Food and Agriculture Organization of the United Nations

MAPPING OF SALT-AFFECTED SOILS

LESSON 2

Software installation and data organization

GLOBAL SOIL PARTNERSHIP

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Recommended citation:

Omuto, C.T., Vargas, R., Viatkin, K., Yigini, Y., 2020. Mapping of salt-affected soils: Lesson 2 – Software installation and data organization. Rome

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Summary

This Lesson is the second step of the capacity-building program, which is designed to build national capacities as well as harmonize procedures for developing information of salt-affected soils at the national and global levels. The overall goal of this Lesion is to support participants in software installation and using the software to organize input data for assessing salt-affected soils at the national level. At the end of the lesson, the participants are expected to have installed software and organized database for mapping salt-affected soils in their countries.

Summary outputs for organizing input national information for assessing salt-affected soils

Item	Description		Timeline
Software	**Installed software for database organization**		One week
	Spreadsheet software	MS Excel	
	GIS database software	QGIS and SAGA	
	Data harmonization software	ILWIS and R	
Data	**Organized input data**		
	Soil indicators of salt problems	EC, ESP, pH	
	GIS layers	Boundary shapefile	
		Spatial layers	

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1 Introduction

1.1 Overview

Proper data organization is an important pedometrics step in digital soil mapping and more so in identification of the true extent of salt-affected soils. Most soil profile data collection are organized in varying soil-depth steps and irregular soilscape patterns. Adequate understanding and modelling of soil variations are enhanced with well-organized input database. Furthermore, properly organized data minimizes syntax errors at the data analysis stage. The focus of this Lesson is to facilitate participants in harmonized organization of input database for assessing salt-affected soils. The input database to be organized was developed during Lesson one of the Capacity Building program. This Lesson, therefore, requires outputs from Lesson one. The Lesson is intended for participants who have completed Lesson one or participants with complete database for mapping salt-affected soils. Its output is a spatially compatible GIS database for national assessment of salt problems.

1.2 Objective

The overall objective of this Lesson is to establish a spatially compatible GIS database for national assessment of salt-affected soils in each member country.

1.3 Expected outcomes

By the end of this Lesson, the participants are expected to:

i. Install and operationalize GIS database software for mapping salt-affected soils
ii. Spatially harmonize input data into a GIS database for mapping salt-affected soils

2 GIS database for assessing salt-affected soils

2.1 Software for GIS database organization

Software is part of the tools and methods for digital soil mapping framework. The following software were downloaded during Lesson one: QGIS, ILWIS, and R. This section discusses some other potential applications of these software in database organization.

2.1.1 Applications in QGIS

QGIS is a versatile and relatively fast software with many GIS functionalities such as GIS database development and organization, GIS operations (layer trimming, projections, format conversion, views, etc.), remote sensing applications (such as image download, correction, pre-processing, classification, band analysis, etc.), map layouts, among others. Its documentation and tutorials for beginners are freely downloadable at https://qgis.org/en/site/forusers/download.html (accessed on 30th October 2019). The software also has a rich contribution of freely downloadable add-on packages known as plugins and a vibrant user-support (for example, through https://gis.stackexchange.com/).

QGIS has a Graphical User Interface (GUI) for easy access to its functions. The e functions are easily accessible through panels or shortcut icons by simple clicks/selection. In addition,

3 Resources

The following resources are useful for implementing the activities during data organization

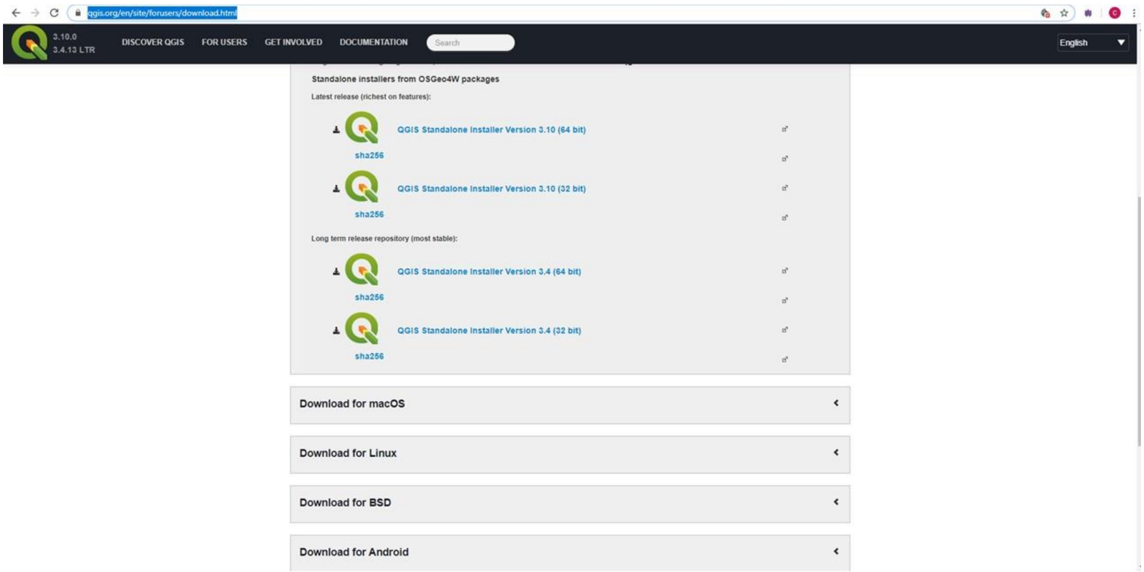
(a) Software (QGIS, ILWIS, Spreadsheet software)
(b) Own dataset (soil profile and GIS layers)
(c) Lecture materials

