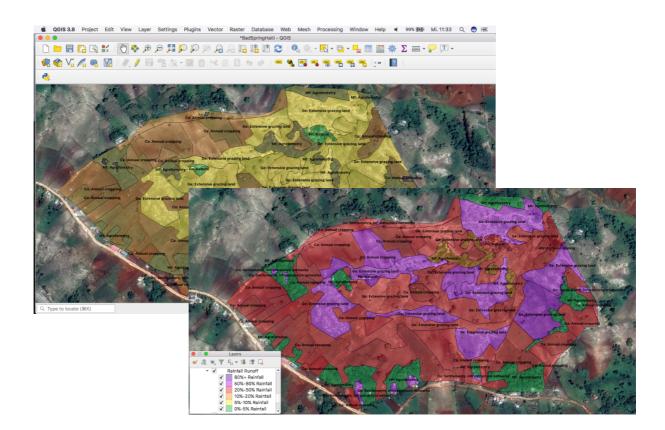
User Manual for the WOCAT SLM Watershed Tool

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 km²) 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 (<u>https://qcat.wocat.net/en/wocat/</u>). 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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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:

- (A) Customizing QGIS (open source version 3.8 or 3.10) for the WOCAT SLM Watershed Tool (only to be done once) Page 4
- (B) Preparing Google satellite image for the Background Page 5
- (C) Assessing current situation for different daily rainfall events Page 6
 - 1) Using the baseline map to delineate the watershed and subdivide it into different land use / management areas, different slope and soil categories. This results in hydrological response units (HRUs).
 - 2) For each HRU the following information is assigned (using tables, drop down categories and explanations):
 - a. Land use/land management and its runoff Curve Number (CN)
 - b. Hydrological condition related to soil cover
 - c. Soil category: four soil types related to their infiltration capacity
 - d. Slope in percent steepness
 - 3) A daily rainfall is assigned and the tool calculates (a) runoff in percent of rainfall and in volume (m³) for each HRU, and (b) the contribution to the total runoff at the outlet of the watershed.

(D) Assessing different land use/land management types and climate extreme scenarios - Page 20

- Good vs. bad Scenarios: the mapped land use/management types and soil conditions can be changed and the impact on runoff compared. This allows to assess the downstream (offsite) impacts/benefits of spreading SLM practices documented in the WOCAT SLM Technology database (https://qcat.wocat.net/en/wocat/)
- 2) Rainfall Scenarios: Impacts of increased extreme rainfall events (in view of climate change) can be predicted and analysed.

Appendix – Page 22

- 1) The Soil Conservation Service Curve Number (Theory)
- 2) How to export the attribute table to Excel

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

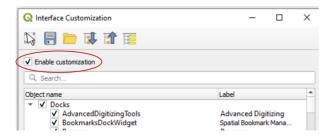
Download and install QGIS version 3.12 of the open source software QGIS. Visit http://www.qgis.org/en/site/

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.

python	12/11/2019 19:14	File folder	
pythonvalidation	11/09/2019 17:44	File folder	
Main_Project_customization	07/02/2018 18:02	Configuration sett	132 KB
💐 working_style_3.8.2	11/09/2019 17:26	QGIS Layer Settings	132 KB
💐 working_style_3.8.2_without_validation	11/09/2019 17:36	QGIS Layer Settings	132 KB
📳 Wshd_Shapefile_Original	03/02/2020 16:18	Compressed (zipp	3 KB

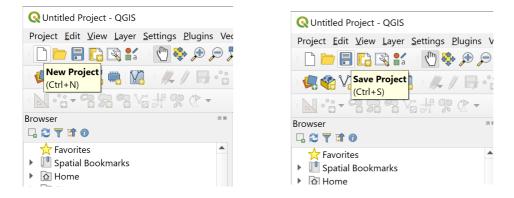
Step A.4

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= $y\&x=\{x\}\&y=\{y\}\&z=\{z\}$

Browser 🗗 🗙	QXYZ Connection ×
□ ○ ▼ Image: Constant of the second s	Connection Details Name Google Hybrid URL \/vt/lyrs=y&x={x}&y={y}&z={z} Authentication Configurations Basic Choose or create an authentication configuration No authenticatior Image: Configuration store encrypted credentials in the QGIS authentication database.
BB2 WMS MS Carto New Connection Esri Imagery Esri Streets	✓ Min. Zoom Level 0 ✓ Max. Zoom Level 18 Referer Tile Resolution Unknown (not scaled)
	OK Cancel

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.

