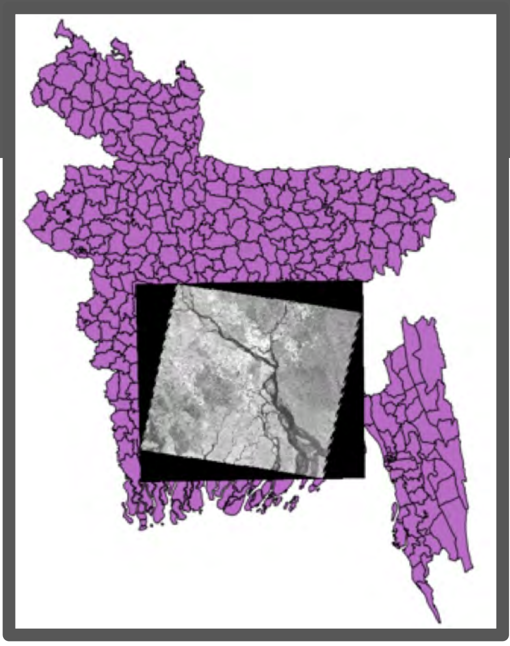
Introduction to basic GIS and spatial analysis using QGIS:

Applications in Bangladesh



Zia Uddin Ahmed

Timothy J. Krupnik

Mustafa Kamal

Introduction to basic GIS and spatial analysis using QGIS:

Applications in Bangladesh

Zia Uddin Ahmed

Timothy J. Krupnik

Mustafa Kamal

Cereal Systems Initiative for South Asia (CSISA)

Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh

by Zia Uddin Ahmed, Timothy J. Krupnik and Mustafa Kamal

CIMMYT, the International Maize and Wheat Improvement Center is the global leader on publicly funded maize and wheat research and related farming systems. Headquartered near Mexico City, CIMMYT works with hundreds of partners throughout the developing world to sustainably increase the productivity of maize and wheat cropping systems, thus improving global food security and reducing poverty. CIMMYT is a member of the CGIAR Consortium and leads the CGIAR Research Programs on MAIZE and WHEAT. The Center receives support from national governments, foundations, development banks and other public and private agencies.

Correct Citation: Ahmed, Z.U., Krupnik, T.J., Kamal, M., 2018. Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh. Cereal Systems Initiative for South Asia (CSISA) and the International Maize and Wheat Improvement Center, CIMMYT. Dhaka, Bangladesh.

Publication Design

M. Shahidul Haque Khan
Md. Nazmul Islam Dulal

Published by

CIMMYT- Bangladesh
House 10/B, Road 53, Gulshan 2, Dhaka 1212
Tel (Land/Fax): +880 2 9896676, +880 2 9894278
Post: P.O. No. 6057, Gulshan, Dhaka 1212, Bangladesh

Published in 2018

This set of training modules was developed by the International Maize and Wheat Improvement Center (CIMMYT) as part of the Cereal Systems Initiative for South Asia (CSISA) project.

Funded by

Partners

CSISA was established in 2009 to promote durable change at scale in South Asia's cereal-based cropping systems. Operating in rural 'innovation hubs' in Bangladesh, India and Nepal, CSISA works to increase the adoption of various resource-conserving and climate-resilient technologies, and to improve farmers' access to market information and enterprise development. CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills. By continuing to work in synergy with regional and national efforts, and by collaborating with myriad public, civil society and private sector partners, CSISA aims to benefit more than eight million farmers by the end of 2020.

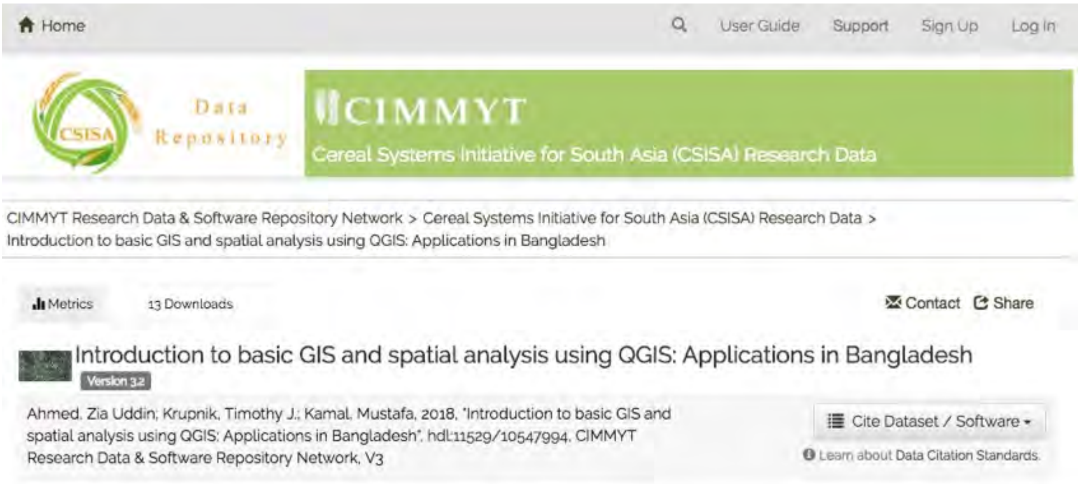
This publication was funded by the United States Agency for International Development (USAID and Bill and Melinda Gates Foundation (BMGF). The views and opinions expressed in this publication are those of the author(s) and do not necessarily reflect the views of BMGF, USAID or the US Government and the other Donors.

Table of Contents

Instructions before you begin using this set of learning modules

Before you begin working with these learning modules, please take time to download the data and other information you will need to complete the hands-on exercises detailed in this book. You can download these files as described below:

1. Go to the following link by [clicking here](). The website that houses the data you need to download looks like shown below:

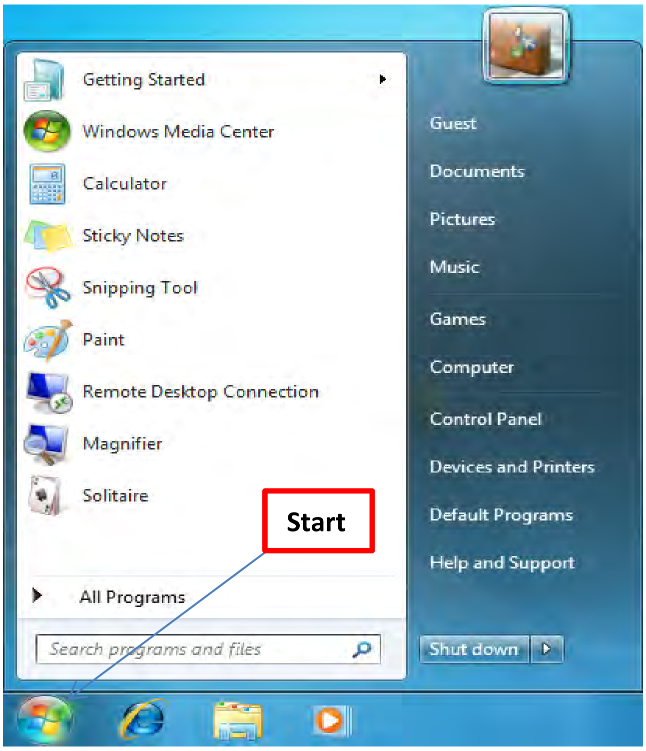


2. You will find listed on this webpage all of the required files that you need to use for each module exercises in this book in zip format, as shown below.
3. Download the ten individual .zip files (one for each of the modules in this book, beginning on Module 3 and ending with Module 13). In total, the files are over 500 MB in size, so they may take some time to download.
4. Keep the files on the local drive of your computer, in a location that is easy to access such as the documents folder or root location of any drive.
5. As you work through the modules in this book, you will find instructions to load different files that are in each of the folders in the zip files. Please open and make use of the downloaded files as required to complete the exercises in each of the modules.
6. Keep these files available, as you will be requested to import them into QGIS for the exercises in the different modules in this book.

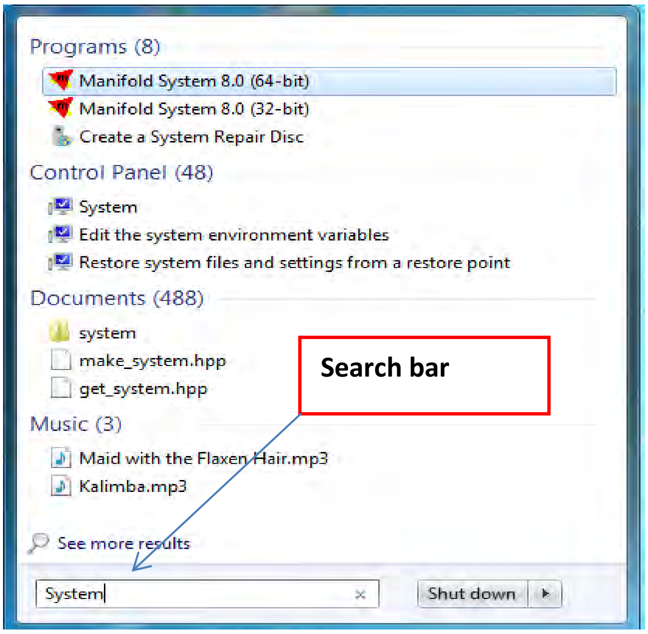
Module 1: Downloading and Installationof Quantum Geographic Information Systems (QGIS), GRASS 7 and R

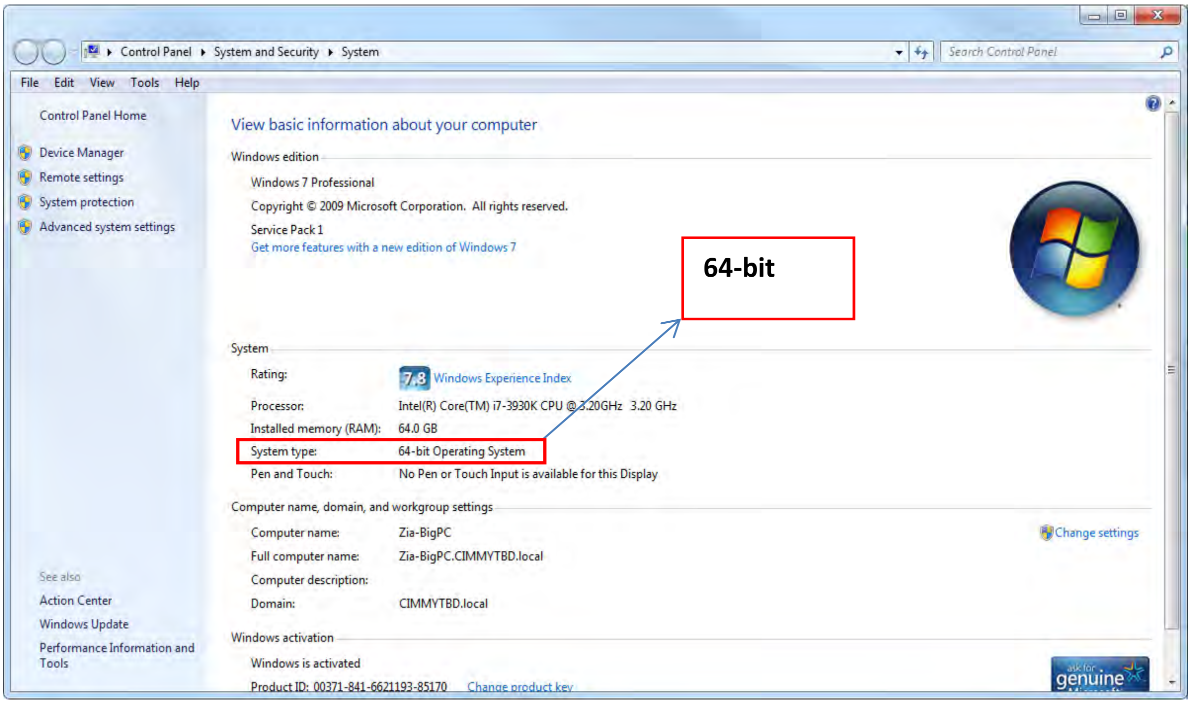
Before downloading and installation of QGIS and other software in Windows, check your Windows System type (32 bit or 64 bit) to assure compatibility.

1. Click the Windows Start button



2. Type "System" in the search bar, and then click System





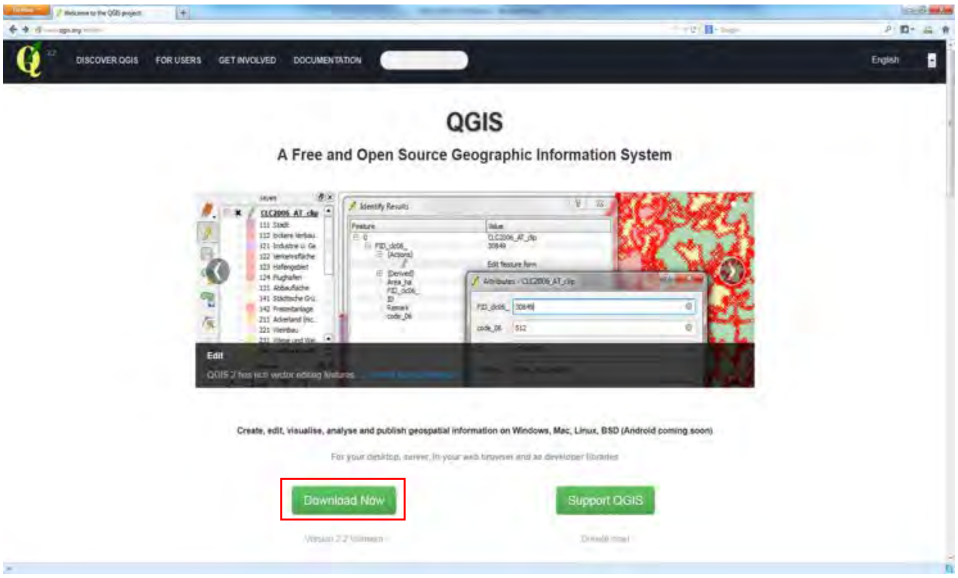
Download QGIS Installers

For installation of the latest version of QGIS please go to https://www.qgis.org/en/site/forusers/download.htmlThe OSGeo4W repository contains a lot of software from OSGeo projects. QGIS and all dependencies (supporting software) are included, along with Python, GRASS 6.4.3 (http://grass.osgeo.org/), SAGA GIS2.0.8 (http://www.saga-gis.org/en/index.html), GDAL (http://www.gdal.org/), etc. If you want to run R-script in QGIS, you have to install latest version of R (http://www.r-project.org/).

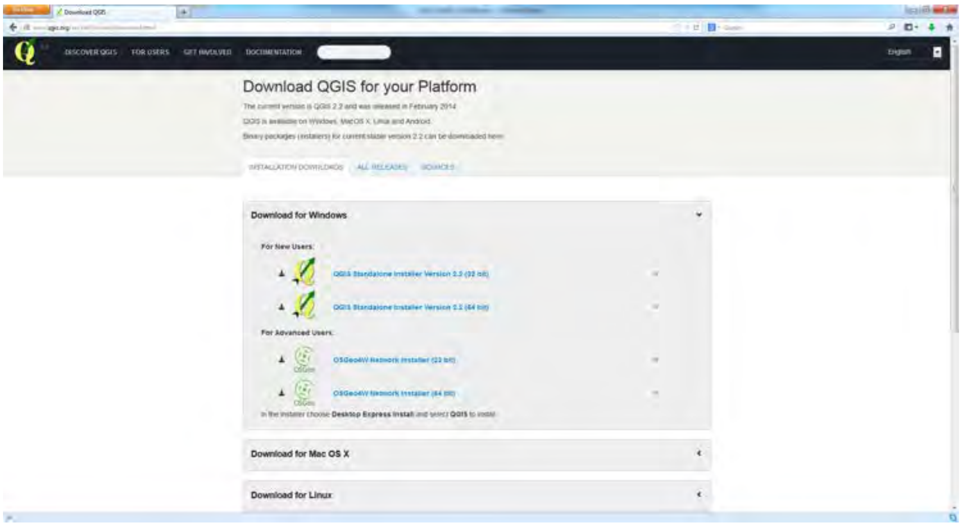
Note that this set of training modules focuses on using Windows for QGIS, although QGIS is also compatible with Macintosh computers. Instillation is similar and many online guides for how to work with QGIS in a MAC environment are available. Please also note that new versions of QGIS, GRASS, GDAL and R may have been released since this publication was completed. Where this is the case, feel free to use the new versions, although you may need to adapt portions of the instructions in each module to some mall extent.

The QGIS installer can be installed from the internet or you can download all required packages beforehand and then apply them. The downloaded files are located in a local directory for future installations. Steps of the downloading QGIS installer are:

1. Click Windows Start button



2. Go to Control panel, then System, then System type



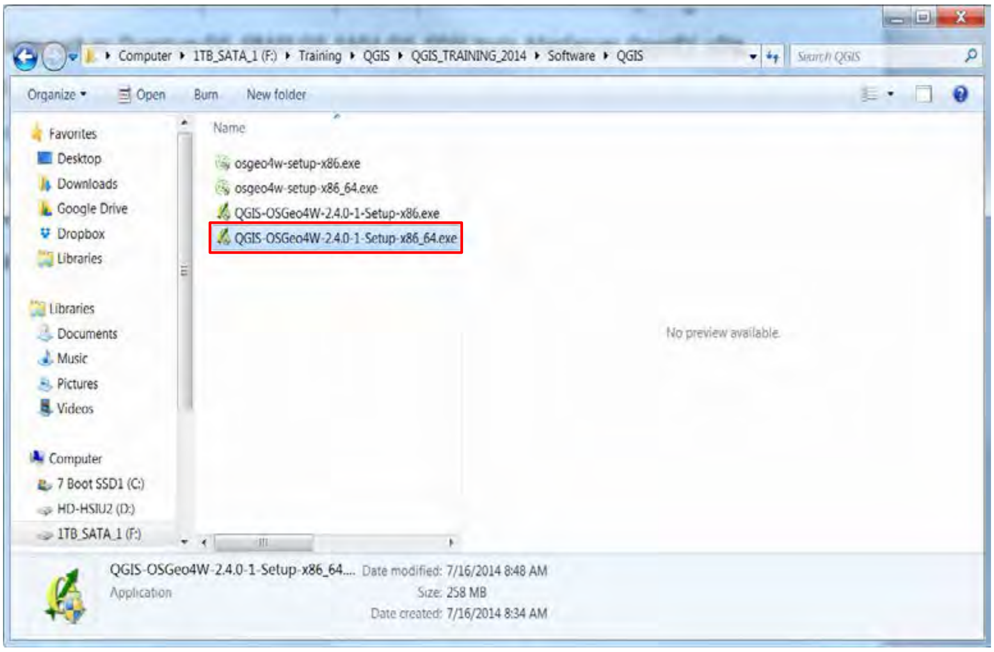
3. Click **Save File**. The installer will be saved in **C:\Users\[yourusername]\Downloads** directory.

Installation of QGIS

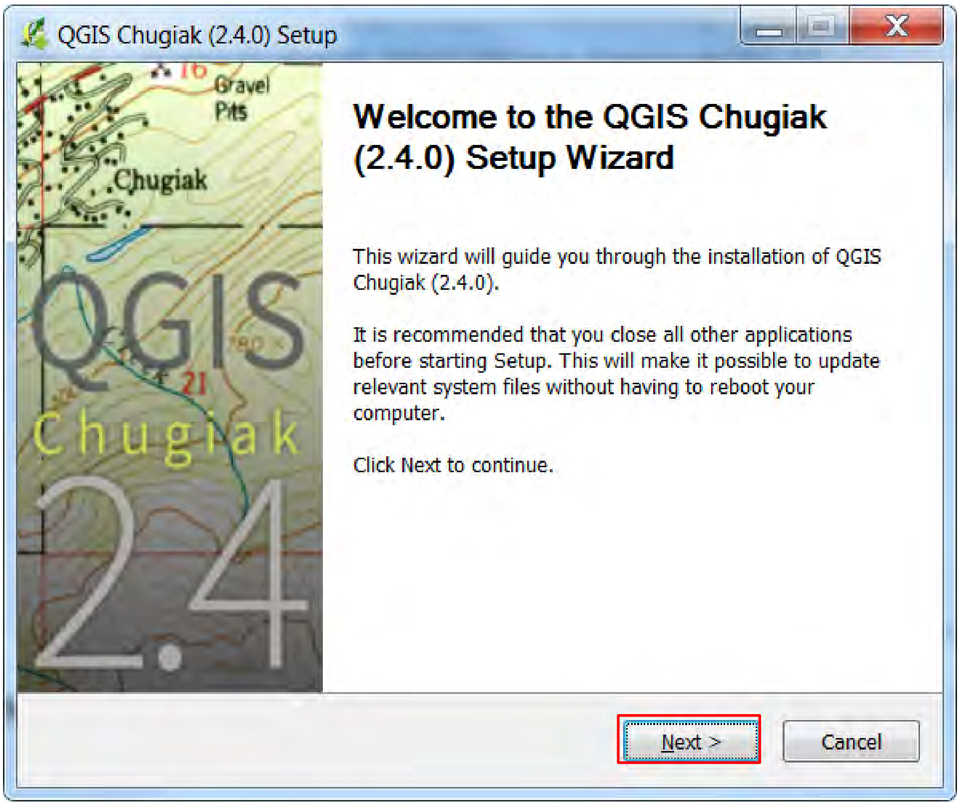
For Windows XP through Windows 8 (both 32 and 64 bit), the **OSGeo4W** installer offers many more choices since it includes the ability to install many other Open Source GIS software packages and libraries such as: Quantum GIS, GRASS GIS, SAGA GIS, GDAL tools, MapServer, OpenEV, uDig, and more.

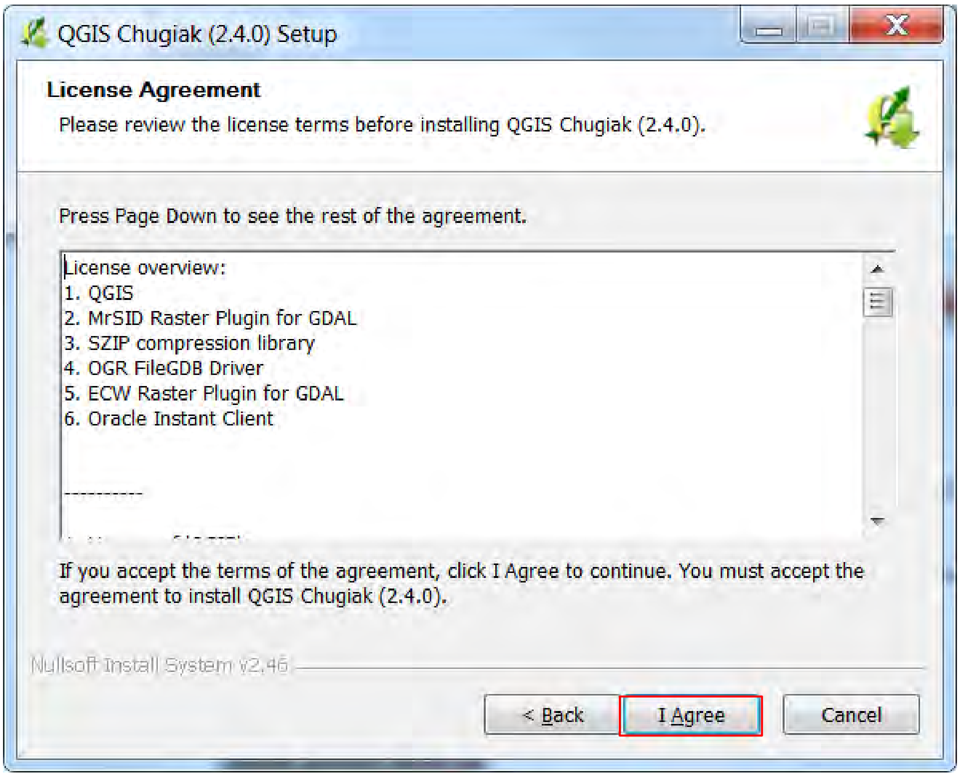
Standalone Installer

1. To download the OSGeo4W installer click here.
2. Navigate to the directory where the downloaded **osgeo4w-setup-x86_64.exe** installercan be found.
3. Right click on the installer and select **Run as administrator.**



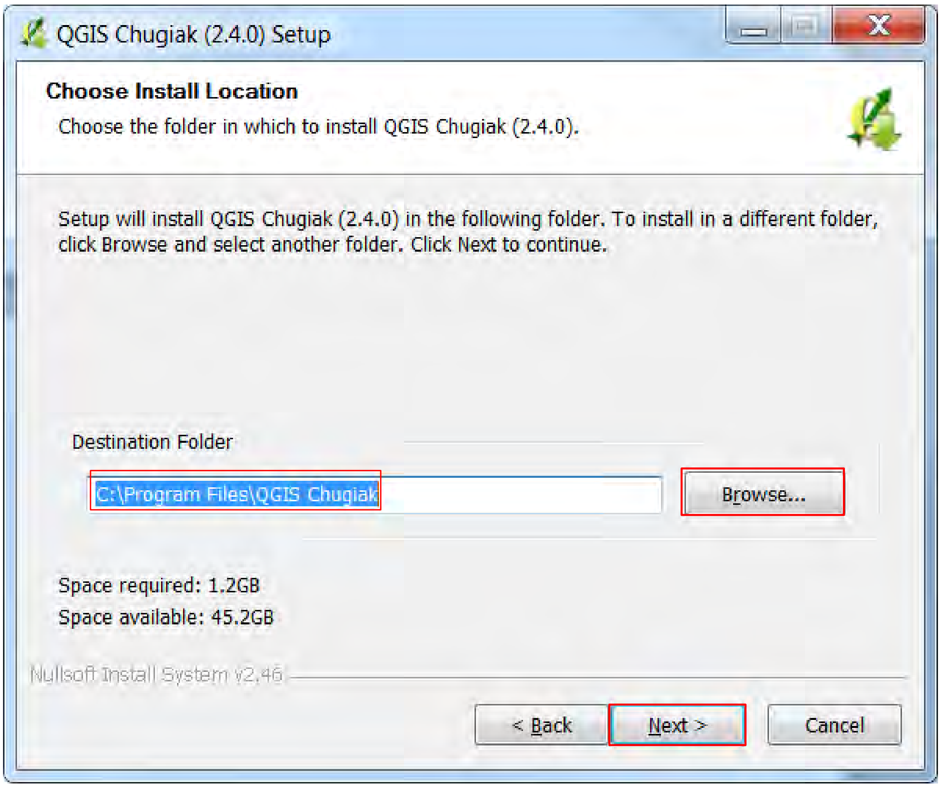
4. Click Next
5. Click I Agree for the License agreement


QGIS Chugiak (2.4.0) Setup
Gravel Pits
Chugiak
QGIS
Chugiak
2.4
Welcome to the QGIS Chugiak (2.4.0) Setup Wizard
This wizard will guide you through the installation of QGIS Chugiak (2.4.0).
It is recommended that you close all other applications before starting Setup. This will make it possible to update relevant system files without having to reboot your computer.
Click Next to continue.
Next >
Cancel

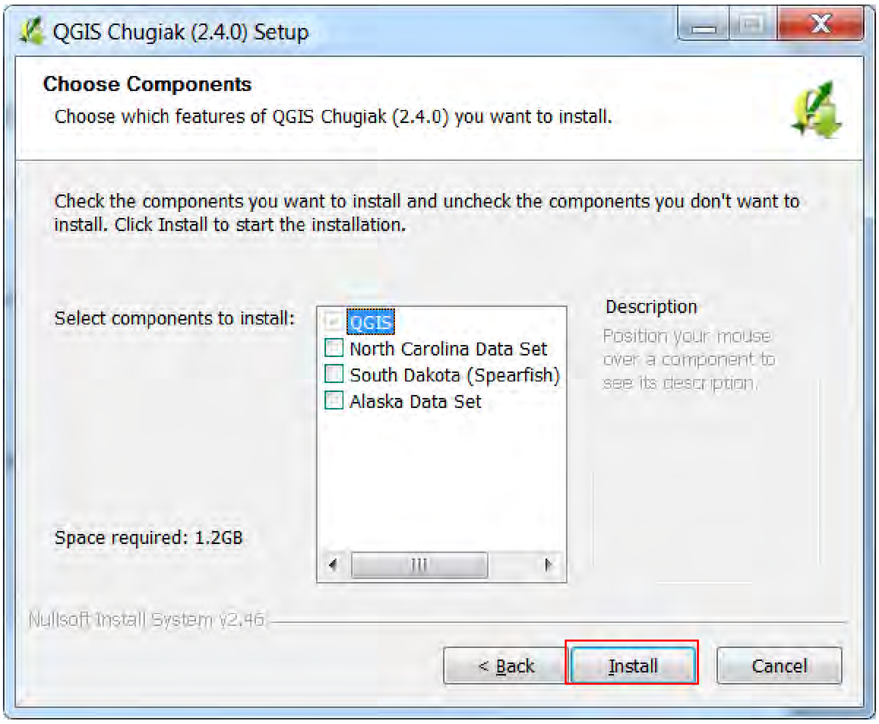

QGIS Chugiak (2.4.0) Setup
License Agreement
Please review the license terms before installing QGIS Chugiak (2.4.0).
Press Page Down to see the rest of the agreement.
License overview:
1. QGIS
2. MrSID Raster Plugin for GDAL
3. SZIP compression library
4. OGR FileGDB Driver
5. ECW Raster Plugin for GDAL
6. Oracle Instant Client

If you accept the terms of the agreement, click I Agree to continue. You must accept the agreement to install QGIS Chugiak (2.4.0).
Nullsoft Install System v2.46
< Back
I Agree
Cancel

6. Keep the default destination folder (C:\Program Files)and click Next



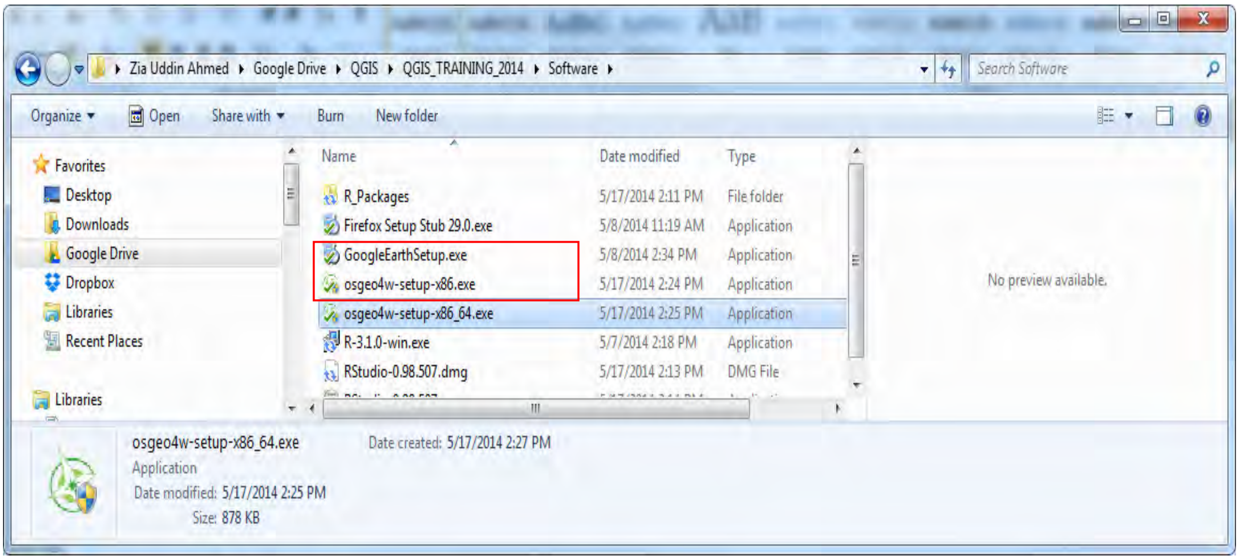
7. Click Install (at this point, there is no need to download training data – we will return to this later). This part of the process takes several minutes.



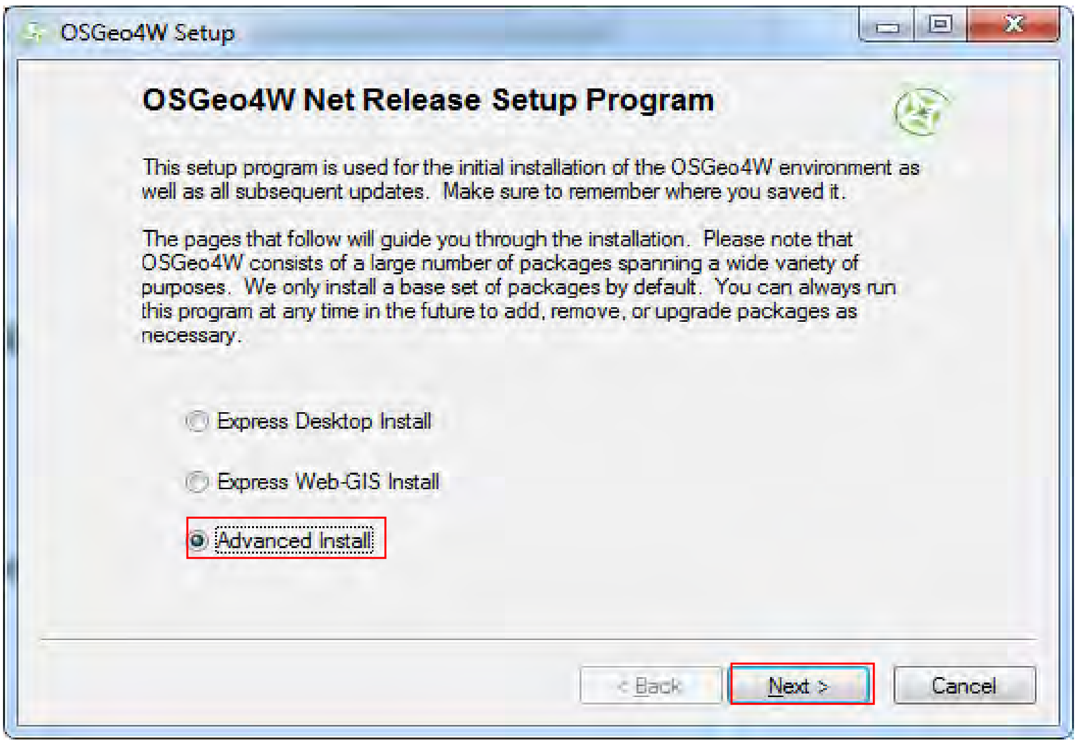
8. Click Finish

Network Installer (for advanced users)

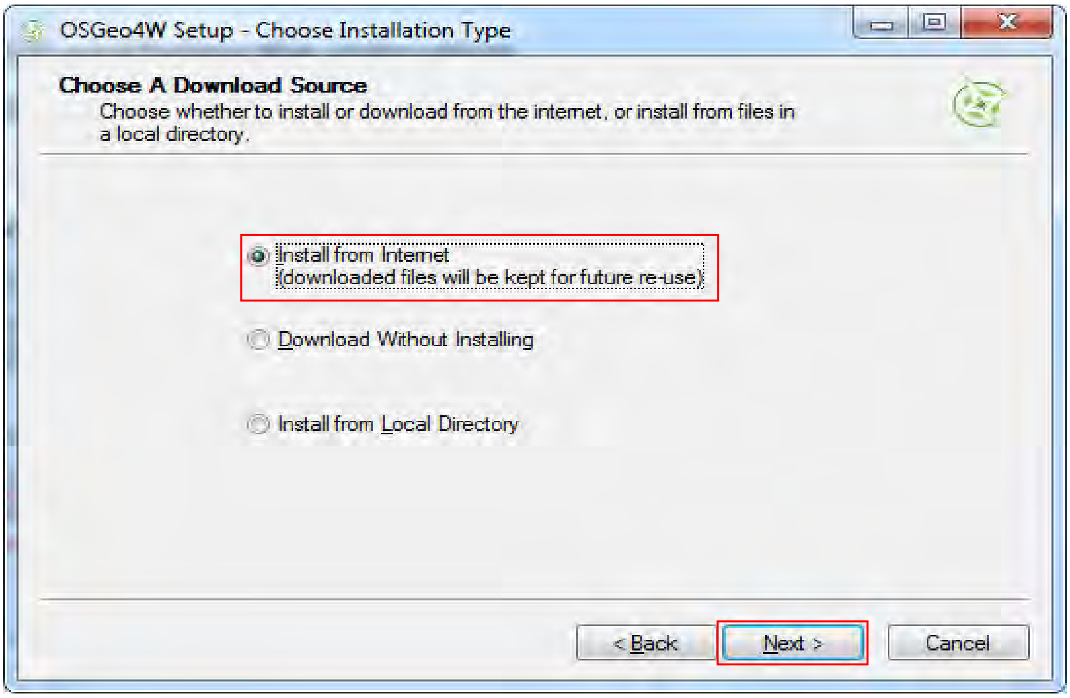
1. To download the OSGeo4W installer click here.
2. Navigate to the directory where the downloaded **osgeo4w-setup-x86_64.exe** installer is exit.