4 Activities

4.1 Software installation

4.1.1 Installing QGIS

Step 1: Go to the site https://qgis.org/en/site/forusers/download.html and download the latest release depending on the computer OS. For example, for Windows 64 bit, download QGIS Standalone Installer Version 3.10 (64 bit).



Step 2: Launch the installer

Step 3: The software (QGIS Desktop with GRASS) is available in a QGIS folder

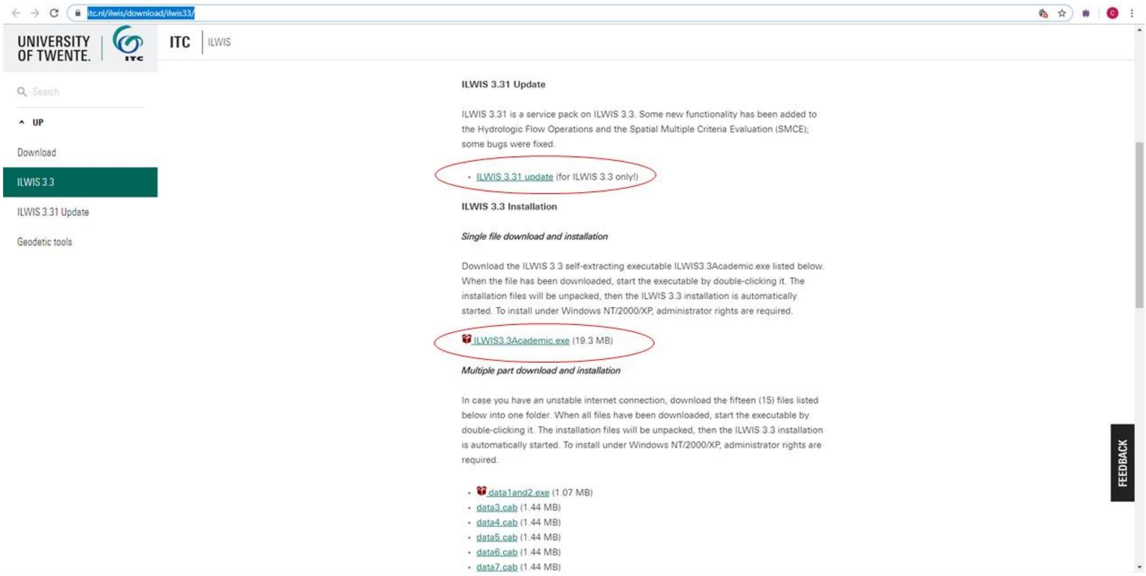
4.1.2 Installing ILWIS

Step 1: Go to the site https://www.itc.nl/ilwis/download/ilwis33/ and download ILWIS3.3Academic.exe (19.3 MB) and ILWIS 3.31 Update (for ILWIS 3.3 only)

Step 2) Install ILWIS3.3Academic.exe (19.3 MB) first and do not start the software yet.

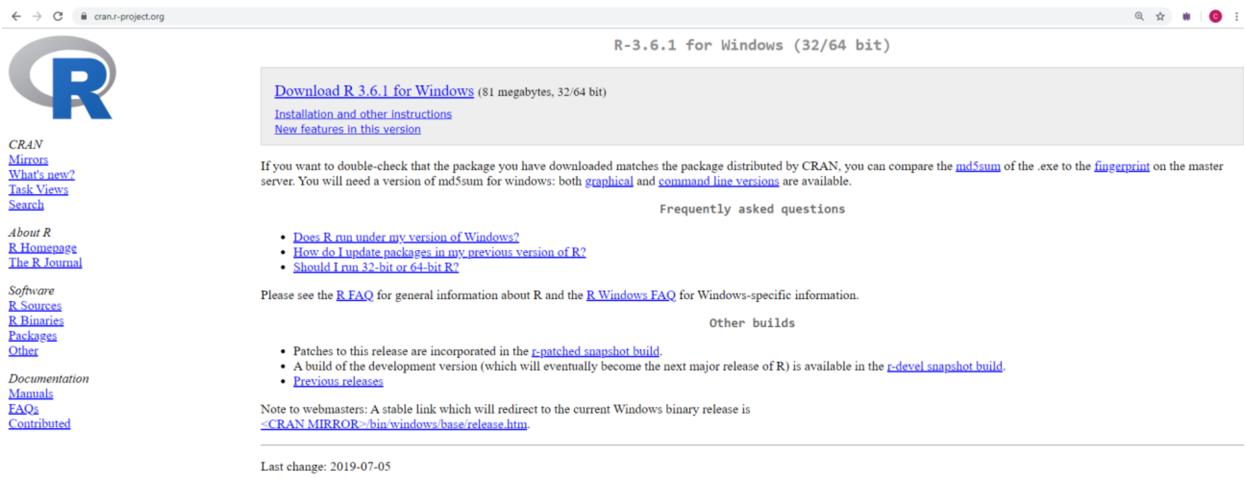
Step 3) Install ILWIS 3.31 Update (for ILWIS 3.3 only). During installation, it will request to locate ILWIS 3.3. Navigate to C:\Program Files (x86)\ILWIS 3.3 Academic and scroll down to choose the blue colored file Ilwis30.exe. Complete the installation