🔇 *Unt	Q *Untitled Project - QGIS													
Project	<u>E</u> dit	View	Layer Sett	ings <u>P</u> lugin	Vect <u>o</u> r	<u>R</u> aster	<u>D</u> atabase	<u>W</u> el	<u>M</u> esh	Pro <u>c</u> essing	<u>H</u> elp			
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	_	Create Layer				Ctrl+L , 🏴 🔏 🖓 🗓 🖥 🖉								
i 🐙 i	~ `	Vn 🥖	Add La	yer				►	V Add	Vector Layer			Ctr	l+Shift+V
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	Add from Layer Definition File			👺 Add Mesh Layer										
			🖹 Copy S	tyle					🤊 🛛 Add	Delimited Tex	t Layer		Ctr	l+Shift+T

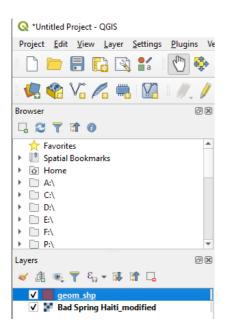
By pressing "Browse" or "...", search the geom_shp.shp file in the folder, which you copied and renamed in Step C.1.

Choose the file with the ".shp" ending.

Name	Date modified	Туре	Size
📓 geom_shp	03/02/2020 16:18	OpenOffice.org 1	87 KB
geom_shp.prj	03/02/2020 16:18	PRJ File	1 KB
geom_shp.qpj	03/02/2020 16:18	QPJ File	1 KB
geom_shp.shp	03/02/2020 16:18	SHP File	12 KB
geom_shp.shx	03/02/2020 16:18	SHX File	1 KB

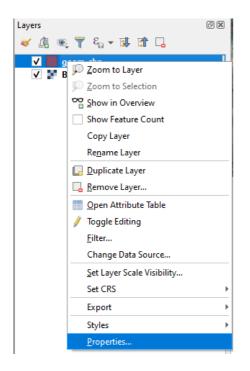
Confirm and close the windows by pressing "Open" and then press "Add" to add the layer and "Close" to close the window.

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.

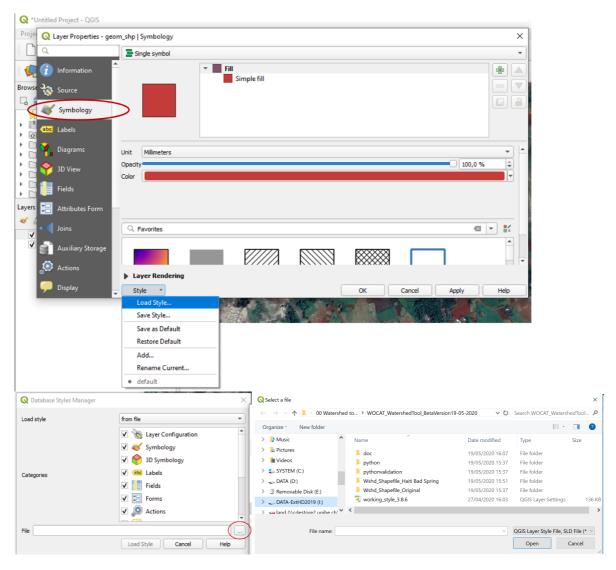


The following window should be opened.

🔇 Layer Properties - geon	m_shp Source	×
Q	▼ Settings	
🥡 Information 📫	Layer name geom_shp displayed as geom_shp	
🗞 Source	Data source encoding System	
ኛ Symbology	Geometry and Coordinate Reference System Set source coordinate reference system	
(abc Labels	EPSG:4326 - WGS 84	
🌳 Diagrams	Create Spatial Index Update Extents	
SD View	▼ Provider Feature Filter	
Fields		
🔚 Attributes Form		
• Joins		
Auxiliary Storage		
Actions	Query Built	der
🦵 Display 🗸	Style * OK Cancel Apply Help	p

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".

