implementers to assess and negotiate with local land users the benefits of SLM onsite, where the practices are implemented but also the benefits offsite by the reduction of flood flows.

The Watershed Tool output data can also be exported to Microsoft Excel for further analysis. As an example, the recharge of groundwater for the different land use / management practices within springsheds can be assessed. This allows users to understand the impacts of land management on spring flows. However, the function of assessing groundwater recharge is not yet available in the current version of the tool and requires further testing. Additional trials to improve and ratify the tool's accuracy, and merging applications is a target for future versions.

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Hanspeter Liniger, Lorenz Joss, Joana Eichenberger, Matthias Fries, Jürg Krauer

This manual gives instructions on how to use the WOCAT SLM Watershed Tool. It describes step by step how to calculate runoff of a watershed from daily rainfall events. Basic knowledge about GIS is of advantage.

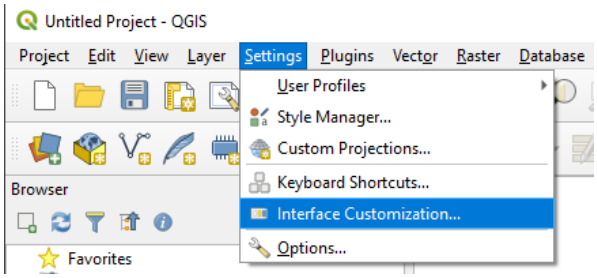
The guideline is divided into four parts:

For further information to WOCAT visit https://www.wocat.net/.

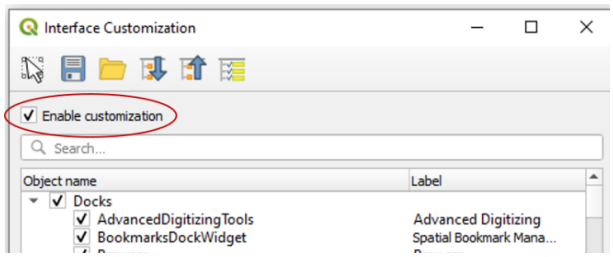
Part A: Customizing QGIS (open source version 3.8 or 3.10) for the WOCAT SLM Watershed TOOL (only has to be done once)

Step A.1
Download and install QGIS version 3.12 of the open source software QGIS. Visit
http://www.qgis.org/en/site/

Step A.2
Open QGIS Desktop.
Go to Settings -> Customization.

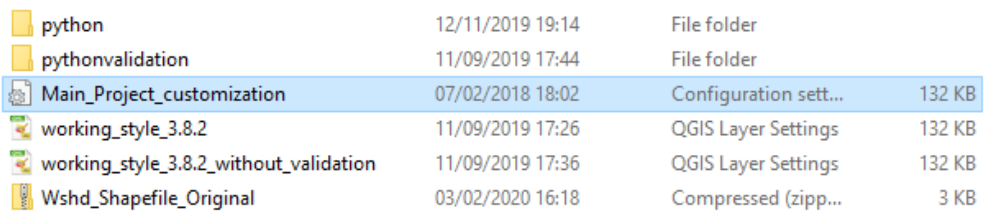


A window pops up. Press “Enable Customization”



Step A.3
Load the customization File (Main_Project_customization.ini) with the “Load from File” (Folder Icon).

Select the “Main_Project_customization” file in the respective folder where you saved it to and press “Open”. Save the changes with OK.

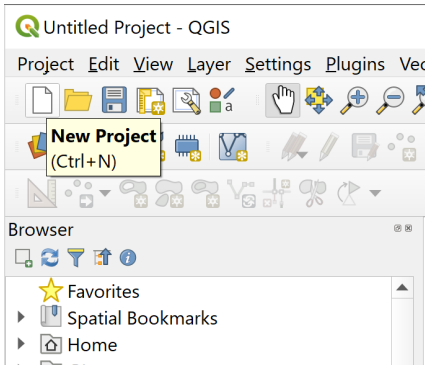


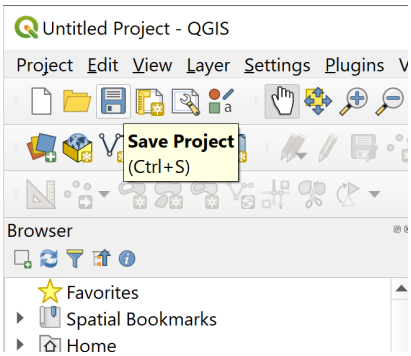
Step A.4
Close QGis and reopen it. The changes are applied now.

Part B: Preparing Google satellite image for the Background

Step B.1

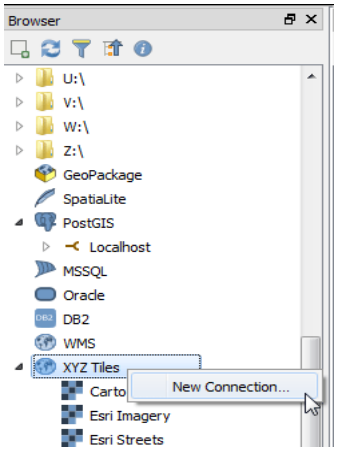
Open a new Project and save it with the name of the watershed

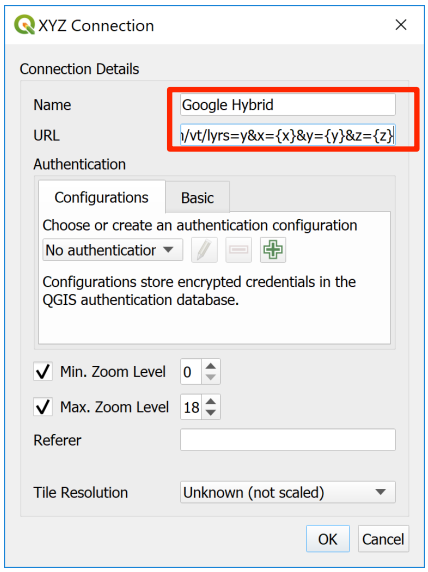




Step B.2

Right Click on **XYZ tiles** in the Browser Window on the left side and choose the option **New Connection**. Write in *Name* "Google Hybrid" and copy-paste the following link in *URL*:
https://mt1.google.com/vt/lyrs=y&x={x}&y={y}&z={z}





Press "OK".

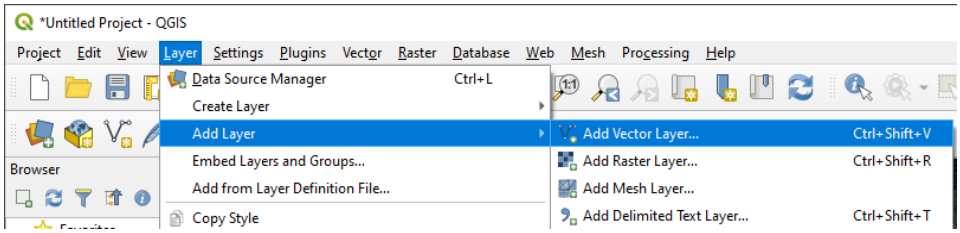
Step B.3

Double-click on the new XYZ Tiles "Google Satellite" you created above and it will appear as a layer. Zoom to your area of interest.

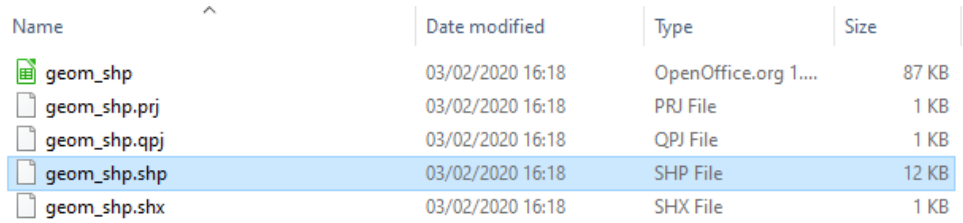
Part C: Use of the WOCAT SLM Watershed Tool

Step C.1
Note that the “geom_shp.shp” will be overwritten in this project. Therefore, for each new project, make a copy of the “Wshd_Shapefile_Original” folder before you start and name it after your project. Keep “Wshd_Shapefile_Original” unchanged.

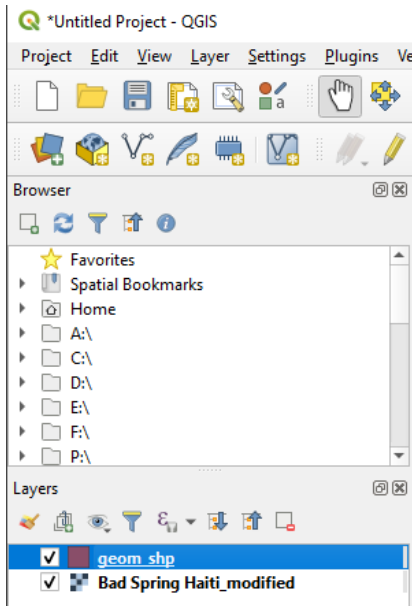
Step C.2
Go to Layer -> Add Layer -> Add Vector Layer to add a new layer. Load “geom_shp.shp” file into the application.