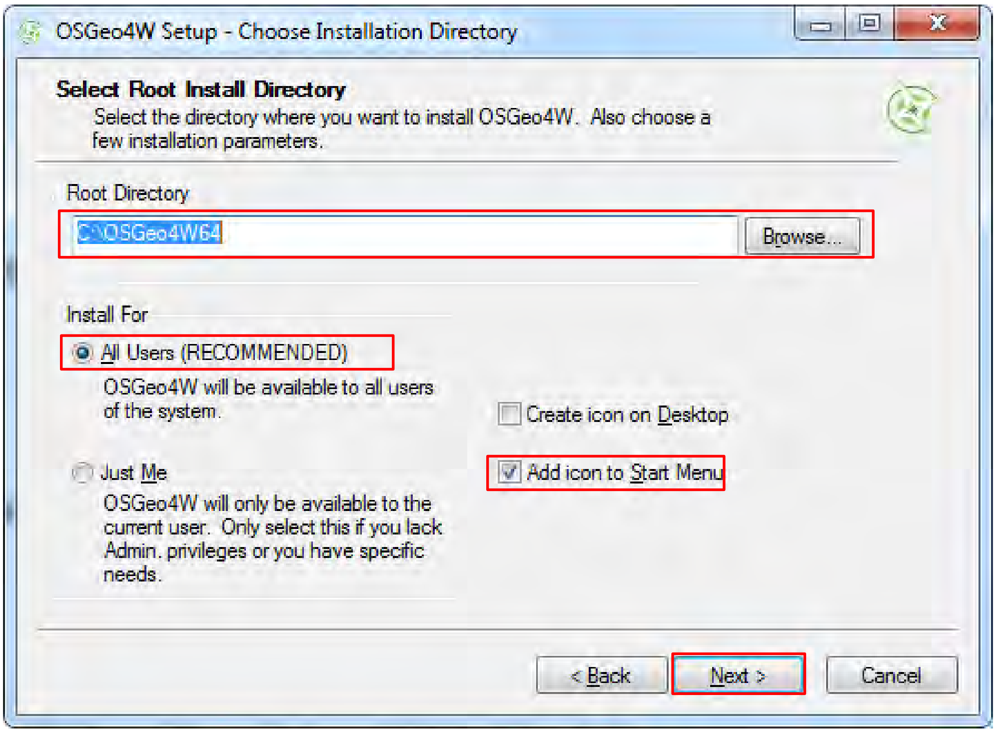
3. Double-click and follow the instruction
4. Choose **Advanced Install** and click **Next**



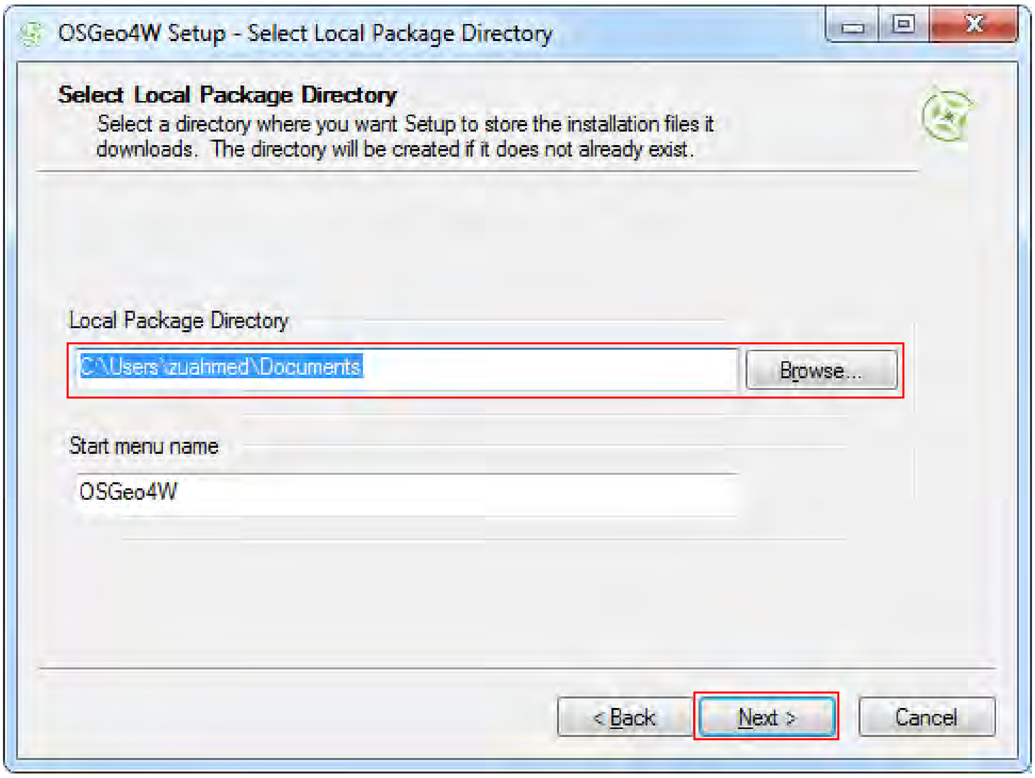
5. Choose **Install From Internet** and click **Next**



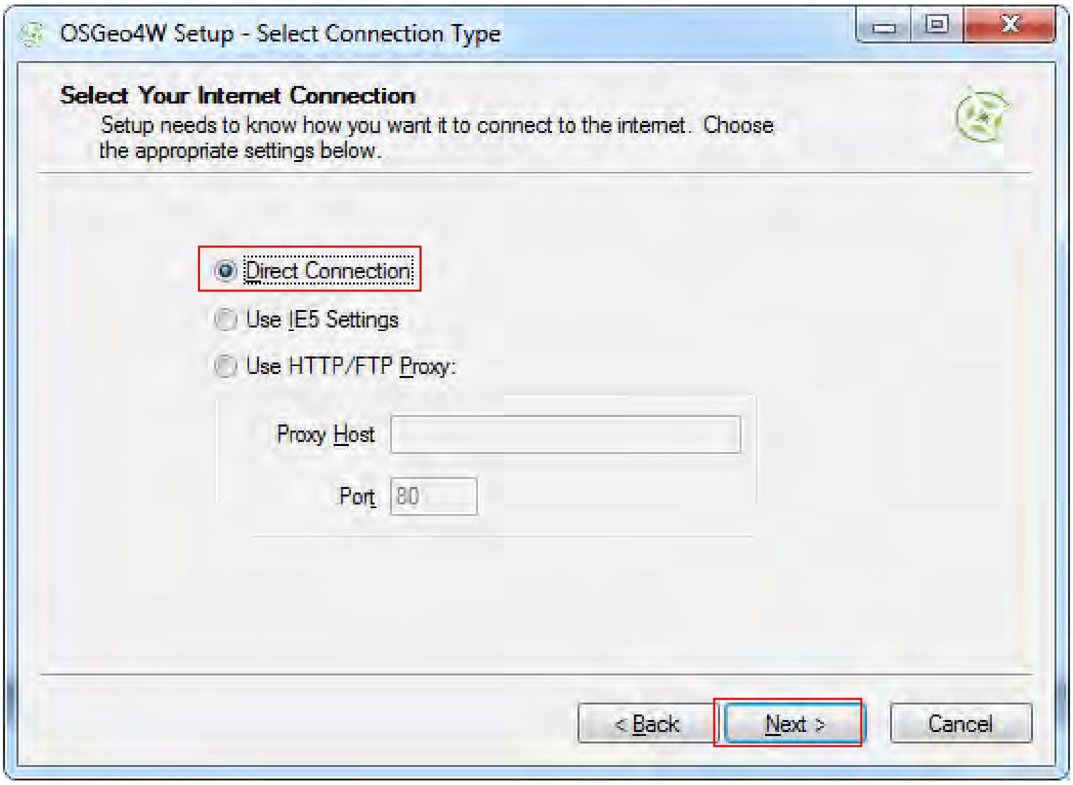
6. Set root directory to: **C:\OSGeo4W** and check the radio button All Users,and click Next



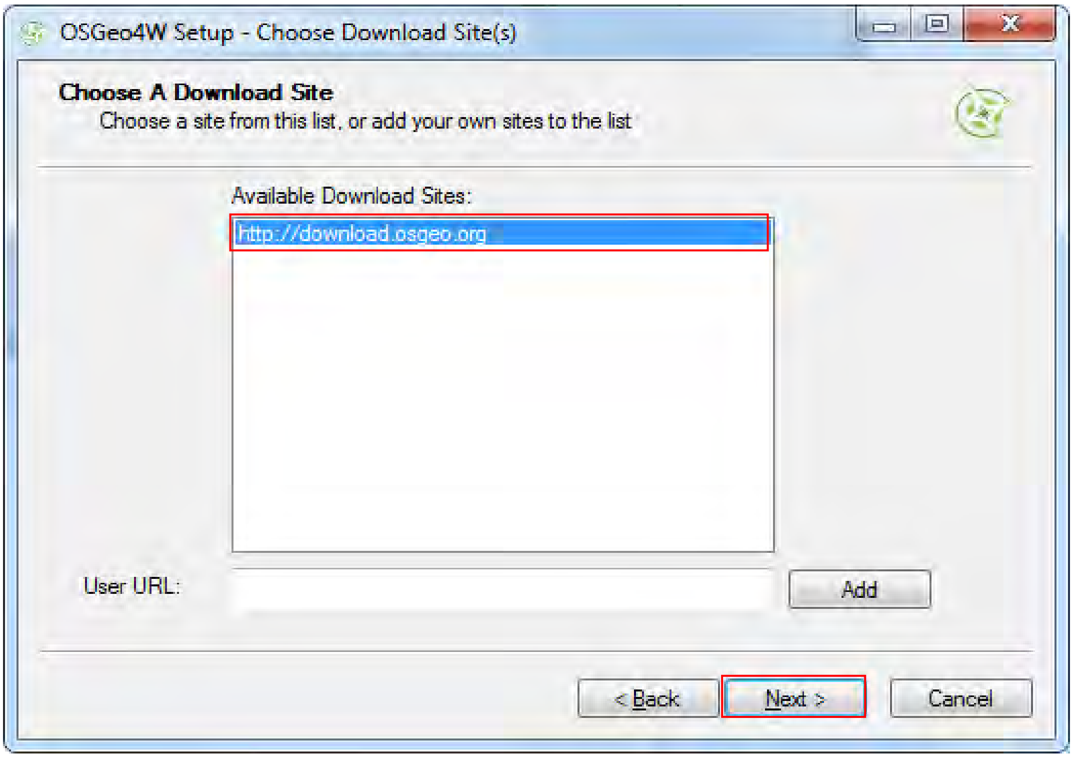
7. Select Local Package Directory (**C:\Users\[yourusername]\Documents**) as a temporary directory, and click **Next**



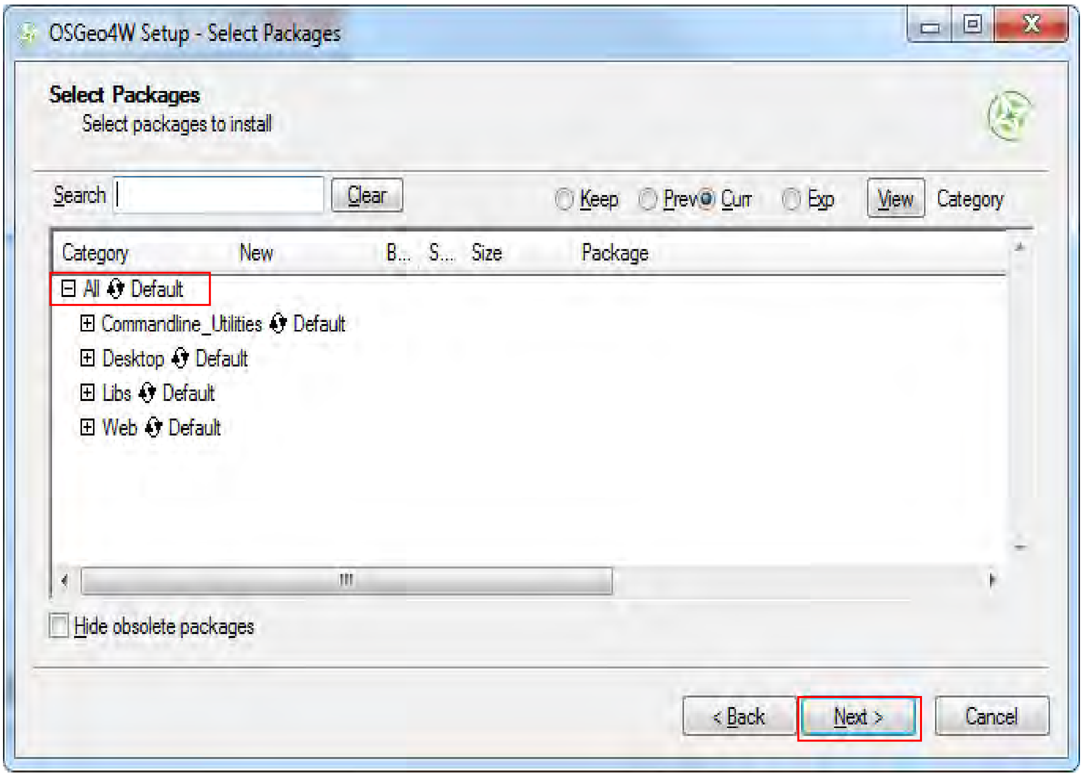
8. Select Direct Connection and click Next



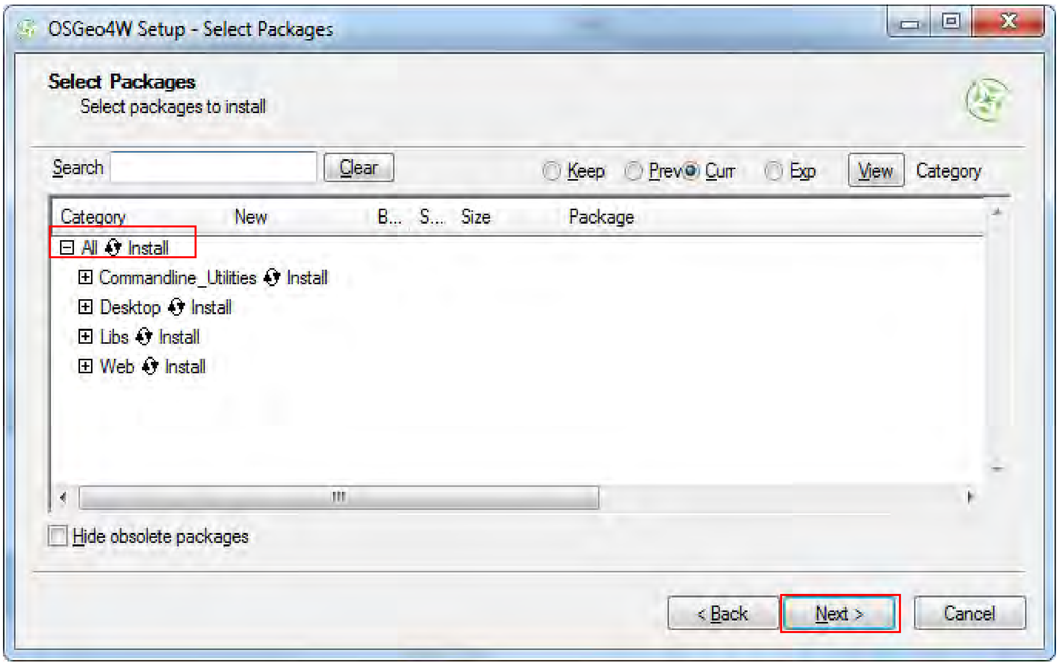
9. Choose download site and click Next



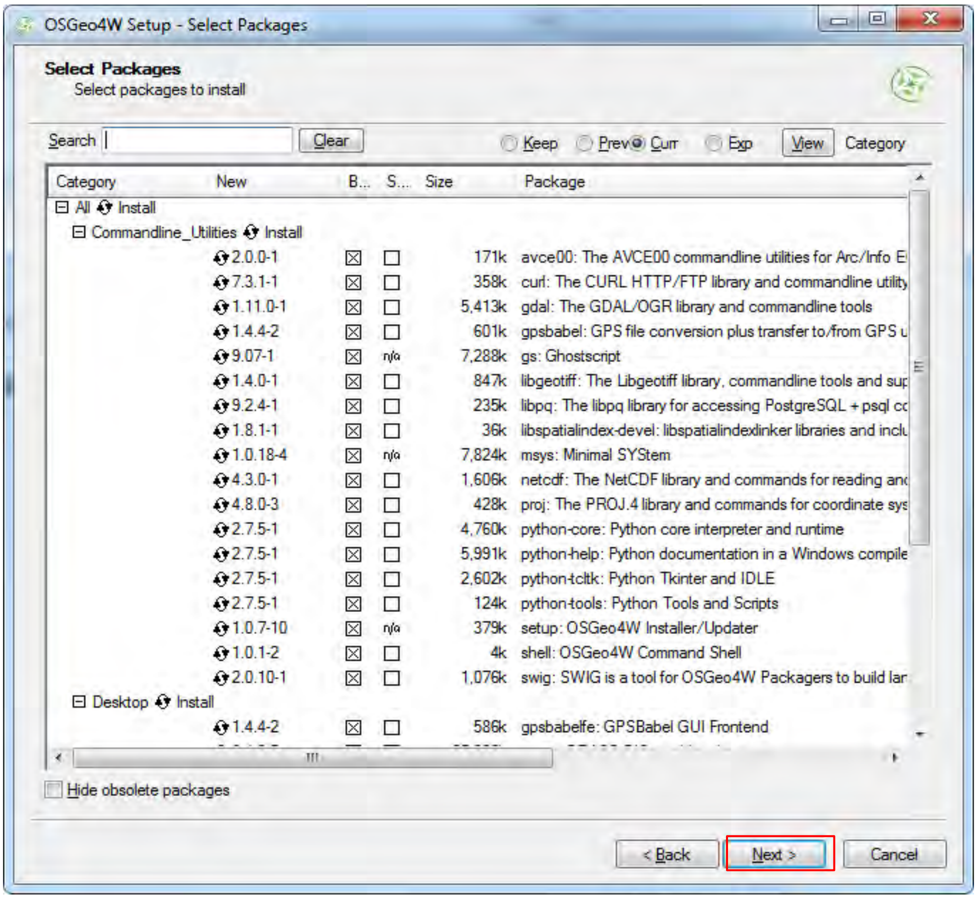
10. Select Packages: In the "Categories field" as shown below, click on the + symbol before "Desktop" to extend the folder tree.



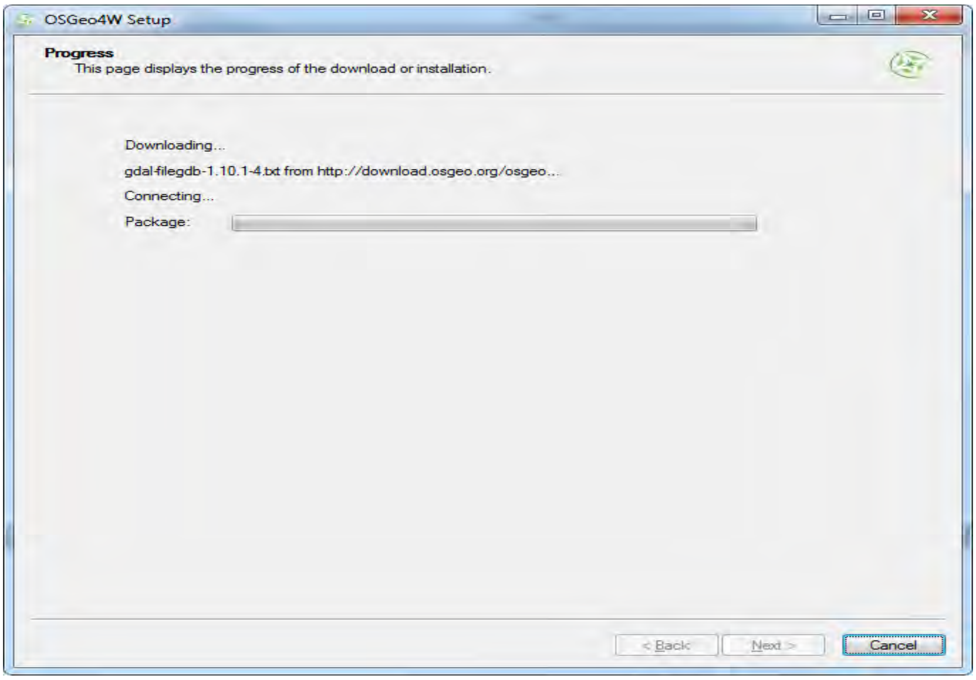
11. Click **+** (expand) and select packages to Install.

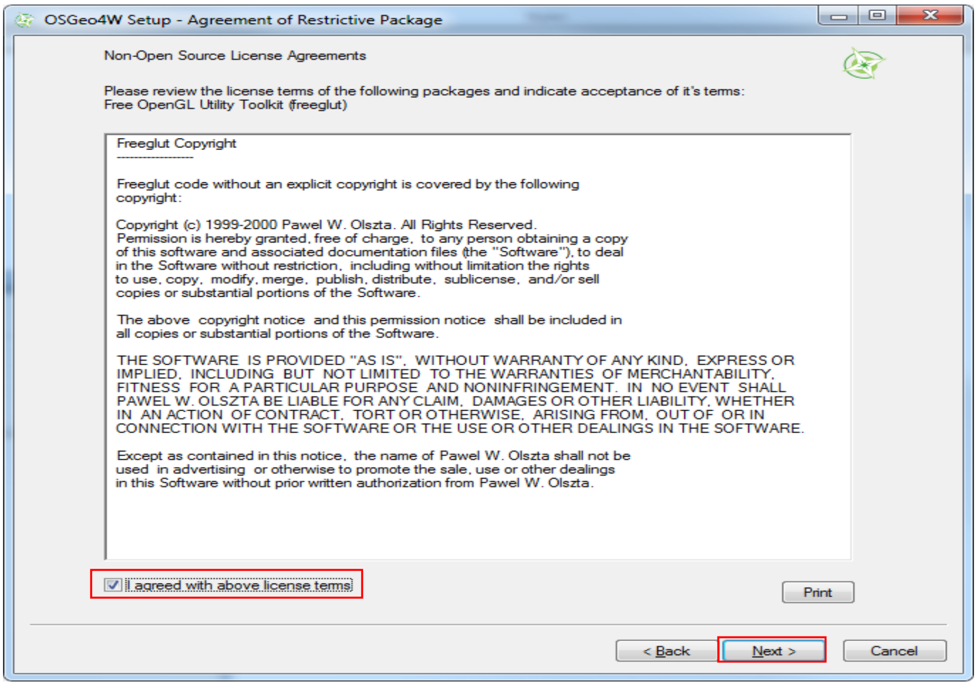


12. Click **Next**

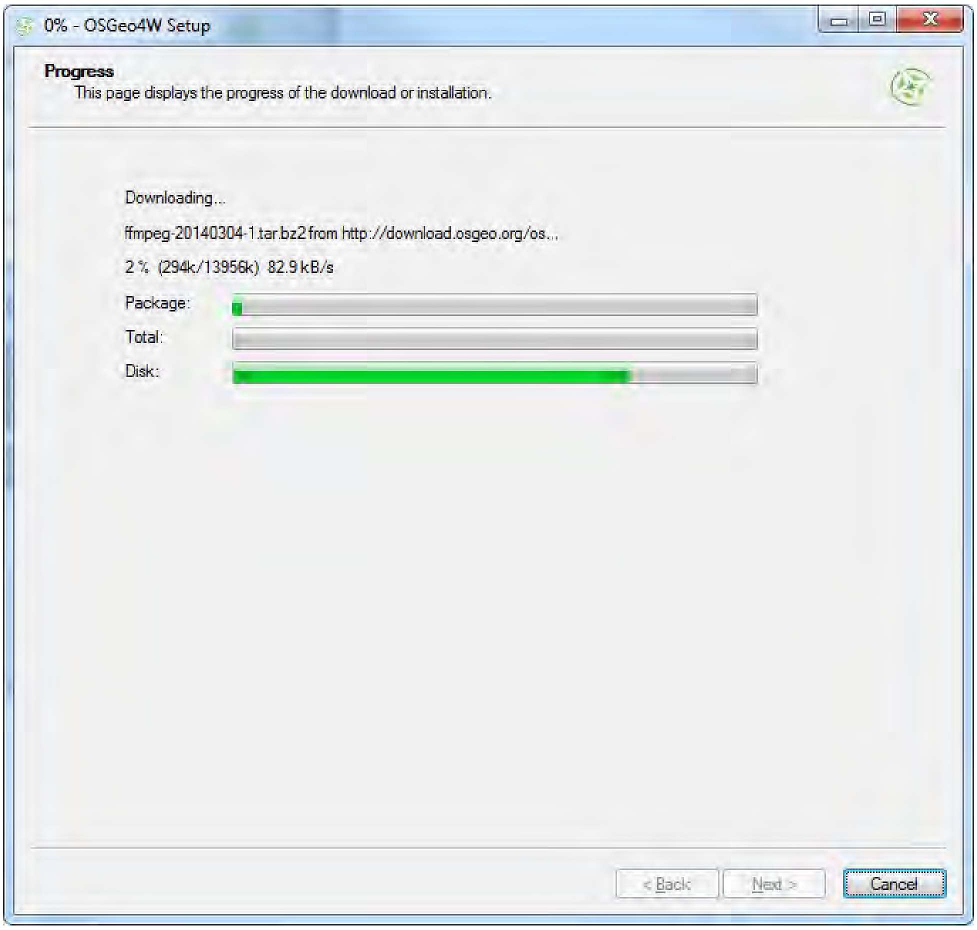


13. Agree License Agreements (this will need to be done 4 times), and Click **Next**





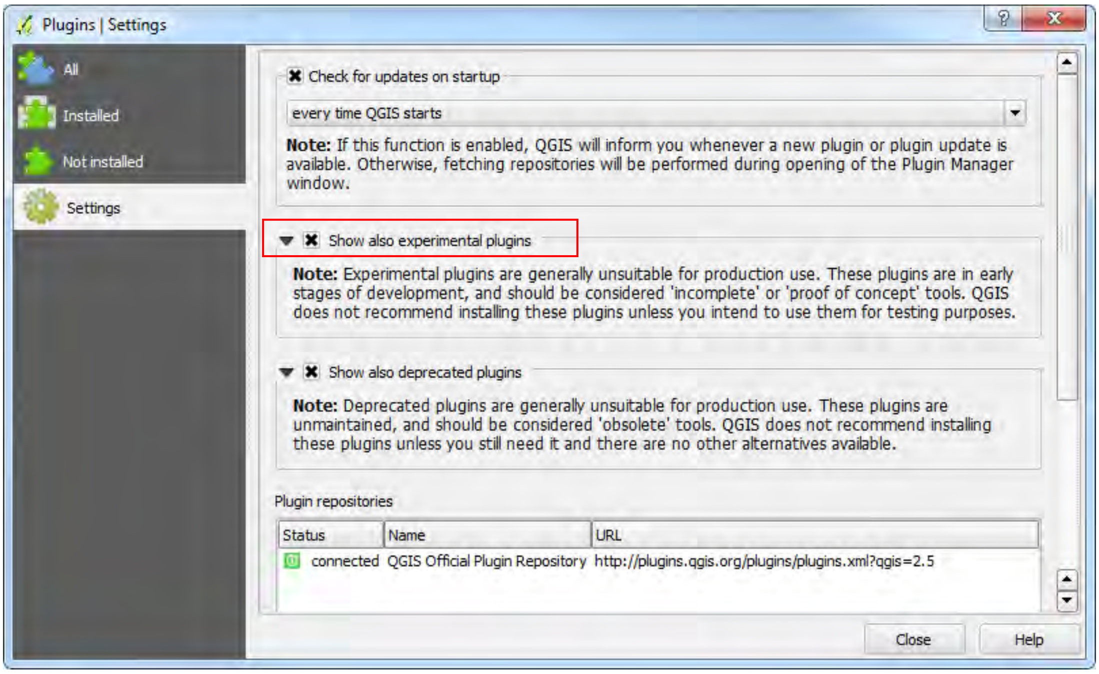
Please wait, download and Installation will take several minutes, especially if you have slow internet.



14. Click Finish

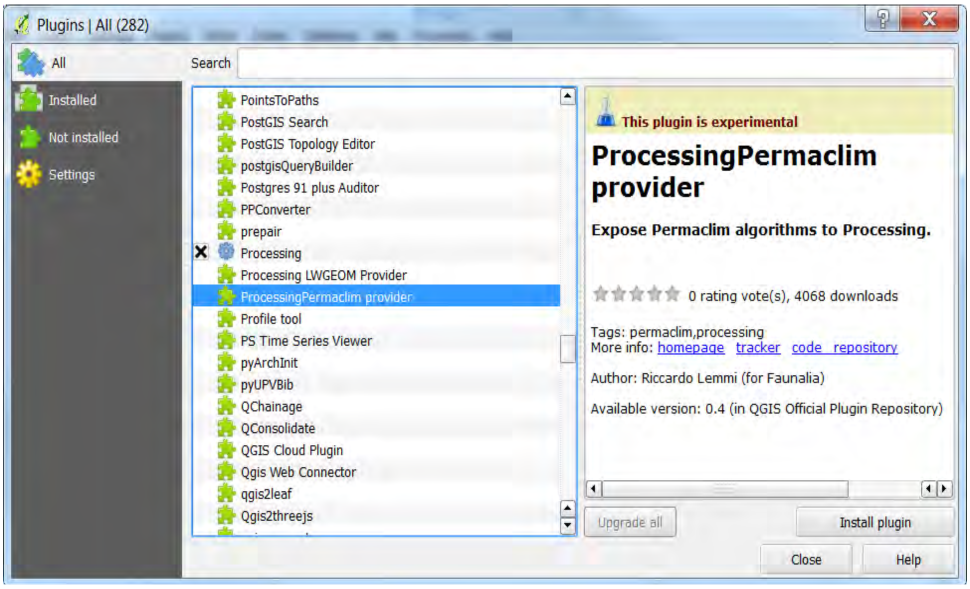
Installation of additional plugins in QGIS

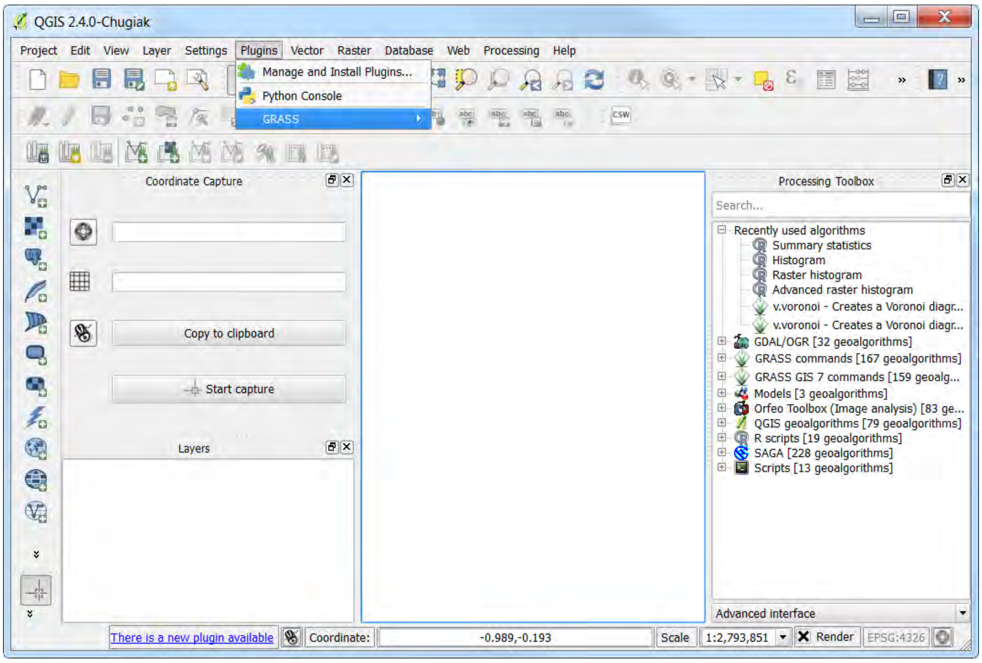
The core engine of QGIS is coded in C++, but additional QGIS plugins are written in the scripting language Python which is easy to learn. A growing community in the field of geo-informatics use Python to extend the functionality of QGIS. You may install additional plugins with your internet connection. **PLUGINS --> MANAGER AND INSTALL PLUGINS --> SETTINGS**. Make sure that'Show also experimental plugins'is turned on.



When the connection with python plugin repositories is established, it becomes possible to install necessary plugins from:

PLUGINS --> MANAGER AND INSTALL PLUGINS --> NOT INSTALLED MENU
You can also activate and deactivate the plugins in the *Installed* tab of the Plugin Manager.





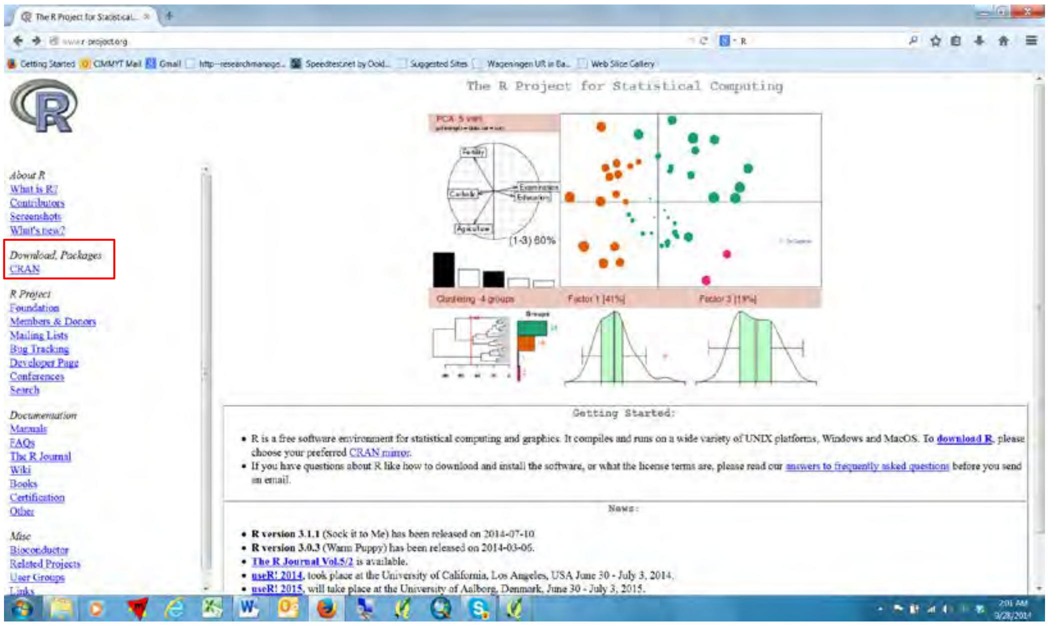
Download and Installation of R

Downloading

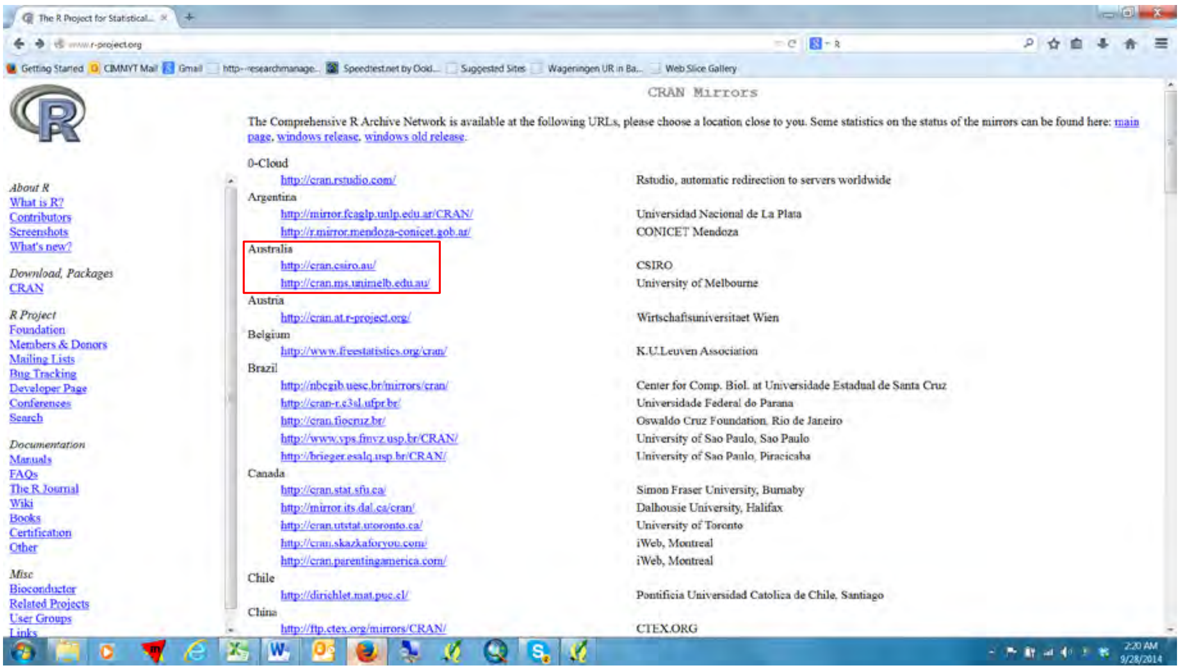
If you want to use R function in QGIS R will need to be installed in your computer. R is an open-source statistical software program that is increasingly popular among scientists. R can download from the R project website (www.r-project.org), a repository CRAN (R development Core Team, 2014). As R is a free program, no identification is required.

1. For R installers, please go to http://www.r-project.org/

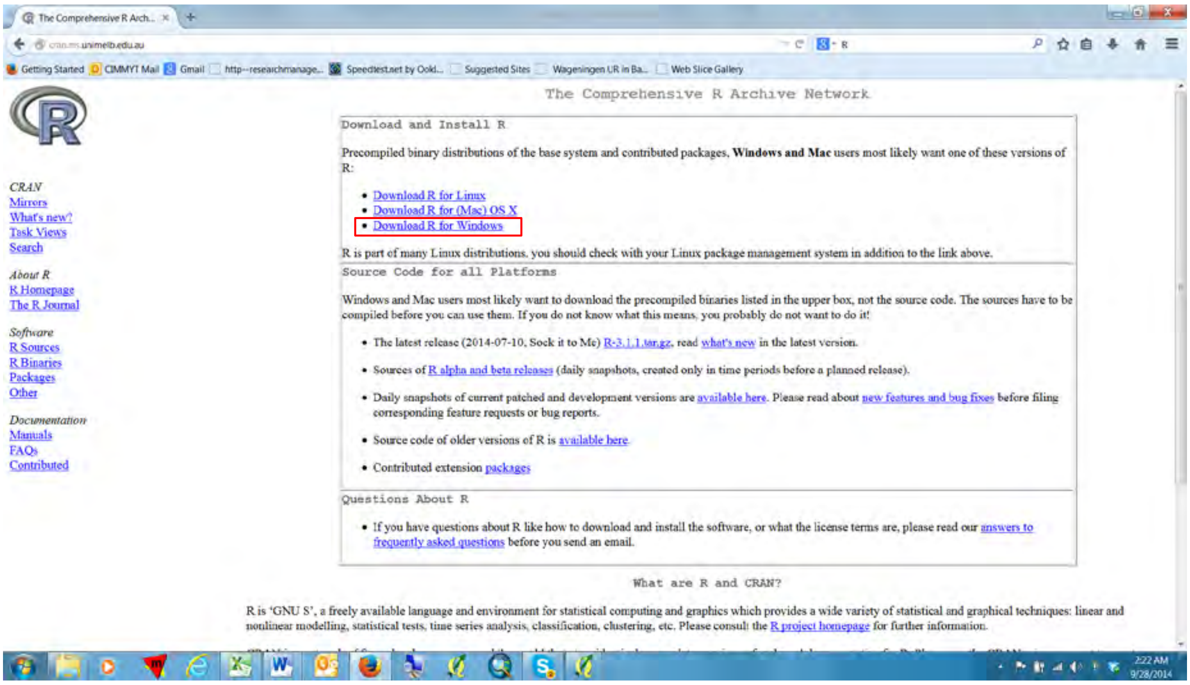
2. Click CRAN for download Packages



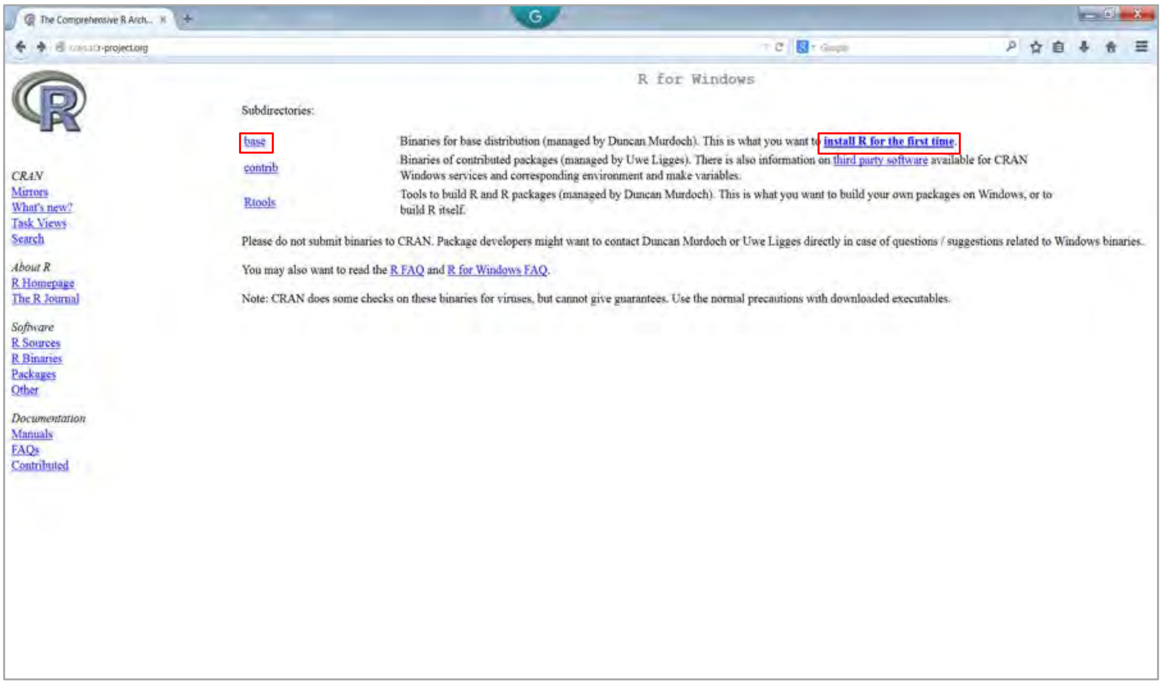
3. Select any CRAN Mirrors from the closest location on the globe proximal to your location