	Drag and drop designer				👻 🌔 how form on add feature				
Information Source Symbology Labels Diagrams 3D View	Available Widgets Fields EG_JD ZONE_JD MAPUNIT_JD AverAnniRa AgrocLimZo	 Form Layout Area Curve Numbs Rainfall/Runc Legal 		-	Alias				
Fields Attributes Form Joins	MaxAlti MinAlti LandForm		Q Python Init Co	de Config					
Auxiliary Storage Auxiliary Storage Actions Display Rendering Variables Metadata Dependencies	SurfPRO LandUseTyp LandManage Slope HydrCond Soilgroup CN AvgRainfal BORainfall		Python Init function Lead fn External fileythoncatcut Function name formOpen		iython\calculation_3.8v3.py 🚳				
Legend QGIS Server Digitizing	ROKainfail ROM3 ROZone WshdContrb TRO WshdMAX AREA				Orfaults Default value Preview Apply default value on update				
	PERIMETER PERIMETER ZoneName ZoneParc SurfHec EGHec CustomCN CN Cube	Ţ			Relation Cardinality				

Step C.6

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

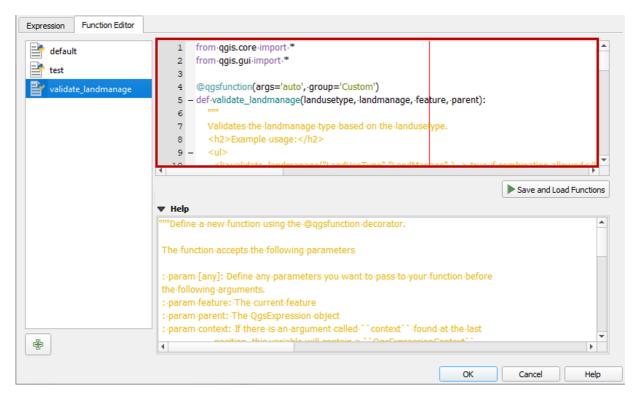
Q		Drag and drop designer			👻 🛃 Show form on add feature 👻
i	Information	Available Widgets	Terrain	#	▼ General
3	Source	EG_ID ZONE_ID	Curve Number Rainfall		Alias Landuse Subtype
~	Symbology	MAPUNIT_ID AverAnniRa AgroClimZo	▶ Legal		Comment Catable Label on top
abo	Labels	MaxAlti MinAlti			▼ Widget Type
1	Diagrams	LandForm SurfPRO LandUseTvn			Value Map 💌
\$	3D View	LandManage 2			Combo box with predefined items. Value is stored in the attribute, description is shown in the combo box.
	Fields	HydrCond Soilgroup			Load Data from Layer Load Data from CSV File
	Attributes Form	1 CN AvgRainfal			Value Description
	Joins	RORainfall ROm3			2 Cp: Perennial (Cp: Perennial (
_	Auxiliary	ROZone WshdContrb TRO			3 Ct: Tree and shr Ct: Tree and shr
	Storage	WshdMAX			4 Fn: Natural Fn: Natural
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Actions	PERIMETER ZoneName			5 Fo: Other Fo: Other
	Display	ZoneHA ZonePerc			6 Fp: Plantations, Fp: Plantations,
Ý	Rendering	SurfHec EGHec			Add 'NULL' value Remove Selected
3	Variables	CustomCN CN_Cube CN_Slope			▼ Constraints
	Metadata	LandOwn LandRights			Not null Enforce not null constraint
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i.	Legend	MaxAreRain UPercAre			Expression description 3
	QGIS Server	ZPercAre MaxZonRain UnitRoAre			Enforce expression constraint
87	Digitizing	UnitRoAre UnitROZone ZoneROAre			▼ Defaults
		MaxZonRo MaxAreRo			Default value E
		AveRainZon AveRainWat			Preview Apply default value on update
		Relations T			Appiy default value on update     V     OK Cancel Apply Help
		Style			OK Cancer Apply Help

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).