Step 4) Launch the software (whose icon should now be on the desktop).



4.1.3 Installing R

Step 1: Go to the site https://cran.r-project.org/ and download the installer suitable for your operating system. For Windows, choosing Download R for Windows takes you to another site from which you choose *Install R for the first time*. Another window for download opens.



Step 2: Install the window installer, choose the language (preferably English), bit rate for your computer, and choose *No (Accept default)* for the start-up options.

4.1.4 Installing RStudio

Step 1: Go to the site https://www.rstudio.com/ , click download Rstudio, the preferred version (like Free RStudio Desktop) and download.

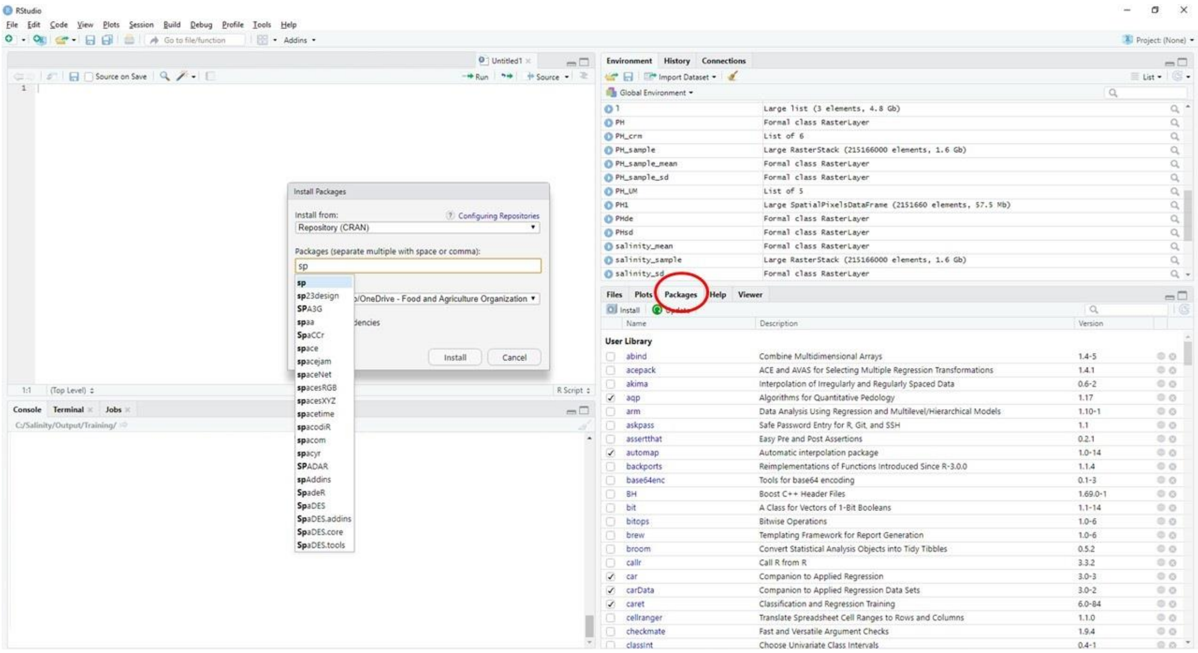
Step 2. Launch the installer and install the software

4.1.5 Installing R package

Step 1: Start RStudio and click the Packages Icon in the bottom right corner, the click *Install.* A window for install Packages pops.