By pressing “Browse” or “…”, search the geom_shp.shp file in the folder, which you copied and renamed in Step C.1.
Choose the file with the “.shp” ending.

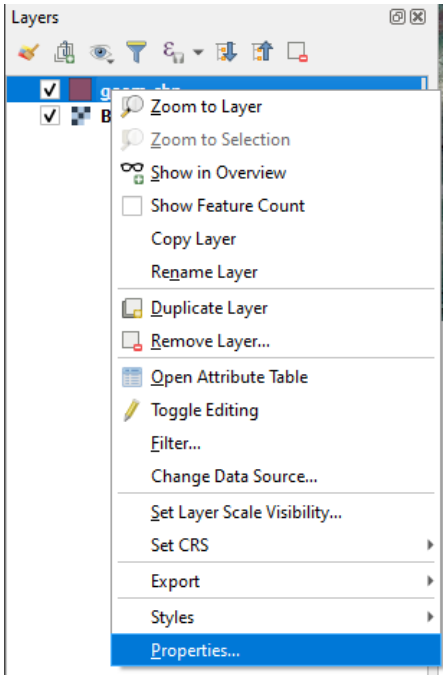


Confirm and close the windows by pressing “Open” and then press “Add” to add the layer and “Close” to close the window.
To the left of the QGIS Window, you can see the Layers Panel. In the Layers Panel, you should now see two layers. One is the uploaded satellite picture, the other the geom_shp file. The colour may vary.

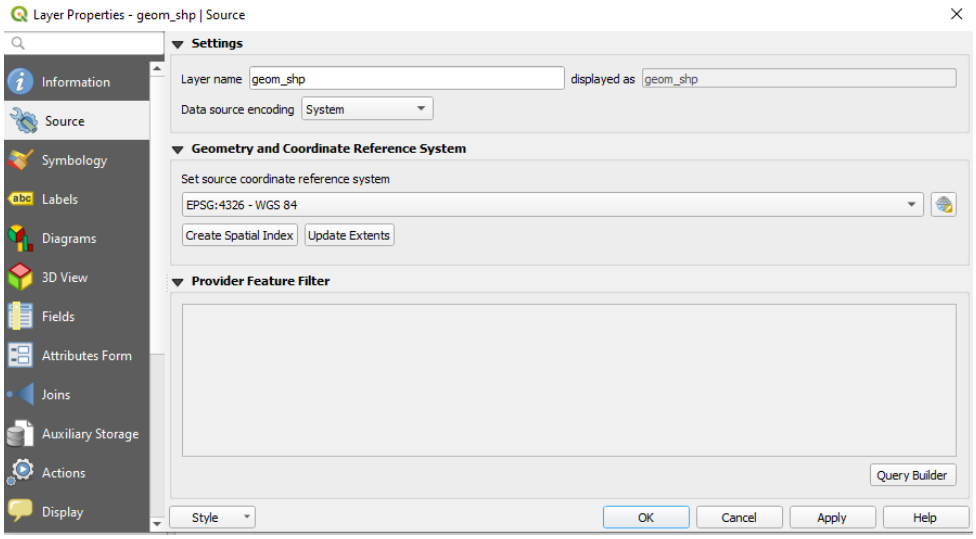


Step C.3

Now right click on the layer geom_shp and open properties.

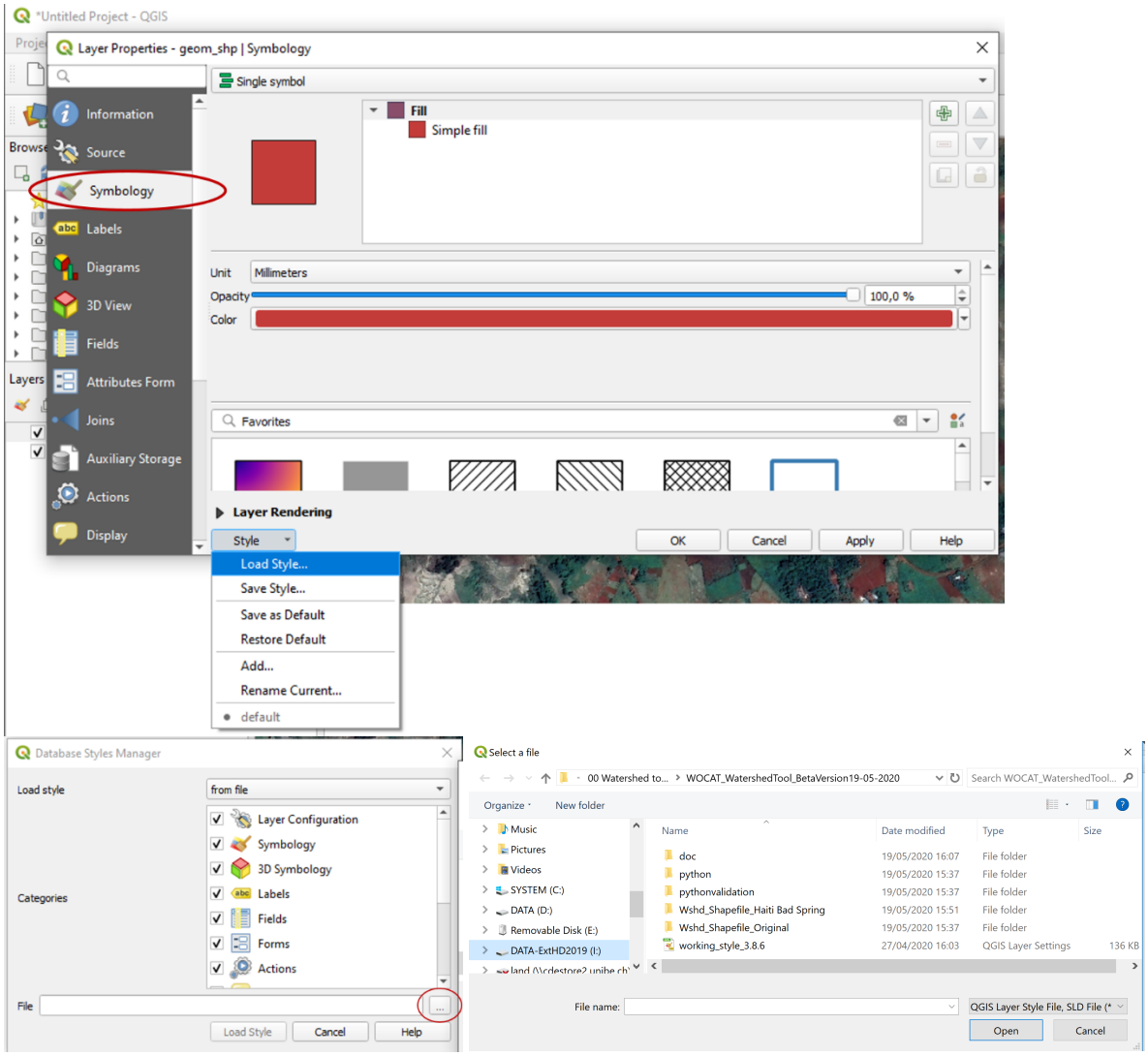


The following window should be opened.



Step C.4

Go to “Symbology” on the left and click on “Style”. Down below to the left, select Style -> Load Style. A new Window Opens. Click on “…” and add the File “working_style_3.8.7” from the respective folder where you saved the customization file.



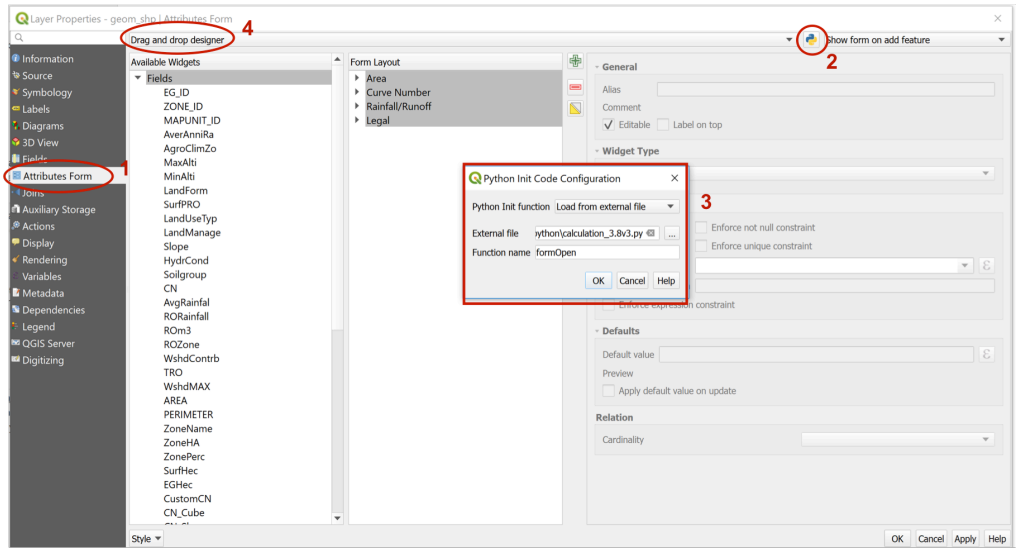
Press open -> Load Style -> Apply.