Expression Function Editor	)1	
default		
New file name: validate_landmanage 3 OK Cancel		
		4
		Save and Load Functions
	▼ Help           Immodel         Performance           Immodel         Performance           The function raccepts the following parameters         Performance	
	: ·param ·[any]: ·Define ·any ·parameters ·you ·want ·to ·pass ·to ·your ·function ·before the ·following ·arguments. : ·param ·feature : ·The ·current ·feature	
(+) 2	: · param parent: The QgsExpression object     : param context: If there is an argument called. `` context`` found at the last	
	ОК	Cancel Help

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).

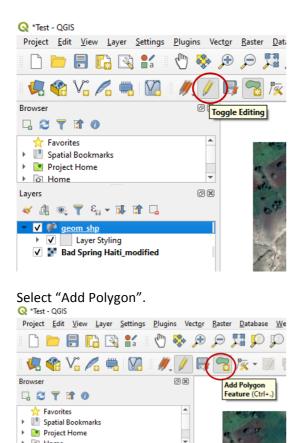


Click "Save and Load Function" and "OK". When closing the "Layer Properties" Window, click "Apply" first and then "OK".

## Step C.7

Now, the outline of the watershed can be drawn.

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



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▼ ✓ Ø geom shp

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Layer Styling
 Bad Spring Haiti_modified

**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.

🔇 *Test - QGIS Project <u>E</u>dit <u>View Layer</u> <u>Settings</u> <u>Plugins</u> Vect<u>or</u> <u>Raster</u> <u>Database</u> <u>Web</u> <u>Mesh</u> Pro<u>c</u>essing <u>H</u>elp 💘 🎕 Vi 🌈 🖏 💹 🛛 🥢 🕞 🔞 🎘 - 🕺 🖷 🖂 🔶 🖉 ? N 2 - 2 2 2 2 2 4 2 - 2 Panels Advanced Digitizing Panel Browser R Browser (2) Panel 🗔 😂 🝸 📬 🕜 ✓ Browser Panel **Favorites**  Spatial Bookmarks GPS Information Panel Project Home Layer Order Panel Home Layer Styling Panel ► 🗋 A:\ ✓ Layers Panel ØX Layers Log Messages Panel 🗸 🏨 🔍 ү 🗞 🗸 🗊 🛄 Overview Panel 🝷 🔽 🏴 geom shp Processing Toolbox Panel Layer Styling Results Viewer Panel V F Bad Spring Haiti_modified Spatial Bookmark Manager Panel Statistics Panel Tile Scale Panel Undo/Redo Panel Toolbars nced Digitizing Too 🖌 Adv ✓ Attributes Toolbar ✔ Data Source Manager Toolbar Digitizing Toolbar ✓ Help Toolbar ✓ Map Navigation Toolbar Project Toolbar Shape Digitizing Toolbar Snapping Toolbar

#### 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.

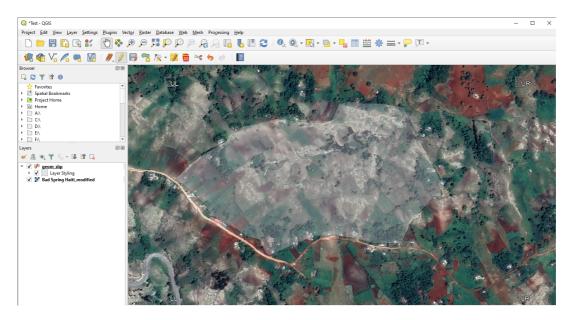
A window named "geom_shp – Feature Attributes" will be opened automatically. It consists of the tabs

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.

ons						
rea Curve Numbe	r Rainfall/i	Runoff	Legal			
Hydologic Respons	e Unit (HRU)					
Area HRU [ha]						
Area HRU [% of Wa	itershed]	NULL				
Area HRU [% of Wa	tershed Zone]	NULL				
Total Watershed						
Area Watershed [ha	NULL					
Watershed Zone						
Watershed Zone				Ŧ		
Area Watershed Zor	ne [ha]	1				
Area Watershed Zor	shed]					