Step 2: If connected to internet, type the name of the package to install (for example sp)

Step 3: Click *Install* button and the package will be installed and ready for use

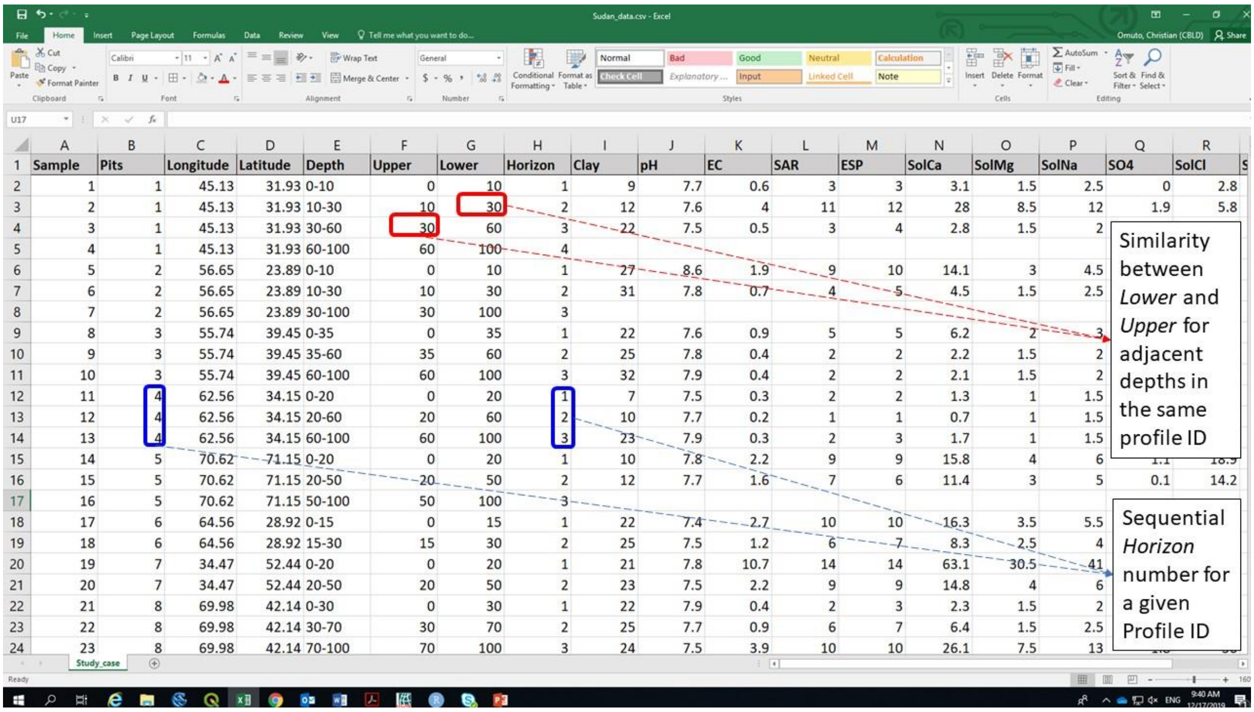


4.2 Database organization

4.2.1 Organizing spreadsheet data

Spreadsheet data should be organized to allow sequential computer scanning during data analysis.

1. Let the first column be the variable for indexing the serial order of the data.
2. Other variables in the database are consecutively ordered beginning with profile ID, Location description (if any), Latitude and Longitude, and sampling depth-range (Figure 4.1).
3. The depth-range is split into two variables: *Upper* and *Lower*. *Upper* denotes the first part of the depth-range while *Lower* denotes the last part of the depth-range. The value of *Upper* in one sample should be the same as the value for *Lower* in the preceding sample for the same profile ID (Figure 4.1).
4. Other variables such as Depth Code (or Horizon number), soil texture components, organic carbon, pH, EC, ESP, and additional soil properties such soluble ions (and/or exchangeable sodium ions and CEC) are also included in that order (Figure 4.1). The Depth Code (or Horizon) should have consecutive numbers beginning from one to the last sampled depth/horizon in each profile. This arrangement creates repeated numbers/codes of the profile ID and Longitude and Latitude values (Figure 4.1).



Sample	Pits	Longitude	Latitude	Depth	Upper	Lower	Horizon	Clay	pH	EC	SAR	ESP	SolCa	SolMg	SolNa	SO4	SolCl
1	1	45.13	31.93	0-10	0	10	1	9	7.7	0.6	3	3	3.1	1.5	2.5	0	2.8
2	1	45.13	31.93	10-30	10	30	2	12	7.6	4	11	12	28	8.5	12	1.9	5.8
3	1	45.13	31.93	30-60	30	60	3	22	7.5	0.5	3	4	2.8	1.5	2		
4	1	45.13	31.93	60-100	60	100	4										
5	2	56.65	23.89	0-10	0	10	1	27	8.6	1.9	9	10	14.1	3	4.5		
6	2	56.65	23.89	10-30	10	30	2	31	7.8	0.7	4	5	4.5	1.5	2.5		
7	2	56.65	23.89	30-100	30	100	3										
8	3	55.74	39.45	0-35	0	35	1	22	7.6	0.9	5	5	6.2	2	3		
9	3	55.74	39.45	35-60	35	60	2	25	7.8	0.4	2	2	2.2	1.5	2		
10	3	55.74	39.45	60-100	60	100	3	32	7.9	0.4	2	2	2.1	1.5	2		
11	4	62.56	34.15	0-20	0	20	1	7	7.5	0.3	2	2	1.3	1	1.5		
12	4	62.56	34.15	20-60	20	60	2	10	7.7	0.2	1	1	0.7	1	1.5		
13	4	62.56	34.15	60-100	60	100	3	23	7.9	0.3	2	3	1.7	1	1.5		
14	5	70.62	71.15	0-20	0	20	1	10	7.8	2.2	9	9	15.8	4	6		
15	5	70.62	71.15	20-50	20	50	2	12	7.7	1.6	7	6	11.4	3	5	0.1	14.2
16	5	70.62	71.15	50-100	50	100	3										
17	6	64.56	28.92	0-15	0	15	1	22	7.4	2.7	10	10	16.3	3.5	5.5		
18	6	64.56	28.92	15-30	15	30	2	25	7.5	1.2	6	7	8.3	2.5	4		
19	7	34.47	52.44	0-20	0	20	1	21	7.8	10.7	14	14	63.1	30.5	41		
20	7	34.47	52.44	20-50	20	50	2	23	7.5	2.2	9	9	14.8	4	6		
21	8	69.98	42.14	0-30	0	30	1	22	7.9	0.4	2	3	2.3	1.5	2		
22	8	69.98	42.14	30-70	30	70	2	25	7.7	0.9	6	7	6.4	1.5	2.5		
23	8	69.98	42.14	70-100	70	100	3	24	7.5	3.9	10	10	26.1	7.5	13		