Step C.5

Now, choose the tab “Attributes Form” on the left (1).

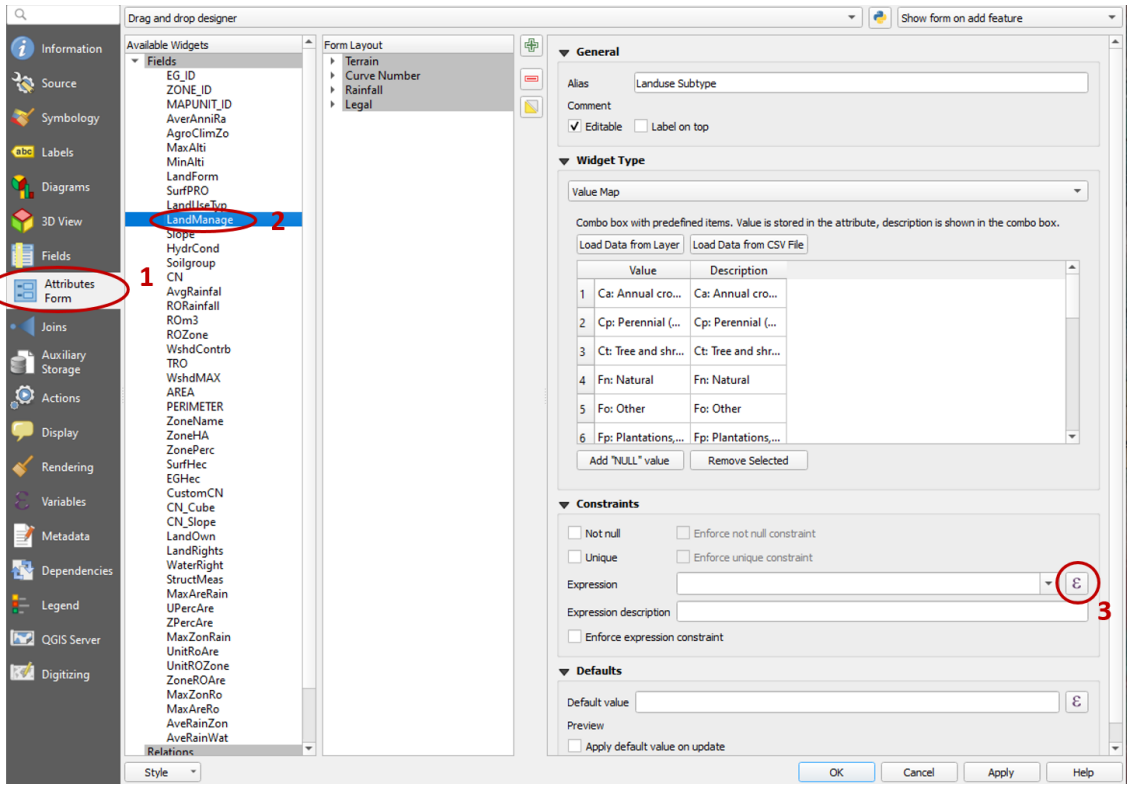
By clicking on the blue-yellow button (2), Press on “…” search from the “Python” folder “calculaction_3.8v3”. Press “Open” (3). Check if the “Python Init function” is set on “Load from external file” and the “Function name” is set on “formOpen”. Click “OK”. Then, check if the “Drag and drop designer” is selected (4).

Press “Apply”.

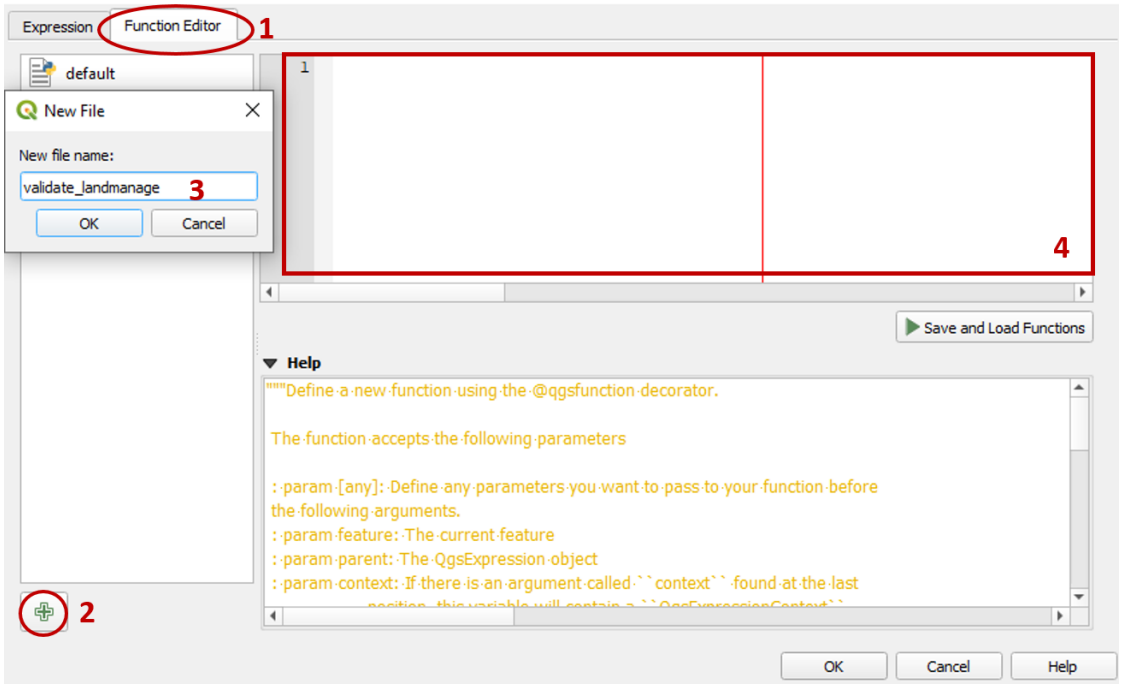


Step C.6

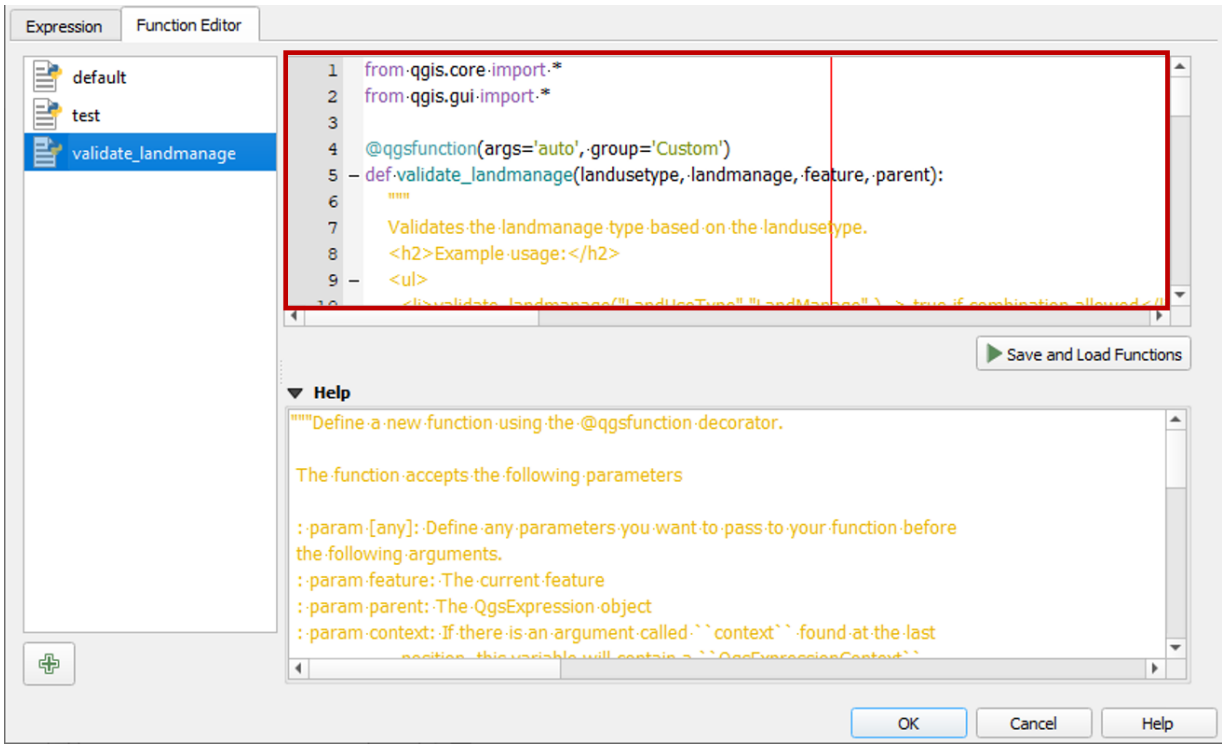
Now, stay in “Attributes Form” (1) but go to “Land Manage” (2) and click on “Ɛ” at the far right bottom (3).