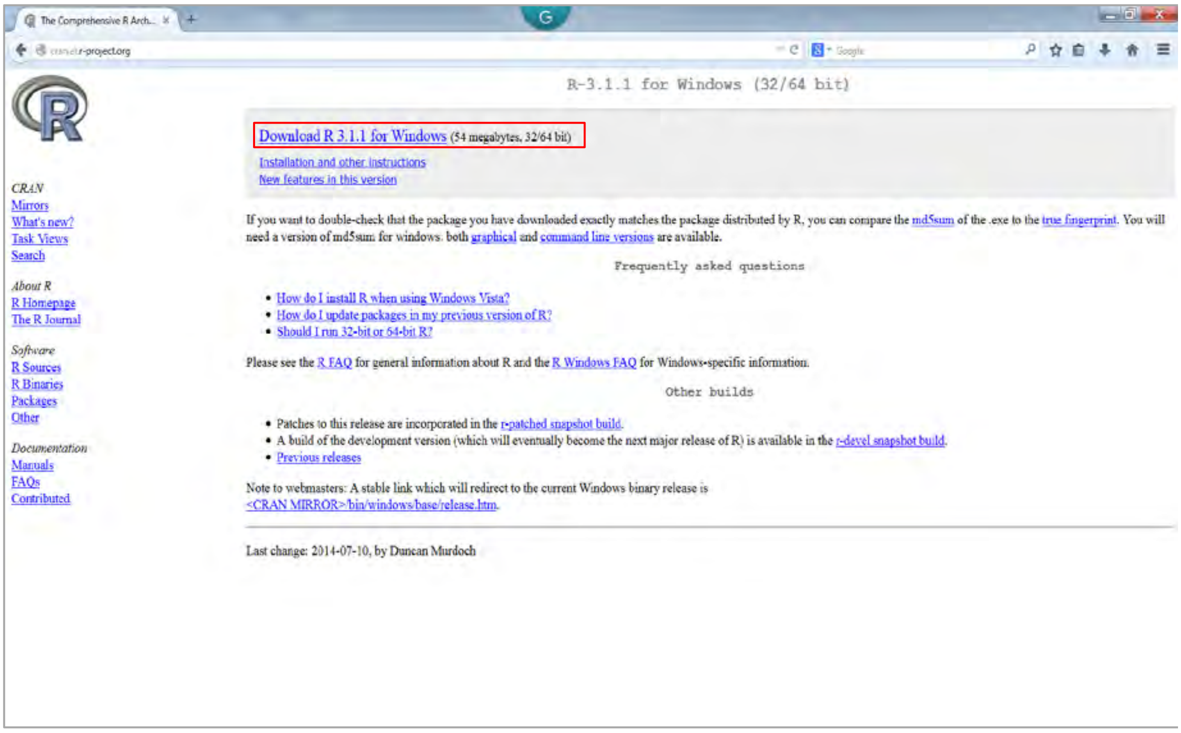
4. Select Download R for windows



5. Click base or install R for the first time



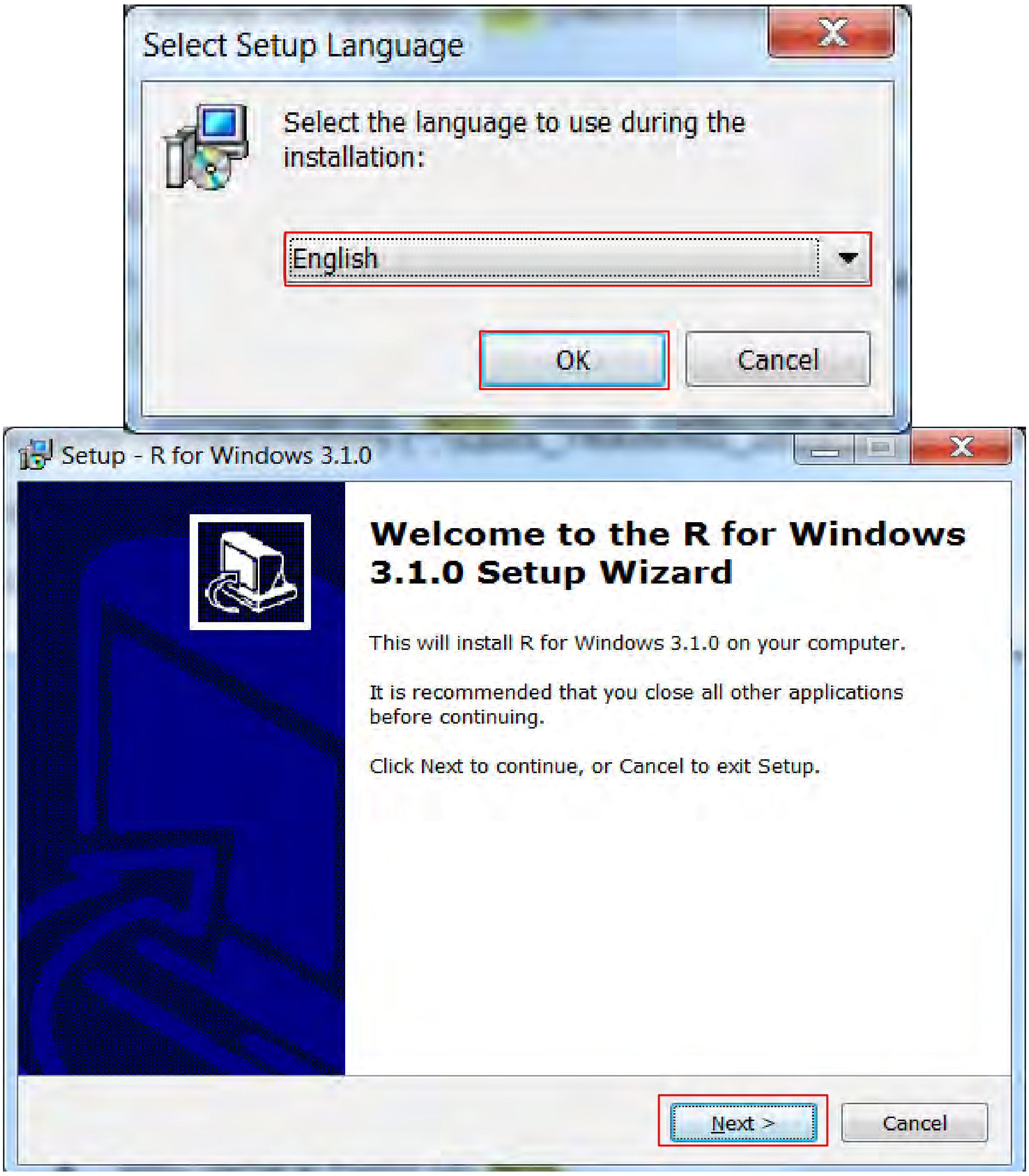
6. In this set of modules, we use R. 3.1.1. Note however that more advanced versions of R have since been released, and you can also use these in place of version 3.1.1. Click Download R. 3.1.1 for Windows



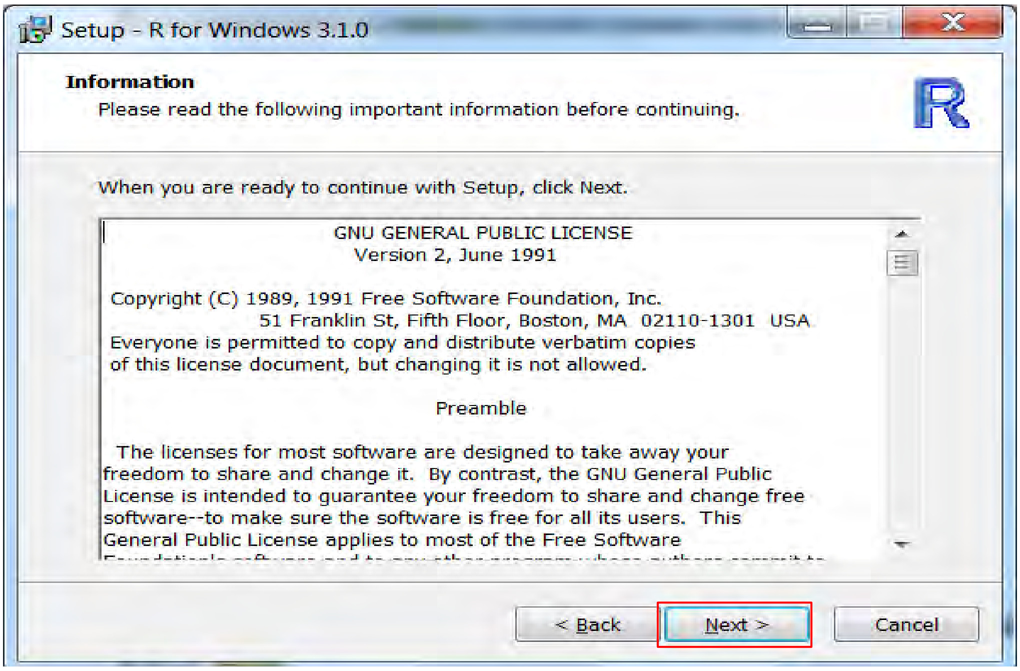
7. Click **Save File**. The installer will be saved in **C:\Users\[yourusername]\Downloads** directory

Installation

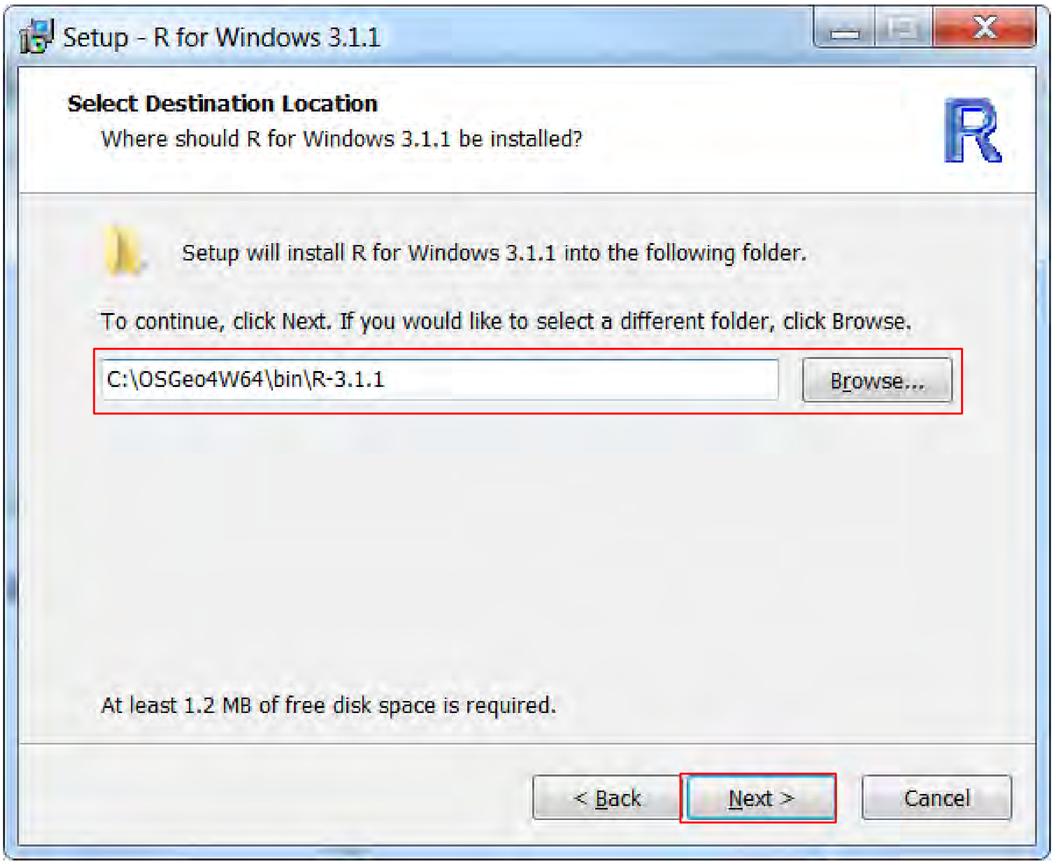
1. To download R-3.1.1 for Windows (32/64 bit)click here.
2. Navigate to the directory where the downloaded **R-3.1.1-win.exe** filejust downloaded.
3. Double-click on it and follow the instructions.
4. **Select Setup Language:** click **OK** (Note: Keep default language English)



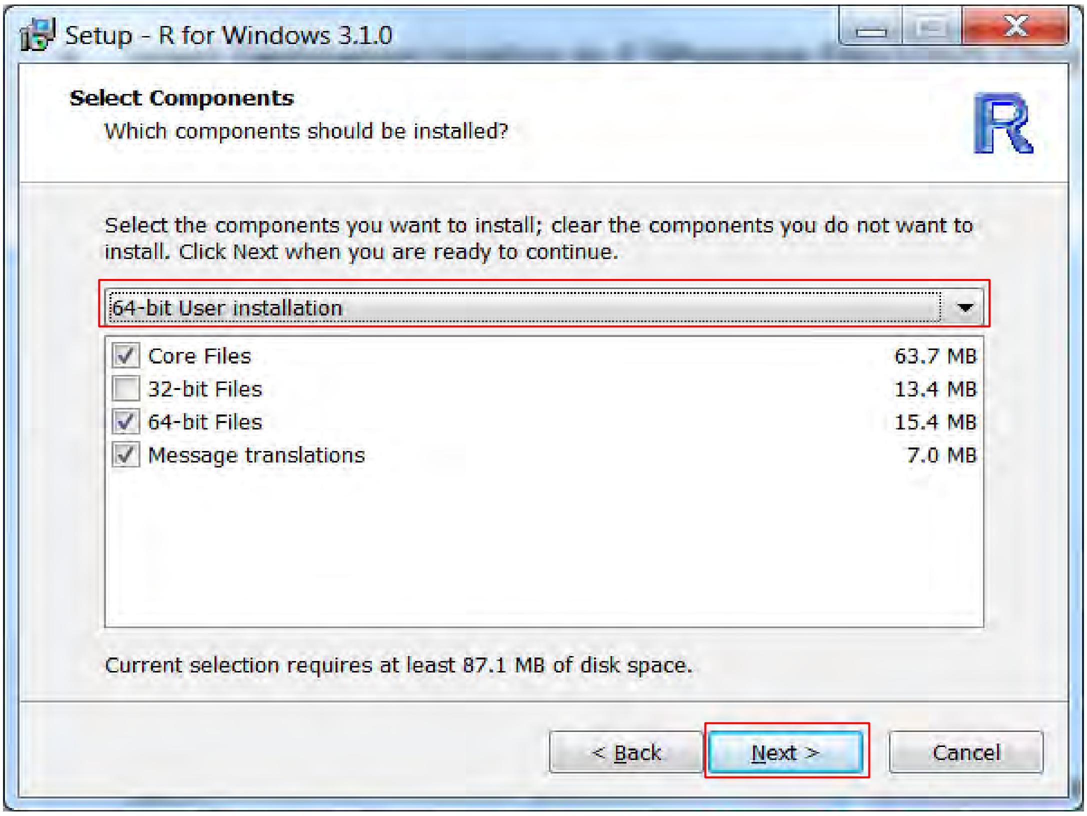
- GNU General Public License: click **Next**



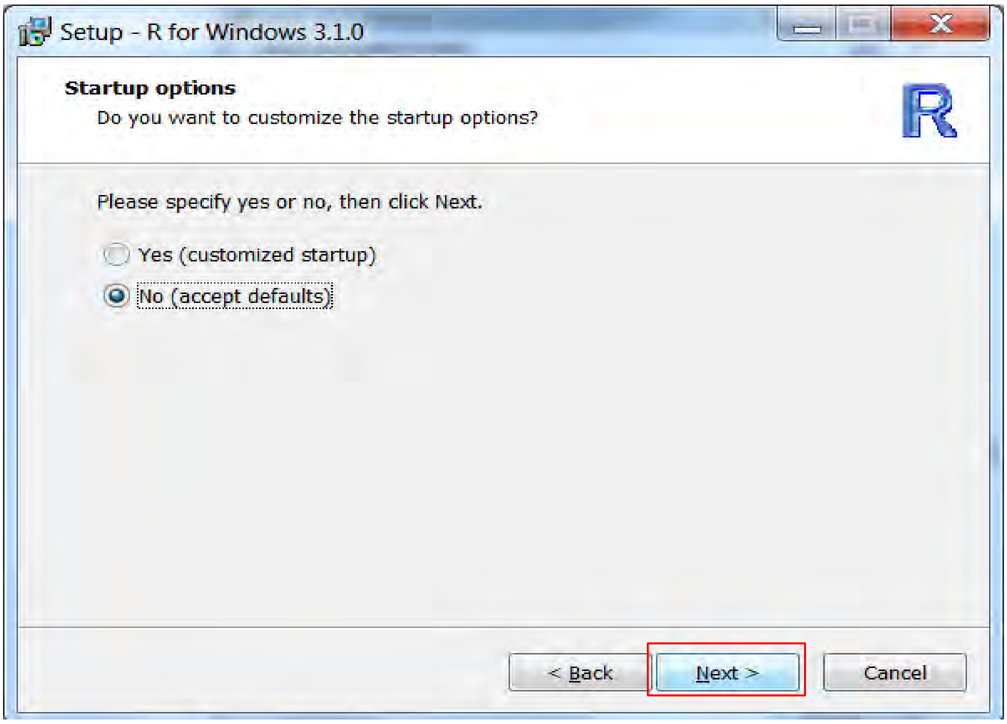
- Select Destination Location as ***C:\OSGeo4W64\bin\R-3.1.1***: click **Next**



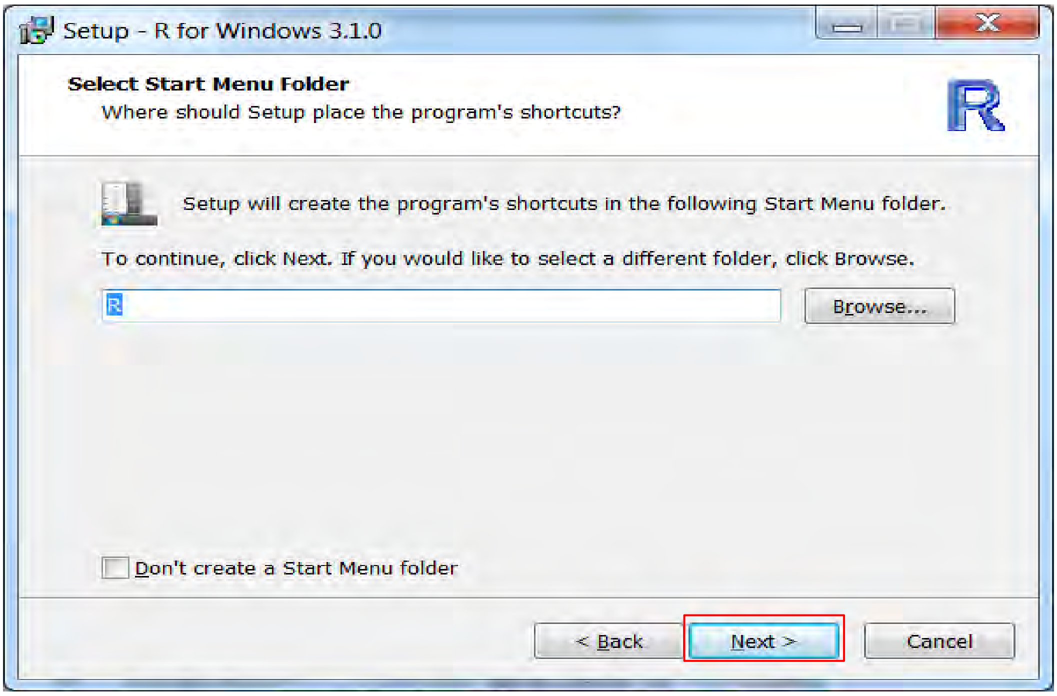
- Select Components: Select 64 or 32-bit according to your system, click **Next**



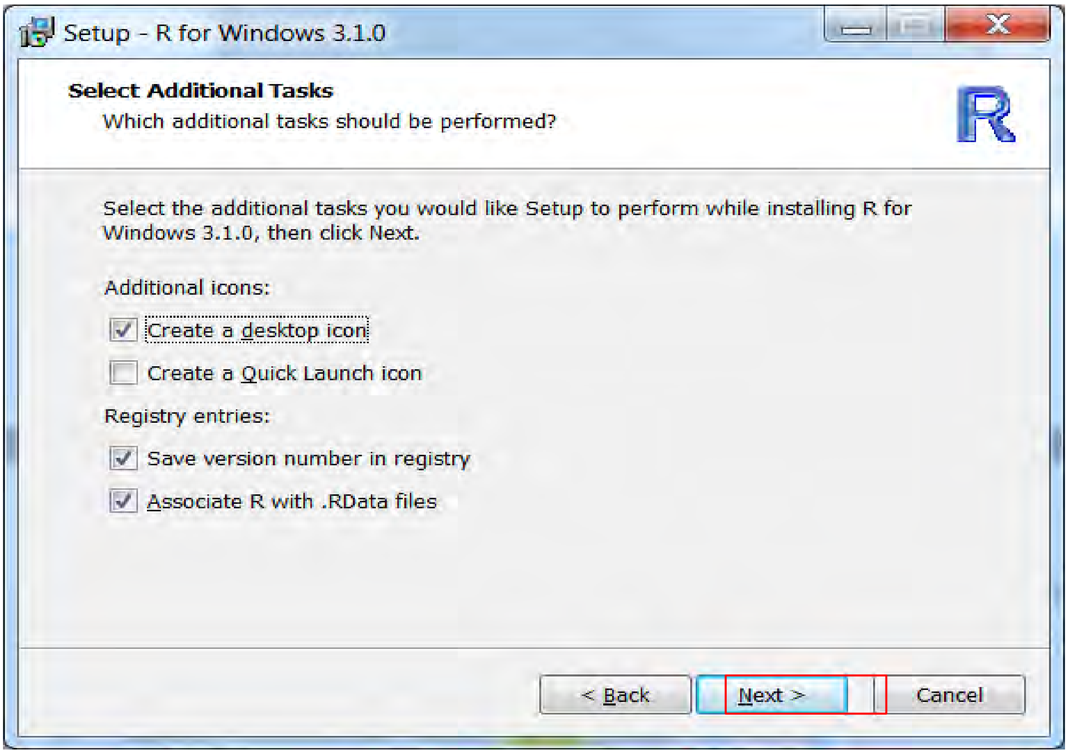
- Start Option: click **Next** (No accept defaults)



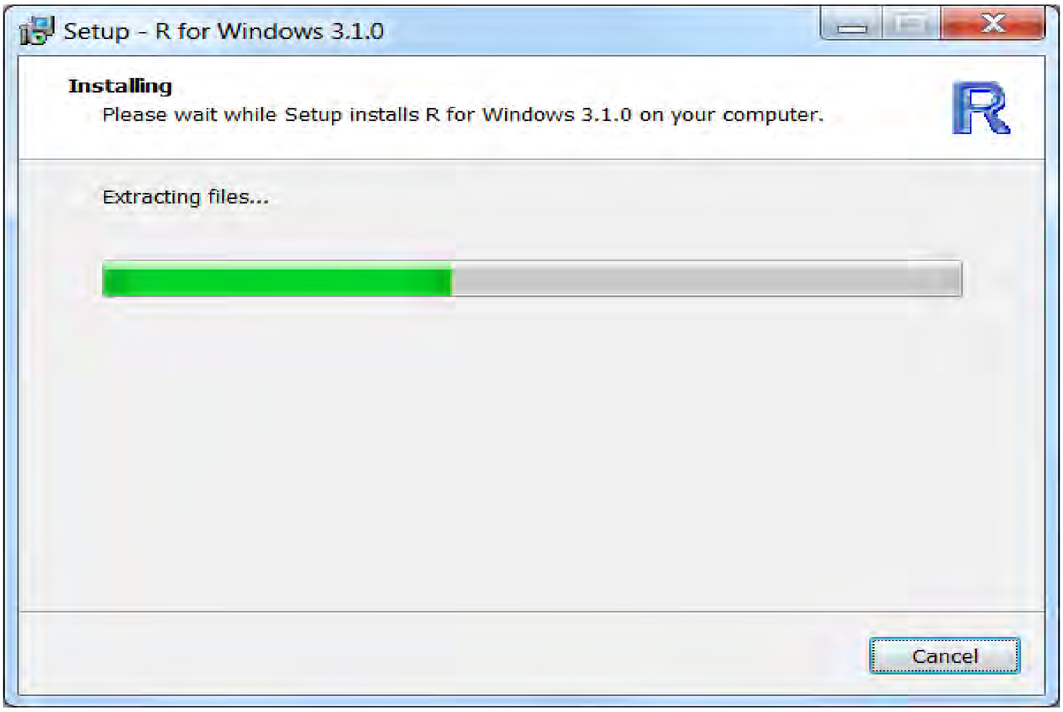
- Select Start Manu Folder: click **Next** (Keep default)



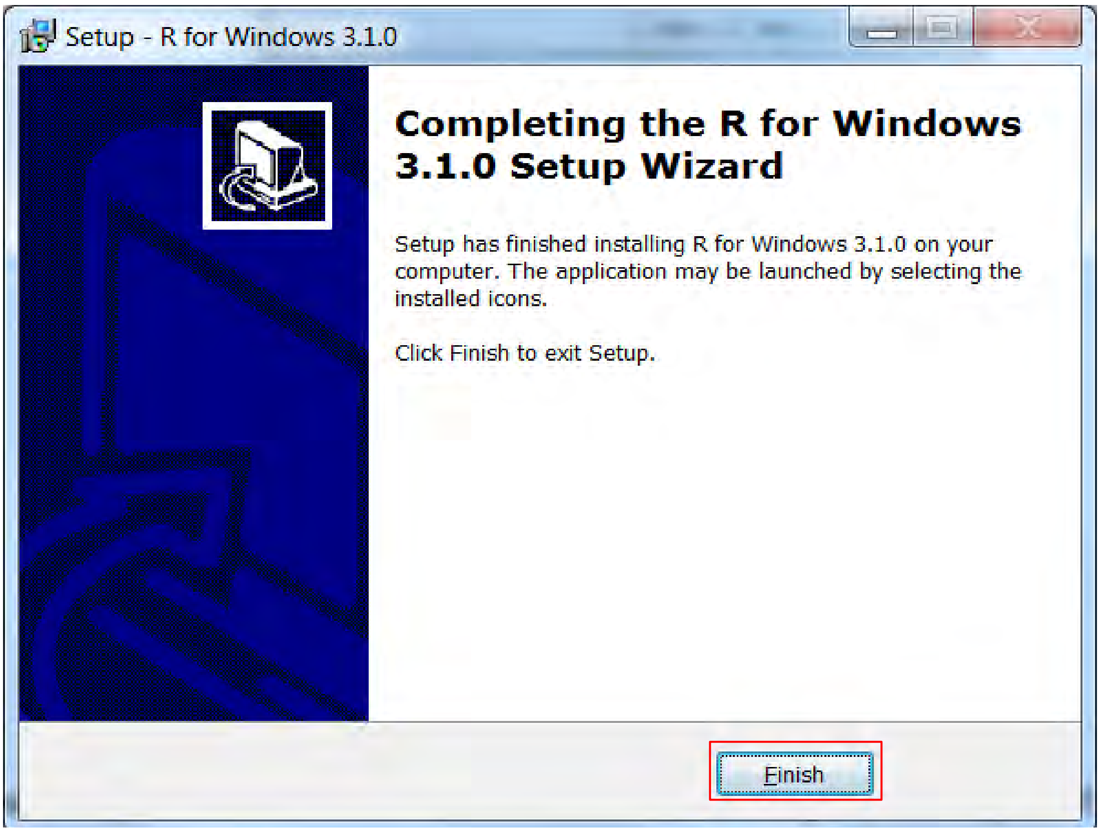
- Select Additional Tasks: click **Next** (Keep default)



- Installation… (this again can take several minutes so please be patient)



- Click Finish



R Packages and Libraries

Packages are collections of **R** functions, data, and compiled code in a well-defined format. The directory where **packages** are stored is called the **library.**

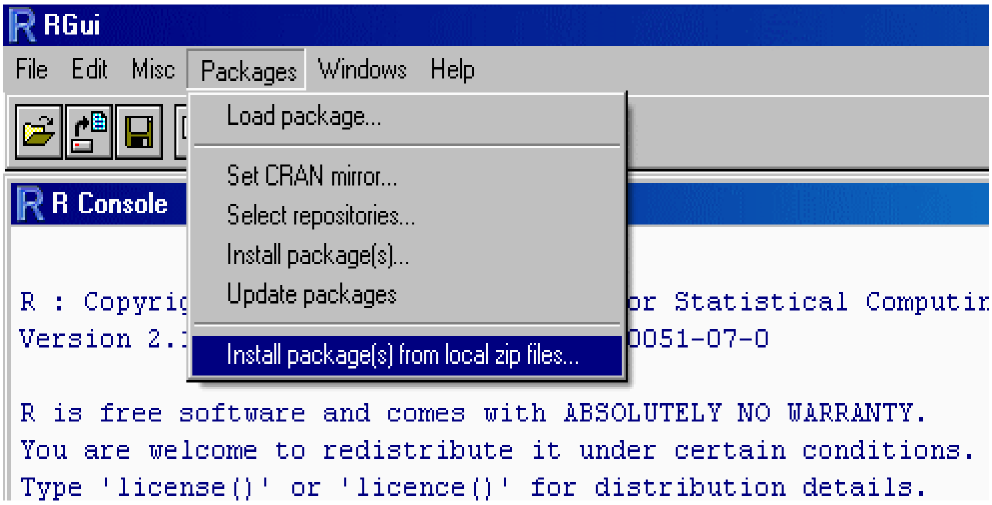
Installation of R-packages

If the R program has already been installed, the installation of any 'package' can be done directly from the console of R through the **Internet** or from the **local drive.**

Installation from a local drive:

1. Click here to download R package named 'agricolae'
2. Open R
3. Click **Packages** from menu bar
   Select **Install packages (s) from local zip files.** Navigate to the directory where **downloaded**packages exist.

Select any package or multi multiple packages with shift key and click "**Open**"



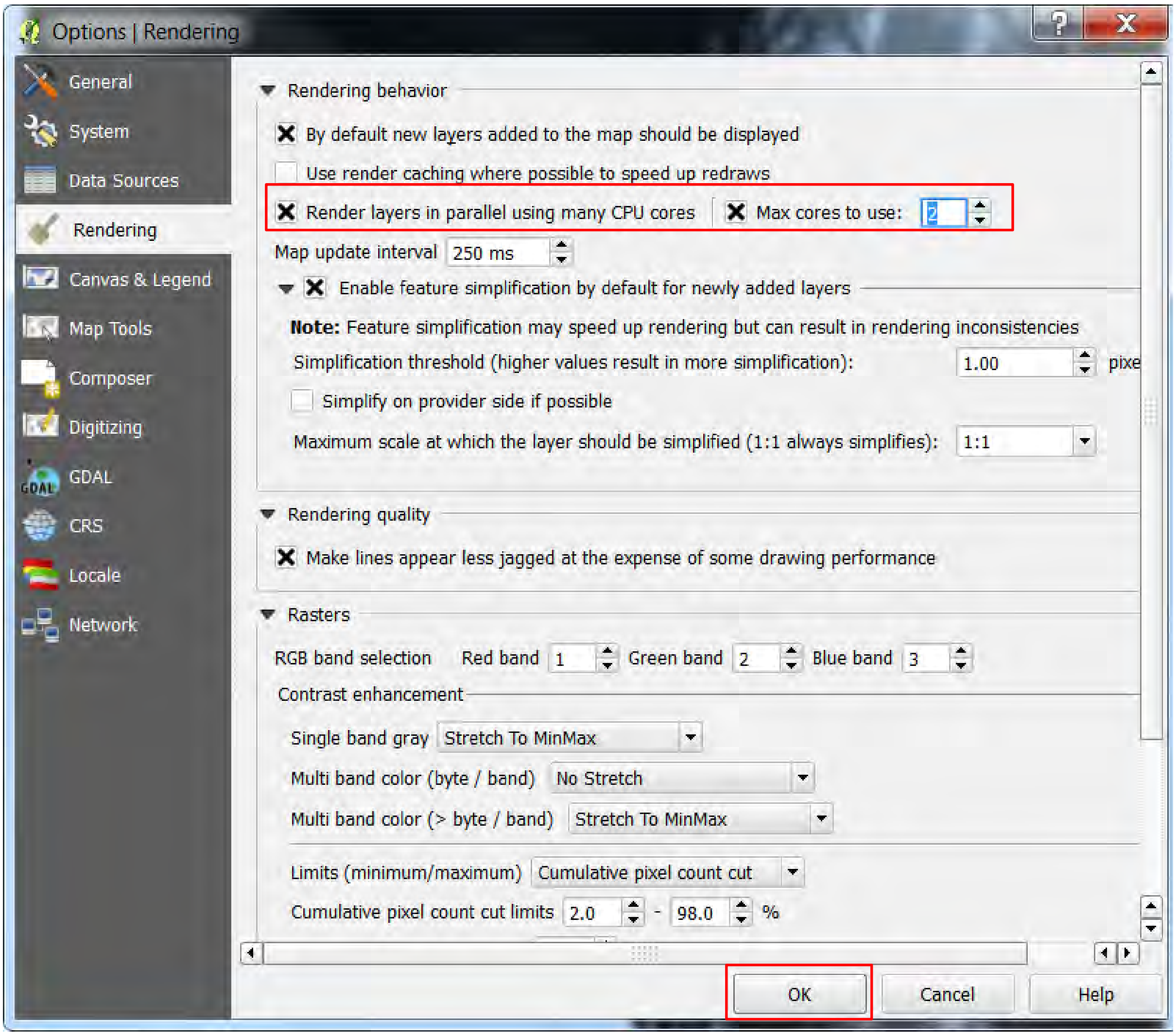
Installation from Internet:

1. Choose **Install Packages** from the **Packages** menu.
2. Select a **CRAN Mirror** (e.g. the location closest to where your computer is)
3. Select a package (e.g. agricolae)

QGIS configuration for R/SAGA/GRASS GIS

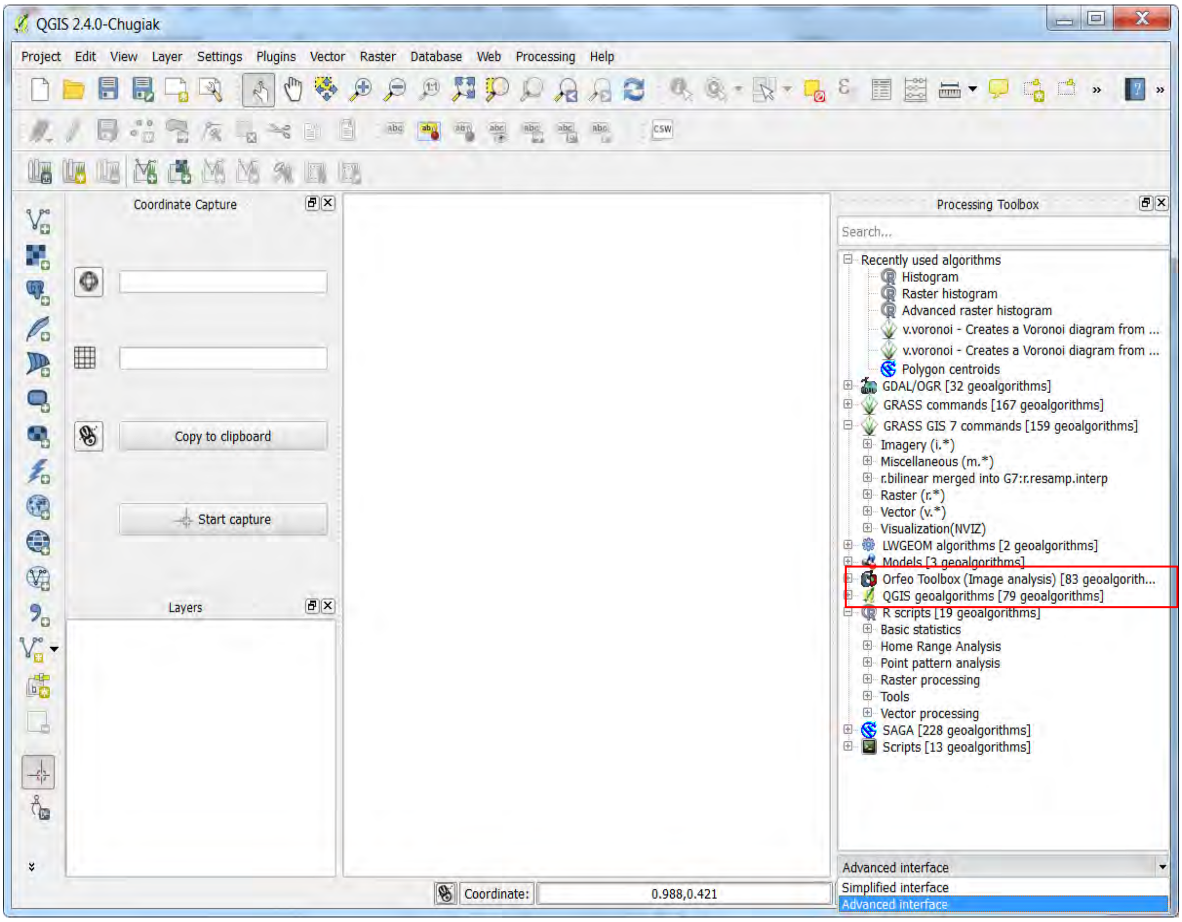
Display settings

In QGIS 2.4.0, the rendering speed of displaying large image data is much improved using multi-threading, which allows the computer to receive multiple commands from the user without significant delays in response. This option is not enabled by default, so it is a good idea for you to turn it on. Go to **SETTINGS --> OPTIONS --> RENDERING**and click the checkbox Render layers in parallel using many CPU cores on. Once this is done, you will find that zooming and moving layers is considerably faster, saving your valuable time.



Configuring the Processing Toolbox

The new spatial processing framework is a highlight of QGIS 2.4. It is based on the Python plugin SEXTANTE coded by Victor Olaya, which integrates a large number of analysis algorithms from different open source projects. The plugin functions are activated by default and can be found under the main menu PROCESSING --> TOOLBOX. A *Processing Toolbox* Window should open on the right side of the GUI after you click on PROCESSING --> TOOLBOX. On the bottom of this window,you will find the drop list button'Simplified interface'. Please switch this to'Advanced interface'.



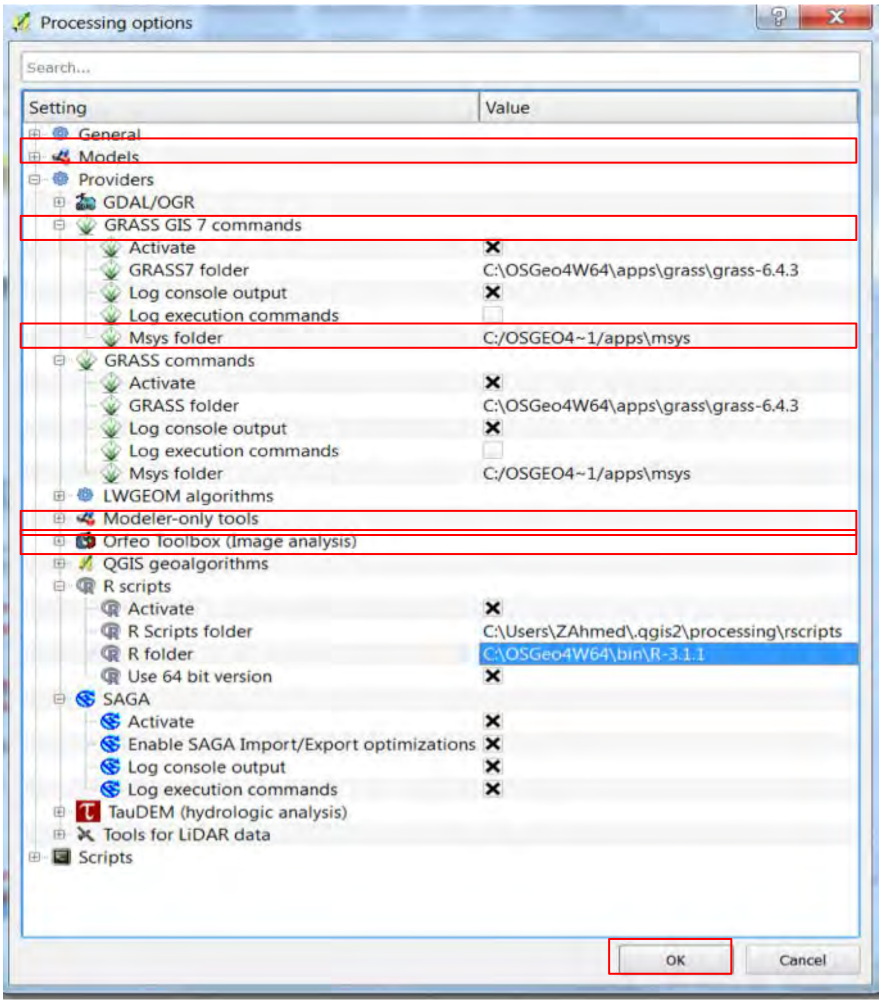
If you correctly followed the guides for QGIS and R installation on the Windows new software versions of GDAL, OTB, GRASS GIS and SAGA, you will find that they are already installed and correctly configured for the *Processing Toolbox*.

PROCESSING --> OPTIONS AND CONFIGURATION --> PROVIDERS. Expand**GRASS GIS 7 COMMANDS, GRASS COMMANDS, R-Scriptsand SAGA**Switch Activateon.