Figure 4.1: Input spreadsheet data format

It is important to ensure that:

- *Upper, Lower,* and *Horizon* of each profile ID increase down the soil profile
- *Latitude, Longitude* and *Profile ID* remain constant for each Profile ID
- *Upper* is equivalent to the first part of the *Depth* range and *Lower* is the second part of *Depth*

4.2.2 Organizing GIS data

(a) Harmonizing coordinate reference system

Harmonization of coordinate reference system (CRS) is done by Reprojection, which is the terminology often used in GIS for transforming one CRS to another. The following points need consideration when *reprojecting* GIS layers:

- Identifying the CRS to use on all GIS layers (here known as harmonized CRS)
- It is important to choose UTM projection for harmonizing all layers CRS
- CRS of each GIS layer and individual need for *reprojection* should be noted before *reprojection*
- *Reprojecting* vector layers requires specifying the CRS when the layers are saved anew
- *When reprojecting* raster layers, *source* CRS (current) and *target* CRS need to be specified

The steps for *reprojecting* vector and raster layers is given in Figure 4.2.

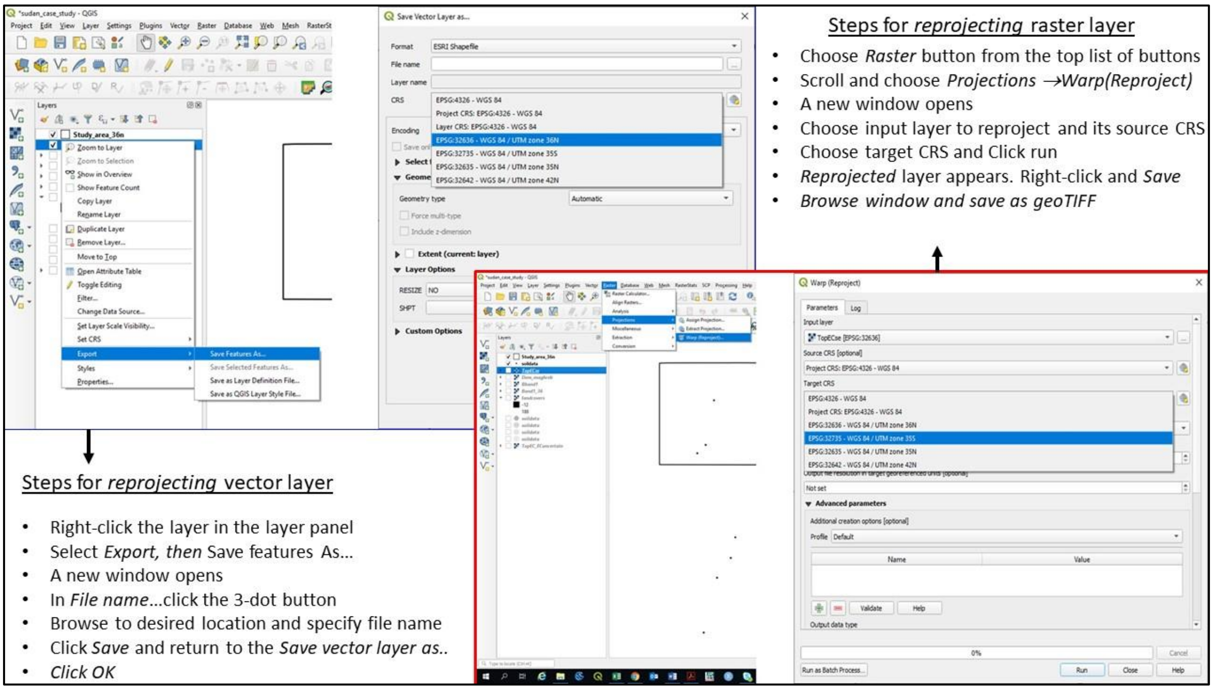


Figure 4.2: Reprojecting GIS layers in QGIS

(b) Harmonizing layer format

Not all GIS layers are available in uniform file format. Sometimes, some soil forming factors such as soil map, geology, and land cover types are only available as polygon vector files. Harmonizing GIS layer formats attempts to convert vector files to raster formats. Except for soil profile data, all GIS layers for mapping salt-affected soils need to be raster layers. Vector-to-raster conversion is a GIS operation used for harmonizing vector polygons into raster data types. Some of the pre-requisite operations before vector-to-raster harmonization include projection harmonization, identification of the target polygon attribute to use in the conversion, decision on the target pixel resolution of the final raster map, and cleaning of missing entries, topology errors, and associated errors in the data entry. Figure 4.3 illustrates the steps for vector-to-raster conversion in QGIS.

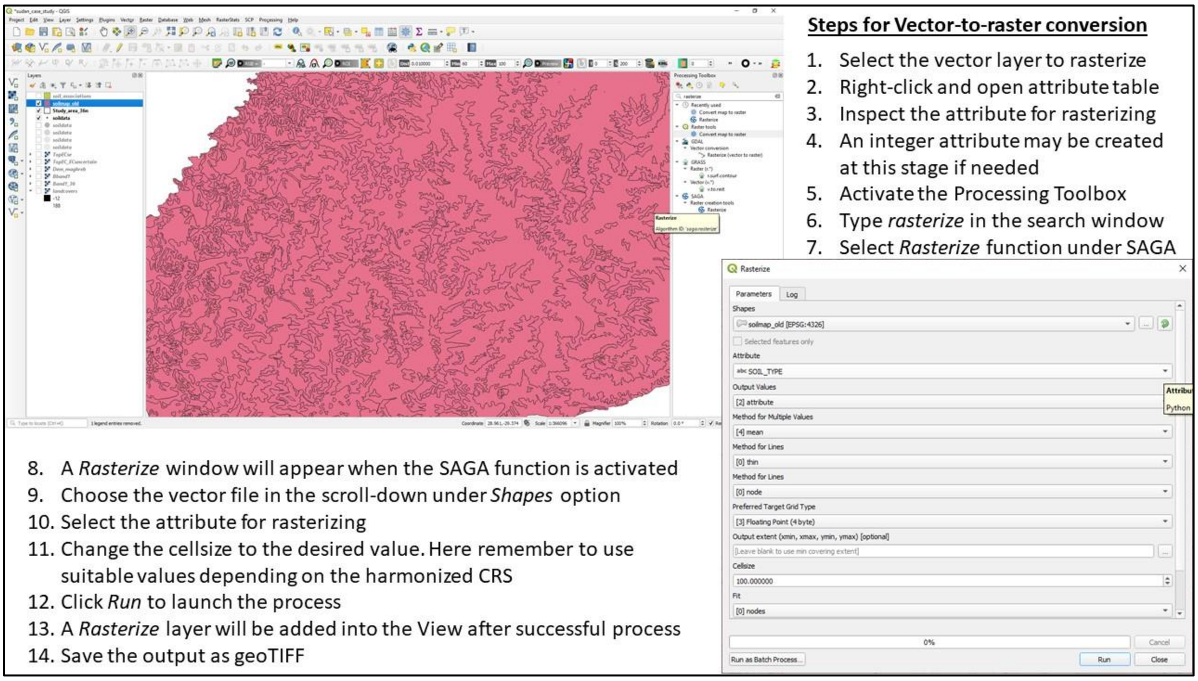


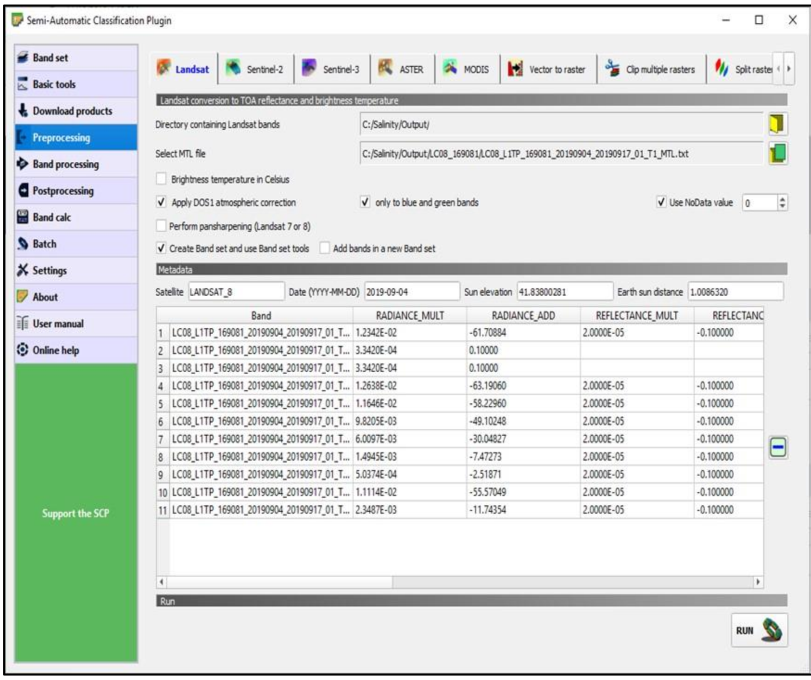
Figure 4.3: Steps for vector-to-raster conversion in QGIS