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

Project <u>E</u> dit <mark>2</mark> View Layer Settings <u>P</u> lugins Vect <u>or R</u> aster <u>D</u> atabase <u>W</u> eb <u>M</u> esh Pro <u>c</u> essing <u>H</u> elp	
- D 🛏 🖪 🖓 🐮 🖑 🏶 🕾 🖓 🖓 🖓 🖓 🖓 🖓 🖓 🔹	🔍 🧟 • 🔣 •
🦛 🎕 Vi 🖍 🖏 🕼 🥒 🕼 🔭 🐨 🐄 🖷 🖂 🔶 🛯	Identify Features (Ctrl+Shift+I)
N 7. 7. 7. 7. V. H 9. V	

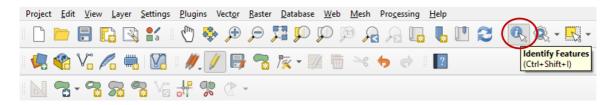
Now the watershed will be separated into three watershed zones (Upper, Middle and Lower Zone). Select the "split features tool" (Scissors icon with two polygons)



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.

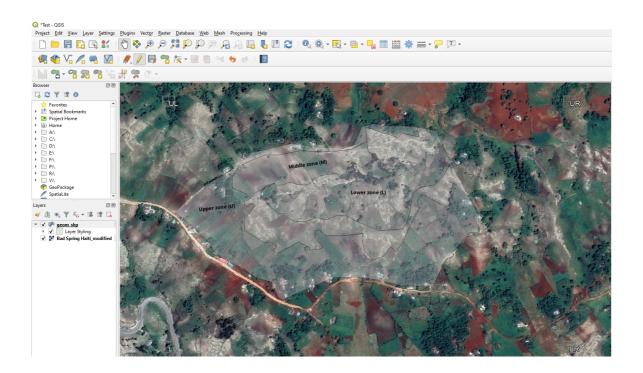


Left-click on a zone. Ignore the error messages by clicking "close" and/or "ok". The window "geom_shp – Feature Attributes" is opened automatically after finishing a line. (If the "identify Results"-window opens on the right-hand side, click on "auto open form" and repeat this step.) Now, define the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

Area Curve Number	Rainfall/Runoff	Legal
Hydologic Response l	Jnit (HRU)	
Area HRU [ha]	8,28	
Area HRU [% of Water	shed] 45.65	5
Area HRU [% of Water	shed Zone] NULL	
Total Watershed		
Area Watershed [ha]	18,13	
Watershed Zone		
Watershed Zone		Upper zone (U) 🔻
Area Watershed Zone [	[ha]	NULL
Area Watershed Zone [	% of Watershed]	

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)

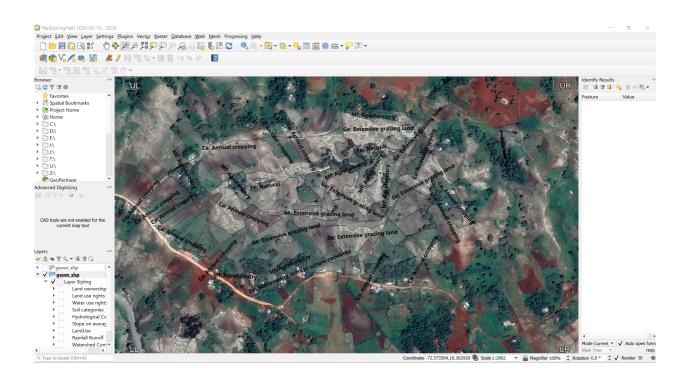
Q	Layer Properties - geom	_shp	Labels									×
Q			🖮 Single labels								-	
i	Information	- L	Value ZoneName // '/r	² 2							• 8	ε
Ĵ	Source		▼ Text Sample									
~	Symbology		Lorem Ipsum									
ab	C Labels		Lorem Ipsum				•	1:2684	-			* *
4	Diagrams		abc Text	Placement						•		
<b>?</b>	3D View		<pre>*ab </pre> Formatting	Offset from centroid	O Horizontal (slow)						-	*
	Fields		Buffer Background	Around centroid	• Free (slow)							
8	Attributes Form		Shadow Callouts	O Using perimeter	Using perimeter (curved)							
•	Joins		♦ Placement	Geometry generator								
2	Auxiliary Storage		A Rendering									
٢	Actions											
9	Display			Point / MultiPoint						+		
*	Rendering			▼ Data defined								
3	Variables			Coordinate X (=, Y (=,								
2	Metadata			Alignment horizontal (, vertical )								•
	Dependencies	•	Style *			ОК		Cancel	Ap	ply	Help	