Change the R Folder: C:\OSGeo4W64\bin\R-3.1.1

R-scripts folder: C:\Users\ZAhmed\.qgis2\processing\rscripts

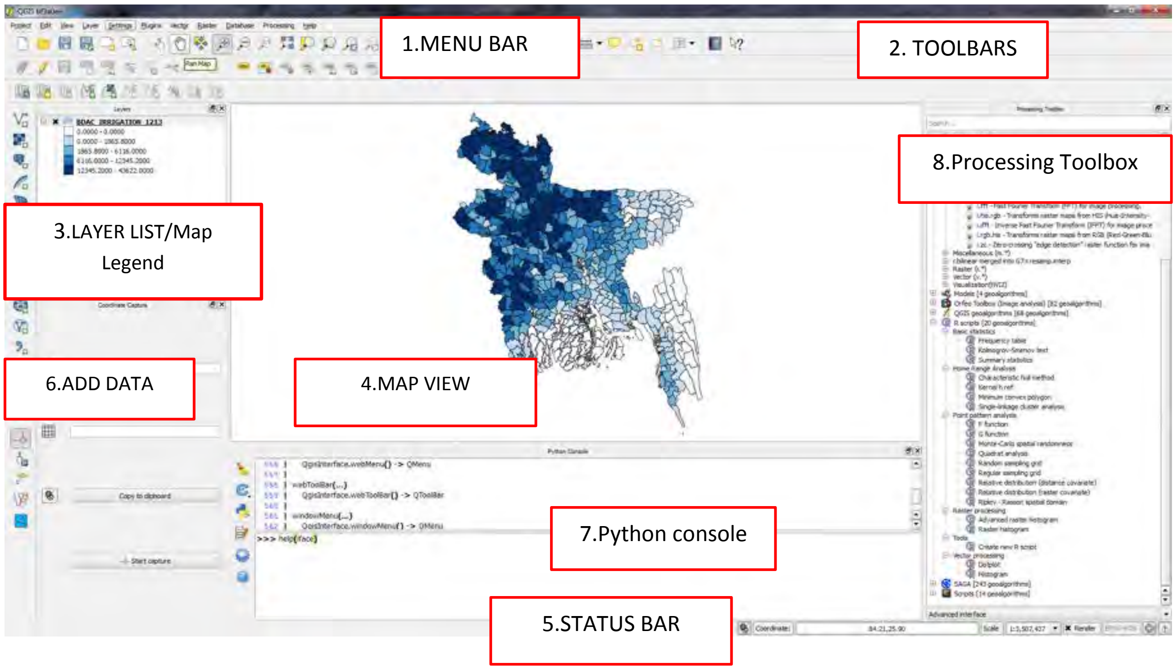
GRASS folder: C:\OSGeo4W64\apps\grass\grass-6.4.3


Processing options
Search...
Setting
Value
General
Models
Providers
GDAL/OGR
GRASS GIS 7 commands
Activate
GRASS7 folder
C:\OSGeo4W64\apps\grass\grass-6.4.3
Log console output
Log execution commands
Msys folder
C:/OSGEO4~1/apps\msys
GRASS commands
Activate
GRASS folder
C:\OSGeo4W64\apps\grass\grass-6.4.3
Log console output
Log execution commands
Msys folder
C:/OSGEO4~1/apps\msys
LWGEOM algorithms
Modeler-only tools
Orfeo Toolbox (Image analysis)
QGIS geoalgorithms
R scripts
Activate
R Scripts folder
C:\Users\ZAhmed\.qgis2\processing\rscripts
R folder
C:\OSGeo4W64\bin\R-3.1.1
Use 64 bit version
SAGA
Activate
Enable SAGA Import/Export optimizations
Log console output
Log execution commands
TauDEM (hydrologic analysis)
Tools for LiDAR data
Scripts
OK
Cancel

Module 2: An overview of the QGIS interface

Note: Much of this module builds upon the online version of the standard QGIS manual (see: http://docs.qgis.org/2.2/en/docs/user_manual/introduction/qgis_gui.html).Further modules begin to use material specific to Bangladesh and South Asia with custom exercises. When you launch QGIS, you will be presented with the GUI like the figure below (the numbers one to six in the boxes below stand for the six major areas of the interface).

QGIS GUI:



Menu BAR

The menu bar is the most important area for accessing most QGIS features. It uses a standard hierarchical menu format. Information on the menus and keyboard shortcuts to access them are listed out below. The good news is that you can also customize and configure the shortcuts as you wish (see using the **[Configure Shortcuts]** tool under '*Settings*'). Most of the menu options have a tool that you can click on, although you need to remember that the menus are not organized precisely like the toolbars. Instead, the toolbar with the tool can be found after each menu option. Note that some menu options will only be visible if you have loaded the plugin beforehand.

Project

Menu Option	Shortcut	Reference	Toolbar
New	Ctrl+N	see *Projects*	*Project*
Open	Ctrl+O	see *Projects*	*Project*

Menu Option	Shortcut	Reference	Toolbar
New from template ‣		see *Projects*	*Project*
Open Recent ‣		see *Projects*	
Save	Ctrl+S	see *Projects*	*Project*
Save As	Ctrl+Shift+S	see *Projects*	*Project*
Save as Image		see *Output*	
New Print Composer	Ctrl+P	see *Print Composer*	*Project*
Composer manager …		see *Print Composer*	*Project*
Print Composers ‣		see *Print Composer*	
Exit |qg|	Ctrl+		

Edit

Menu Option	Shortcut	Reference	Toolbar
Undo	Ctrl+Z	see *Advanced digitizing*	*Advanced Digitizing*
Redo	Ctrl+Shift+Z	see *Advanced digitizing*	*Advanced Digitizing*
Cut Features	Ctrl+X	see *Digitizing an existing layer*	*Digitizing*
Copy Features	Ctrl+C	see *Digitizing an existing layer*	*Digitizing*
Paste Features	Ctrl+V	see *Digitizing an existing layer*	*Digitizing*
Add Feature	Ctrl+.	see *Digitizing an existing layer*	*Digitizing*
Move Feature(s)		see *Digitizing an existing layer*	*Digitizing*
Delete Selected		see *Digitizing an existing layer*	*Digitizing*
Rotate Feature(s)		see *Advanced digitizing*	*Advanced Digitizing*
Simplify Feature		see *Advanced digitizing*	*Advanced Digitizing*
Add Ring		see *Advanced digitizing*	*Advanced Digitizing*
Add Part		see *Advanced digitizing*	*Advanced Digitizing*
Delete Ring		see *Advanced digitizing*	*Advanced Digitizing*
Delete Part		see *Advanced digitizing*	*Advanced Digitizing*
Reshape Features		see *Advanced digitizing*	*Advanced Digitizing*

Menu Option	Shortcut	Reference	Toolbar
Offset Curves		see *Advanced digitizing*	*Advanced Digitizing*
Split Features		see *Advanced digitizing*	*Advanced Digitizing*
Merge Selected Features		see *Advanced digitizing*	*Advanced Digitizing*
Merge Attr. of Selected Features		see *Advanced digitizing*	*Advanced Digitizing*
Node Tool		see *Digitizing an existing layer*	*Digitizing*
Rotate Point Symbols		see *Advanced digitizing*	*Advanced Digitizing*

View

Menu Option	Shortcut	Reference	Toolbar
Pan Map			*Map Navigation*
Pan Map to Selection			*Map Navigation*
Zoom In	Ctrl++		*Map Navigation*
Zoom Out	Ctrl+-		*Map Navigation*
Select ‣		see *Select and deselect features*	*Attributes*
Identify Features	Ctrl+Shift+I		*Attributes*
Measure ‣		see *Measuring*	*Attributes*
Zoom Full	Ctrl+Shift+F		*Map Navigation*
Zoom To Layer			*Map Navigation*
Zoom To Selection	Ctrl+J		*Map Navigation*
Zoom Last			*Map Navigation*
Zoom Next			*Map Navigation*
Zoom Actual Size			*Map Navigation*
Decorations ‣		see *Decorations*	
Map Tips			*Attributes*

Menu Option	Shortcut	Reference	Toolbar
New Bookmark	Ctrl+B	see *Spatial Bookmarks*	*Attributes*
Show Bookmarks	Ctrl+Shift+B	see *Spatial Bookmarks*	*Attributes*
Refresh	Ctrl+R		*Map Navigation*

Layer

Menu Option	Shortcut	Reference	Toolbar
New ‣		see *Creating new Vector layers*	*Manage Layers*
Embed Layers and Groups ...		see *Nesting Projects*	
Add Vector Layer	Ctrl+Shift+V	see *Working with Vector Data*	*Manage Layers*
Add Raster Layer	Ctrl+Shift+R	see *Loading raster data in QGIS*	*Manage Layers*
Add PostGIS Layer	Ctrl+Shift+D	see *PostGIS Layers*	*Manage Layers*
Add SpatiaLite Layer	Ctrl+Shift+L	see *SpatiaLite Layers*	*Manage Layers*
Add MSSQL Spatial Layer	Ctrl+Shift+M	see *label_mssql*	*Manage Layers*
Add Oracle GeoRaster Layer		see *Oracle GeoRaster Plugin*	*Manage Layers*
Add SQL Anywhere Layer		see *SQL Anywhere Plugin*	*Manage Layers*
Add WMS/WMTS Layer	Ctrl+Shift+W	see *WMS/WMTS Client*	*Manage Layers*
Add WCS Layer		see *WCS Client*	*Manage Layers*
Add WFS Layer		see *WFS and WFS-T Client*	*Manage Layers*
Add Delimited Text Layer		see *Add Delimited Text Layer*	*Manage Layers*
Copy style		see *Style Menu*	
Paste style		see *Style Menu*	
Open Attribute Table		see *Working with the Attribute Table*	*Attributes*
Toggle Editing		see *Digitizing an existing layer*	*Digitizing*
Save Layer Edits		see *Digitizing an existing layer*	*Digitizing*
Current Edits ‣		see *Digitizing an existing layer*	*Digitizing*

Menu Option	Shortcut	Reference	Toolbar
Save as...			
Save selection as vector file...		See *Working with the Attribute Table*	
Remove Layer(s)	Ctrl+D		
Set CRS of Layer(s)	Ctrl+Shift+C		
Set project CRS from Layer			
Properties			
Query...			
Labeling			
Add to Overview	Ctrl+Shift+O		*Manage Layers*
Add All To Overview			
Remove All From Overview			
Show All Layers	Ctrl+Shift+U		*Manage Layers*
Hide All Layers	Ctrl+Shift+H		*Manage Layers*

Plugins

Menu Option	Shortcut	Reference	Toolbar
Manage and Install Plugins		see *Managing Plugins*	
Python Console			
Geocode ‣			
GRASS ‣		see *GRASS GIS Integration*	*GRASS*
Openlayers Plugin ‣			

Vector

Menu Option	Shortcut	Reference	Toolbar
Coordinate Capture ‣		see *Coordinate Capture Plugin*	*Vector*
Dxf2Shp ‣		see *Dxf2Shp Converter Plugin*	*Vector*
GPS ‣		see *GPS Plugin*	*Vector*

Menu Option	Shortcut	Reference	Toolbar
Open Street Map ‣		see *Loading OpenStreetMap Vectors*	
Road Graph ‣		see *Road Graph Plugin*	
Spatial Query ‣		see *Spatial Query Plugin*	*Vector*
Topography Checker ‣			*Vector*
Analysis Tools ‣			
Research Tools ‣			
Reprocessing Tools ‣			
Geometry Tools ‣			
Data management Tools ‣			

Raster

Menu Option	Shortcut	Reference	Toolbar
Raster calculator		see *Raster Calculator*	
Georeferencer ‣		see *Georeferencer Plugin*	*Raster*
Heatmap ‣		see *Heatmap Plugin*	*Raster*
Interpolation ‣		see *Interpolation Plugin*	*Raster*
Terrain Analysis			
Zonal Statistics ‣		see *Zonal Statistics Plugin*	*Raste*
Projection ‣			
Conversion ‣			
Extraction ‣			
Analysis ‣			

Database

Menu Option	Shortcut	Reference	Toolbar
DB Manager ‣			*Database*
eVis ‣		see *eVis Plugin*	*Database*
Offline editing ‣			
Spit ‣		see *SPIT Plugin*	*Database*

Processing

Menu Option	Shortcut	Reference	Toolbar
Toolbox		see *The toolbox*	*Toolbox*
Graphical Modeler		see *The graphical modeler*	
History and Logs		see *The history manager*	
Options and configuration		see *Configuring the processing framework*	
Results viewer		see *Configuring external applications*	
Commander	Ctrl+Alt+M	see *The SEXTANTE Commander*	

Toolbar

The toolbar provides access to most of the same functions as the menus, plus additional tools used when you are interacting with the map. Each toolbar item has "pop-up" help menus available. Hold your mouse selection tool over the item and a short description of the tool's purpose will be displayed to guide you.

Every menu bar can be moved around according to your needs. Additionally, every menu bar can be switched off using your right mouse button, obtained by holding the mouse over the toolbars and right clicking (read also *Panels and Toolbars*).

Tip: **Restoring toolbars**

If you have accidentally hidden all your toolbars, you can retrieve them by choosing menu option Settings ‣ Toolbars ‣. *If a toolbar disappears under Windows, which seems to be a problem in QGIS from time to time, you have to remove \HKEY_CURRENT_USER\Software\QGIS\qgis\UI\state in the registry. When you restart QGIS, the key is written again with the default state, and all toolbars are visible again.*

Map Legend/Layer List

All the layers in your project will be listed in the map legend. If you check the box in each legend entry, you can hide or reveal the layer of interest. You can drag around the layer once you select it to change the Z-ordering. Z-ordering means that layers listed nearer the top of the legend are shown on top of those below them in the legend. You can stop Z-ordering by clicking 'Layer order' on the panel.

Your layers are organized into groups on the panel. This can be achieved in two ways:

1. Right click in the legend window and choose *Add Group*. Next type the group name as you choose it, then hit enter. Next, click on an existing layer and drag it onto the group – this will add it to the group you have named.
2. With the other method, you can choose some layers, right click in the legend window, and select the option *Group Selected*. This will move the chosen layers into the new group automatically.

To move a layer out of a group, you can either drag it out or right click and select '*Make to top-level' item*. Groups can be nested inside other groups to create hierarchies.
Remember: The checkbox for a group will show or hide all the layers in the group – this is done with just one click. The content of the right mouse button context menu also depends on whether the selected legend item *is a raster or a vector layer. For GRASS vector layers,* Toggle editing *is not available. See section*Digitizing and editing a GRASS vector layer*for information on editing GRASS vector layers.*

The right mouse button menu for raster layers reveals the following information:

- *Zoom to layer extent*
- *Zoom to Best Scale (100%)*
- *Stretch Using Current Extent*
- *Show in overview*
- *Remove*
- *Duplicate*
- *Set Layer CRS*
- *Set Project CRS from Layer*
- *Save as ...*
- *Properties*
- *Rename*
- *Copy Style*
- *Add New Group*
- *Expand all*
- *Collapse all*
- *Update Drawing Order*

Additionally, according to layer position and selection

- *Make to top level item*
- *Group Selected*

Right mouse button menu for vector layers

- *Zoom to Layer Extent*
- *Show in Overview*
- *Remove*
- *Duplicate*
- *Set Layer CRS*
- *Set Project CRS from Layer*
- *Open Attribute Table*
- *Toggle Editing* (not available for GRASS layers)
- *Save As ...*
- *Save Selection As*
- *Filter*
- *Show Feature Count*
- *Properties*
- *Rename*

- *Copy Style*
- *Add New Group*
- *Expand all*
- *Collapse all*
- *Update Drawing Order*

Additionally, according to layer position and selection

- *Make to top-level item*
- *Group Selected*

Right mouse button menu for layer groups

- *Zoom to Group*
- *Remove*
- *Set Group CRS*
- *Rename*
- *Add New Group*
- *Expand all*
- *Collapse all*
- *Update Drawing Order*

It is possible to select more than one layer or group at the same time by holding down the Control (Ctrl) key while selecting the layers with the left mouse button. You can then move all selected layers to a new group at the same time.You are also able to delete more than one Layer or Group at once by selecting several Layers with the Ctrl key and pressing Ctrl+D afterwards. This way all selected Layers or groups will be removed from the layer's list.

Map View

This is the "core business" of QGIS - maps are displayed in this area. This is where you will do most of your work. The types of maps you see here will depend on the vector and raster layers you have chosen to load. The map view can be panned (moved so your view changes) left and right (this shifts the focus so you can see different regions of the map) and zoomed in and out. A number of other operations can be done to your map, as described in the toolbar section above.. The map view and the legend are important to each other operationally - the maps in view reflect changes you make in the legend area.

Tip: **Zooming the Map with the Mouse Wheel**

You can use the mouse wheel to zoom in and out on the map. Place the mouse cursor inside the map area and roll the wheel forward to zoom in or backwards to zoom out. You can customize the behavior of the mouse wheel zoom using the *Map tools* menu under the *Settings* ‣ *Options* menu.

Tip: **Panning the Map with the Arrow Keys and Space Bar**

The arrow keys can be used to pan the map to the left or right, or up and down. Place the mouse cursor inside the map area. Next click on the right arrow on the keyboard to pan East, or the left arrow key to pan West, or the up arrow key to pan North, and the down arrow key to pan South. You can also pan the map using the space bar or the click on mouse wheel by moving the mouse while holding down space bar (or clicking on the mouse wheel).

Status Bar

The status bar shows you your current position on the map (indicated by where the mouse cursor is) in map coordinates (e.g. meters or decimal degrees). As you move the mouse, the coordinates change. On the left of the coordinate display in the status bar you will find a button toggles between showing your coordinate position, or the view extent resulting when you pan in or out of the map.

Just adjacent to the coordinate display is the scale display. This shows the scale of the map at the view setting you have chosen (it will change as you zoom in or out). Take note of the scale selector that allows you to choose between predefined scales that range from 1:500 to 1:1,000,000.

The progress bar can be found in the status bar. This shows progress of rendering as you bring each successive layer into the map view. This can take some time with data heavy layers.

If a new plugin or a plugin update is available for your QGIS, you will see a message that tells you so on the far right of the status bar. On the right side of the status bar is a small check box that can be used to temporarily stop layers being rendered into the map view (see Section *Rendering* below). The icon immediately stops the current map rendering process. This is useful if you realize you accidently brought in the wrong layer.

Just to the right of the rendering area you will find the EPSG code of the current project Coordinate Reference System (CRS), and a projector icon. Click on it to open data on the projection properties of the layer.

Tip: **Calculating the correct Scale of your Map Canvas**

Degrees is the default unit when you boot up QGIS. Hence, any layer you add will automatically be projected in degrees To change or get your corrected scale values, you can either change this setting to meters manually in the *General* tab under *Settings* ‣ *Project Properties* or, you can select a project CRS clicking on the CRS status icon in the lower right-hand corner of the status bar. In the last case, the units are set to what the project projection specifies, e.g. '+units=m' for units as meters.

For more information, please see:
http://docs.qgis.org/2.2/en/docs/user_manual/introduction/qgis_gui.html

Module 3: Loading Spatial Data and Visualization in QGIS

The data set for this exercise is located in: *MODULE_03\ Data* directory:

1. *Upazila boundary of Bangladesh (polygon- BD_UPZ_GCS.shp)*
2. *British Geological Survey (BGS) groundwater Arsenic data (point shape file- bgs_groundwater.shp)*
3. Road network maps of Bangladesh (BD_road_network.shp)
4. *Landsat-5 image for Bangladesh (LT51370442010030KHC00_B4.TIF)*

Vector Data

In this exercise, we will use three types of **ESRI shapefiles (**also called a shapefile**).** These types include **polygons, points and line or polylines.** What is a shapefile? It is the most common form of geospatial vector data used in GIS software and analyses. Shapefiles were designed and are now regulated by ESRI, and are meant to work interchangeably to communicate data between ESRI and GIS products. Shapefiles are built from a number of constituent files. Three unique files are required to save the main data that is used to make a shapefile, including: **.shx (**shape index format; this tags the shapefile with a position so users can move it forward and backward among layers, a **shp (**shape format, which stores geometric data, and a **.dbf (**attribute format file; which holds attributes (information) for the shapes in the file). Some people refer to the .shp files as the unique shapefile itself. While this makes sense according to name, all three files are actually required to use a shapefile.

Polygons

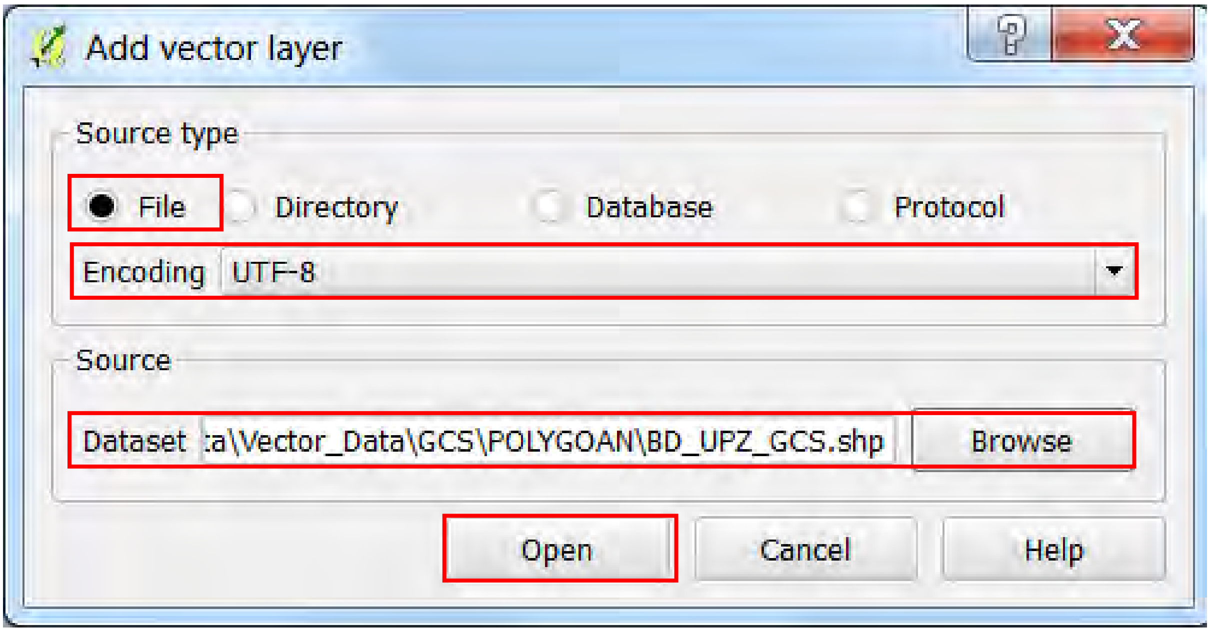
Polygons are two-dimensional geographical features covering a portion of the earth's surface, for example, forests, lakes, administrative boundaries, farmers' fields, or any other organizational unit the user defines. Polygons are important because their area and perimeter can be measured.

In this exercise, we will use upazila (sub-district level) data from Bangladesh. These data have been downloaded from https://www.humanitarianresponse.info/applications/data/datasets/locations/bangladesh.

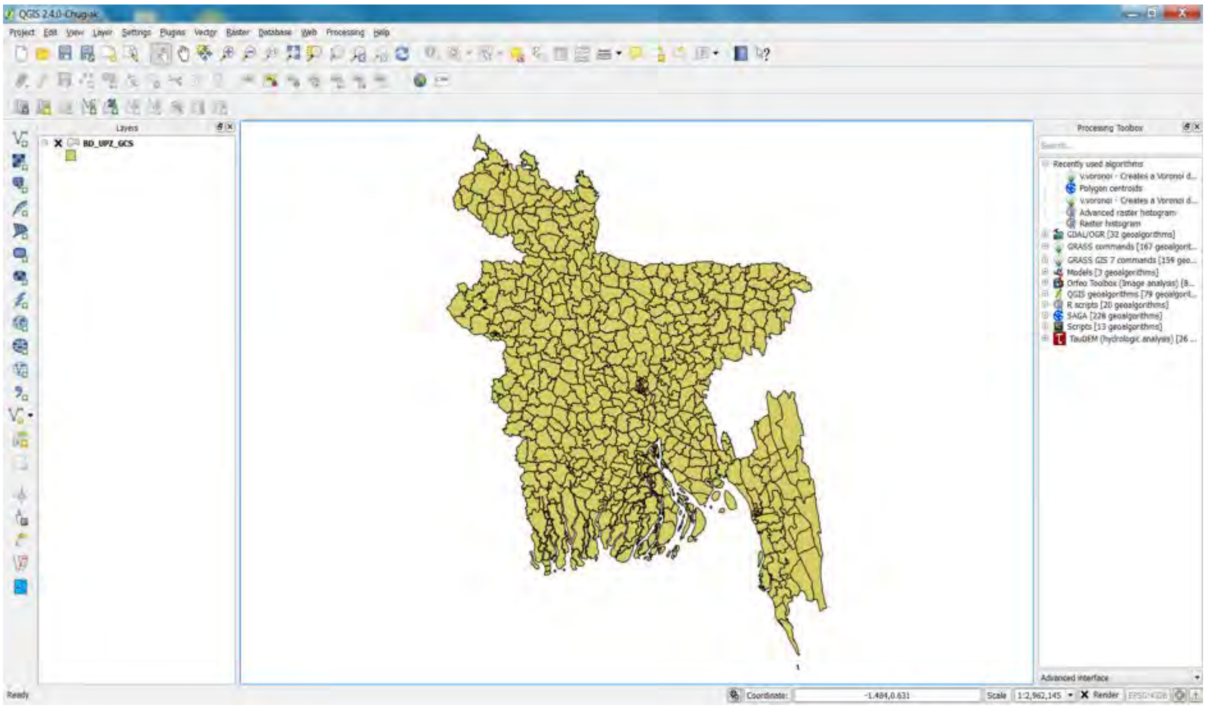
Steps:

1. First, launch **QGIS Desktop 2.4** from your desktop
2. Click the **Add Vector Layer** Icon
3. or Click **Layer** on Menu bar and then **Add Vector Layer** (alternatively, this can also be chosen from your browser)
4. Select **File** from Source Type
5. Select Encoding UTF-8 from the popup menu (*please see http://en.wikipedia.org/wiki/UTF-8*)
6. *Then click browse and select BD_UPZ_GCS.shp* (note now the shapefile comes with two additional associated files, as discussed above – maintaining these files in place in your folder is critical for assuring that the shape files load correctly)

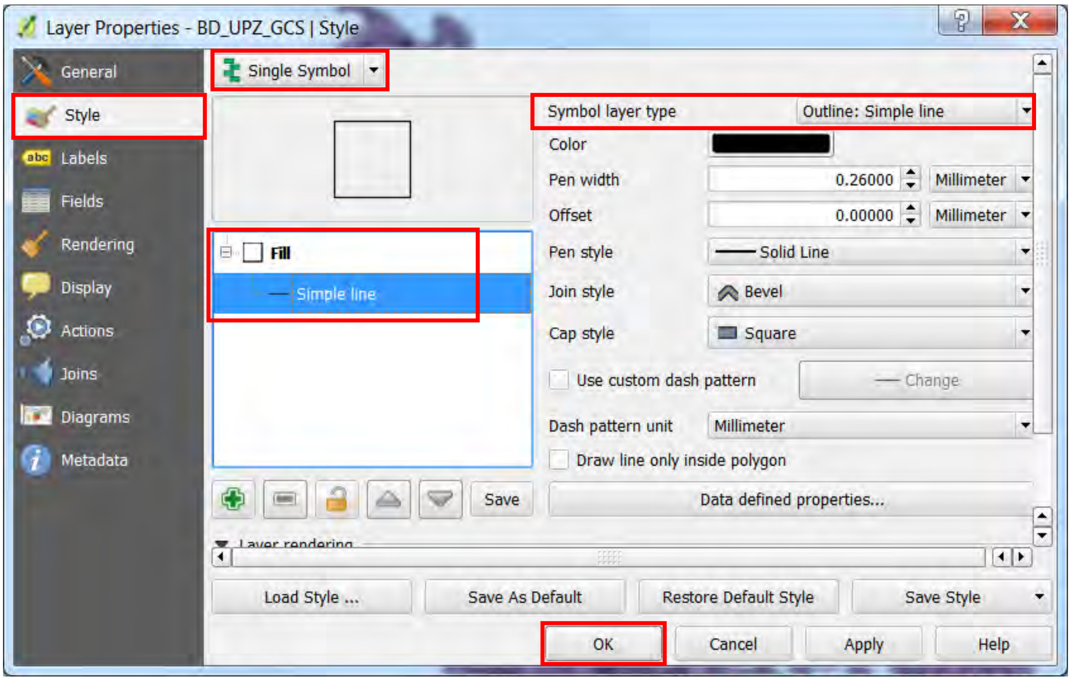
7. Then click **Open**



8. After clicking **Open**, the map should appear on the QGIS canvas

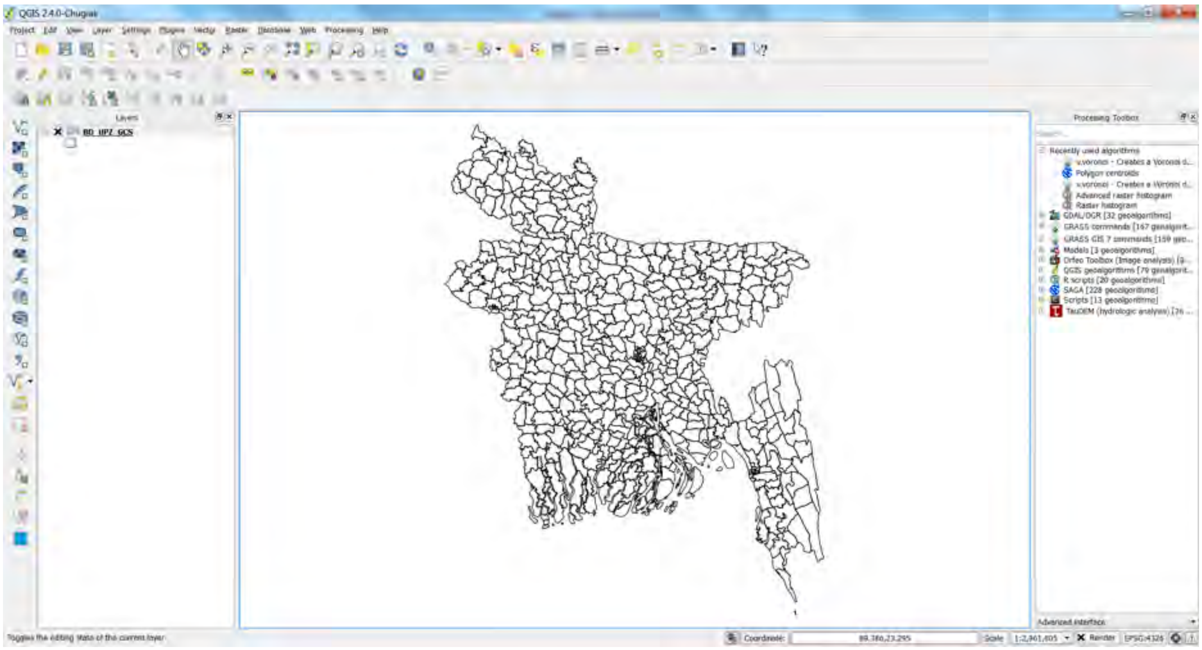


9. In the Layers menu to the left of the map viewer, right-click on



BD_UPZ_GCS.shp and select **PROPERTIES --> STYLE.** Keep Single symbol and change FILL from Simple fill to Outline: Simple line from Symbol Layer type, then click OK.

If done correctly, the resulting map viewer will look like the following image:



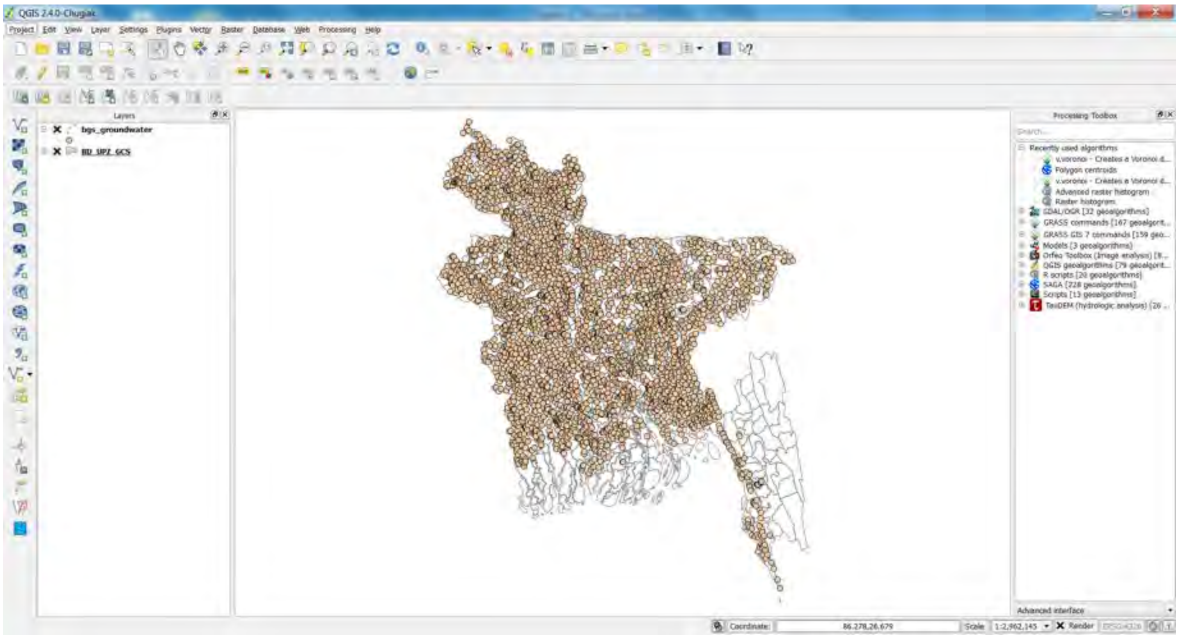
Points Vector

Zero-dimensional points are important for geographical features like wells, soil-sampling locations that can be best expressed by a single reference point. These points confer the least information about these file types, and are best to represent geographical data that are very small scale and with limited area. Examples include cities, villages, wells, farms, markets, etc. that you would not represent with polygons. The main drawback of a point feature, however, are that they cannot be used to make measurements (as you can with a polygon).

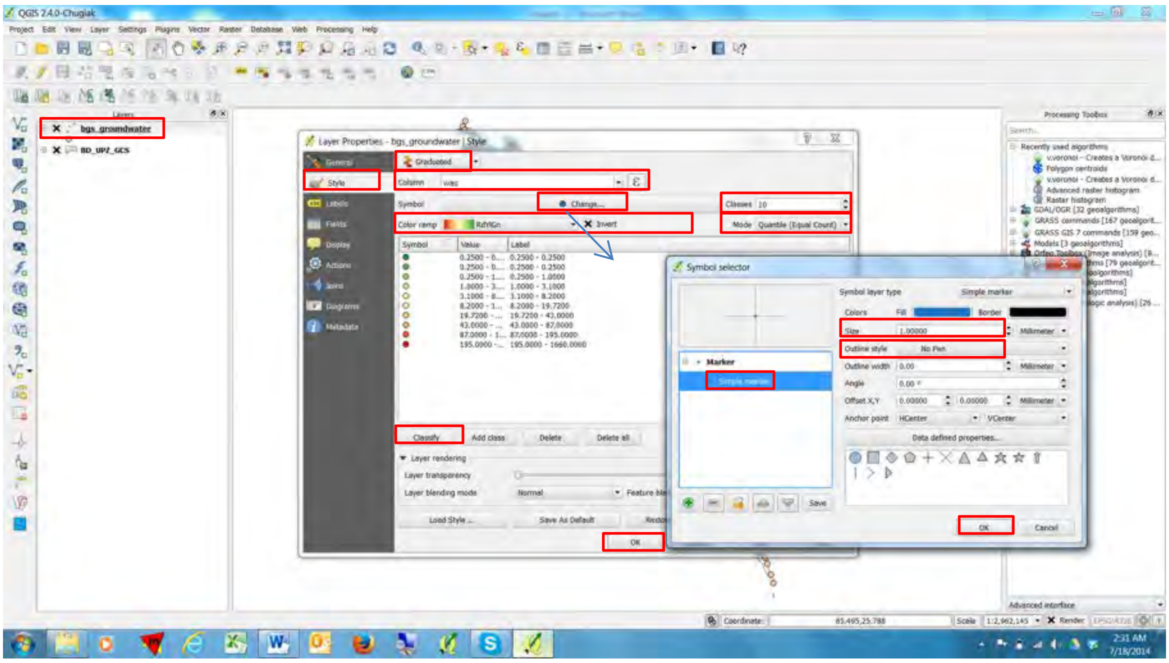
In this exercise, we will use *British Geological Survey Groundwater Quality* data for Bangladesh (http://www.bgs.ac.uk/research/groundwater/health/arsenic/Bangladesh/data.html) as CSV file. This CSV file contains the results of a geochemical survey of 3,534 boreholes from 61 of the 64 districts of Bangladesh. All 3,534 boreholes were georeferenced. From this CSV file, we have created a shape file (point vector map).

Steps:

1. Click **Add Vector Layer** Icon
2. Select **File** from Source Type
3. Select Encoding UTF-8 from the popup menu
4. *Then click browse and select* ***bgs_groundwater.shp***
5. Then click **Open.** The resulting data should look like the map below:

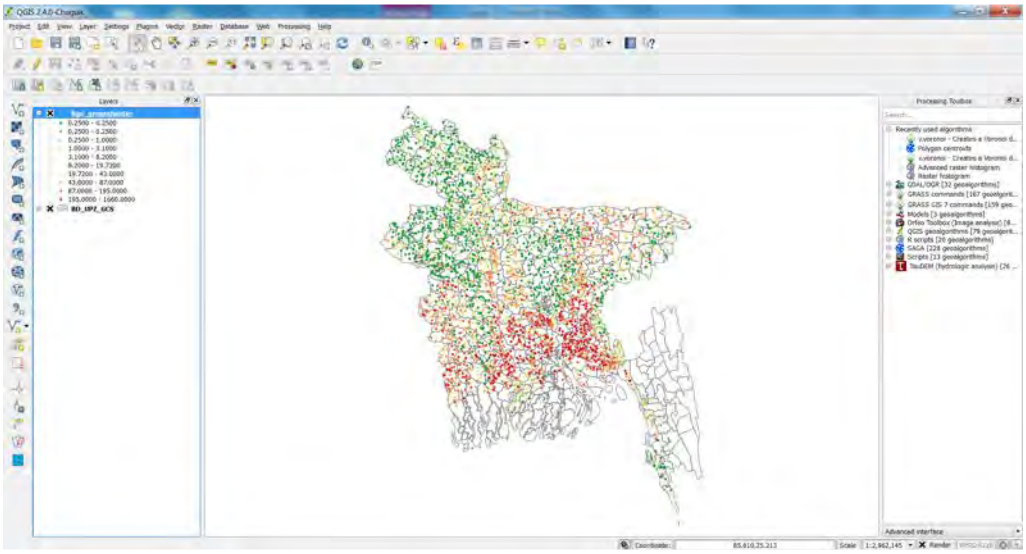


6. Now right-click on ***bgs_groundwater.shp*** (note that it may simply be called '***bgs_groundwater***' in the layers menu (to the left of the map viewer)and select **PROPERTIES --> STYLE.**
7. Change Single symbol to Graduate symbol.
8. Select Colum "was" (groundwater arsenic concentration, ug/L)
9. Click Symbol: Change
10. From Popup-windows, select Marker → Simple marker
11. Then, choose Size 1 mm and Outline style No Pen, then click OK.
12. Select Color ramp RdYlGn and check Invert
13. Choose Classes 10 and Mode Quantile
14. Click Classify and then OK



The resulting map should look like the display below. These steps are important if you wish to display georeferenced data that have a gradient of values, for example in this case the arsenic level in sampled groundwater for each of the points. Using this method, you can easily visualize how arsenic concentrations appear to increase towards the southern region of Bangladesh.

Note that if the color ram classification does not appear to be as shown below, you can go to **PROPERTIES -->STYLE** and then click **INVERT TO** the left of the color ramp source. You can also decide to use a different color ramp scheme all together, as you choose.



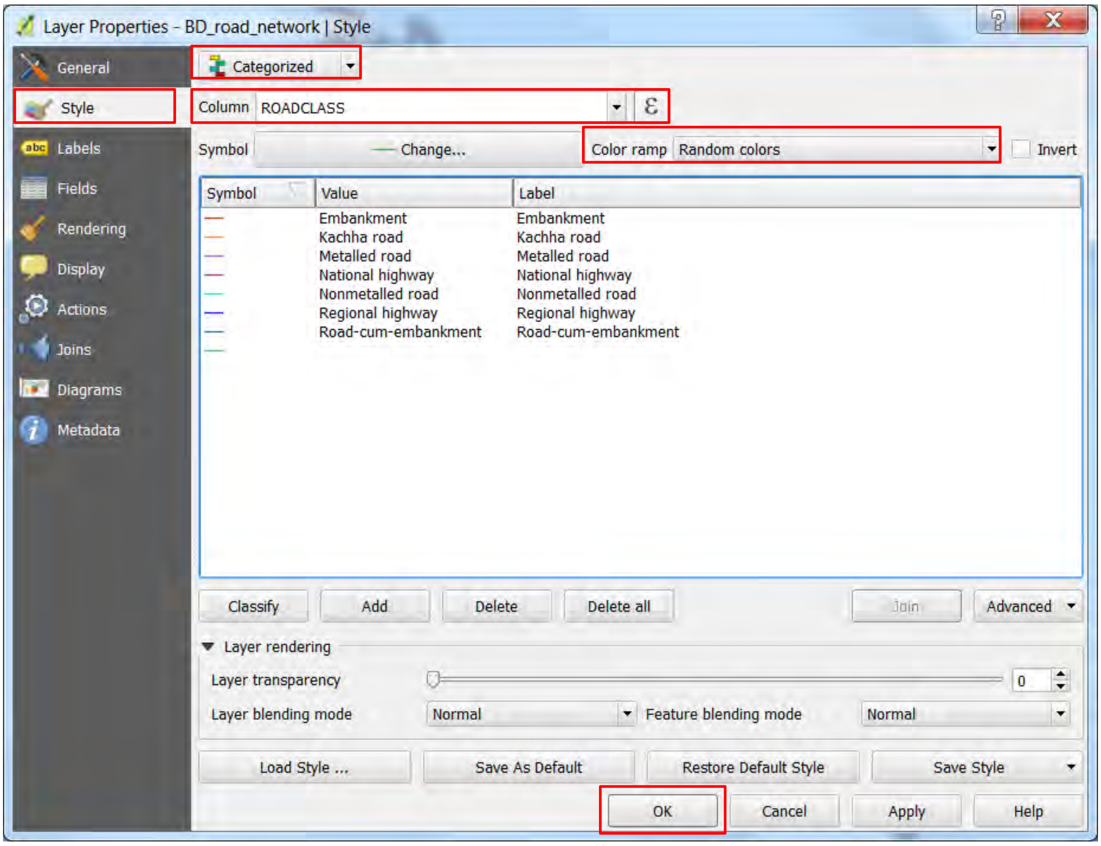
Lines or Polylines

One-dimensional lines, also called polylines, are used to represent geographical features like rivers, roads, railroads, trails, and topographic lines. Note that these features are linear in nature and do not have area like polygons. Hence, they can measure distance.In this exercise we use road network maps of Bangladesh. This map has been downloaded from https://www.humanitarianresponse.info/applications/data/datasets/locations/bangladesh.