(c) Image correction

Freely downloadable remote sensing images have varied characteristics that need harmonization before application in spatial modelling of salt-affected soils. These characteristics range from differences in spatial extent, image digital numbers, image conversion models to land surface reflectance, and downloaded file format. Most downloaded images are wrapped in compressed files such as .zip, .rar or .gz. They should be unpacked into commonly used GIS file formats such as geoTIFF, ASCII, HDF, etc. Software such as WinZip or WinRar or 7-Zip unpacks the compressed files into a preferred destination folder (such as C:/Salinity/Output). Sometimes the unpacked file may still contain compressed files and another unpacking may be necessary to extract the GIS files. It is important that different zipped files are unzipped into different folders to avoid over-writing metafiles and for processing each file independently. Semi-Automatic Classification Plugin (SCP) in QGIS provides a quick way for simultaneous geometric and radiometric correction of remote sensing images. The plugin has many functions for handling different types of remote sensing images such as Landsat, Sentinel-2, Sentinel-3, ASTER, MODIS, etc. Figure 4.4 illustrates how these types of images are corrected using SAC plugin in QGIS.

(d) Digital terrain modelling

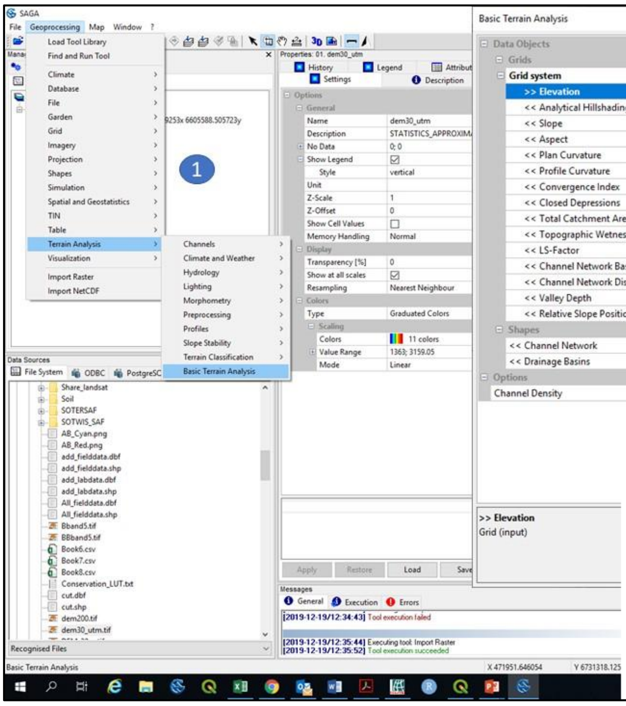
Terrain modelling focuses on determining relief parameters influencing soil formation or translation of soil salts during leaching, runoff or wind erosion. Relief parameters are primary or secondary attributes. Primary attributes are derived from the altitude and directional location of the topographic surface. They include slope, aspect, curvature, flow accumulation and up-slope flow contributing area. Secondary attributes are obtained from the altitude and derivatives of the primary attributes. They include indices such as topographic wetness index, compound topographic index, stream power index, etc. SAGA software has a module for developing 14 terrain parameters from DEM input (Figure 4.5)

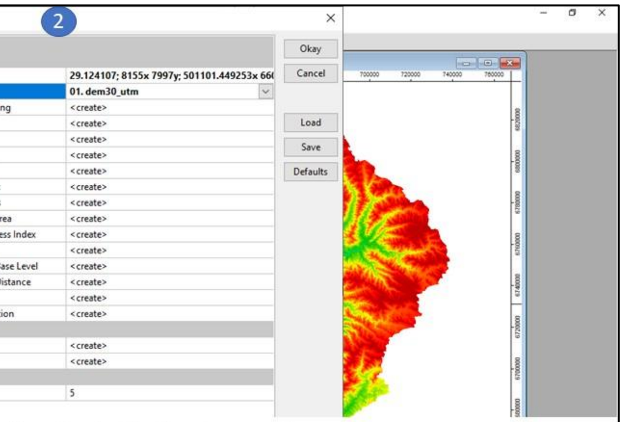


Steps for image correction using SAC

1. Select and set the working CRS for the QGIS window. Harmonized CRS is preferred
2. Launch the plugin
3. Select *Preprocessing* button
4. Select the image type (say Landsat)
5. In front of the *Directory containing landsat bands*: Select the folder containing the unpacked Landsat images. Each folder is processed at a time
6. Select the MTL file, which is a textfile with MTL at the end of the file name.
7. If the image type is Sentinel-2, the textfile name ends with MSI
8. Click *Run* to execute the command. A prompt for choosing the output folder comes up. The folder with the downloaded image (step 4 above) is preferred
9. If the image type is MODIS, the no need for the textfile since the information is already contained in the header-file.
10. The corrected image images will be loaded into the QGIS view window.
11. Repeat the steps for all downloaded image scenes