A new window will open. Go to “function editor” (1) and click on the green plus (2) in order to make a new file. Name it “validate_landmanage” (3), click “OK”. Delete the content in upper window (4).



Now, go to the folder where the Watershed Tool is saved and open the file “validate_landmanage” in the folder “pythonvalidation”. If it does not open automatically use right mouse click and “open with” function and select a text editor app (e.g. “Notepad”()
Select and copy the whole script and paste it the validate _landmanage-file just created before in QGIS. (Paste where you deleted the content in the step before).

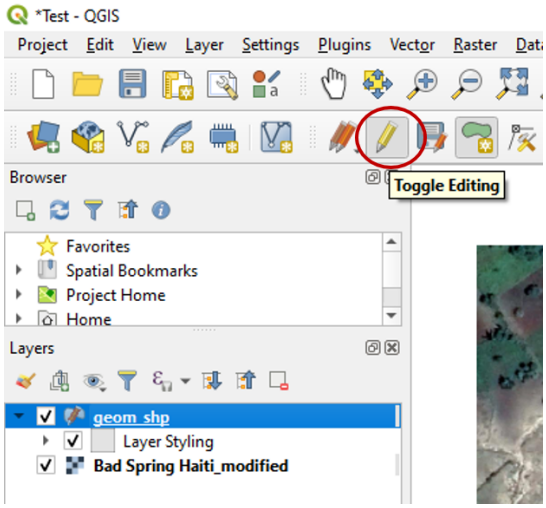


Click “Save and Load Function” and “OK”. When closing the “Layer Properties” Window, click “Apply” first and then “OK”.

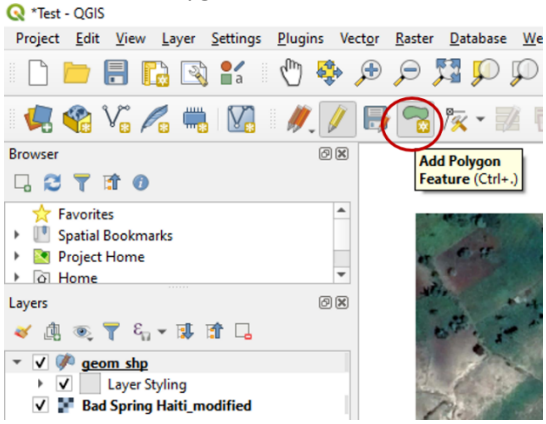
Step C.7
Now, the outline of the watershed can be drawn.

If you wish to adjust the image to the size of the QGIS window, select the Google Image layer in the layer panel and press “zoom to layer” 

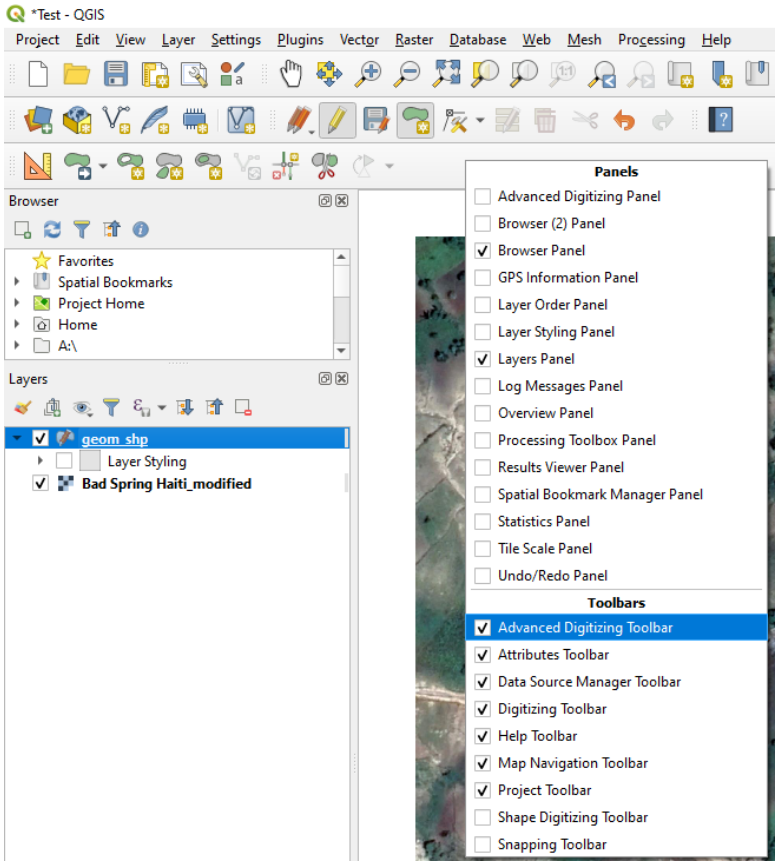
Select again the “geom_shp” in the Layers Panel to the left and press the “Toggle Editing” button.



Select “Add Polygon”.



Note: If for some reason the icon are not showing, right click somewhere in the gray area and check if the “Advanced Digitizing Toolbar” is activcated.

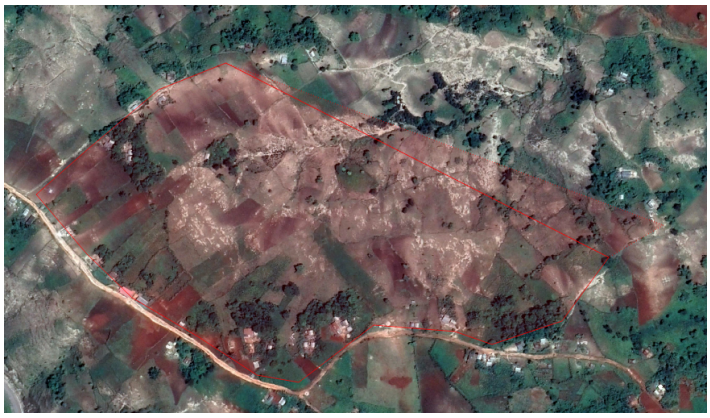


Step C.8

Now the outline of the watershed can be drawn.

Make sure to always have the geom_shp layer selected when working and the “Troggle Editing” as well as the “Add Polygon” icons are activated.

By left-clicking, set a starting point. By clicking a second time, the first line of the outline is drawn. Continue to draw the outline of the watershed.

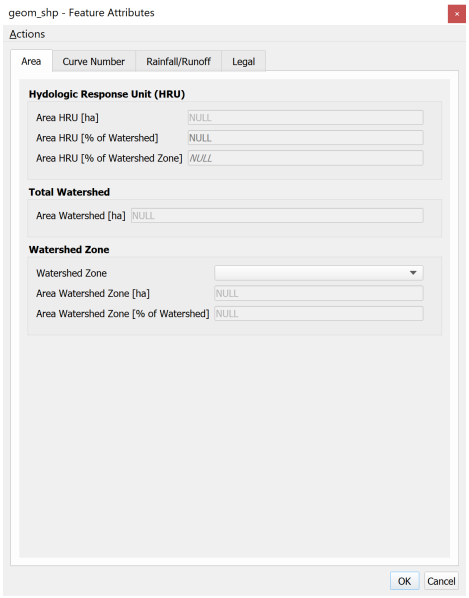


Note: If you made a mistake, press the “backspace key” on your keyboard to draw the point again. Use the hand icon to navigate across the satellite image.

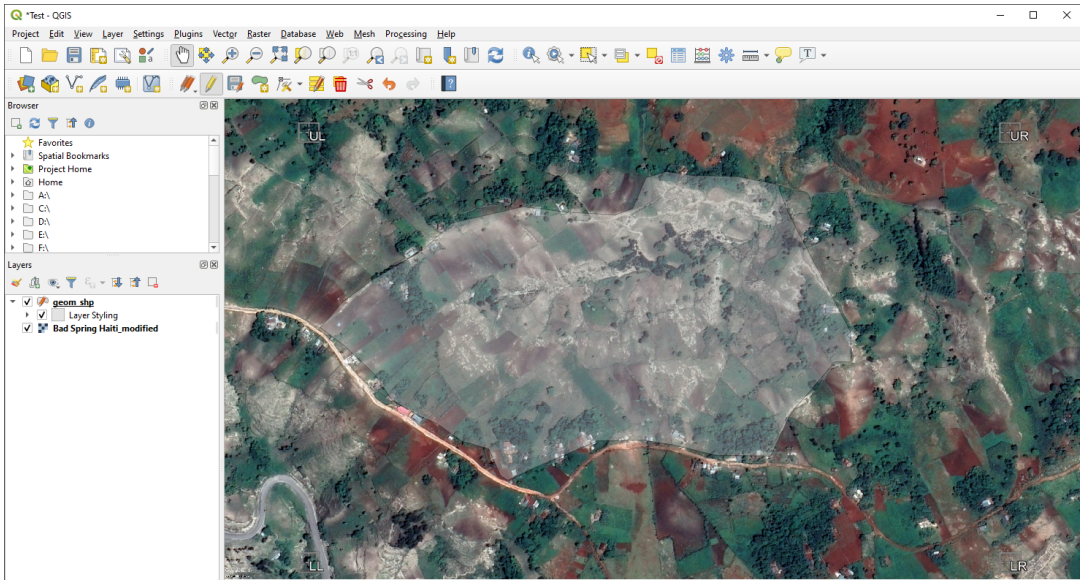
Finish the outline of the Watershed by right-clicking close to the starting point. Error messages might appear, they can be ignored by clicking OK/Yes.