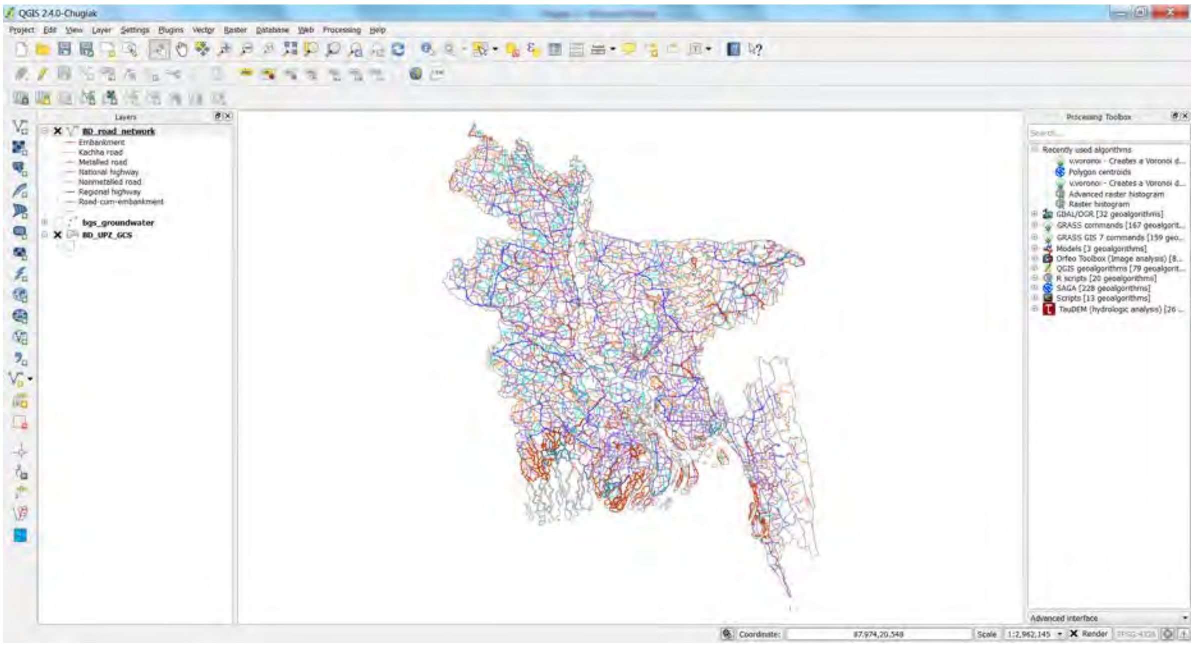
Steps:

1. Click **Add Vector Layer** Icon
2. Select **File** from Source Type
3. Select Encoding UTF-8 from the popup menu
4. *Then click browse and select **BD_road_network.shp***
5. Then click **Open**
6. Right clicking on ***BD_road_network.shp***and select **PROPERTIES --> STYLE.**
7. Change Single symbol to Categorized.
8. Then click **CLASSIFY** to display the road data.

9. Select Colum "ROADCLASS" and Color ramp Random colors
10. Click Classify and then, OK



The resulting output should look like the below map, made more easily visible by deselecting the groundwater and Upazila shapefiles in the layers menu.



Raster data

Raster data can be thought of as particular type of geographical information. Using a grid format, it covers the space of each cell, the smallest measurement unit in the in the grid, aligning it with a measured geographical feature in this location. Combined into a matrix, a raster is a grid of cells. Some sources of raster data could include satellite or aerial images and droneimager (though these types are rare) or maps that have been scanned. Data types are flexible, including discrete and categorical data, such as those used in soil or land-use maps, or continuous data as in digital elevation models, precipitationgradient maps, or pollutant concentration maps, etc. Raster data are meant to be used in a complementary way to vector data applications in GIS, so they are commonly integrated in analyses and map making.

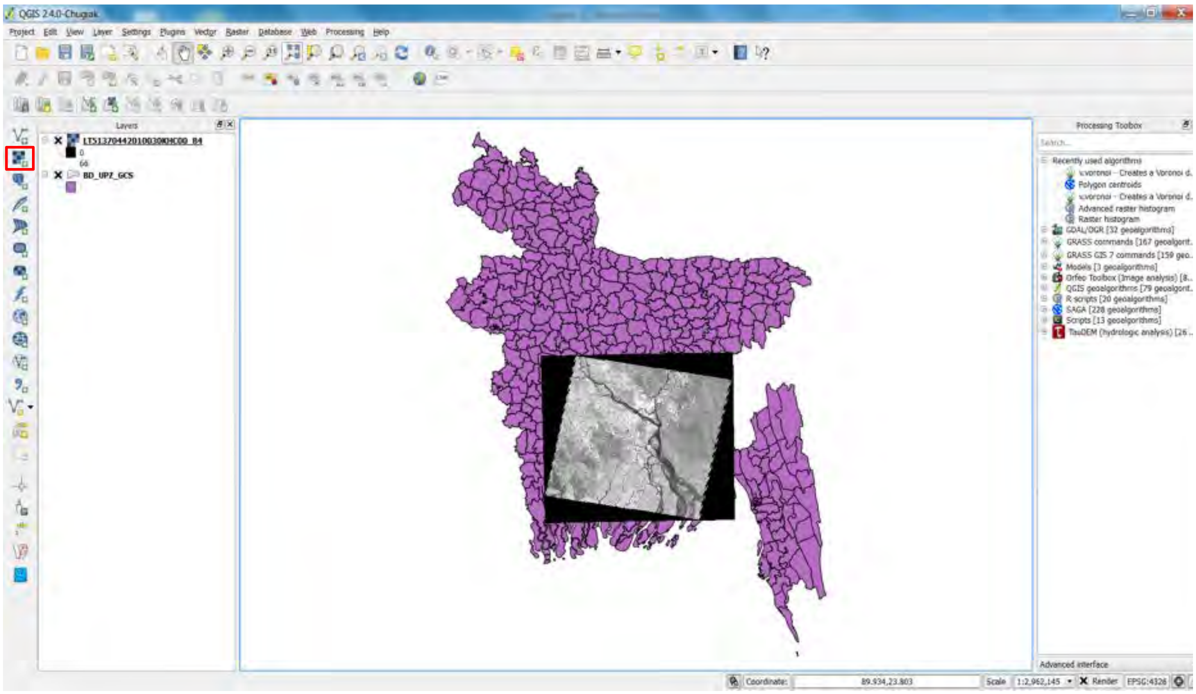
In this exercise, we will use one scene (row 137 and row 44) of Landsat-5 TM satellite images acquired on 30/01/2010. The Landsat-5 was collected and distributed by the USGS's Center for Earth Resources Observation and Science (EROS) (http://eros.usgs.gov/satellite-imagery).

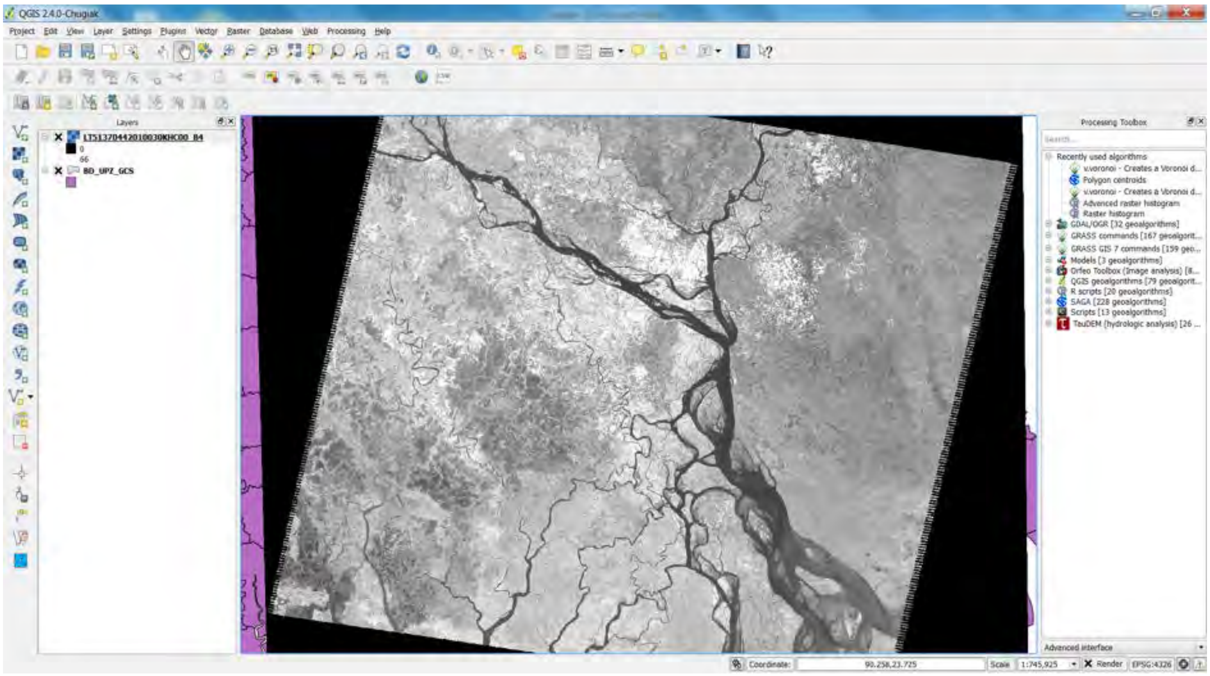
Steps:

1. Click the **Add raster layer** button and select the file ***LT51370442010030KHC00_B4.TIF*** from ~\MODULE_03\Data\LT51370442010030KHC00. After clicking Open, the map should appear on the QGIS canvas.

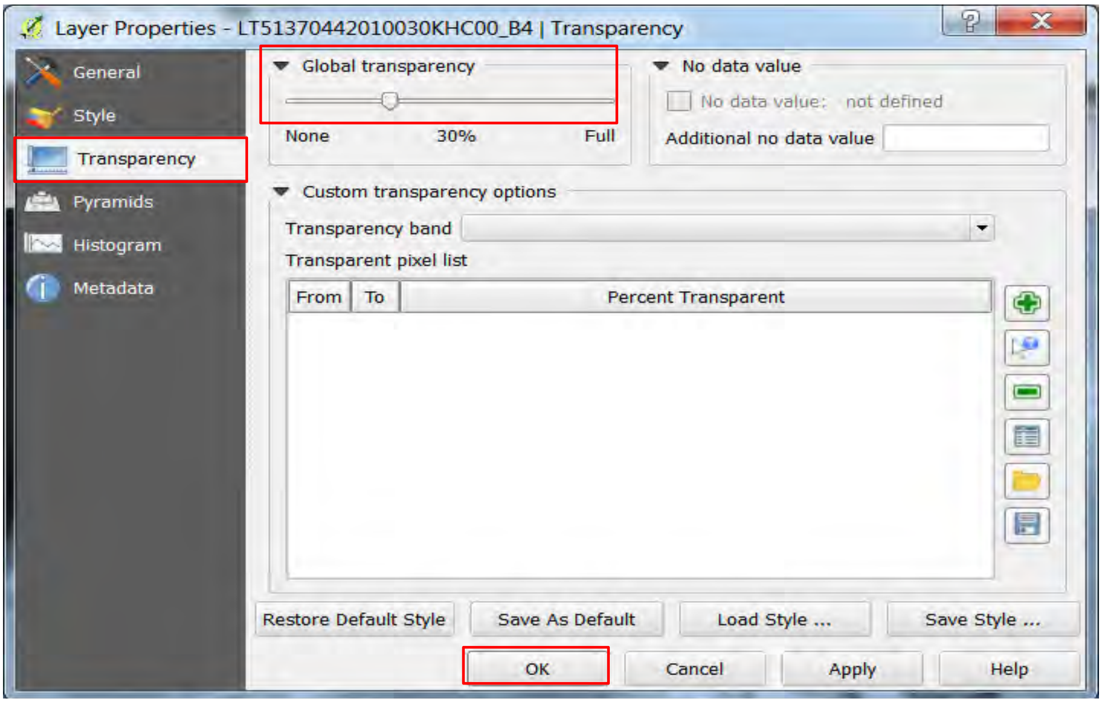
   The resulting map should look roughly like the one below:

   Use the tools for zooming in to increase the map scale and zoom in on the scene of southern Bangladesh and its rivers. Use the panning tool to move the map in the desired direction. If you get lost while moving the map around, you can always zoom back to the map by clicking the **Zoom to layer** button.

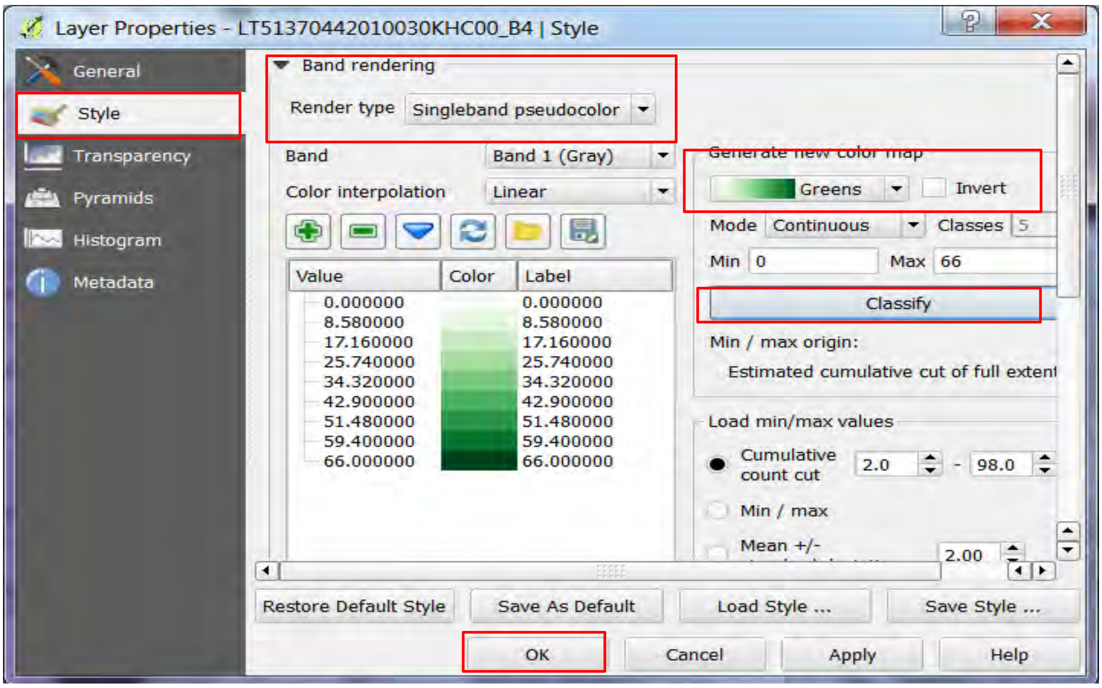


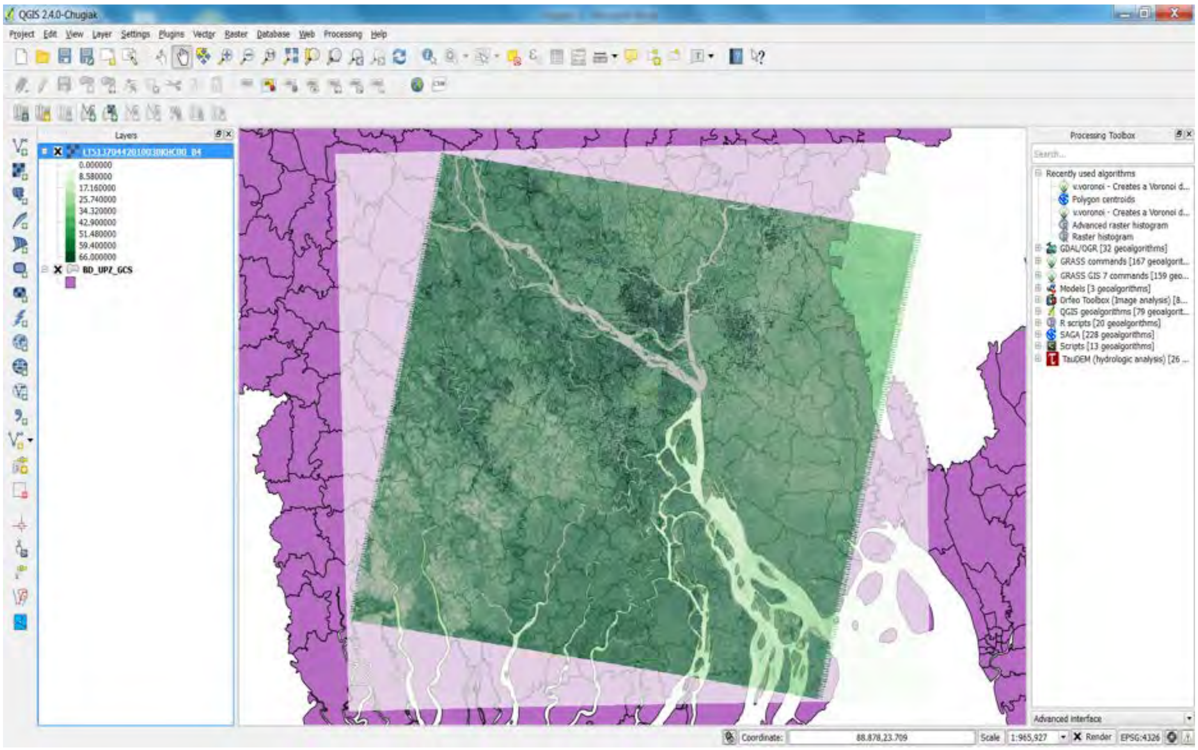


2. Adjust the appearance of the image by right-clicking on ***LT51370442010030KHC00_B4.TIF*** and selecting **PROPERTIES --> TRANSPARENCY --> ADJUST GLOBAL TRANSPARENCY SCALE PERCENTAGE** (30%)and confirming with **Apply** or **OK**. Note that the 'apply' button is useful to check the format of a map after you have changed its properties, but before formally accepting them. This allows you to make a number of modifications and verify them with ease.



3. To change map color and symbols, again select the layer with a right click and choose **PROPERTIES --> STYLE.** From the pulldown menu,**Render type**, select **Singleband pseudocolor.** A different menu will come up, where you may select the style of the color map in the section **Generate new color map**. Also, make sure your color interpretation is marked to 'Linear'. Click **Classify** and confirm with **Apply** or **OK**.





Saving QGIS Project

Your QGIS session is considered as an individual Project. You can only work on one project at a time in QGIS, and you can save your Project (or open a new one) in the following ways.

PROJECT-->SAVE AS
Save you work

PROJECT-->SAVE
Load saved projects into a QGIS session using

PROJECT-->OPEN
If you wish to clear your session and start fresh, choose

PROJECT-->NEW
Either of these menu options will prompt you to save the existing project if changes have been made since it was opened or last saved.

Module 4: Coordinate Reference Systems in QGIS

Coordinate reference systems use data presented in either projected or geographic coordinate systems (see below), and are used to provide a framework to identify real-world locations.

Geographic coordinate system

The earth is not a perfect sphere, despite being often depicted as such. Because of this, different spheroid representations of the earth exist. Geographic coordinate systems use latitude and longitude to measure and indicate locations on the globe, defined as a function of direction and distance from a center point. Where representations of the globe however differ, so will the central point from which coordinate systems are measured. This complicates use of different coordinate systems, especially when they are to be compared, or data in one system is imported into a GIS basal layer that uses a different system. This often requires transformation of the coordinate system to assure alignment in the workspace. The most common geographic coordinate system is the World Geodetic system 84 (WGS84) (**EPSG: 4326**), represented as follows:

```
GEOGCS["WGS 84",
DATUM["WGS_1984",
SPHEROID["WGS
84",6378137,298.257223563,
AUTHORITY["EPSG","7030"]],
AUTHORITY["EPSG","6326"]],
PRIMEM["Greenwich",0,
AUTHORITY["EPSG","8901"]],
UNIT["degree",0.01745329251994328,
AUTHORITY["EPSG","9122"]],
AUTHORITY["EPSG","4326"]]
```

Projected coordinate system

Cartesian (x,y coordinates) approaches are used to define locations in projected coordinate systems, which consider the global as a flat, two dimensional surface based on a flattened representation of a sphere on a flat plane, with geographical coordinate systems. This approach is useful where accurate distance, angle, and area measurements are needed. The term ‘projection’ is often used interchangeably with projected coordinate systems.

Commonly use projected coordinate systems include

- **Universal Transverse Mercator (UTM)**
- **Lambert Conformal Conic**
- **Albers Equal Area**

The most widely utilized two-dimensional Cartesian coordinate system is the Universal **Transverse Mercator** (**UTM**) system. UTM is interesting in that it is a horizontal positional representation of the globe, and can be used to identify positions without having to know their vertical location on the ‘y’ axis. It is nonetheless different than geographical coordinate systems in that it is not a single mapped projection. It also represents the earth as sixty different zones, each composed of six-degree longitudinal bands, with a secant transverse Mercator projection in each. The Bangladesh falls in zone 45N (**EPSG**[1]:32645) and zone 46N (**EPSG: 32646**).

Parameters of UTM zone 45 and 46N

UTM Zone 45N (EPSG:32645)	**UTM Zone 46N (EPSG:32646)**
PROJCS["WGS 84 / UTM zone 45N", GEOGCS["WGS 84", DATUM["WGS_1984", SPHEROID["WGS 84",6378137,298.257223563, AUTHORITY["EPSG","7030"]], AUTHORITY["EPSG","6326"]], PRIMEM["Greenwich",0, AUTHORITY["EPSG","8901"]], UNIT["degree",0.01745329251994328, AUTHORITY["EPSG","9122"]], AUTHORITY["EPSG","4326"]], UNIT["metre",1, AUTHORITY["EPSG","9001"]], PROJECTION["Transverse_Mercator"], PARAMETER["latitude_of_origin",0], PARAMETER["central_meridian",87], PARAMETER["scale_factor",0.9996], PARAMETER["false_easting",500000], PARAMETER["false_northing",0], AUTHORITY["EPSG","32645"], AXIS["Easting",EAST], AXIS["Northing",NORTH]]	PROJCS["WGS 84 / UTM zone 46N", GEOGCS["WGS 84", DATUM["WGS_1984", SPHEROID["WGS 84",6378137,298.257223563, AUTHORITY["EPSG","7030"]], AUTHORITY["EPSG","6326"]], PRIMEM["Greenwich",0, AUTHORITY["EPSG","8901"]], UNIT["degree",0.01745329251994328, AUTHORITY["EPSG","9122"]], AUTHORITY["EPSG","4326"]], UNIT["metre",1, AUTHORITY["EPSG","9001"]], PROJECTION["Transverse_Mercator"], PARAMETER["latitude_of_origin",0], PARAMETER["central_meridian",93], PARAMETER["scale_factor",0.9996], PARAMETER["false_easting",500000], PARAMETER["false_northing",0], AUTHORITY["EPSG","32646"], AXIS["Easting",EAST], AXIS["Northing",NORTH]]

Bangladesh Transverse Mercator (BTM) (EPSG 3106)

For mapping of Bangladesh with a UTM projection system, a new projection system was developed by Survey of Bangladesh, referred to as the Bangladesh Transverse Mercator (BTM) (EPSG 3106). For conversion of WGS-84 Ellipsoid to Local Ellipsoid (Everest 1830), a custom coordinate reference system is necessary with datum transformation parameters that known as 7 parameters projection system.

Conversion parameter from WGS-84 Ellipsoid to Local Ellipsoid (Everest 1830)

Everest-1830 ellipsoid
Semi-major axis a (+a) = 6377276.34518 m
Semi-minor axis b (+b) = 6356075.41511 m

Inverse flattening 1/f = 300.8017

Datum Transformation Parameters

Method	:	Seven Parameters
Rotation X	:	0
Rotation Y	:	0
Rotation Z	:	0
Translation X	:	283.729 m
Translation Y	:	735.942 m
Translation Z	:	261.143 m
Scale	:	0 ppm

Projection parameter

Projection method	:	Transverse Mercator
Latitude of origin (+lat_0)	:	0° N
Central meridian (+lat_0)	:	90° E
False Northing (+y_0)	:	-2,000,000 m
False Easting (+x_0)	:	500000 m
Scale factor (+k)	:	0.9996

In QGIS, the following parameters (PORJ 4) are needed for transforming CGS/ UTM with WGS84 to BTM with a local Ellipsoid (Everest 1830)

PORJ 4 (EPSG_3106_BTM_D_GULSAN_NEW.PRJ4):

```
+proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500000 +y_0=0 +a=6377276.345
+b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_defs
```

In ArcGIS, the following PRJ file is needed (EPSG_3106_BTM_D_GULSAN_NEW.PRJ) for transformation.

PRJ:

```
PROJCS["Gulshan 303 / Bangladesh Transverse
Mercator",
    GEOGCS["Gulshan 303",
        DATUM["Gulshan_303",
            SPHEROID["Everest 1830 (1937
Adjustment)",6377276.345,300.8017,
                AUTHORITY["EPSG","7015"]],
TOWGS84[283.7,735.9,261.1,0,0,0,0],
            AUTHORITY["EPSG","6682"]],
        PRIMEM["Greenwich",0,
            AUTHORITY["EPSG","8901"]],
        UNIT["degree",0.0174532925199433,
            AUTHORITY["EPSG","9122"]],
        AUTHORITY["EPSG","4682"]],
    PROJECTION["Transverse_Mercator"],
    PARAMETER["latitude_of_origin",0],
    PARAMETER["central_meridian",90],
    PARAMETER["scale_factor",0.9996],
    PARAMETER["false_easting",500000],
    PARAMETER["false_northing",0],
    UNIT["metre",1,
        AUTHORITY["EPSG","9001"]],
    AXIS["Easting",EAST],
    AXIS["Northing",NORTH],
    AUTHORITY["EPSG","3106"]]
```

The data set for this exercise is located in: *MODULE_04\ Data* :

1. *Upazila boundary of Bangladesh (polygon- BD_UPZ_GCS.shp)*
2. *Landsat-5 image for Bangladesh (LT51370442010030KHC00_B4.TIF)*
3. Four DEM raster in ALL_SHEETS_DEM_GCS sub-directory

Transforming Geographic Coordinate Systems to *Projected coordinate system*

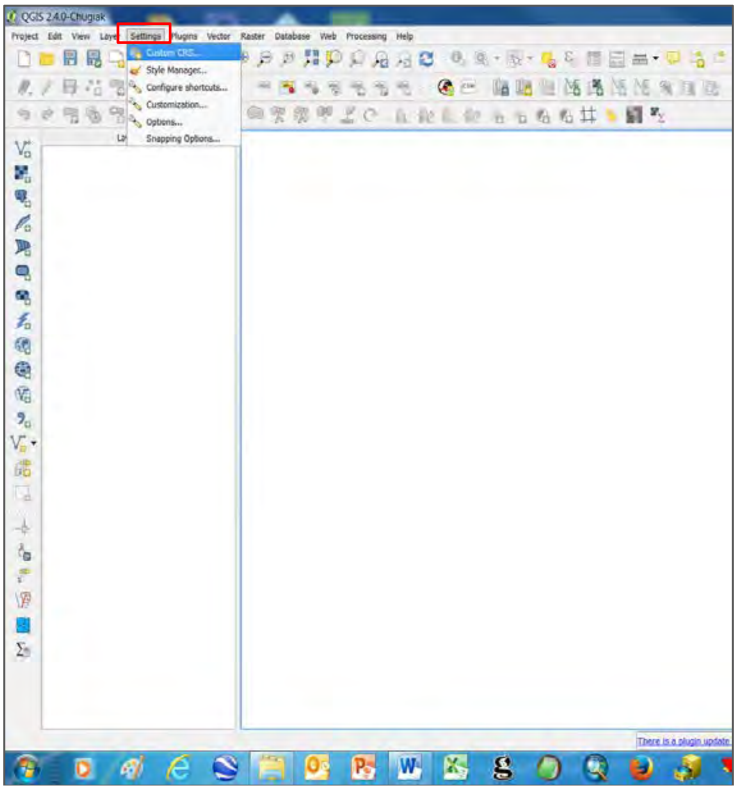
Create a custom CRS

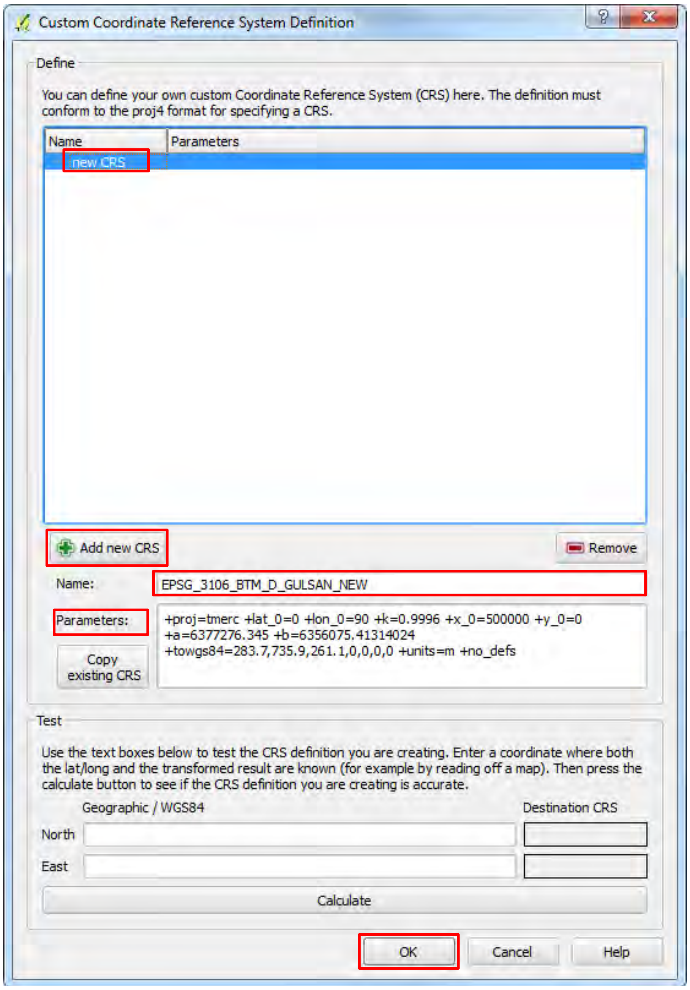
In this section, we will learn how to transform geographic Coordinate Systems to a projected coordinate system ***in QGIS.*** First, we have **to create a custom CRS in** QGIS for transforming from GCS or UTM with WGS-84 Ellipsoid to BTM with a Local Ellipsoid (Everest 1830)

1. First, launch **QGIS Desktop 2.4** from your desktop
2. Click **Setting -> Custom CRS**
3. In **Custom Coordinate Reference System Definition** window, click **Add new CRS**
4. In **Name Section**, type "**EPSG_3106_BTM_D_GULSAN_NEW**"
5. Copy the following text and paste it in the **Parameters** section.

```
+proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500000
+y_0=0 +a=6377276.345 +b=6356075.41314024
```

6. Then Click **OK**
7. A new CRS named **EPSG_3106_BTM_D_GULSAN_NEW** will be created in QGIS. We will use this CRS for all projection transformation in this exercise.



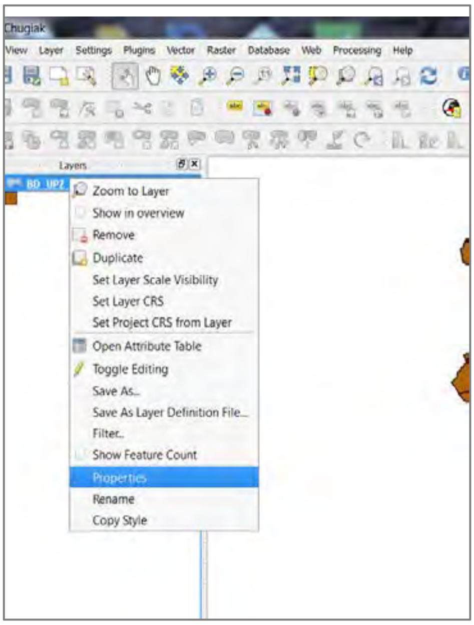


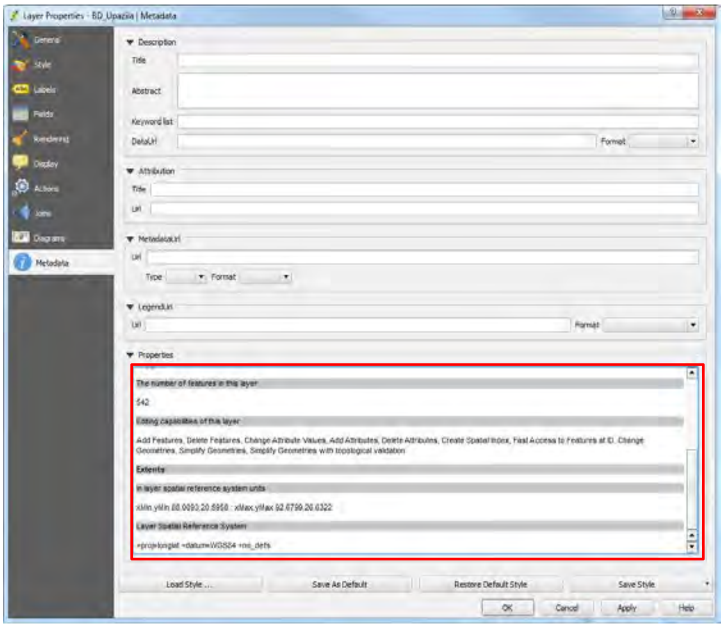
Vector Data CRS

Checking the Coordinate Reference System

In this exercise, we will learn how to check the coordinate system of vector data in QGIS. This is important to assure you are working with the right systems, and to determine why some layers may not render as expected.

1. If you have not done so already, launch **QGIS Desktop 2.4.**0 from your desktop
2. Click and load the ***BD_UPZ_GCS.shp*** file
3. To find the coordinate reference system (CRS) layer, first right click on the layer name in the layer section, then click ***Properties***. Next, click on the ***Metadata*** tab. The CRS is displayed under the **Layer Spatial Reference System**header under **Properties**. The example below shows that the layer projection is ***Geographic coordinate system*** and the datum is ***WGS84***.

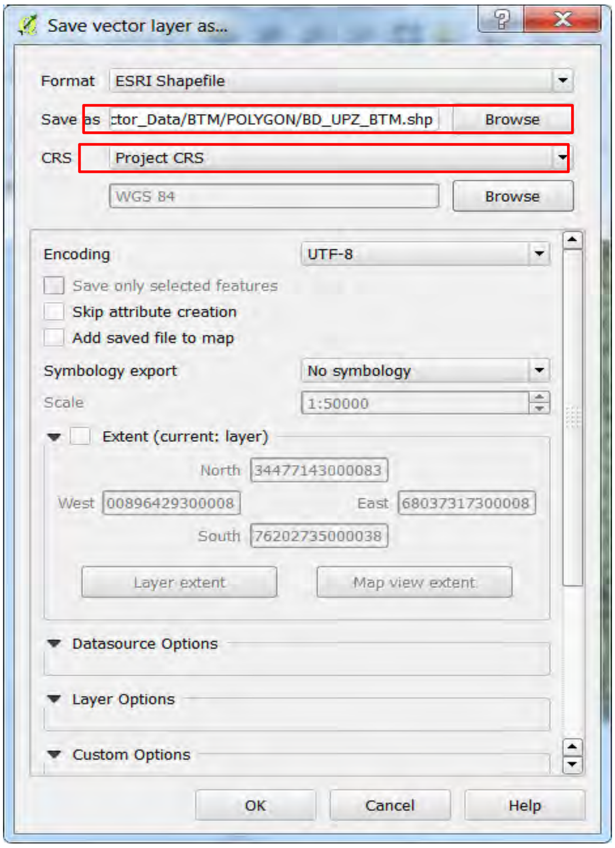


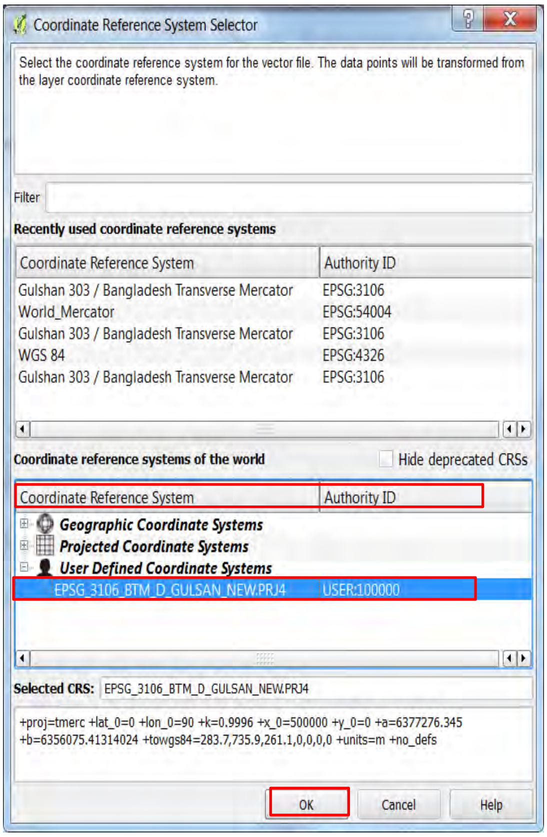


Projection of a Vector Data

We have already shown the *BD_UPZ_GCS vector layer in a Geographic Coordinate Systems with a datum WGS84 (**EPSG:4326**). In the following exercise, you will next learn how to convert GCS to BTM using a custom CRS that we created before. This process is important to correct for incorrect projections, and to align layers you are working with in an analysis.*

1. Click and select ***BD_UPZ_GCS.shp*** file**.** After clicking **Open**, the map should appear on the QGIS canvas (if not already completed in the step above).
2. Right click on the ***BD_UPZ_GCS.shp*** in the layers menu, then click **Save as**
3. Use the **Save as *Browse'***option to choose ***(MODULE_04\Data***) for the new layer to be saved and give the layer name as ***BD_UPZ_BTM.shp*,** and hit return.
4. In the CRS section, select **Project CRS** and then Click **Browse**
5. Scroll down in the **Coordinate reference system of world section** of the **Coordinate Reference SystemSelector** window, and select **EPSG_3106_BTM_D_GULSAN_NEW** from***User defined Coordinate Systems***(this may take time for you to find, but be patient).
6. Next, click **OK.**
7. Then Click **OK** again.