## 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  $\bigcirc$  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  $\times$  and  $\checkmark$  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".

ge	om_shp - Feature Attribute	25		×
<u>A</u> c	tions			
	Area Curve Number	Rainfall/Runoff Legal		
	Landuse Type	Grazingland	•	
	Landuse Subtype Cp: Perennial (non-woody) cropping		•	×
	Specific Cropland Measures	default / none	•	×
	Hydrologic Condition	A: Poor	•	×
	Soil Group	D	•	<ul> <li>Image: A second s</li></ul>
	Slope [%]	39.13563269853592	×	
	Curve Number (CN)	91.000000		
	Adjusted CN	NULL		
	CN 3	96,68222		
	CN corrected for Slope	92,89407		
			ОК	Cancel

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  $\bigcirc$ . Note that the Curve Number was calculated on bases of the information given.

geom_shp - Feature Attribut	tes	×
<u>A</u> ctions		
Area Curve Number	Rainfall/Runoff Legal	
Landuse Type	Grazingland	•
Landuse Subtype	Ge: Extensive grazing land	~ ~
Specific Cropland Measures	s default / none	~ ~
Hydrologic Condition	A: Poor	~ ~
Soil Group	D	~ ~
Slope [%]	40	
Curve Number (CN)	91.000000	
Adjusted CN	NULL	
CN 3	96,68222	
CN corrected for Slope	92,89407	
	ОК	Cancel

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  $\bigcirc$  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.

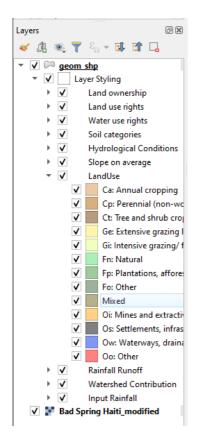
ions		
rea Curve Number Rainfall/Runoff	Legal	
Hydrologic Response Unit (HRU)		
Rainfall		
Rainfall HRU [mm] 20		0
Runoff		
Runoff HRU [% of Rainfall]	36.527190	
Runoff HRU [mm]	7.305438	
Runoff HRU [m3]	39.459066	
Runoff HRU [% of Watershed Runoff]	9,96508906254095	6
Runoff HRU [% of Watershed Zone Runo	off] 25,420388185344343	1
Watershed Zone		
Rainfall		
Rainfall Watershed Zone [mm]	20,00	
	20,00 917,0947982158892	0
Rainfall Watershed Zone [mm]	917,0947982158892	
Rainfall Watershed Zone [mm] Rainfall Watershed Zone [m3]	917,0947982158892	0
Rainfall Watershed Zone [mm] Rainfall Watershed Zone [m3] Rainfall Watershed Zone [% of Watershe	917,0947982158892	0
Rainfall Watershed Zone [mm] Rainfall Watershed Zone [m3] Rainfall Watershed Zone [% of Watershe Runoff	917,0947982158892 24 Rainfail] 25,187515498751495 155,226056	ଅ
Rainfall Watershed Zone [mm] Rainfall Watershed Zone [m3] Rainfall Watershed Zone [% of Watershe <b>Runoff</b> Runoff Watershed Zone [m3]	917,0947982158892 24 Rainfail] 25,187515498751495 155,226056	1
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#### 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.

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( + j	Layer Styling							
$\overline{\mathbf{v}}$	Bad Spring Haiti_modified							

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.

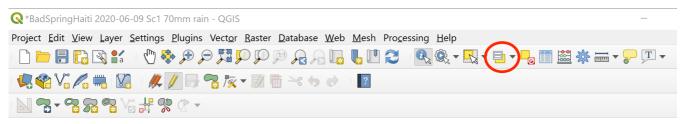
After you have changed the land use and land management, you can compare the impacts of the current land use/ land management (done in the previous project) and the land use scenario you just created now (current project).