A window named “geom_shp – Feature Attributes” will be opened automatically. It consists of the tabs

Area, Curve Number, Rainfall/Runoff and Legal. Go to Rainfall and insert a value for “Rainfall HRU” (you can adapt it later). Press “OK” to exit the window.

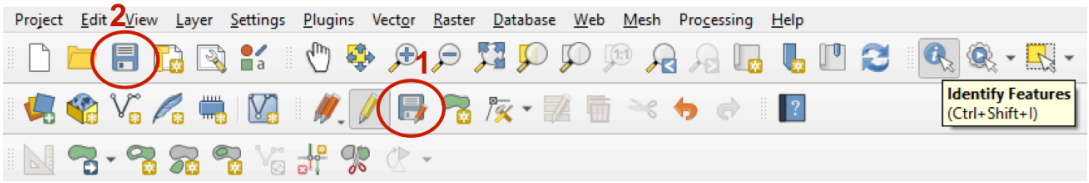


You can now see the finished outline of the watershed.
Note that you can only draw one watershed per project. Otherwise, the runoff of all watersheds drawn combined will be calculated in the end.



Step C.9
Attention! For saving, click on „save layer edits“ (1) AND „save project“ (2).

Step C.10

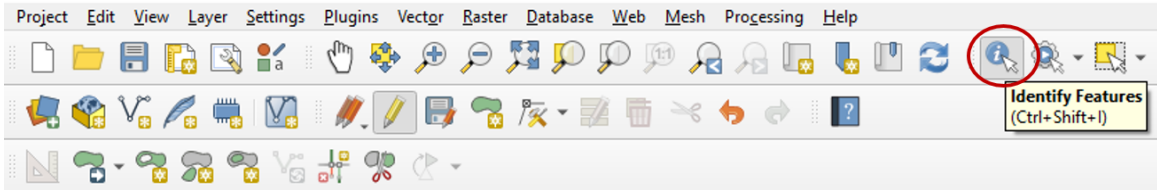


Now the watershed will be separated into three watershed zones (Upper, Middle and Lower Zone).
Select the “split features tool” (Scissors icon with two polygons)

Now, separate the lower zone of the watershed. Note that you have to start and finish outside of the polygon you want to split. Right-click to execute the cut and exit the tool. The watershed should now be separated into two parts. Repeat the step for separating the third zone.

Step C.11

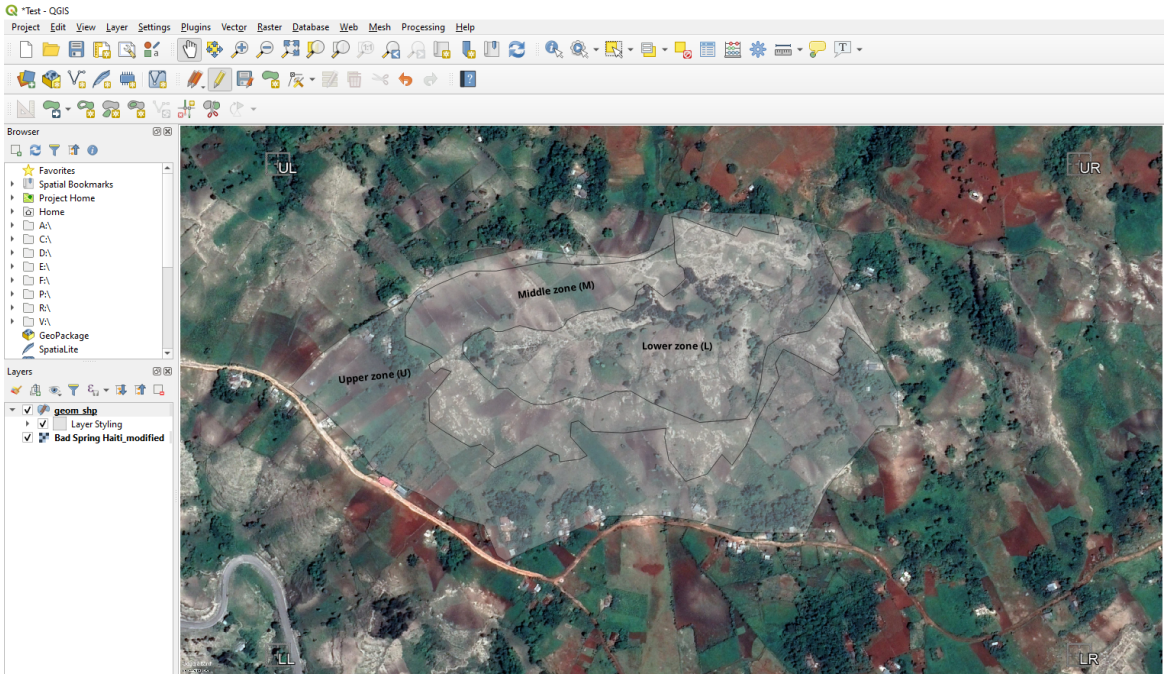
In the next step, the zones are named as lower, middle, and upper zone.
To do this, select the “Identify Feature Tool” on the upper hand.



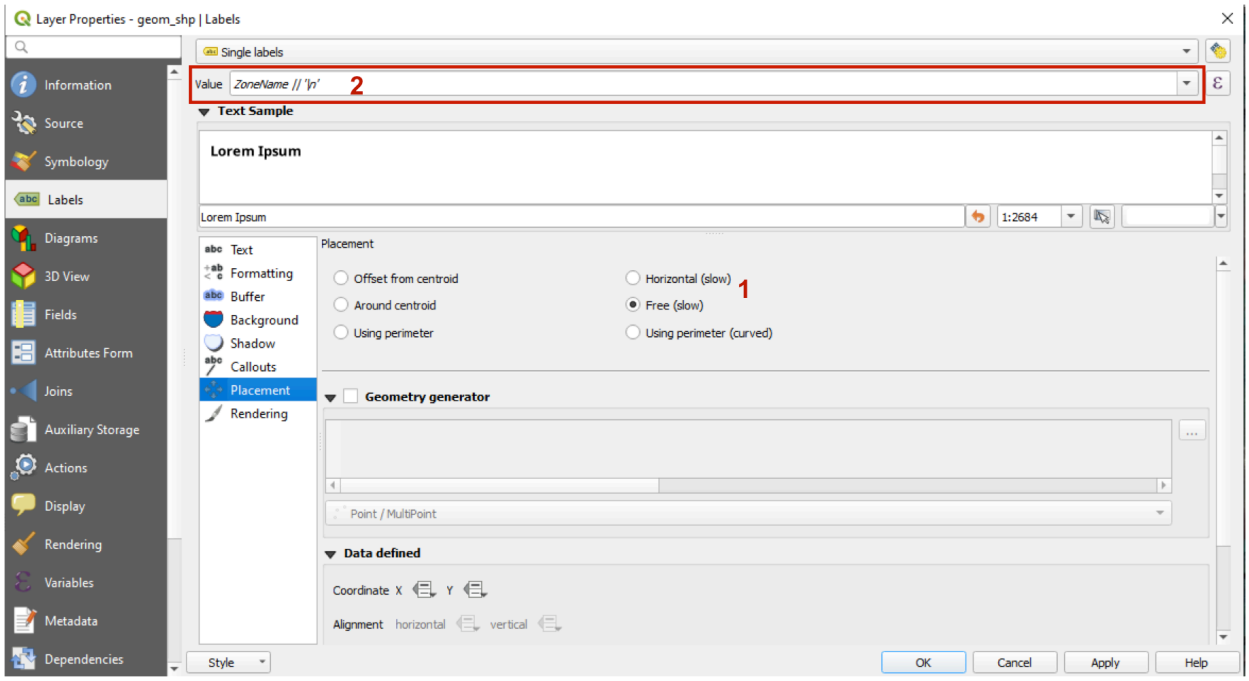
Left-click on a zone. Ignore the error messages by clicking “close” and/or “ok”. The window “geom_shp – Feature Attributes” is opened automatically after finishing a line. (If the “identify Results”-window opens on the right-hand side, click on “auto open form” and repeat this step.) Now, define the zone by selecting the zone name. Press OK and the name should be displayed on the map. Repeat for every zone.

Note that the tool already calculated the area of the Watershed and Watershed Zones. If not, close it and reopen it (2-3 times).