Raster Data CRS

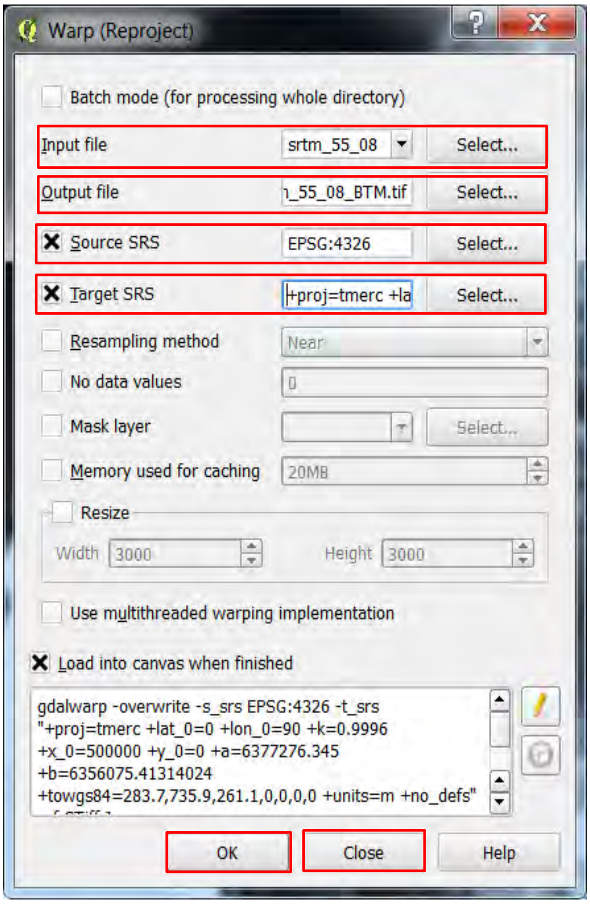
In this exercise, which focuses on raster data as defined in Module 3, we will use Landsat 5 TM scenes downloaded from the http://glovis.usgs.gov/ website. These data have been projected in Universal Transverse Mercator (UTM) Zone 46 with the WGS84 datum (**ESPG:32646**). We can re-project a single file or multiple files with batch projection mode from geographic coordinate systemto our custom CRS **(EPSG_3106_BTM_D_GULSAN_NEW).**

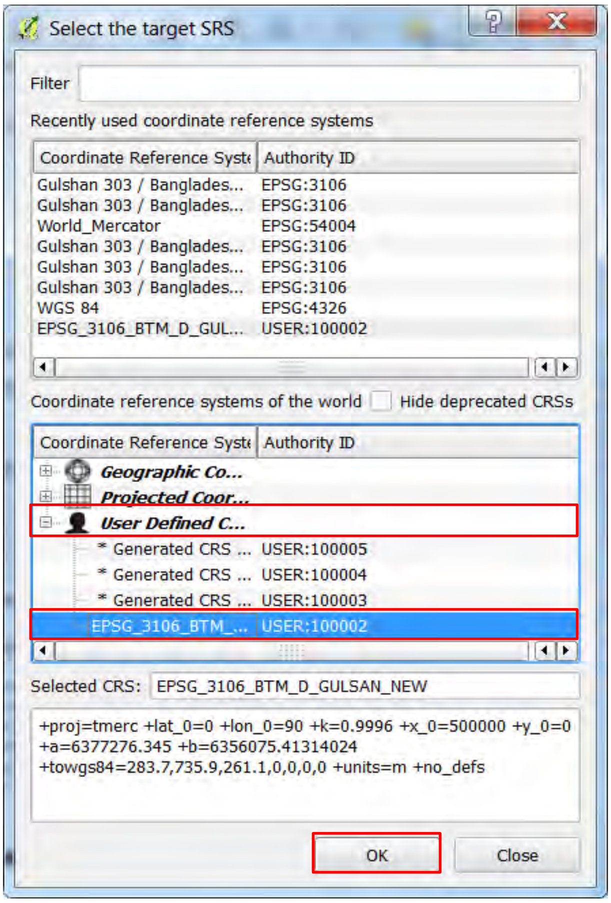
Checking the Coordinate Reference System

1. Click the **Add raster layer** button and select the file ***srtm_55_08.tif*** from **ALL_SHEETS_DEM_GCS** sub-directory of Chaper_03/Data folder.
2. After clicking Open, the map should appear on the QGIS canvas> If you encountered an error, make sure you are opening the file under the raster prompt.
3. Check the MetaData tab in the Properties window for this raster to determine what the Spatial Reference System (SRS) is. The SRS is displayed under the **Layer Spatial Reference System**header under **Properties.** The projection of this raster is ***Geographic coordinate system***and the datum is ***WGS84***.

Projection of a Single Raster:

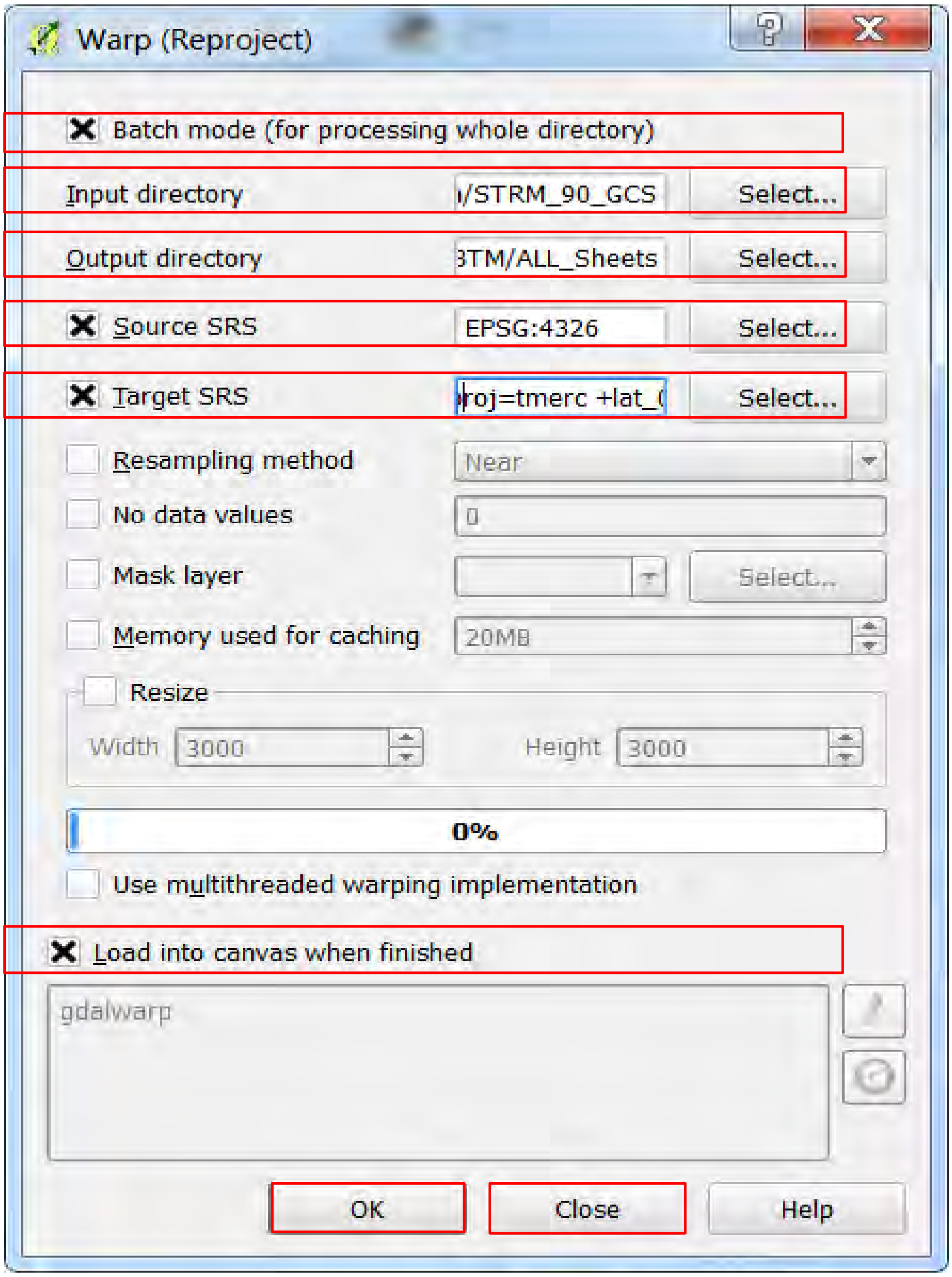
1. On your top-bar menu, click **Raster->Projection->Warp(Repoject)**
2. Define Output file as **strm_55_08_BTM** and file type **GeoTIFF** and save it in *MODULE_04/Data/*
3. **EPSG:32646** will be popping up as **Source SRS**
4. Check Target SRS and Select **EPSG_3106_BTM_D_GULSAN_NEW** as Target SRS
   and click OK
5. Click OK again and then, Close





Batch Projection of Multiple Rasters:

1. Launch **QGIS Desktop 2.4** from your desktop
2. Click **Raster->Projection->Warp (Reproject)**
3. Check Batch mode (for processing whole directory)
4. Select ***ALL_SHEETS_DEM_GCS*** as an Input directory.
5. Select ***ALL_SHEETS_DEM_BTM*** as a Output directory
6. Select EPSG:4326 as Source SRS and **EPSG_3106_BTM_D_GULSAN_NEW as a Target SRS**
7. Click **OK.**


Warp (Reproject)
Batch mode (for processing whole directory)
Input directory
ı/STRM_90_GCS
Select...
Output directory
3TM/ALL_Sheets
Select...
Source SRS
EPSG:4326
Select...
Target SRS
roj=tmerc +lat_(
Select...
Resampling method
Near
No data values
0
Mask layer
Select...
Memory used for caching
20MB
Resize
Width
3000
Height
3000
0%
Use multithreaded warping implementation
Load into canvas when finished
gdalwarp
OK
Close
Help

Module 5: Working with GPS data

In this section, we will show how to create a point shape file from text delimited GPS data in QGIS. In QGIS, text delimited file is an attribute table. Each separate column has a separate and defined data character, and each row is independent. The first row references column names. ACSV (Comma Separated Values) file is the most widely used type of text-delimited file, with each column separated by a comma. Longitude and latitude measurements should be in **decimal degree** (DD) format only. Other formats like degrees (d), minutes (m), and seconds (s) will result in errors. Note that GPS unit coordinates are not always pre-formatted to DD, hence where this is the case, conversion will be necessary. DD can be rapidly calculated in Excel using the formula below.

$$DD = D + \frac{M}{60} + \frac{S}{3600}$$

After calculation, be sure to save your output as a CSV file for import into QGIS.

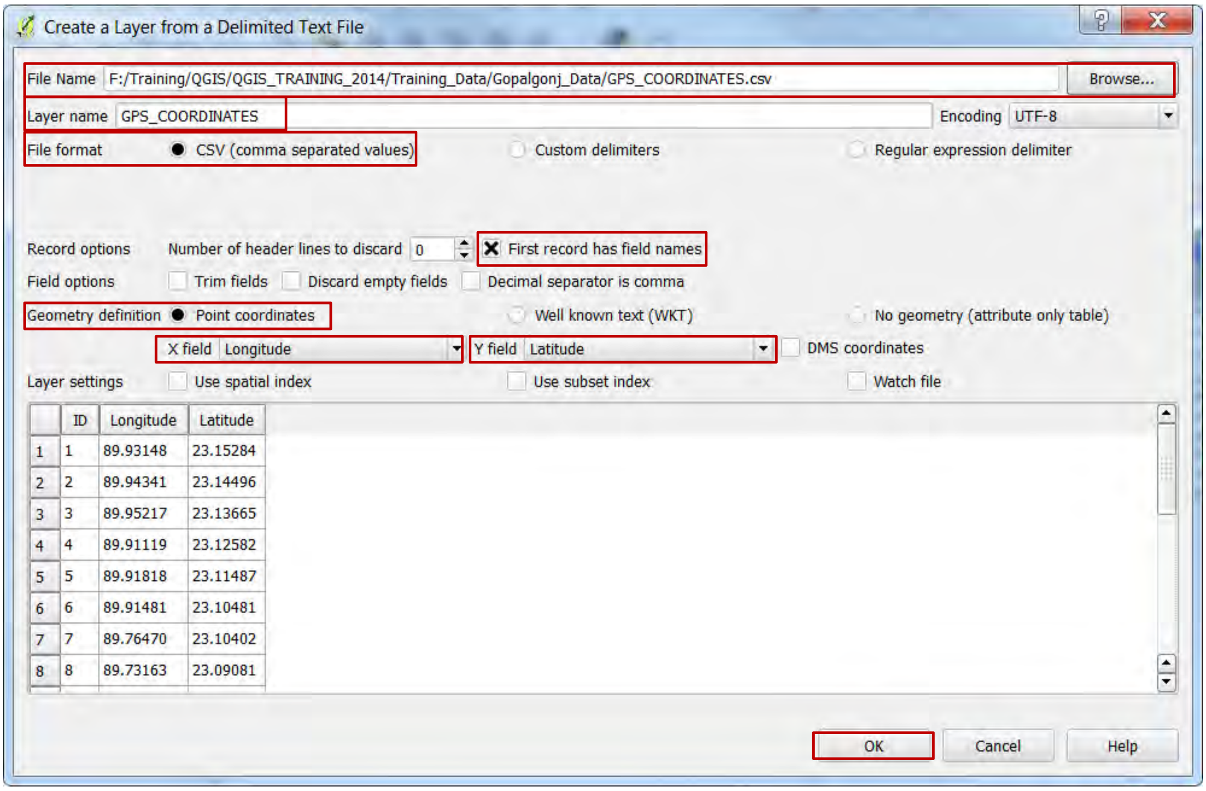
In this exercise, we will use Soil Resource Development Institute (SRDI) soil survey data of Gopalganj District (Gopalganj_SoilData.csv). You will learn how to manipulate attribute tables and how to join data. The soil samples were collected from 0-20 cm soil depth from > 460 locations across Bangladesh, and were analyzed for pH, SOC, P, K etc. The following steps will be used to create a point shape file with GPS and attribute data:

1. Load GPS the coordinates as a delimited CSV file (with geometry – point coordinates)
2. Load soil attribute data (with no geometry)
3. Join soil data with GPS data to create an integrated file
4. Save as 'GPS_CORDINATES' layer file to point shape file

Load GPS coordinate as a delimited CSV file (with geometry – point coordinates)

Steps:

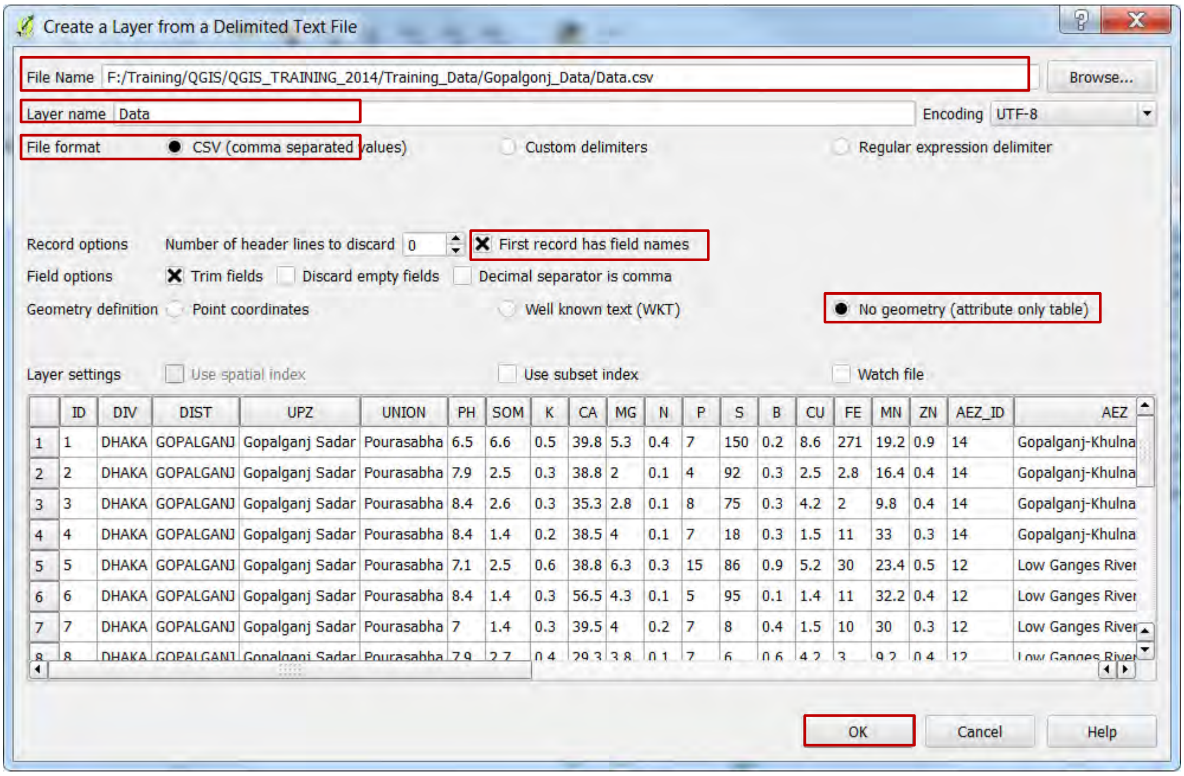
1. First, launch **QGIS Desktop 2.4** from your desktop
2. Click the **Add Delimited Text** Icon
3. or Click **Layer** on Menu bar and then **Add Delimited Text**
4. Click Browse and Open **GPS_COORDINATES.csv** from ***MODULE_05/Data***sub-directory
5. Select Checkbox First record has field name (default)
6. Check **Geometry definition: Point coordinates**
7. Select **X field: Longitude and Y field: Latitude**
8. Click **OK**
9. The **GPS_COORDINATES** will appear on the layer canvas



Load soil attribute data (with no geometry)

Steps:

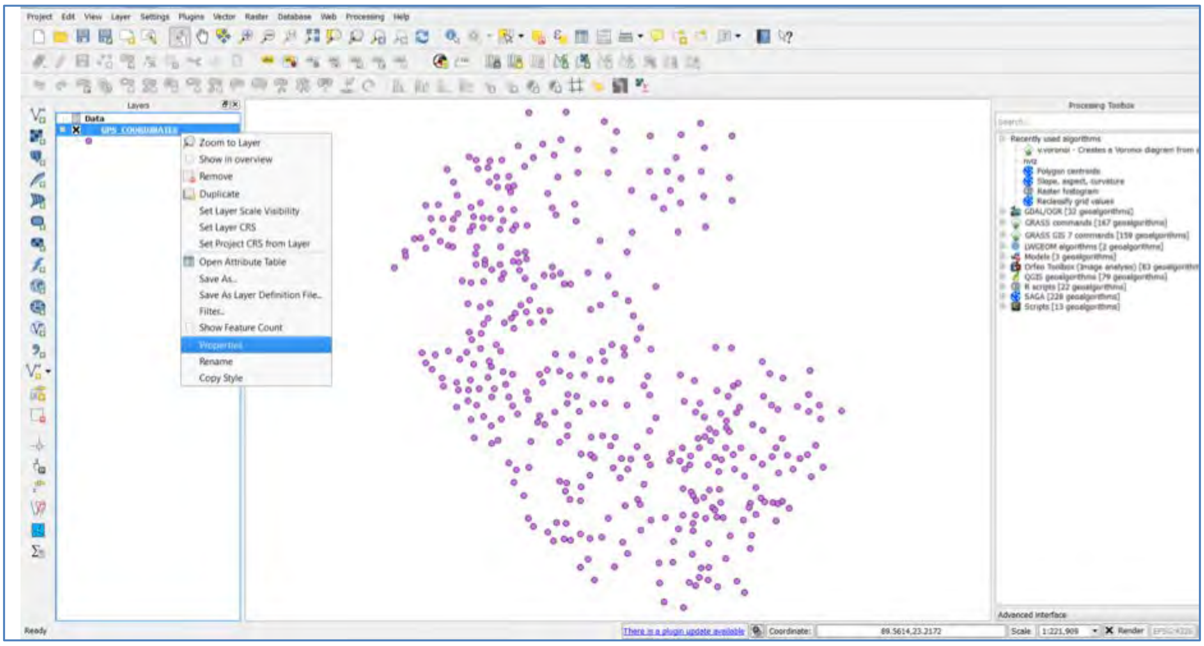
1. Click the **Add Delimited Text** Icon
2. or Click **Layer** on Menu bar and then **Add Delimited Text**
3. Click browse and select D**ata.csv** from MODULE_***05*** ***Data*sub-**directory
4. Select Checkbox First record has field name (default)
5. Check **Geometry definition: No geometry (attribute only table)**
6. Click **OK**
7. The **data** will appear on layer canvas



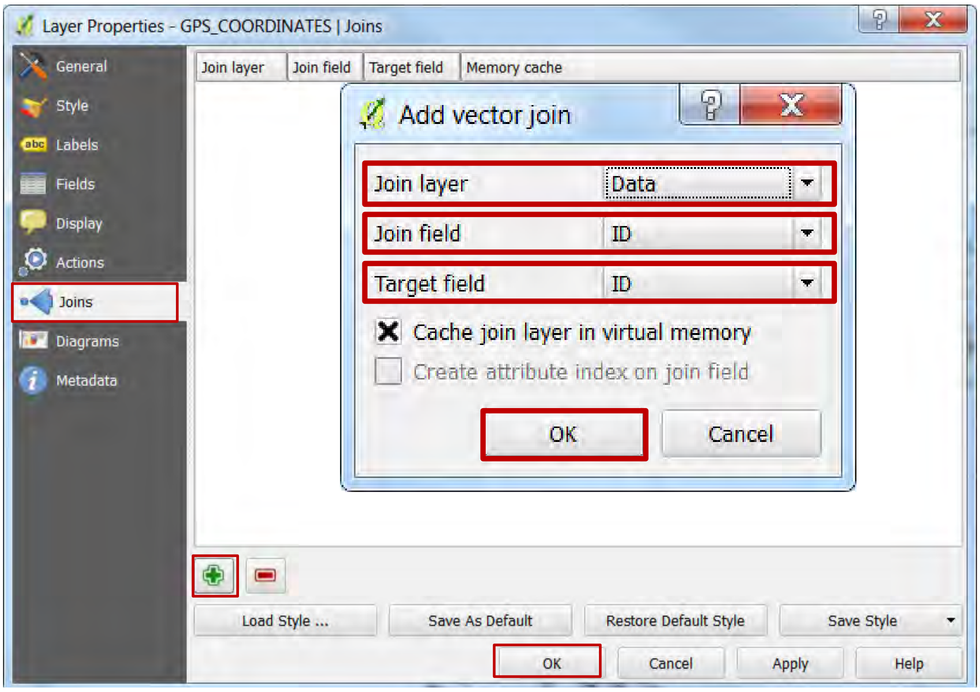
Join soil data with GPS data

Steps:

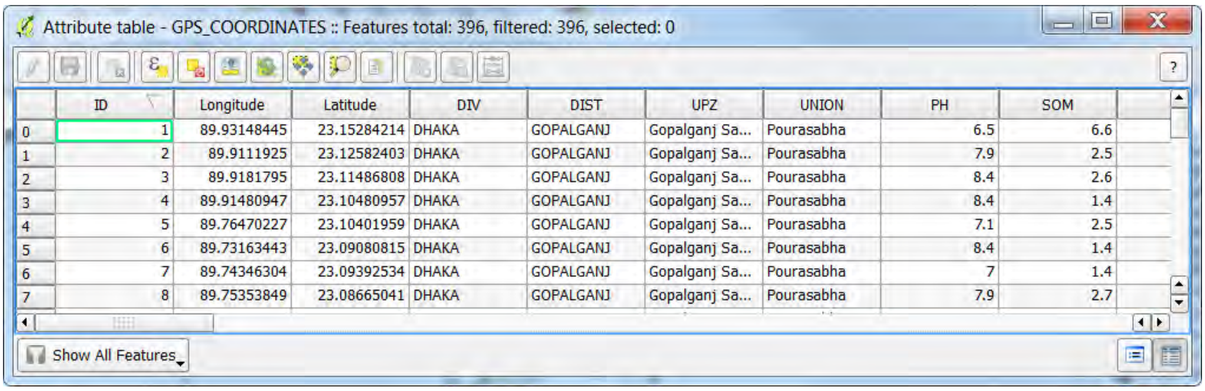
1. Right click on **GPS_COORDINATES** select **PROPERTIES-->JOINS**



2. Click **+**
3. Select **Data** as Join layer, **ID** as Join and Target field and then click OK (Add vector join windows).
4. Click OK again



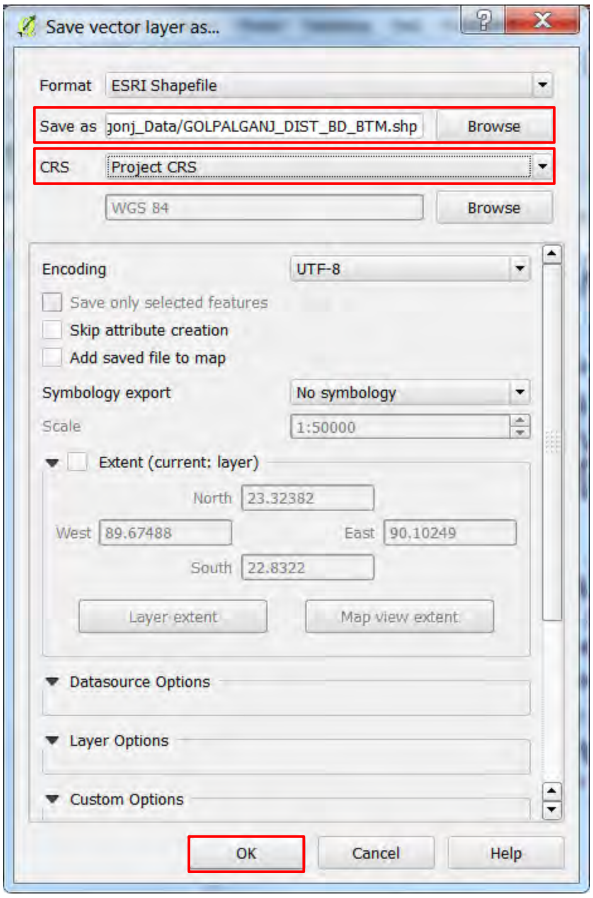
5. Right click on **GPS_COORDINATES** select**Open attribute table.** Now you can see that all of the soil data has successfully joined with layer data. Close the attribute table when completed.

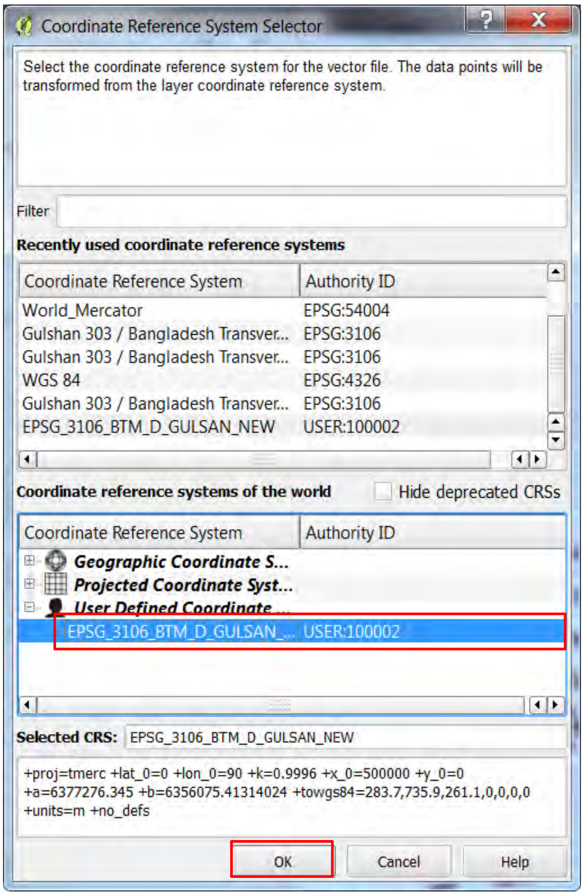


Save as GPS_CORDINATES layer file to a point shape file

1. Right click on the **GPS_COORDINATES**,thenclick **Save as.**
2. Use the '**Save as *Browse*'**option to choose ***MODULE_05\Data*** for the new layer to be saved and give the layer name as ***GOLPALGANJ_SOIL_DATA_BTM.shp***

3. In the CRS section, select **Project CRS** and then Click **Browse**
4. Scroll down in **Coordinate reference system of world section** of the **Coordinate Reference SystemSelector** window, select **EPSG_3106_BTM_D_GULSAN_NEW** from ***User defined Coordinate Systems*** (alternatively, you may locate it in the 'recently used coordinate reference systems' list).
5. Select this**,** and click **OK.**
6. Then Click **OK** again. This saves the projected shapefile with the joined attribute table data for later use.





Module 6: Working with Tabular data

In this module, you will learn:

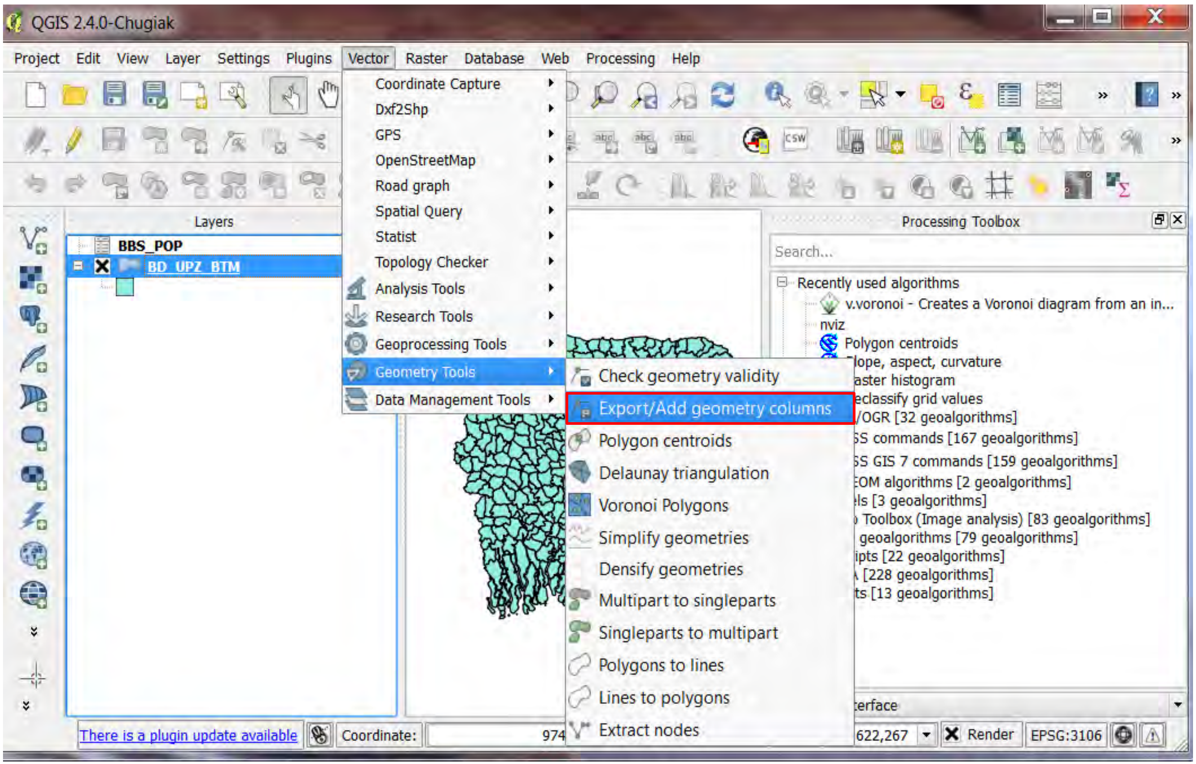
- how to calculate polygon area
- use the field calculator
- join attribute data with polygons
- generate simple statistics of a vector field
- select a polygon using an expression

Calculate Polygon Area

Before calculating polygon area, it is important to make sure your layer is in a projected coordinate system (not in latitude/longitude), and in the correct units. (i.e. If your layer's projection has 'meters' as units, your area will be square meters and hence will be incorrect). You can calculate polygon area in several ways:

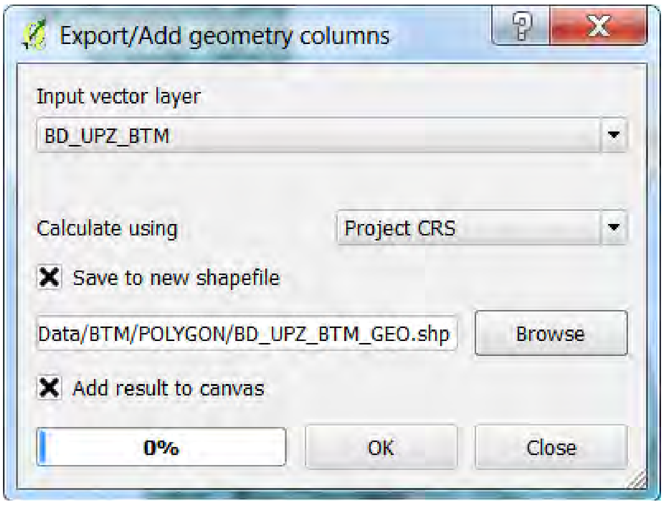
A. Using Vector-Geometry Tool:

4. First, launch **QGIS Desktop 2.4** from your desktop
5. Load ***BD_UPZ_BTM.shp***. *(~MODULE_06\Data)*
6. Click on **Vector->Geometry Tools->Export/add geometry columns**

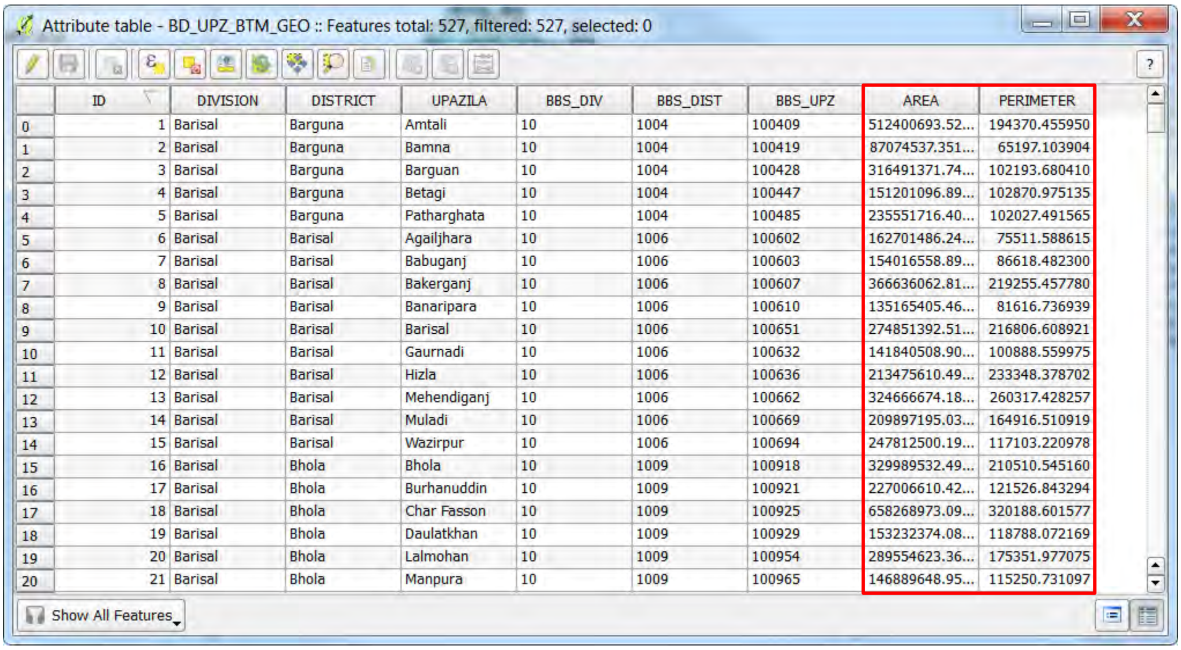


7. Select BD_UPZ_BTM layer
8. Select Project CRS in Calculating using

9. Select the Checkbox **Save to new shapefile** and **Browse** to directory *(~MODULE_06\Data and* save as **BD_UPZ_BTM_GEO.shp**
10. Select the Checkbox **Add result to canvas** and click on **OK and then Close**



11. **Looking at the attribute table, BD_UPZ_BTM_GEO** now has two addition column titles **Area** (sq.m) and **Perimeter.**


Attribute table - BD_UPZ_BTM_GEO :: Features total: 527, filtered: 527, selected: 0

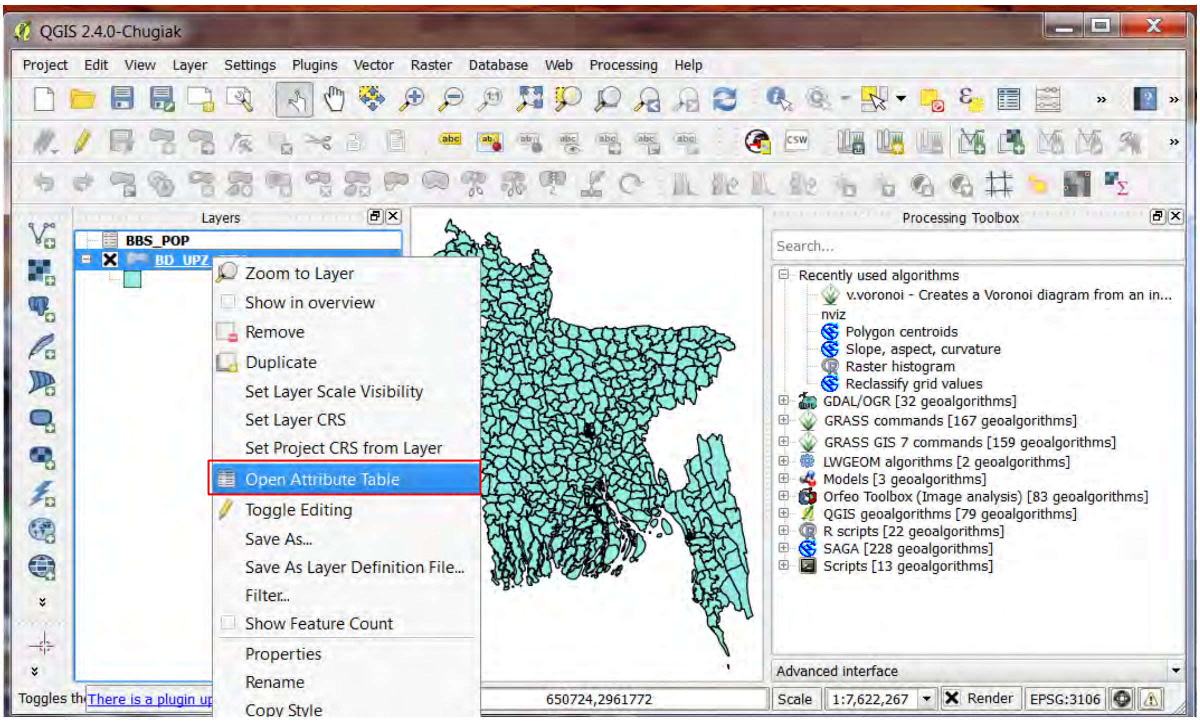
	ID	DIVISION	DISTRICT	UPAZILA	BBS_DIV	BBS_DIST	BBS_UPZ	AREA	PERIMETER
0	1	Barisal	Barguna	Amtali	10	1004	100409	512400693.52...	194370.455950
1	2	Barisal	Barguna	Bamna	10	1004	100419	87074537.351...	65197.103904
2	3	Barisal	Barguna	Barguan	10	1004	100428	316491371.74...	102193.680410
3	4	Barisal	Barguna	Betagi	10	1004	100447	151201096.89...	102870.975135
4	5	Barisal	Barguna	Patharghata	10	1004	100485	235551716.40...	102027.491565
5	6	Barisal	Barisal	Agailjhara	10	1006	100602	162701486.24...	75511.588615
6	7	Barisal	Barisal	Babuganj	10	1006	100603	154016558.89...	86618.482300
7	8	Barisal	Barisal	Bakerganj	10	1006	100607	366636062.81...	219255.457780
8	9	Barisal	Barisal	Banaripara	10	1006	100610	135165405.46...	81616.736939
9	10	Barisal	Barisal	Barisal	10	1006	100651	274851392.51...	216806.608921
10	11	Barisal	Barisal	Gaurnadi	10	1006	100632	141840508.90...	100888.559975
11	12	Barisal	Barisal	Hizla	10	1006	100636	213475610.49...	233348.378702
12	13	Barisal	Barisal	Mehendiganj	10	1006	100662	324666674.18...	260317.428257
13	14	Barisal	Barisal	Muladi	10	1006	100669	209897195.03...	164916.510919
14	15	Barisal	Barisal	Wazirpur	10	1006	100694	247812500.19...	117103.220978
15	16	Barisal	Bhola	Bhola	10	1009	100918	329989532.49...	210510.545160
16	17	Barisal	Bhola	Burhanuddin	10	1009	100921	227006610.42...	121526.843294
17	18	Barisal	Bhola	Char Fasson	10	1009	100925	658268973.09...	320188.601577
18	19	Barisal	Bhola	Daulatkhan	10	1009	100929	153232374.08...	118788.072169
19	20	Barisal	Bhola	Lalmohan	10	1009	100954	289554623.36...	175351.977075
20	21	Barisal	Bhola	Manpura	10	1009	100965	146889648.95...	115250.731097

Show All Features

B. Using Field Calculator:

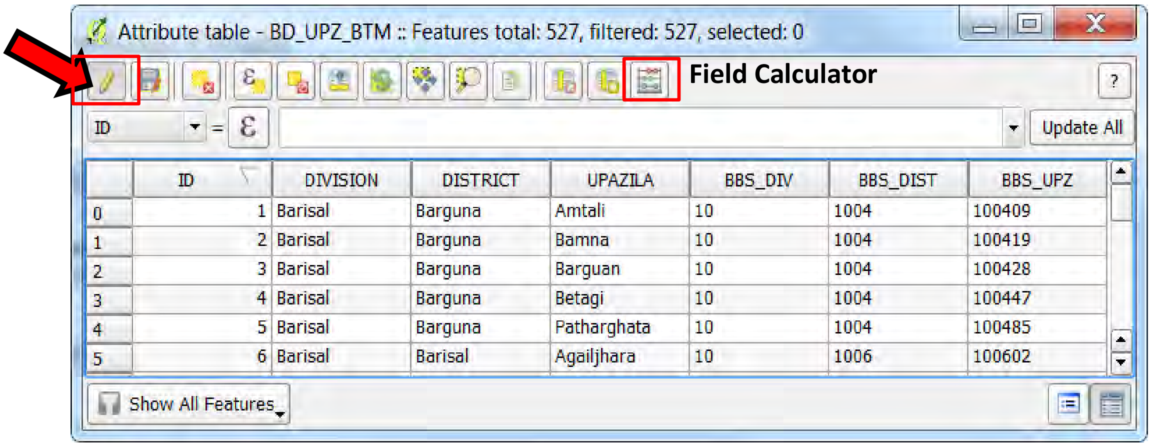
The Field calculator is a tool for automatically calculating the area of a polygon where the expression is $area and add a new column in the attribute table of the original layer.