Figure 4.4: Image processing using semi-automatic classification plugin





<u>Steps for deriving terrain parameters</u>

1. Import the DEM: *Geoprocessing* then *File* then *Grid* then *Import* then *Import Raster*
2. Launch the pre-processing (fill sinks if necessary): *Geoprocessing, Terrain Analysis, Preprocessing, Fill Sinks* (and use option of choice, (say the 1st one))
3. Launch Basic Terrain Analysis: *Geoprocessing, Terrain Analysis, Basic Terrain Analysis*
4. Basic Terrain Analysis window opens
5. On Grid system: scroll to select the spatial characteristic of the loaded DEM
6. On Elevation: Scroll to choose the appropriate DEM
7. Click Okay to run the process.
8. Export the layers: *Geoprocessing, File, Grid* then *Import* then *Export Raster*

Figure 5.9: Steps for digital terrain analysis in SAGA

(e) Final GIS database

All spatial data in the GIS database should have uniform CRS (i.e. harmonized CRS). In addition, all raster layers should have uniform pixel resolution. Uniform pixel resolution is obtained by resampling all the raster layers to the preferred spatial resolution. A map-list in ILWIS is one way of ensuring that all harmonized raster layers have uniform CRS and pixel resolution. Figure 4.6 gives the steps for creating a map-list of harmonized raster layers

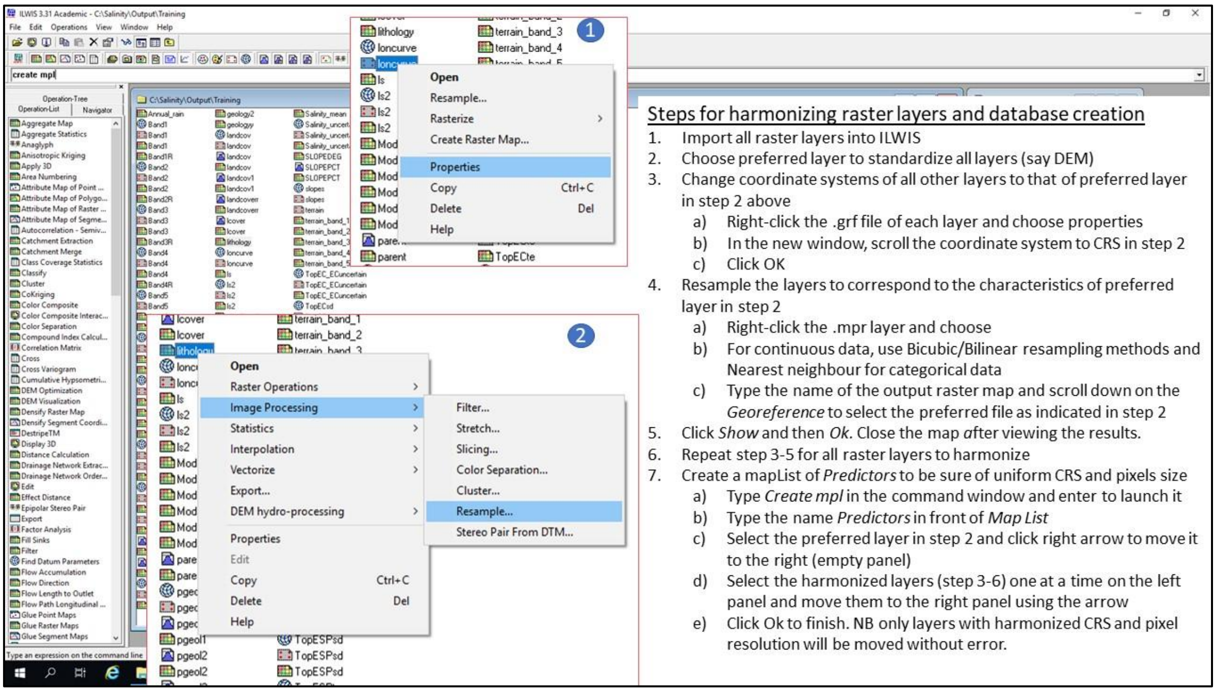


Figure 4.6: Creating spatially harmonized GIS database in ILWIS

5 Outputs

Each participant is expected to produce the following at the end of this lesson:

1. Organized database of indicators of salt-affected soils (EC, pH, ESP)
2. Organized database of GIS layers (land cover, climate, geology, images, DEM, soil map, etc.)
3. Installed computer software for mapping salt-affected soils

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Thanks to the financial support of

Ministry of Finance of the Russian Federation

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AFACI Asian Food & Agriculture Cooperation Initiative

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