The finished map will look similar to this:



If the Labels do not appear in the right polygon, right-click on the geom_shp and go to Properties -> Labels -> Placement and click on “free(slow)” (1). You can also change the variable to be shown as Lable (2) (e.g. Landuse Subtype). Please note that you always first have to press “Apply” and then “OK” (if there are both options)

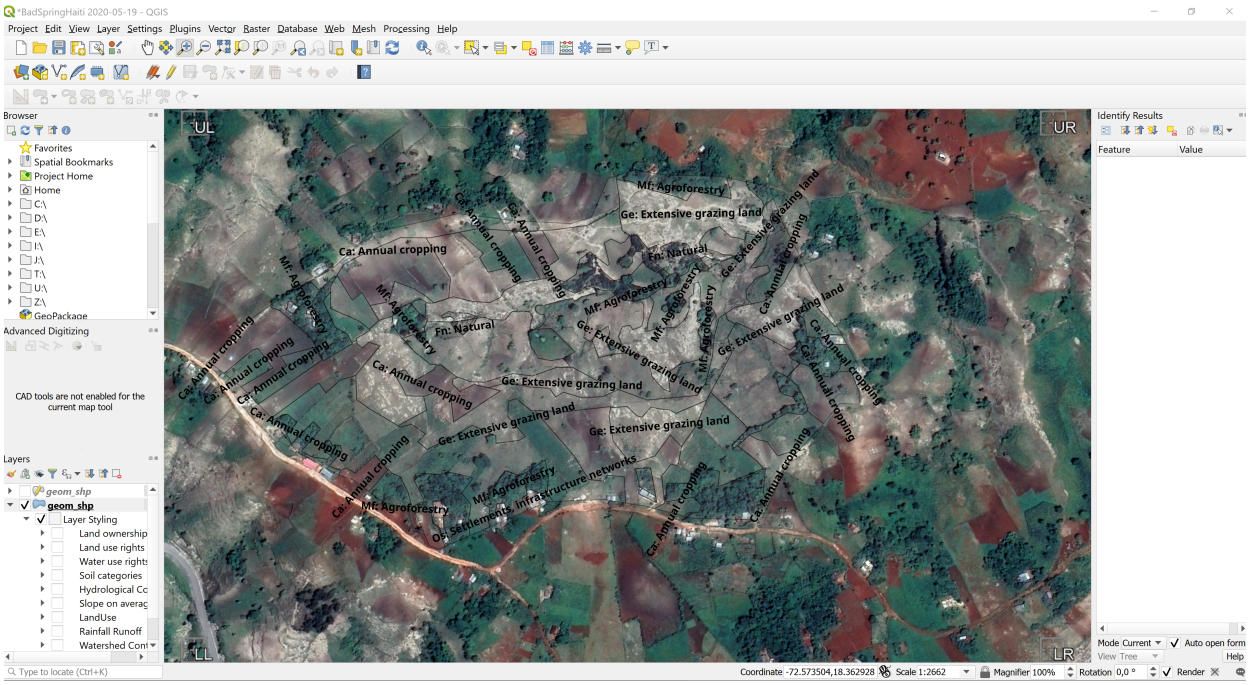


Step C.12

Now we are going to separate the zones into the Hydrologic Response Units (HRUs). The method is the same as before when we separated the watershed into three zones. In the same way, the zones are separated into different HRUs.

Therefore, select the “Split Features tool” again. Divide the zone by drawing a line across the zone and right-click to exit the tool.

For a better separation of the HRUs, also try other tools available, such as “Fill Ring” or “Merge Selected Features”. You can find these tools under “Edit” (at the top left).



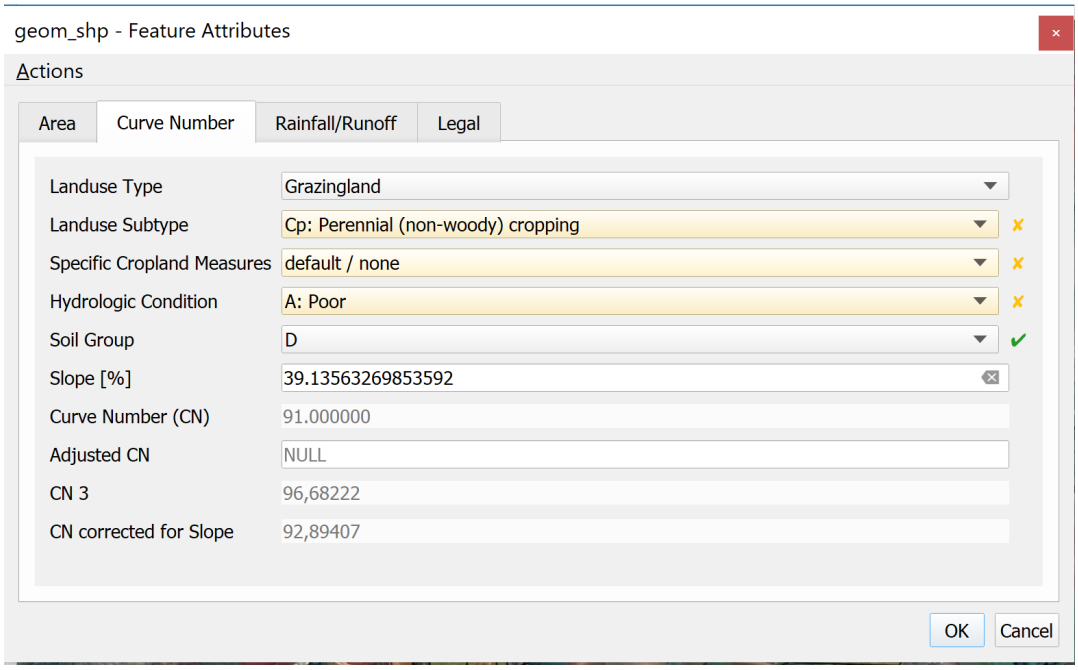
Step C.13

Now information is given to each of the HRU. Again, use  on the upper hand and select a polygon (HRU). The same window as before will be opened again.

First, select the tab “Curve Number”. In this tab, you are asked to give the following information about the HRU:

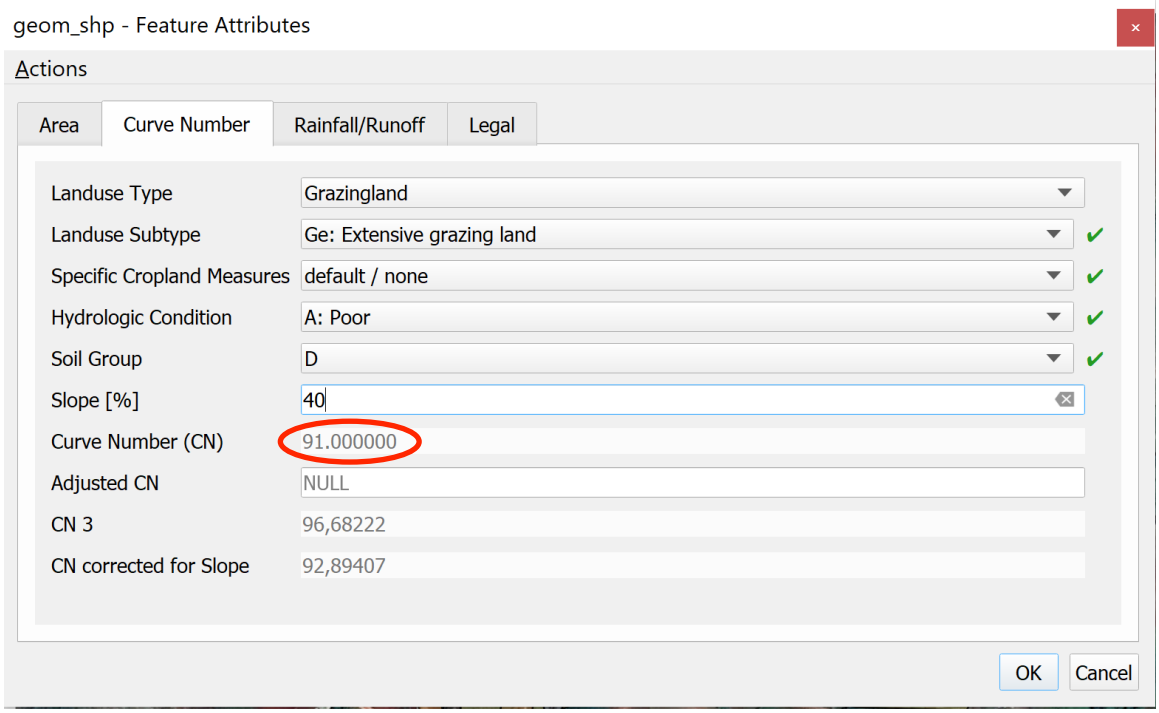
Land use type:	Define the basic land use
Land use subtype:	Define the land use suptype
Specific Cropland Measure:	Define the measures for cropland
Hydrologic Condition:	Select the hydrologic condition
Slope:	Define the Slope of the Land Use Zone
Soil Group:	Define the soil group of the area

Note: The definition of the land use follows the USDA definition (see annex). Therefore, only certain combinations are possible. With ✗ and ✓ the tool in inform you if the combination you chose is valid or not. For more information on the possible combinations see the Document “Possible Combinations”.



After selecting the land use type and subtype, the specific cropland measure, the hydrologic conditions, the soil group and the slope, press OK to apply the changes.

Reopen the window again with  . Note that the Curve Number was calculated on bases of the information given.



Close and reopen the window again. This is needed for the tool to calculate the Slope Corrected Curve Number.