1. If you have not already done so, right click on *BD_UPZ_BTM.shp*, select Open Attribute Table



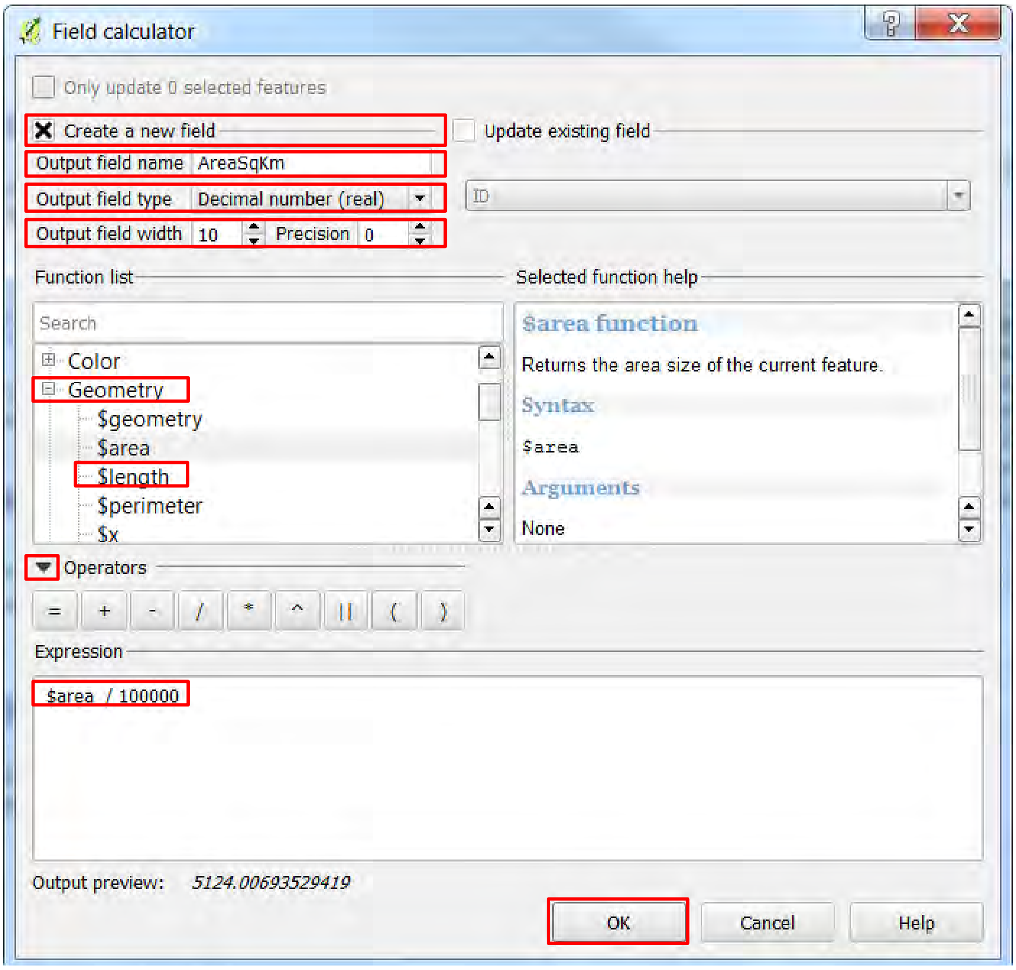
2. Click **Toggle editing mode** and then **Open Field Calculator** (Note: Field Calculator is only activated in editing mode)

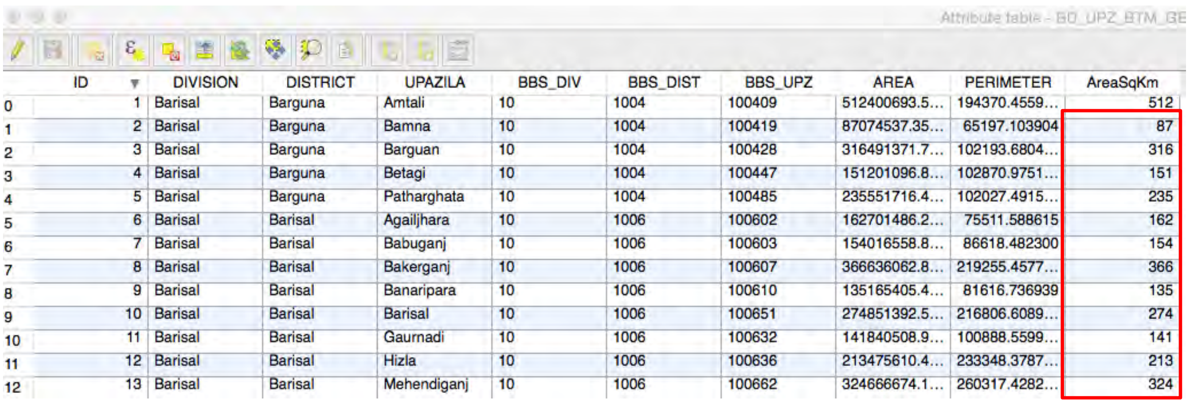
Toggle editing mode



3. In Field calculator, window select the Checkbox Create a new field
4. Type 'AreaSqKm' in Output field Name and select 'Decimal number (real)' in the Output field type

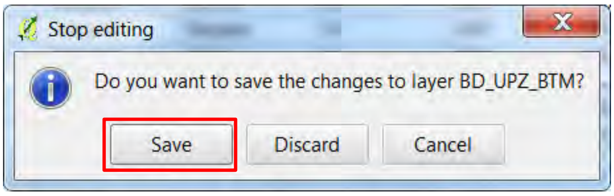
5. From the Function list select Geometry-> $area and double click it
6. In Expression windows, divide $area by 1000000 (the number of meters in a km^2) and then click OK.
7. A new field named AreaSqKm will be created in attribute table of existing BD_UPZ_BTM layer.





	ID	DIVISION	DISTRICT	UPAZILA	BBS_DIV	BBS_DIST	BBS_UPZ	AREA	PERIMETER	AreaSqKm
0	1	Barisal	Barguna	Amtali	10	1004	100409	512400693.5...	194370.4559...	512
1	2	Barisal	Barguna	Bamna	10	1004	100419	87074537.35...	65197.103904	87
2	3	Barisal	Barguna	Barguan	10	1004	100428	316491371.7...	102193.6804...	316
3	4	Barisal	Barguna	Betagi	10	1004	100447	151201096.8...	102870.9751...	151
4	5	Barisal	Barguna	Patharghata	10	1004	100485	235551716.4...	102027.4915...	235
5	6	Barisal	Barisal	Agailjhara	10	1006	100602	162701486.2...	75511.588615	162
6	7	Barisal	Barisal	Babuganj	10	1006	100603	154016558.8...	86618.482300	154
7	8	Barisal	Barisal	Bakerganj	10	1006	100607	366636062.8...	219255.4577...	366
8	9	Barisal	Barisal	Banaripara	10	1006	100610	135165405.4...	81616.736939	135
9	10	Barisal	Barisal	Barisal	10	1006	100651	274851392.5...	216806.6089...	274
10	11	Barisal	Barisal	Gaurnadi	10	1006	100632	141840508.9...	100888.5599...	141
11	12	Barisal	Barisal	Hizla	10	1006	100636	213475610.4...	233348.3787...	213
12	13	Barisal	Barisal	Mehendiganj	10	1006	100662	324666674.1...	260317.4282...	324

8. Finally, click Toggle editing mode again and save your work. These data can be used for a number of subsequent analyses

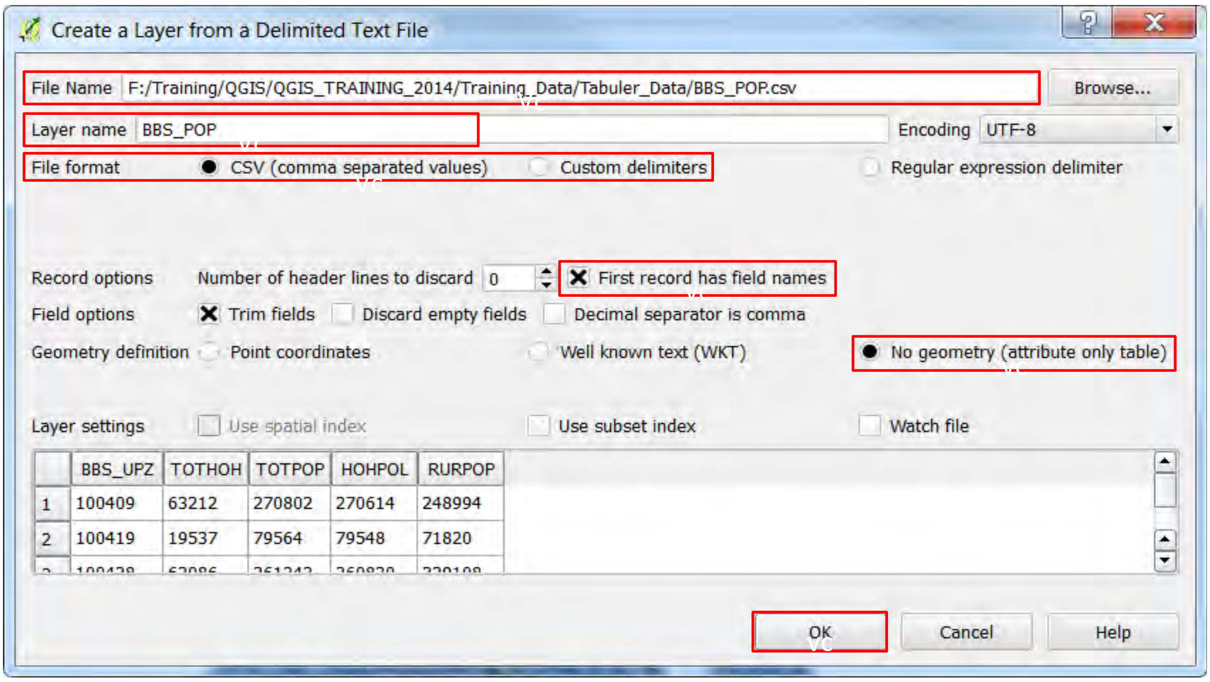


Calculate Population Density using Field Calculator

Load Census Population data

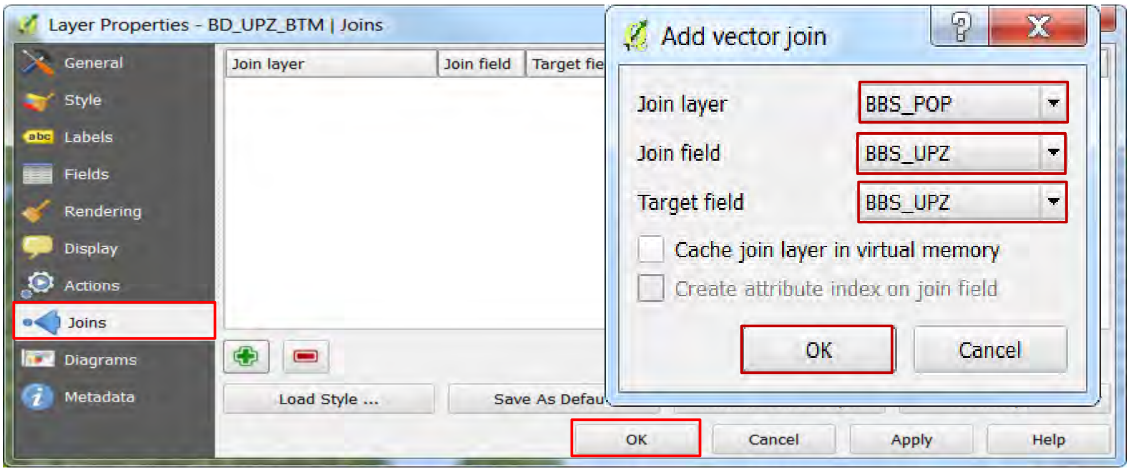
In this section, we will show you how to join Census population data with upazila shape file using a common field (BBS_UPZ). First, we have to load BBS_ POP.csv file in QGIS.

1. Click **Add Delimited Text** Icon
2. or Click **Layer** on Menu bar and then **Add Delimited Text**
3. Click browse and select **BBS_POP.csv** from **~MODULE_06\Data** directory
4. Select Checkbox **First record has field name** (default)
5. Check **Geometry definition: No geometry (attribute only table)**
6. Click **OK**
7. The **population data** will appear on layer



Join Census Population data with Upazila Layer

1. Right click on **BD_UPZ_BTM** select **Properties->Joins**
2. Click **+**, select BBS_UPZ as Join and Target field. Do not alter the BBS_POP join layer field. Then click OK to exit, and ok again to exit the layer properties.

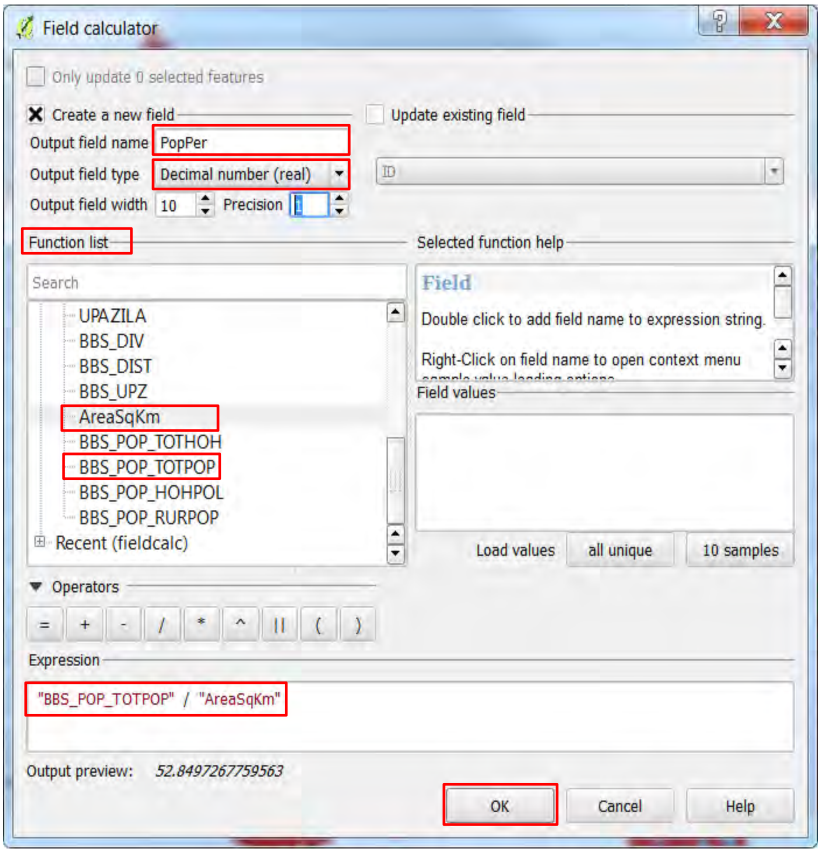


Calculate Population Density

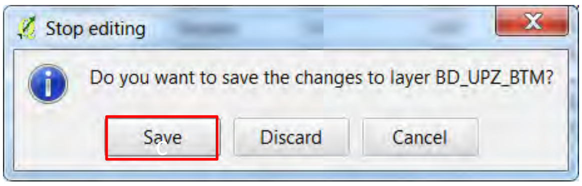
In this section, we calculate population density per square kilometer using total upazila population divided by upazila area.

1. Right click on *BD_UPZ_BTM.shp*, select Open Attribute Table
2. Click **Toggle editing mode** and then **Open Field Calculator** (Note: Field Calculator is only activated in editing mode)
3. In the Field calculator window select the Checkbox Create a new field
4. Type **PerPop** in Output field Name and select Decimal number (real) in Output field type and Precision 1.
5. From Function list select Fields and values
6. Divide "**BBS_ POP_TOTPOP**" by "**AreaSqKm**" in Expression windows

7. Then, click OK

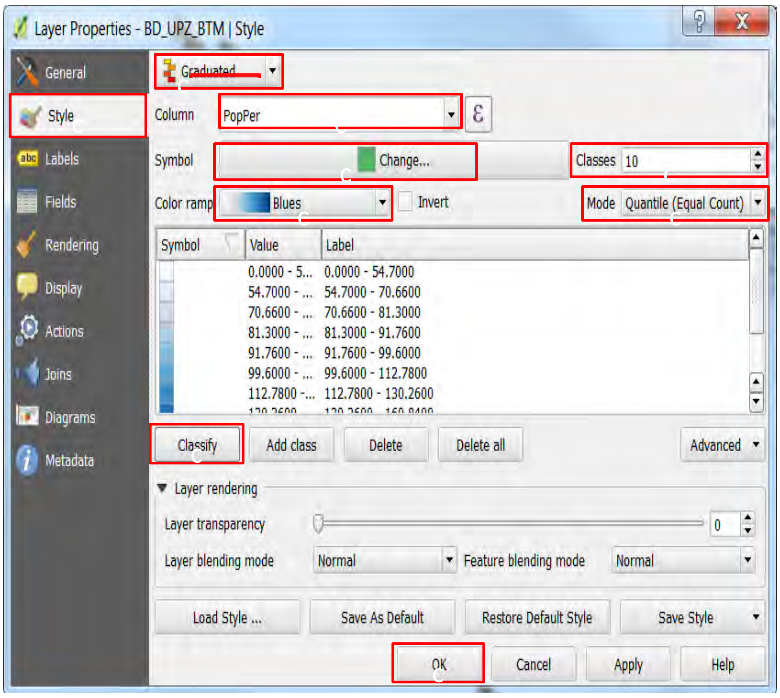


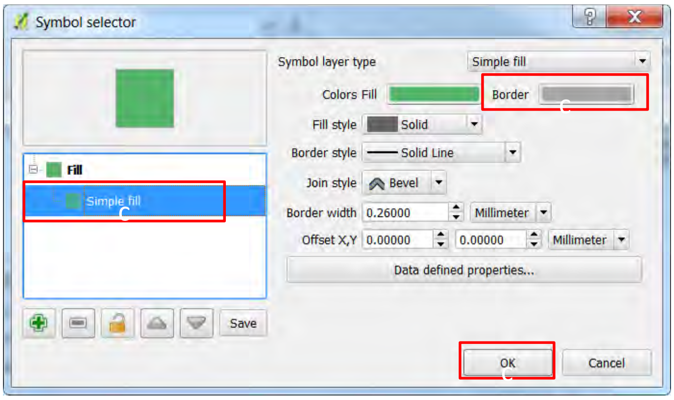
9. Finally, click Toggle editing mode again and save your work.

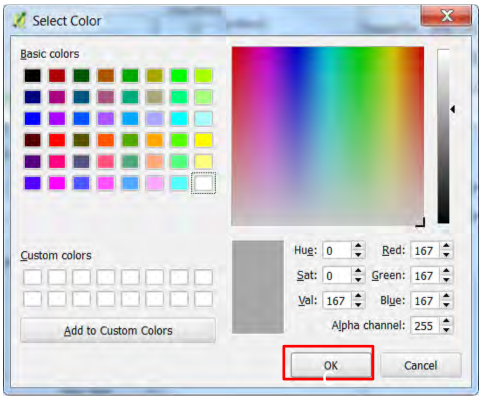


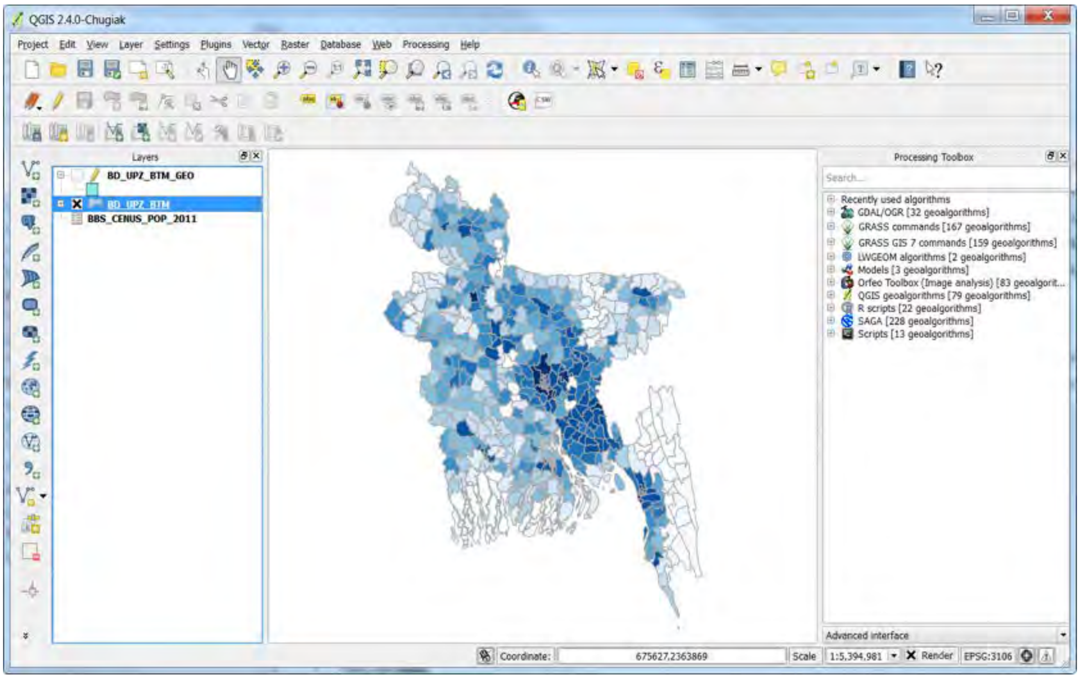
Visualization of Population Density

1. Right-click on ***BD_UPZ_BTM.shp***and select **PROPERTIES --> STYLE.**
2. Change Single symbol to Graduate symbol.
3. Select Colum "PerPop"
4. Click Symbol: Change
5. From Popup-windows, select Border color light grey
6. Click OK
7. Select Color ramp Blue
8. Choose Classes 10 and Mode Quantile
9. Click Classify and then OK


Layer Properties - BD_UPZ_BTM | Style
General
Style
Labels
Fields
Rendering
Display
Actions
Joins
Diagrams
Metadata
Graduated
Column
PopPer
Symbol
Change...
Classes
10
Color ramp
Blues
Invert
Mode
Quantile (Equal Count)
Symbol
Value
Label
0.0000 - 54.7000
54.7000 - 70.6600
70.6600 - 81.3000
81.3000 - 91.7600
91.7600 - 99.6000
99.6000 - 112.7800
112.7800 - 130.2600
Classify
Add class
Delete
Delete all
Advanced
Layer rendering
Layer transparency
Layer blending mode
Normal
Feature blending mode
Normal
Load Style ...
Save As Default
Restore Default Style
Save Style
OK
Cancel
Apply
Help


Symbol selector
Fill
Simple fill
Save
Symbol layer type
Simple fill
Colors Fill
Border
Fill style
Solid
Border style
Solid Line
Join style
Bevel
Border width
0.26000
Millimeter
Offset X,Y
0.00000
0.00000
Millimeter
Data defined properties...
OK
Cancel


Select Color
Basic colors
Custom colors
Add to Custom Colors
Hue:
0
Sat:
0
Val:
167
Red:
167
Green:
167
Blue:
167
Alpha channel:
255
OK
Cancel



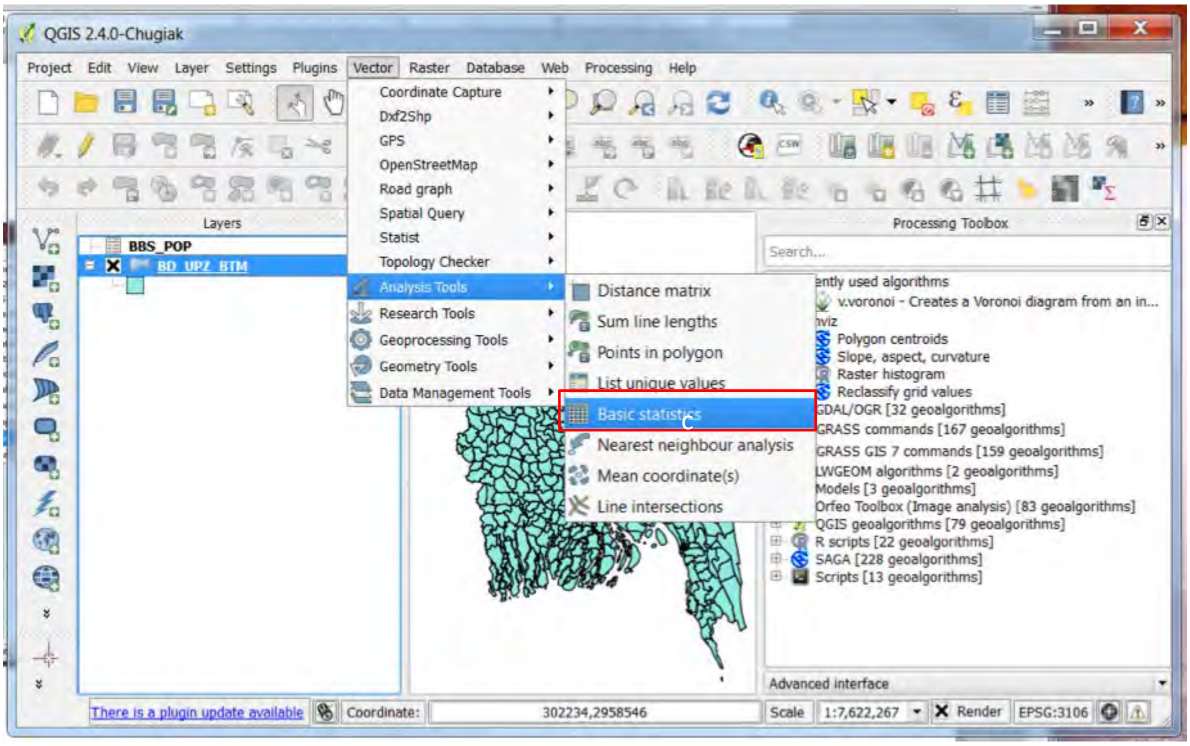
Selecting Area by Expression

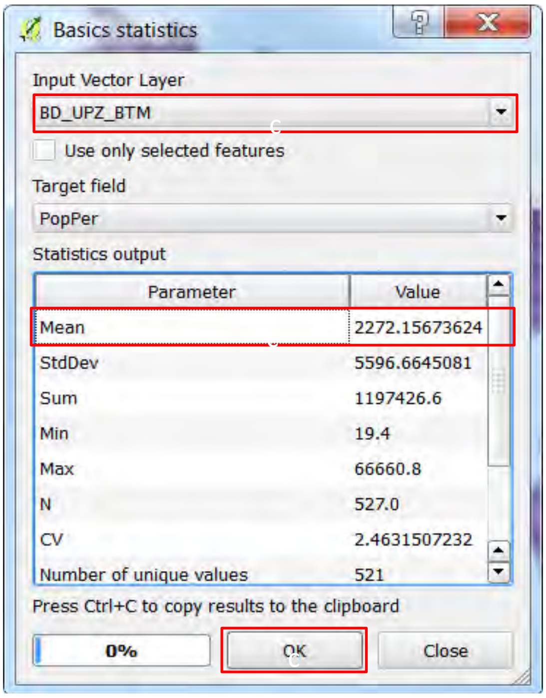
In this section, we will show how to select upazila or thanas where population densities are equal or higher than the country mean population density. First, we have to calculate simple statistics of population density. In QGIS, we can calculate statistics of a field in different ways:

Simple Statistics of a Vector Field

Option 1:

1. Select VECTOR-->ANALYSIS TOOL> BASICS STATISTICS
2. Select BD_UPZ_BTM as Input Vector Layer
3. PerPop as Target field
4. Select OK

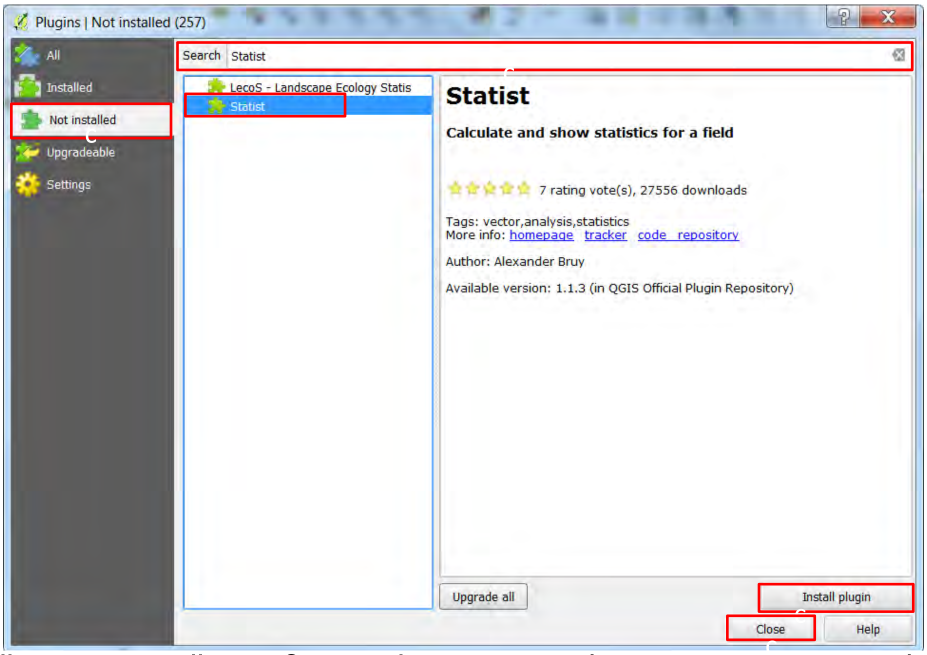

QGIS 2.4.0-Chugiak
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Coordinate Capture
Dxf2Shp
GPS
OpenStreetMap
Road graph
Spatial Query
Statist
Topology Checker
Analysis Tools
Research Tools
Geoprocessing Tools
Geometry Tools
Data Management Tools
Distance matrix
Sum line lengths
Points in polygon
List unique values
Basic statistics
Nearest neighbour analysis
Mean coordinate(s)
Line intersections
Layers
BBS_POP
BD_UPZ_BTM
Processing Toolbox
Search...
Advanced interface
There is a plugin update available
Coordinate: 302234,2958546
Scale 1:7,622,267
Render
EPSG:3106


Basics statistics
Input Vector Layer
BD_UPZ_BTM
Use only selected features
Target field
PopPer
Statistics output
Parameter
Value
Mean 2272.15673624
StdDev 5596.6645081
Sum 1197426.6
Min 19.4
Max 66660.8
N 527.0
CV 2.4631507232
Number of unique values 521
Press Ctrl+C to copy results to the clipboard
0%
OK
Close

Option 2:

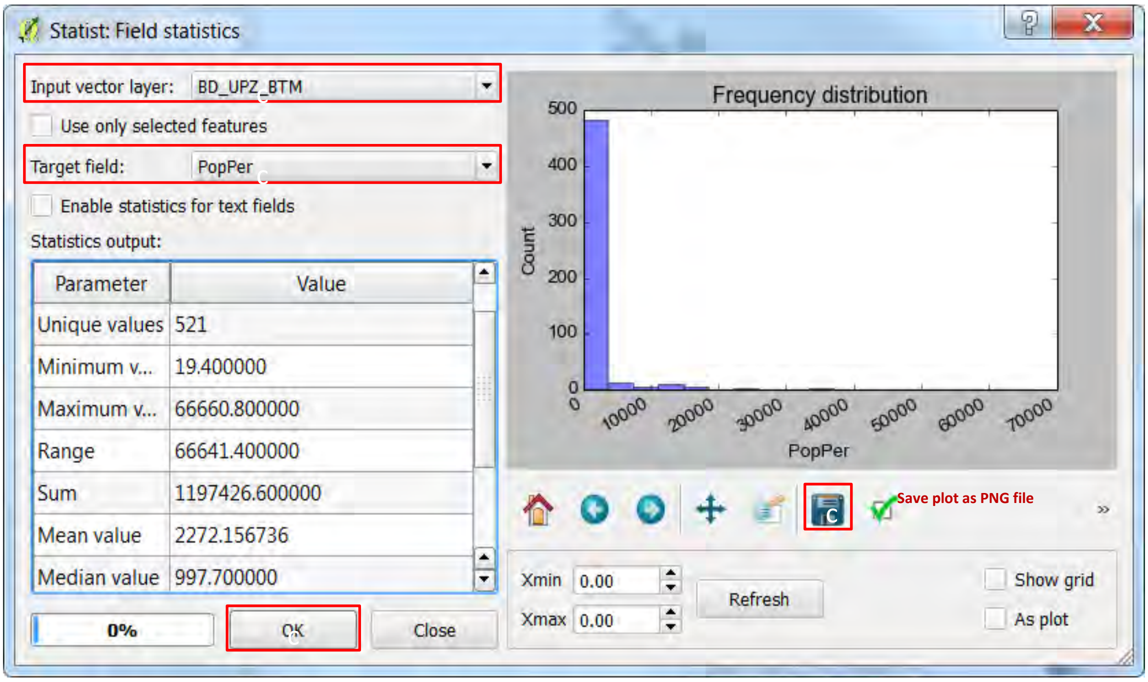
We can calculate simple statistics and histogram of a field of a vector layer using "Statist" plugin. If "Statist" has not been installed yet, you have to install it in QGIS first. (*Important: your computer must be connected with internet for installation of any QGIS plugin*)

1. Select PLUGINS-->MANAGE AND INSTALL PLUGINS→NOT INSTALLED
2. Type "**Statist**" in **search bar**
3. Select **Statist** and click Install plugin
4. After installation, click Close.



After installation, we will use Statist plugin to get descriptive statistics and frequency distribution of population density data.

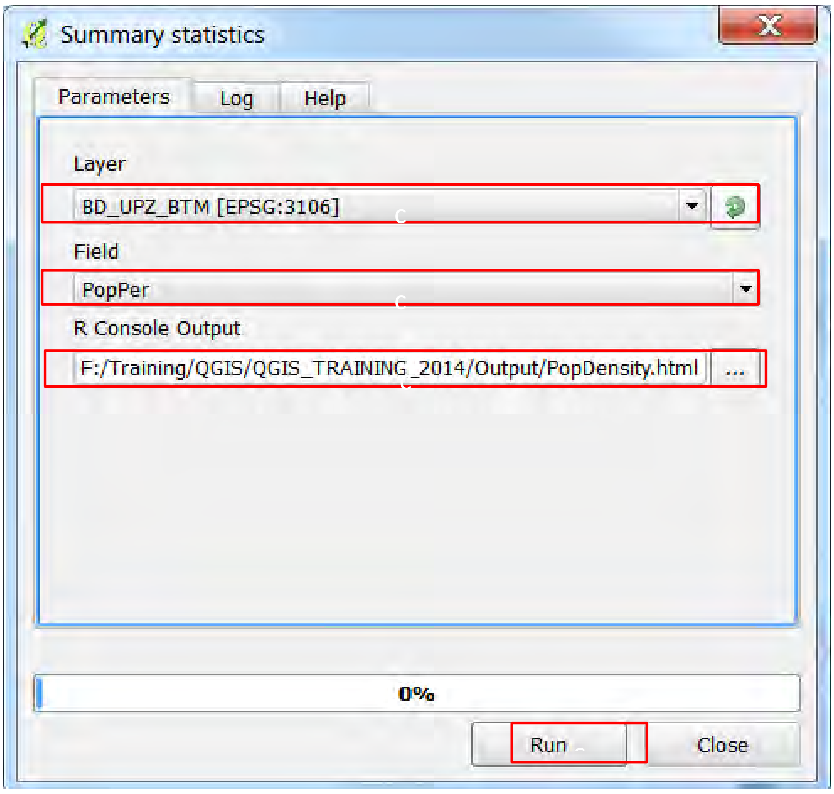
1. Select VECTOR-->STATIST→STATIST
2. Select **BF_UPZ_BTM** as Input vector layer
3. PopPer as Target field and check Show grid
4. Click OK and then, Close
5. We can save histogram as PNG file in your output directory.

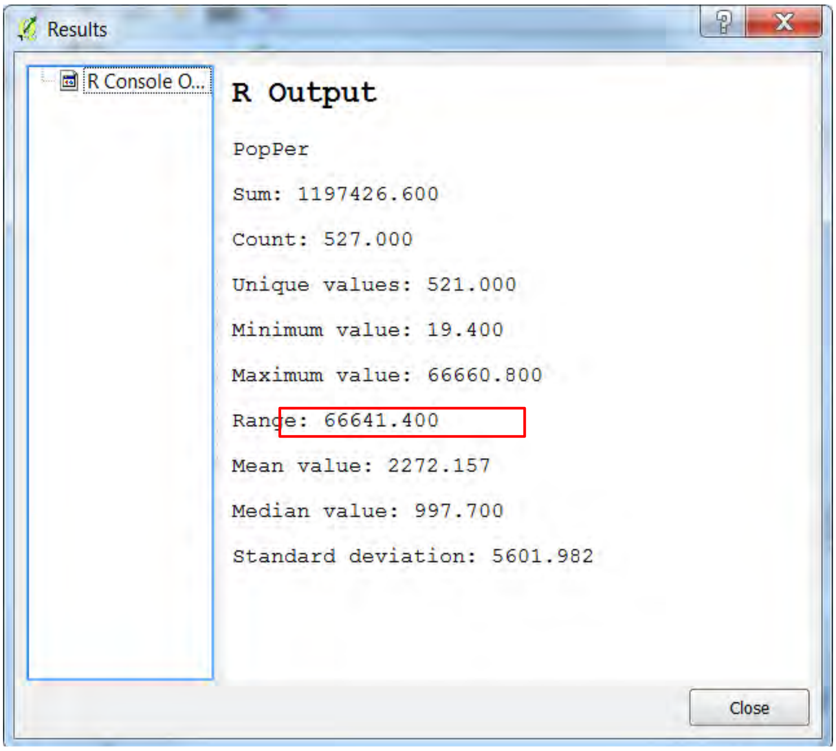


Option 3:

We can use **R-Script** in QGIS to calculate simple statistics of population density data.

1. In the **Processing** → **Toolbox**, select R-scripts -->Basic statistics →Summary statistics
2. In Summary Statistics window, select BD_UPZ_BTM as a Layer and PopPer as a Field
3. Click Run and R output will be showed in Result window.



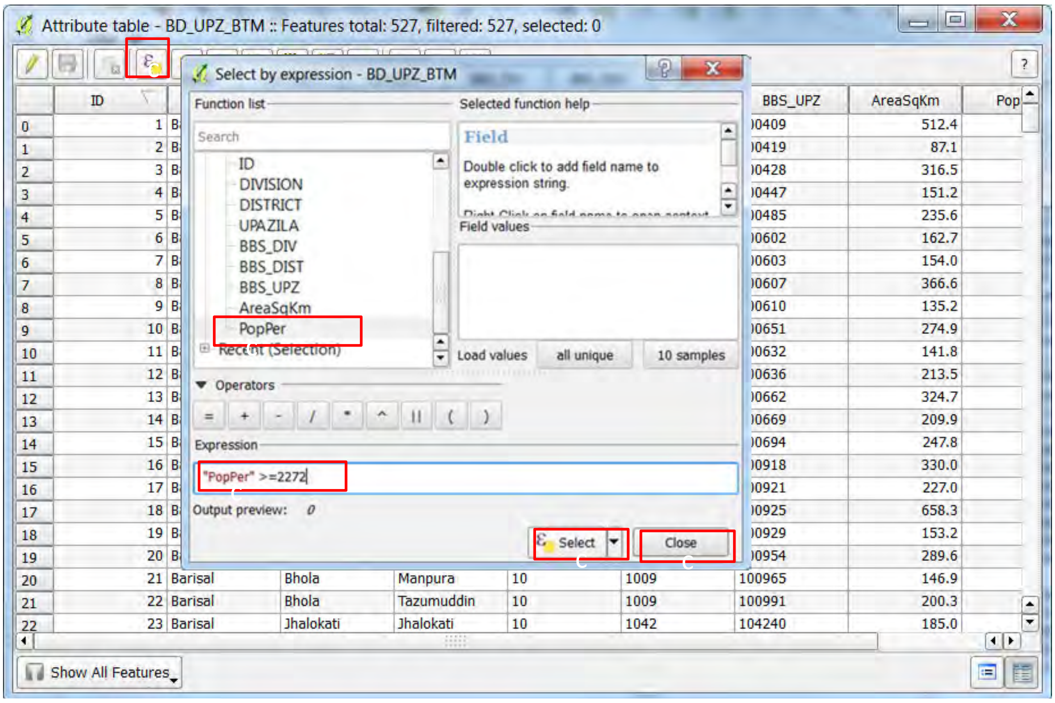


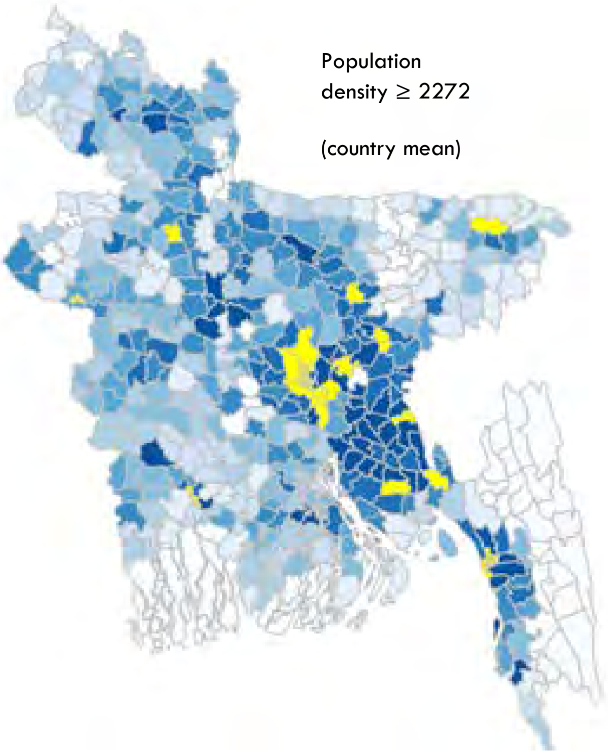
Select Polygon using Expression

In this section, we will learn how to use Expressions to select upazila (sub-districts) where population density is higher than the country mean (2,272 people/sq. Km).