#### 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".

1		< 🖻 🖻   🗞 🗮 N	🖳 🍸 🖀 🗞 🔎 🔰		i 🗐 🛱 🍭								
abc	Rainfall HRU [mm]		3 = 🔻	70							👻 Upda	ite All Update :	Select
	EG_ID	MAPUNIT_ID	LandForm	.% of \	Landuse Type	anduse Subtyp	Slope [%]	ologic Cond	I Soil Group	Numbe	Rainfall HRU [mm]	THRU [% of	Ri off
1 a	a12b60d4-14f3	{e53841a1-c06c	(NULL)	0.12	Other	Os: Settleme	14.52612043486	(NULL)	D	82.00	70	51.582135	36
2 a	a12b60d4-14f3	{1784f54f-9d09	(NULL)	1.18	Mixed	Mf: Agrofore	33.57122498558	C: Good	A	32.00	70	0.000000	0.0
3 a	a12b60d4-14f3	{80349f66-444b	(NULL)	0.53	Mixed	Mf: Agrofore	52.52734929171	C: Good	В	58.00	70	13.668051	9.5
4 a	a12b60d4-14f3	{ac2d9585-d44a	(NULL)	0.24	Other	Os: Settleme	10.88409816220	(NULL)	D	82.00	70	51.582135	36
5 a	a12b60d4-14f3	{3fdea9fc-48fd	(NULL)	0.18	Other	Os: Settleme	11.29232831764	(NULL)	D	82.00	70	51.582135	36
5 a	a12b60d4-14f3	{a85cec68-e918	(NULL)	0.66	Mixed	Mf: Agrofore	36.06505561295	C: Good	A	32.00	70	0.000000	0.0
7 a	a12b60d4-14f3	{aba19d46-03b0	(NULL)	0.07	Other	Os: Settleme	20.49754575760	(NULL)	D	82.00	70	51.582135	36
8 a	a12b60d4-14f3	{e6d40708-f83c	(NULL)	0.10	Other	Os: Settleme	22.40155801638	(NULL)	D	82.00	70	51.582135	36
9 a	a12b60d4-14f3	{9d2e11b2-f651	(NULL)	0.05	Other	Os: Settleme	13.41319920903	(NULL)	D	82.00	70	51.582135	36
10 a	a12b60d4-14f3	{7f385b82-b6bd	(NULL)	0.06	Other	Os: Settleme	5.083033594820	(NULL)	D	82.00	70	51.582135	36
11 a	a12b60d4-14f3	{730f2fe1-4340	(NULL)	0.02	Other	Os: Settleme	7.838384375852	(NULL)	D	82.00	70	51.582135	36
12 a	a12b60d4-14f3	{0cebd9c6-5dbd	(NULL)	1.62	Mixed	Mf: Agrofore	32.47369267889	C: Good	А	32.00	70	0.000000	0.0
13 a	a12b60d4-14f3	{1730140c-4cdb	(NULL)	2.47	Cropland	Ca: Annual cr	25.23945943804	A: Poor	В	77.00	70	41.608657	29
4 a	a12b60d4-14f3	{bb90c0f6-58fd	(NULL)	2.97	Grazingland	Ge: Extensive	39.13563269853	A: Poor	D	91.00	70	72.996355	51
15	12b60d4_14f3_	1c54e473d-0544		0.35	Cronland	Ca: Annual cr	11 570/17/558/	A: Poor	R	77.00	70	41 608657	20

*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".* 



Area	Curve Number	Rainfall/Runoff	Legal			
Hyd	ologic Response l	Jnit (HRU)				
Are	ea HRU [ha]				Exclude Field	
Are	ea HRU [% of Water	shed]		Case sensitive	Exclude Field	
Tota	al Watershed					
Are	ea Watershed [ha]				Exclude Field	
Wat	ershed Zone					
Wa	atershed Zone		Jpper zone (U	•	Equal to (=)	
Are	ea Watershed Zone [	ha]			Exclude Field	
Are	ea Watershed Zone [	% of Watershed]			Exclude Field	

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 closeseeded 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.

 $\rightarrow$  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.

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You can also Screenshot the maps for further use.