If the Curve Number is not shown try following steps:

- Close the window and reopen it again (sometimes it takes 2-3 attempts)
- Consult the PDF “Possible Combinations” to see if the combination chosen is allowed.

Note: If the Curve Number does not correspond to observations made in the field, you can adapt it by inserting a number between 0-100 under “CustomCN”.

In the tab legal, following additional information can be given:

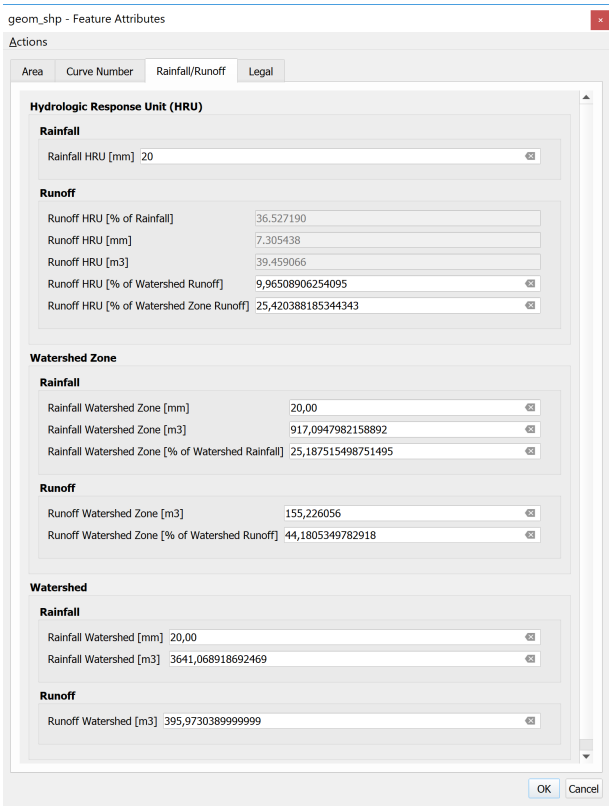
Land Ownership: Who owns the land?
Land Rights: Who uses the land?
Water Rights: Water rights of the land use

However, this information is not needed for the calculation itself.

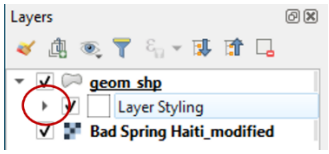
Step C.14
Repeat Step C13 for every HRU/polygon in order to calculate the runoff for each polygon and for the entire watershed.

Step C.15

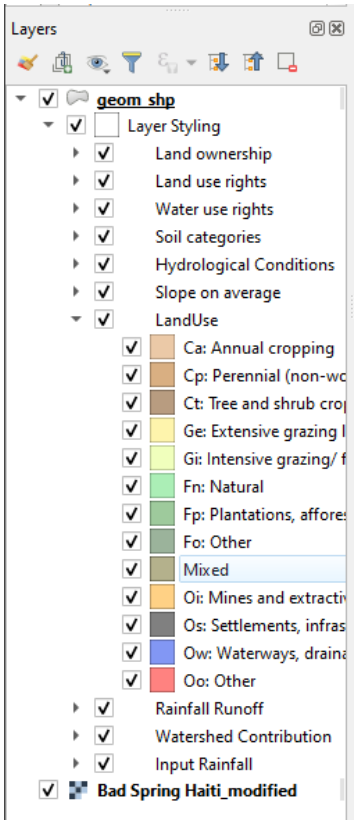
Now everything is calculated. By using  select a HRU and reopen the “Rainfall/Runoff” tab in “Feature Attributes”. This window shows the information on Rainfall and Runoff for the selected HRU, the corresponding watershed zone and the entire watershed.



Step C.16
To better display the results, the watershed can be colored according to different attributes. To do so, left click the arrow next to the Layer Styling in the Layers Panel.



Only check the map you want to display. In this example, the watershed is colored by the different land use types that were defined. The colors can by changed by right clicking on the name.



You can also Screenshot the maps for further use.

Part D: Assessing different land use/land management types and climate extreme scenarios

Changing land use and land management

In order to assess the impact of different land use and land management types, save the project under another name and open the new one.

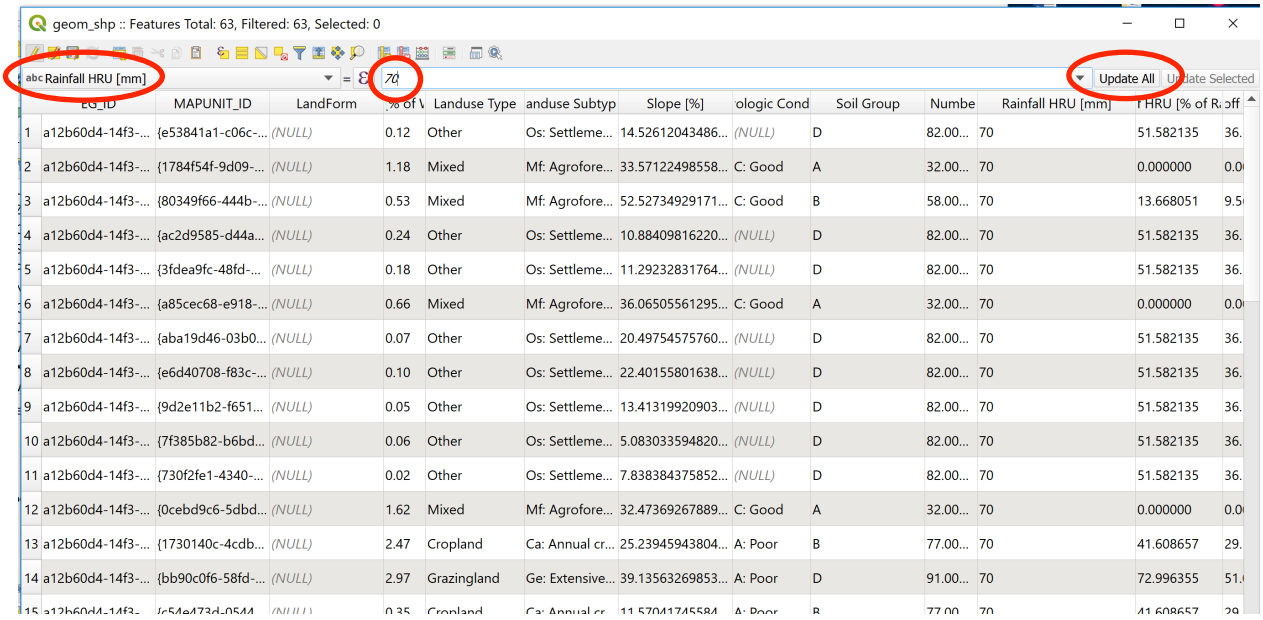
Go to  and click on a polygon whose land use type you want to change. Go to the tab called Curve Number and make the changes.

Note: Also consider changing the soil type since the infiltration capacity of the soil is largely dependent on the land use practice: under the same soil, the infiltration capacity is better with improved vegetation cover and poorer on degraded soils.

After you have changed the land use and land management, you can compare the impacts of the current land use/ land management (done in the previous project) and the land use scenario you just created now (current project).

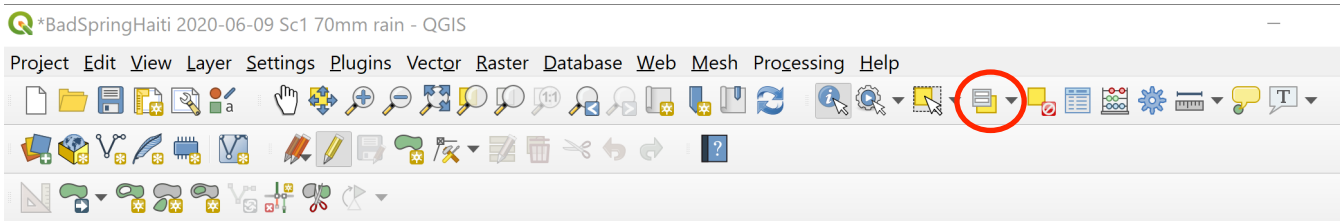
Assessing different climate extremes

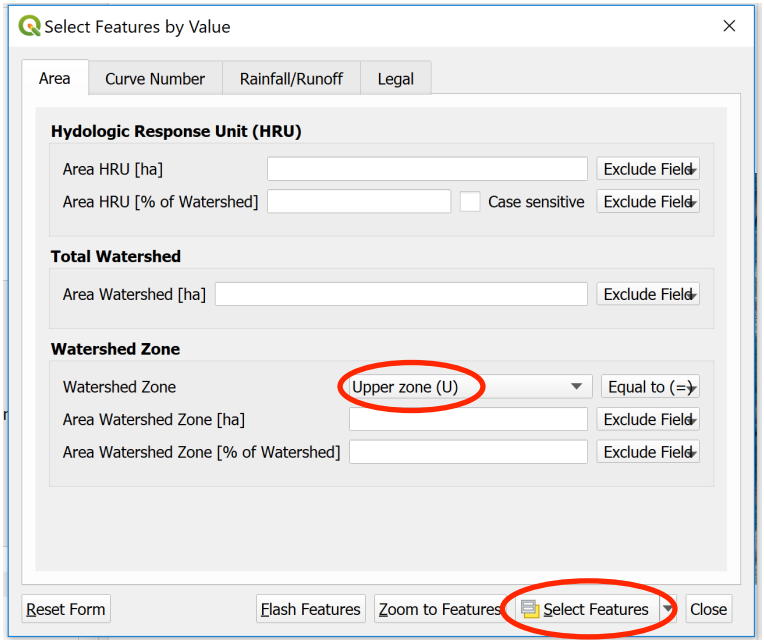
Change rainfall for <u>all</u> HRUs: Go to the attribute table and select the toggle editing mode. Select "Rainfall HRU [mm]" in the drop down list in the upper left. Insert the rainfall amount [mm] (i.e. 70) and click on "update all".



	EG_ID	MAPUNIT_ID	LandForm	% of	Landuse Type	anduse Subtyp	Slope [%]	ologic Cond	Soil Group	Numbe	Rainfall HRU [mm]	THRU [% of R	off
1	a12b60d4-14f3-...	{e53841a1-c06c-...	(NULL)	0.12	Other	Os: Settleme...	14.52612043486...	(NULL)	D	82.00...	70	51.582135	36.
2	a12b60d4-14f3-...	{1784f54f-9d09-...	(NULL)	1.18	Mixed	Mf: Agrofore...	33.57122498558...	C: Good	A	32.00...	70	0.000000	0.0
3	a12b60d4-14f3-...	{80349f66-444b-...	(NULL)	0.53	Mixed	Mf: Agrofore...	52.52734929171...	C: Good	B	58.00...	70	13.668051	9.5
4	a12b60d4-14f3-...	{ac2d9585-d44a...	(NULL)	0.24	Other	Os: Settleme...	10.88409816220...	(NULL)	D	82.00...	70	51.582135	36.
5	a12b60d4-14f3-...	{3fdea9fc-48fd-...	(NULL)	0.18	Other	Os: Settleme...	11.29232831764...	(NULL)	D	82.00...	70	51.582135	36.
6	a12b60d4-14f3-...	{a85cec68-e918-...	(NULL)	0.66	Mixed	Mf: Agrofore...	36.06505561295...	C: Good	A	32.00...	70	0.000000	0.0
7	a12b60d4-14f3-...	{aba19d46-03b0...	(NULL)	0.07	Other	Os: Settleme...	20.49754575760...	(NULL)	D	82.00...	70	51.582135	36.
8	a12b60d4-14f3-...	{e6d40708-f83c-...	(NULL)	0.10	Other	Os: Settleme...	22.40155801638...	(NULL)	D	82.00...	70	51.582135	36.
9	a12b60d4-14f3-...	{9d2e11b2-f651...	(NULL)	0.05	Other	Os: Settleme...	13.41319920903...	(NULL)	D	82.00...	70	51.582135	36.
10	a12b60d4-14f3-...	{7f385b82-b6bd...	(NULL)	0.06	Other	Os: Settleme...	5.083033594820...	(NULL)	D	82.00...	70	51.582135	36.
11	a12b60d4-14f3-...	{730f2fe1-4340-...	(NULL)	0.02	Other	Os: Settleme...	7.838384375852...	(NULL)	D	82.00...	70	51.582135	36.
12	a12b60d4-14f3-...	{0cebd9c6-5dbd...	(NULL)	1.62	Mixed	Mf: Agrofore...	32.47369267889...	C: Good	A	32.00...	70	0.000000	0.0
13	a12b60d4-14f3-...	{1730140c-4cdb...	(NULL)	2.47	Cropland	Ca: Annual cr...	25.23945943804...	A: Poor	B	77.00...	70	41.608657	29.
14	a12b60d4-14f3-...	{bb90c0f6-58fd-...	(NULL)	2.97	Grazingland	Ge: Extensive...	39.13563269853...	A: Poor	D	91.00...	70	72.996355	51.
15	a12b60d4-14f3-	{c54e473d-0544	(NULL)	0.35	Cropland	Ca: Annual cr	11.57041745584	A: Poor	B	77.00	70	41.608657	29

Change rainfall for HRUs <u>of a specific watershed zone</u>: There is also the possibility to have different rainfall amounts within the watershed (i.e. if you have a bigger watershed and there is more rainfall in the upper zone). To do so, go to "select feature by value". Under Watershed Zone select the zone whose rainfall you want to change, click on "select features" and click "OK".





On the map you can now see the selected polygons. Now go to the attribute table and select the toggle editing mode and select “Rainfall HRU [mm]” in the drop down list in the upper left. Insert the rainfall amount [mm] (i.e. 70) and click on “update selected”.

Appendix

I. Theory on the Soil Conservation Service Curve Number (SCS-CN) Method

The SCS-CN is the most popular and widely applied method for estimating runoff based on a single rainfall event. It is a dimensionless number ranging from 0 to 100 and is determined based on land use and land cover (LULC), hydrologic soil group, and antecedent soil moisture condition. The method is built on the water balance equation and the two following hypothesis: (a) ratio of the actual direct runoff to the potential runoff is equal to the ratio of the actual infiltration to the potential infiltration, and (b) the quantity of the initial abstraction is some fraction of the potential infiltration.

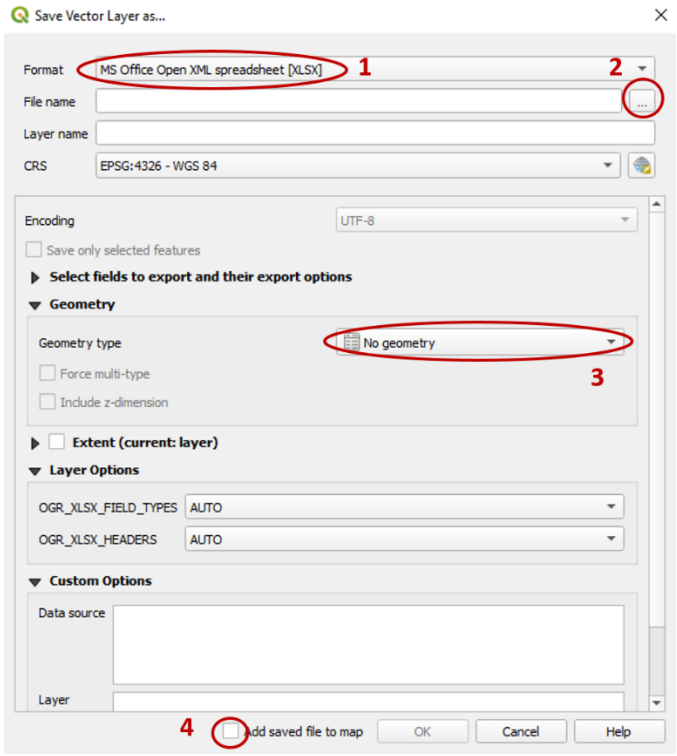
Following major factors determine the SCS-CN: land use, specific cropland measure, hydrologic condition and hydrologic soil group.

- Land use: The land use type has a big impact on the CN. Urban areas, for instance, are impervious surfaces and increase runoff. There are different methods to determine cover type, for instance, aerial photos or land us maps.
- Specific cropland measure: A cropland measure is a modifier of the cover type and describes the land use management of cultivated agricultures. It includes practices such as terracing, contouring, crop rotation and no tillage.
- Hydrologic condition: The hydrologic condition indicates the effect vegetation cover has on infiltration and runoff and is usually estimated by the density of plant and residue cover. Good hydrologic condition refers to soils, which usually have a low runoff potential for the particular hydrological soil group, the type of cover and the treatment. The following factors need to be taken into account when estimating the impact of vegetation cover on infiltration and runoff: a) canopy or density of vegetation; b) amount of year-round cover; c) amount of grass or close-seeded legumes in rotation; d) percentage of residue cover; and e) degree of surface roughness. The threshold value of what is considered poor, fair and good hydrologic condition varies depending on the land cover class.
- Hydrologic soil group (A, B, C, D): According the SCS-CN method, soils are divided into four groups, which indicate the minimum infiltration rate after prolonged wetting.
    - Group A: Soils with low runoff potential and high infiltration rate, they usually consist of sand or gravel and remain permeable even when completely wetted.
    - Group B: Soils with a moderate infiltration when they are wet, they often consist of silt loam or loam.
    - Group C: Soils with low infiltration when thoroughly wetted, they consist of clay or loam layers. This impedes the downward movement of the water.
    - Group D: Soils with nearly no infiltration when thoroughly wetted, they consist mainly of clay and have a high swelling potential.

  → *Note: the soil group highly depends on the land use and land management. The lack of vegetation cover leads to clogging and sealing of the topsoil, which hinders infiltration. Good vegetation cover, however, provides good soil texture, which improves infiltration.*

II. Export Attribute Table:

To retrieve the data from QGis for further use in Excel etc., rightclick on “geom_shp” and go to Export -> “Save Features as”. Select the MS Office Open XLM spreadsheet (1). Click on the “…” to choose a name and location to save the excel sheet (2). Set “No geometry” and uncheck the ”add saved file to map”-button. Then click ok.



You can also Screenshot the maps for further use.