1. Right click on ***BD_UPZ_BTM.shp***, select Open Attribute Table
2. Click Select by expression
3. From the Function list, select Fields and Values
4. Double click PerPop, type >=2272 in **Expression** window and
5. Click Select and then, click Close.
6. The newly assigned yellow color in the map shows the upazilas where population density is equal or greater than the country mean.

Select by expression

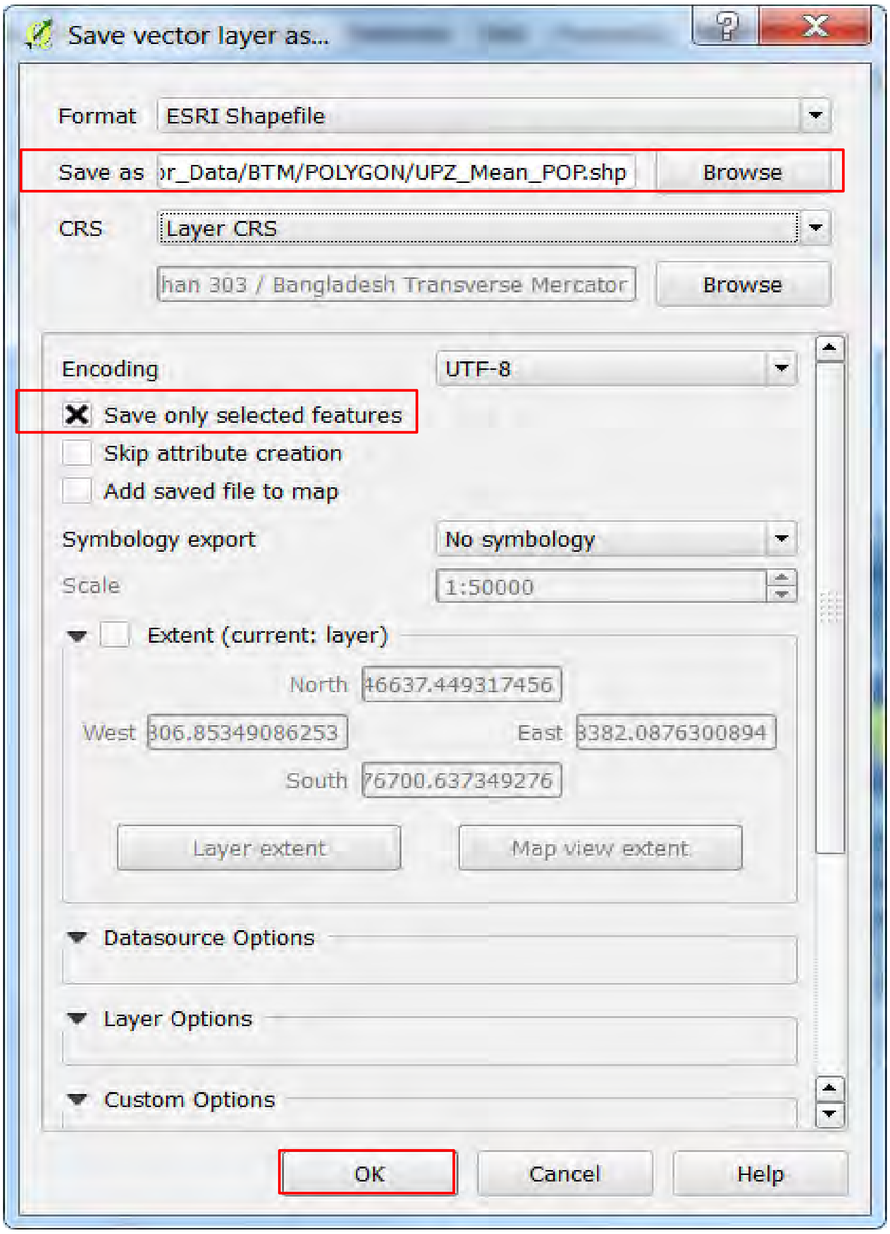




Population density ≥ 2272

(country mean)

7. We can save these selected upazila as a new shape file. Just right click on ***BD_UPZ_BTM.shp***, select Save As. In **Save vector layer windows**, **Browse to** destination location and check Save only selected features and then click OK.



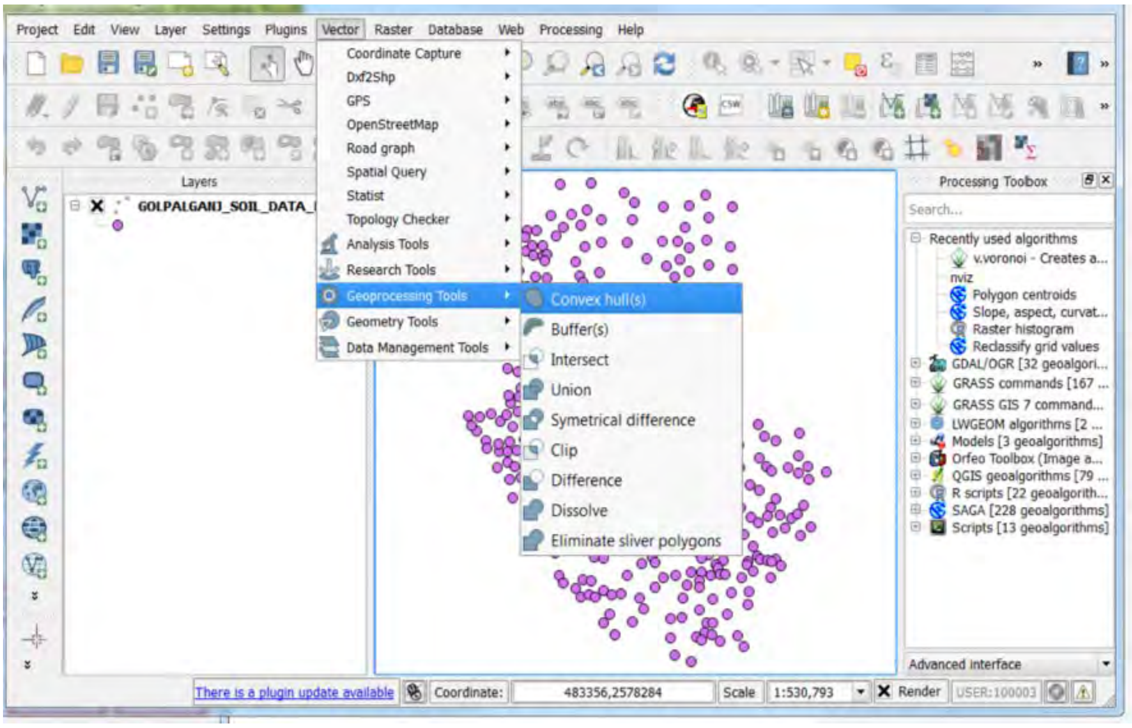
Module 7: Working with Vector Data

In this module, we will show some important techniques for vector data geoprocessing and analysis tools in QGIS.

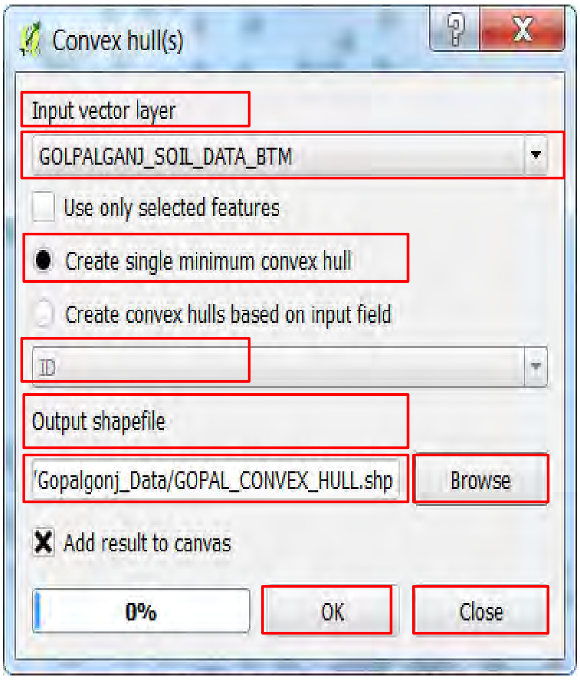
Convex Hull

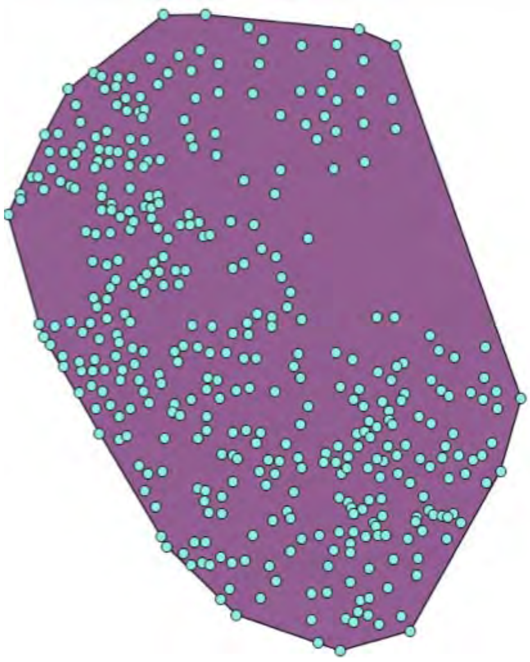
A **convex hull** takes the outer border nodes from a vector shape (which you will recall may consist of points, lines or polygons) and uses them to develop a polygon of the minimum sized area that surrounds all features in the dataset, but that also avoids any concave angles. Below, we will use SRDI soil sampling point (***GOLPALGANJ_SOIL_DATA_BTM***) data from Gopalganj district to create a convex hullusing geoprocessing tools.

8. Click **Add Vector Layer** Icon
9. Select **File** from Source Type, and then select Encoding UTF-8 from the popup menu
10. Then click browse and select ***GOLPALGANJ_SOIL_DATA_BTM.shp*** file *(~MODULE_07\Data)*
11. Then click **Open**
12. Click **Vector -> Geoprocessing Tools -> Convex hull (s)**



13. Check Create single minimum convex hull
14. Browse to the directory *(~MODULE_07\Data) and* save as *GOPAL_CONVEX_HULL.shp*
15. Click Add result to canvas (if not already clicked)
16. Click OK and Close



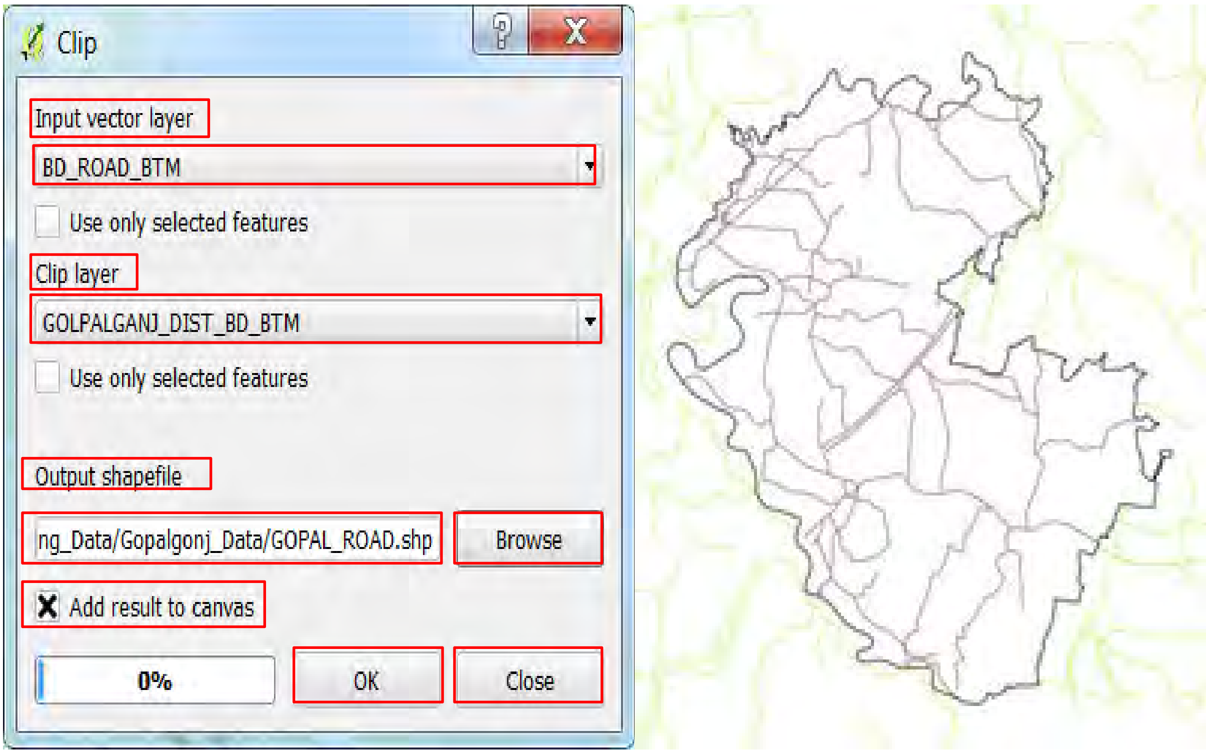


Clipping

Clipping creates a new shape that is based on the area of the input layer, but that is overlapped by a clipping layer. This is similar to the process of intersecting layers, but differs because the attributes of the chosen layer are copied only to the new shape. Below, we will use Gopalganj district boundary to clip road network polylines, inundation class land type polygons, and BGS groundwater arsenic point data.

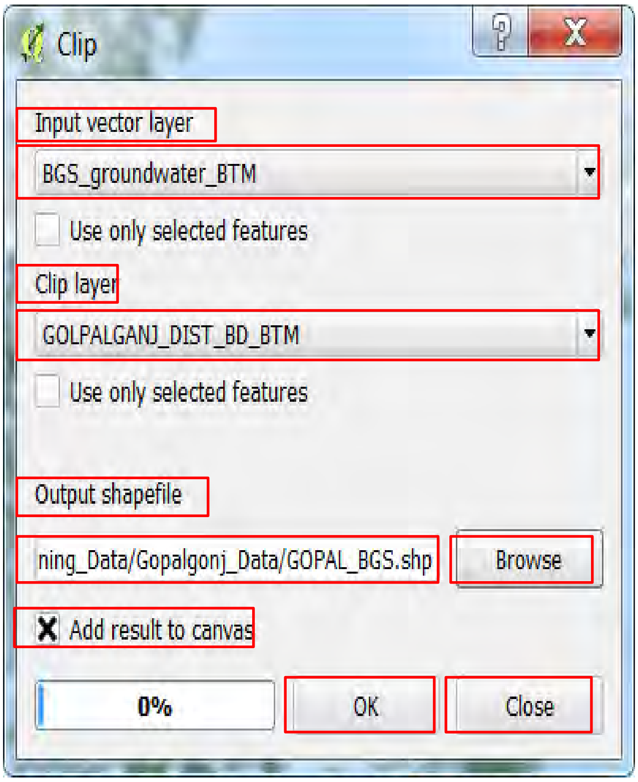
Polyline

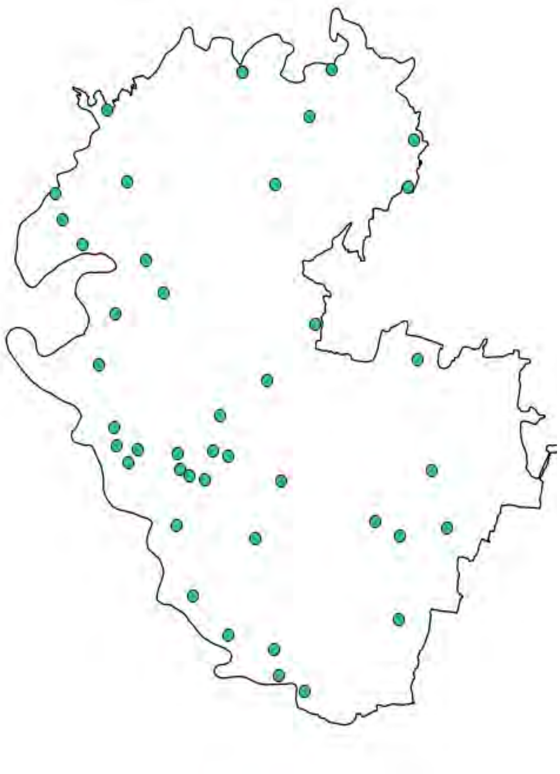
1. First, load GOPALGANJ_***DIST_BD_BTM.shp***and***BD_ROAD_BTM.shp****(~MODULE_07\Data) files* in QGIS canvas.
2. Click **Vector -> Geoprocessing Tools -> CLIP**
3. Select **BD_ROAD_BTM** as an Input vector layer and ***GOPALGANJ_DIST_BD_BTM*** as aClip layer
4. Check **Add result to canvas**
5. **Browse** to the directory *(~MODULE_07\Data)* *and then* save as **GOPAL_ROAD.shp**
6. Click OK and Close.



Point layer

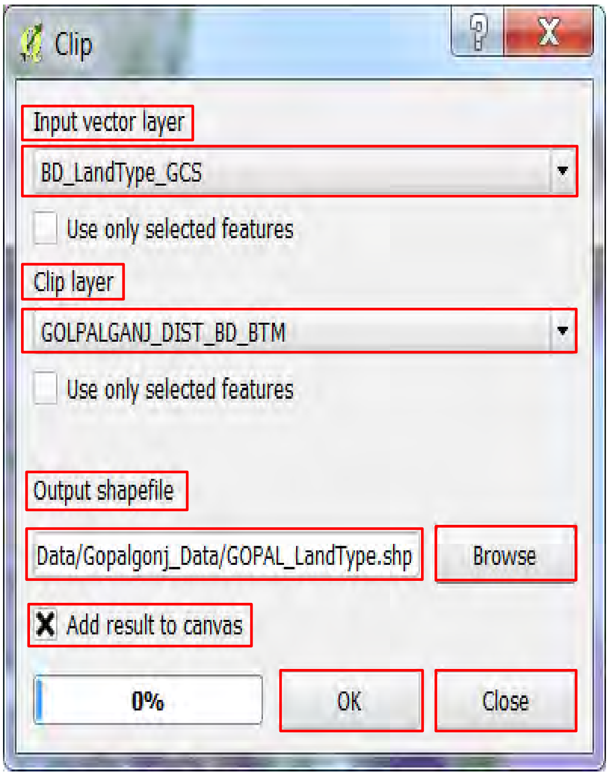
1. Load GOPALGANJ_***DIST_BD_BTM.shp*** and ***BGS_groundwater_BTM.shp*** *(~MODULE_07\Data)* files in QGIS canvas.
2. Click **Vector -> Geoprocessing Tools -> CLIP**
3. Select ***BGS_groundwater_BTM*** as a Input vector layer and ***GOPALGANJ_DIST_BD_BTM*** as a Clip layer
4. Check **Add result to canvas**
5. **Browse** to the directory *(~MODULE_07\Data)* and save as ***GOPAL_BGS.shp***
6. Click OK and Close

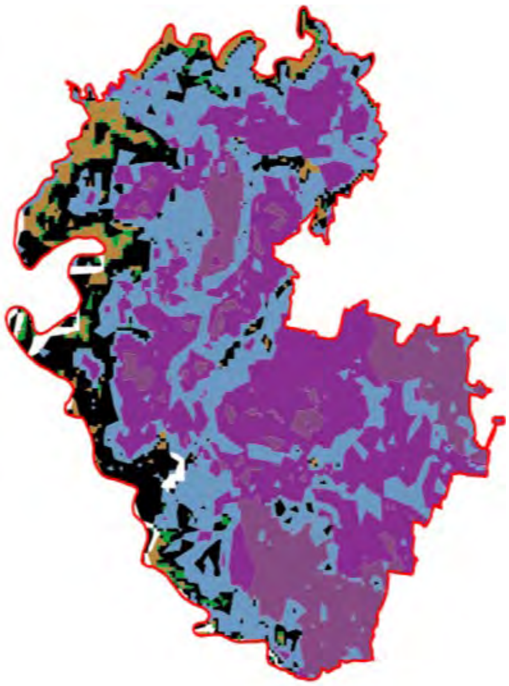




Polygons

1. Load GOPALGANJ_***DIST_BD_BTM.shp*** and ***BD_Lantype_BTM.shp*** *(~MODULE_07\Data)* files in QGIS canvas.
2. Click **Vector -> Geoprocessing Tools -> CLIP**
3. Select ***BD_Landtpe_BTM*** as a Input vector layer and ***GOPALGANJ_DIST_BD_BTM*** as a Clip layer
4. Check **Add result to canvas**
5. **Browse** to the directory *(~MODULE_07\Data***)*** and save as ***GOPAL_LandType.shp***
6. Click OK (it will take several minutes to process all data and complete this work) and then, click Close.



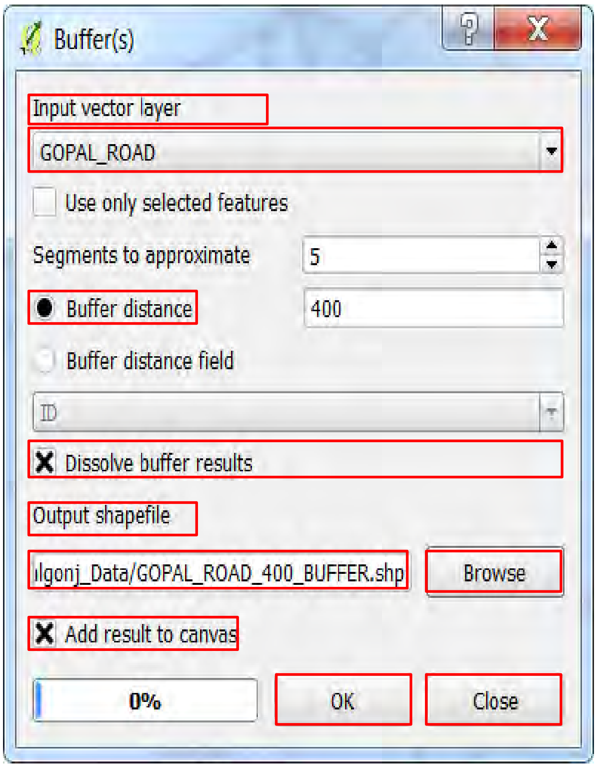


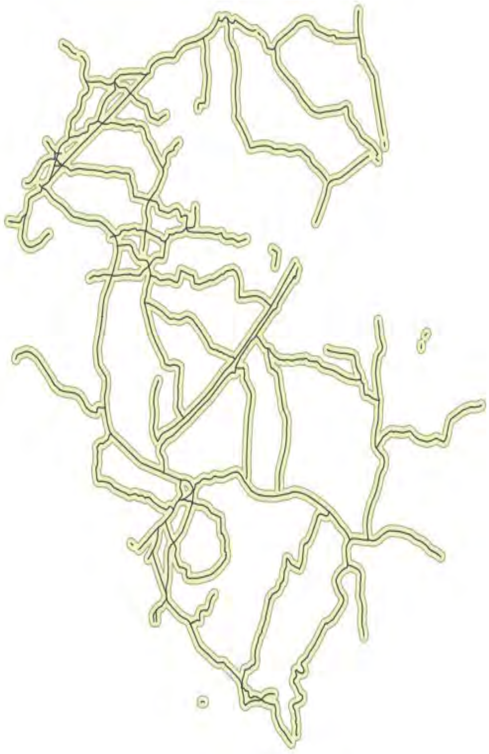
Buffer

Buffering creates an envelope of space around selected features in source layer or file. For this reason, buffers are sometimes referred to as a zone of a specified distance around a polygon, line, or point features. Buffering is often used for proximity analysis. In this section, we will create 400 m buffer zones around the road network and BGS sampling points of Gopalganj district. Such a buffer could be used later on to examine the extent of farmland or sampling points within the buffer, etc. This activity thus has many uses for spatial quantification and data analysis.

Buffering of Polylines

1. Load GOPAL_***ROAD.shp*** file (*~MODULE_07\Data)* in QGIS canvas.
2. Click Vector -> Geoprocessing Tools -> Buffer (S)
3. Select ***GOPAL_ROAD*** as a Input vector layer
4. **400** m as Buffer distance
5. Check Dissolve buffer results and Add result to canvas
6. Browse to the directory *(~MODULE_07\Data)* and save as ***GOPAL_ROAD_400_BUFFER.shp***





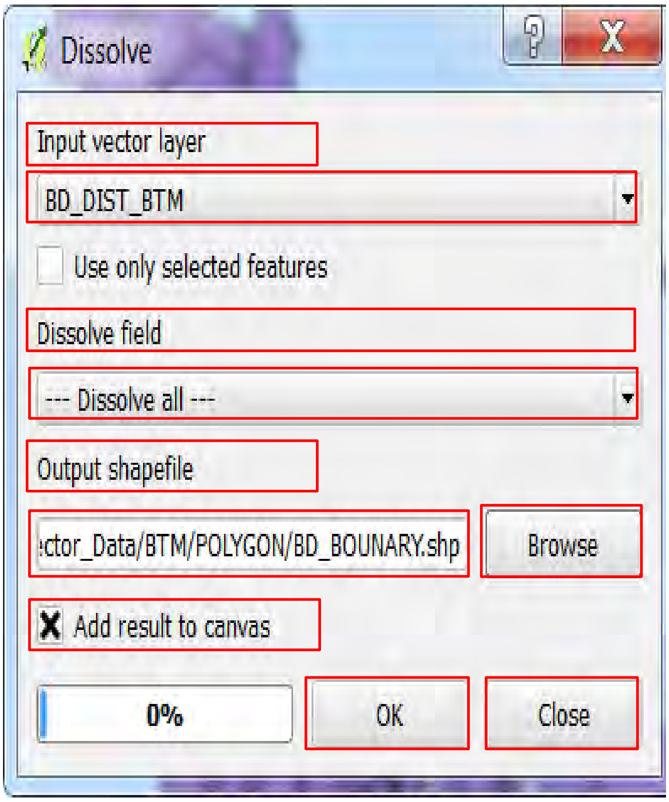
Buffering of Point layers

1. Load GOPAL_***ROAD.shp*** file (*~MODULE_01\Data)* in QGIS canvas.
2. Click Vector -> Geoprocessing Tools -> Buffer (S)
3. Select ***GOPAL_BGS*** as a Input vector layer
4. **400** m as Buffer distance
5. Check Dissolve buffer results and Add result to canvas
6. Browse to the directory *(~MODULE_07\Data)* and save as ***GOPAL_BGS_400_BUFFER.shp***

Dissolve

Dissolve separates overlapping areas in the same layer. Here, we will use a district shape file to create a country boundary shape file after dissolving boundary all districts.

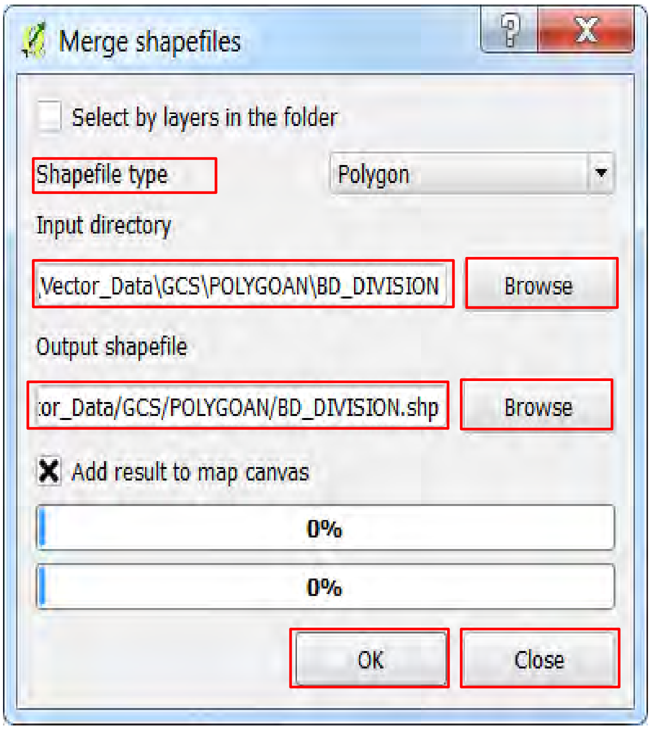
1. Load ***BD_DIST_BTM.shp*** file *(MODULE_07\Data)* in QGIS canvas.
2. Click Vector -> Geoprocessing Tools -> Dissolve
3. Select ***BD_DIST_BTM*** as a Input vector layer
4. Select ***Dissolve all*** in Dissolve field
5. Check Add result to canvas
6. Browse to the directory *(~MODULE_07\Data\)* and *then* save as ***BD_BOUNDARY_BTM.shp***
7. Click OK and Close.



Merge shapefiles

Here, you will learn how to merge multiple shape files to create a single shapefile. We will use layers from seven divisions of Bangladesh to create the single layer file.

1. Click Vector -> Data Management Tools -> Merge shapefiles to one
2. Select ***Polygon*** as Shapefile type
3. Browse and select Input directory folder *~MODULE_07\Data\\BD_DIVISION*
4. Browse to the directory folder *(~MODULE_07\Data)*and save as ***BD_DIV_GCS.shp.***
5. Click Add result to canvass, then OK and then, close. Note that you may need to accept each layer by clicking OK again if additional windows appear.



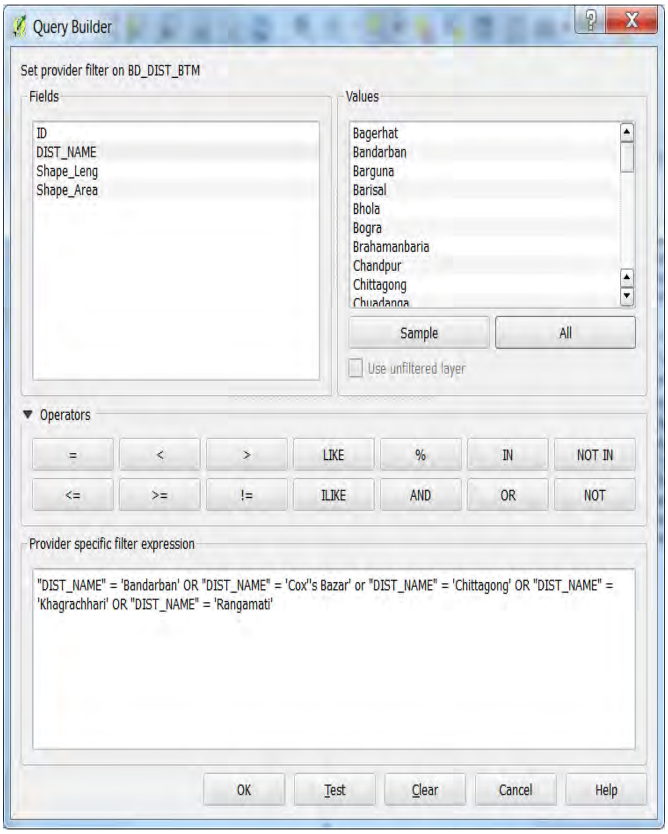
Using Query Builder to Select Areas

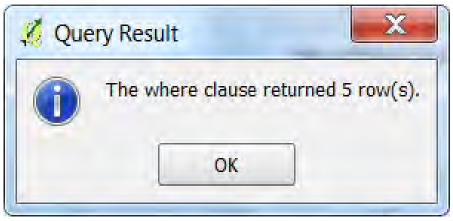
In this section, we will create a shape of the hilly districts using Query Builder. This is a useful process that can be later employed to sort spatial data according to queries that you can build (e.g., to show areas larger or smaller than a specified number or by capturing specified data).

1. Load ***BD_DIST_BTM.shp*** file *(~MODULE_07\Data)* in QGIS canvas.
2. Right click on ***BD_DIST_BTM*** and select Filter
3. In the Fields form, select***DIST_NAME*** and double click on it, and it should appear in the Expression form.
4. Click All in Values form and all district names should appear in the values form.
5. Then, click once on the operator button "=", and double click on'Bandarban' and then click "OR" .
6. Double click ***DIST_NAME*** and click " =", click **'Cox's Bazar'**.
7. Repeat steps 4-5 for ***Chittagong, Khagrachhari, and Rangamati***districts. The final expression should look as follows:

> *"DIST_NAME" = 'Bandarban' OR "DIST_NAME" = 'Cox''s Bazar' or "DIST_NAME" = 'Chittagong' OR "DIST_NAME" = 'Khagrachhari' OR "DIST_NAME" = 'Rangamati'*

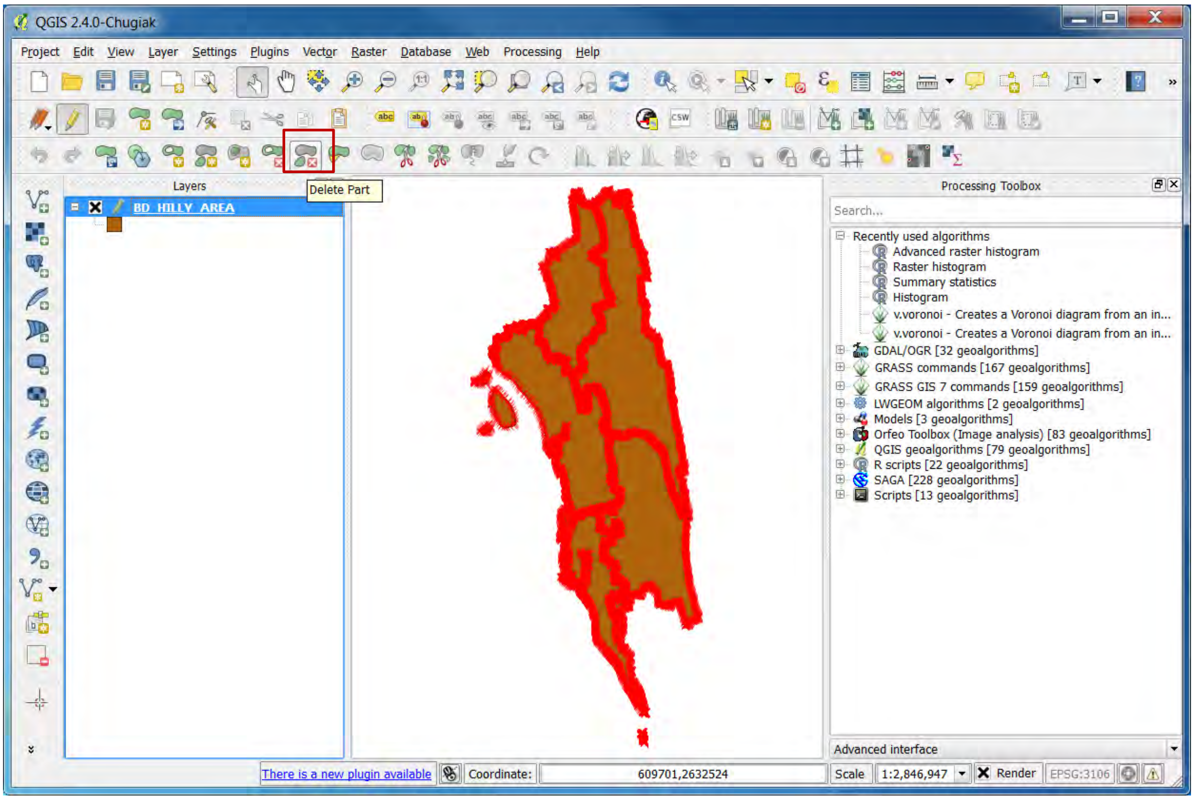
8. Click TEST which will validate the expression. If correct, your result of the test will indicate that the where clause returned five rows of data.
9. Then, click OK
10. Save selected districts as **BD_HILLY_AREA**.shpin *~MODULE_07\Data*





Polygon Editing

1. Load ***BD_HILLY_AREA_BTM.shp*** file *(~MODULE_07\Data)* in QGIS canvas.
2. Click View -> Toolbars and Check Advanced Digitizing
3. Then, click Layer -> Toggle Editing
4. Click Delete Part tools
5. With this tool we can delete all islands in the HILLY_HILLY_AREA layer file.
6. After deleting, click Layer -> Toggle Editing and save your work.


QGIS 2.4.0-Chugiak
Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help
Delete Part
Layers
BD_HILLY_AREA
Processing Toolbox
Search...
Recently used algorithms
Advanced raster histogram
Raster histogram
Summary statistics
Histogram
v.voronoi - Creates a Voronoi diagram from an in...
v.voronoi - Creates a Voronoi diagram from an in...
GDAL/OGR [32 geoalgorithms]
GRASS commands [167 geoalgorithms]
GRASS GIS 7 commands [159 geoalgorithms]
LWGEOM algorithms [2 geoalgorithms]
Models [3 geoalgorithms]
Orfeo Toolbox (Image analysis) [83 geoalgorithms]
QGIS geoalgorithms [79 geoalgorithms]
R scripts [22 geoalgorithms]
SAGA [228 geoalgorithms]
Scripts [13 geoalgorithms]
Advanced interface
There is a new plugin available
Coordinate: 609701,2632524
Scale 1:2,846,947
Render
EPSG:3106

Module 8: Working with Raster Data

You will recall that raster data refers to a particular type of geographical model. Using a grid format, data covers the space of each cell, the smallest measurement unit in the in the grid, aligning it with a measured geographical feature for a particular location. When combined into a matrix, a raster is a grid of cells. In this module, you will learn how to process information from the SRTM (Shuttle Radar Topographic Mission) 90m Digital Elevation Database (v4.1) that we have downloaded from their http://www.cgiar-csi.org/data/srtm-90m-digital-elevation-database-v4-1 website. A total 4 sheets cover entirety of Bangladesh. These data have been projected in a Geographic (Latitude/Longitude) projection, with the WGS84 horizontal datum and the EGM96 vertical datum. Processing such data is an important part of the analytical process of working with raster data. We will use the following steps to process these raster data:

1. Mergers (mosaic) of multiple sheets to create a continuous raster
2. Clipping the Merged-DEM with the Bangladesh country boundary
3. Re-projection of the Clipped-DEM to a custom CRS.

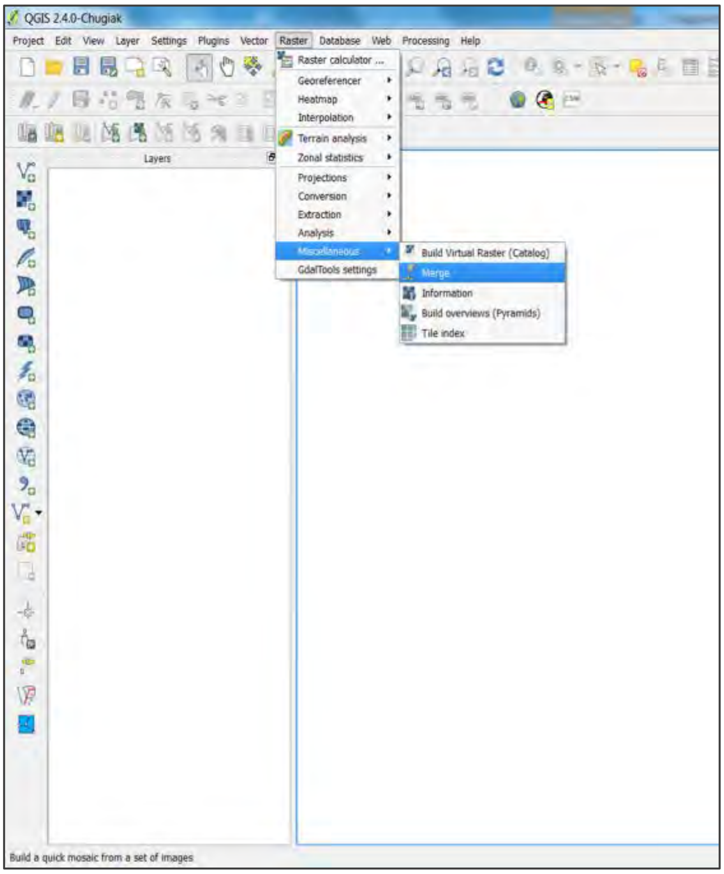
The data for this exercise are located in: ~*MODULE_08\ Data*\ directory:

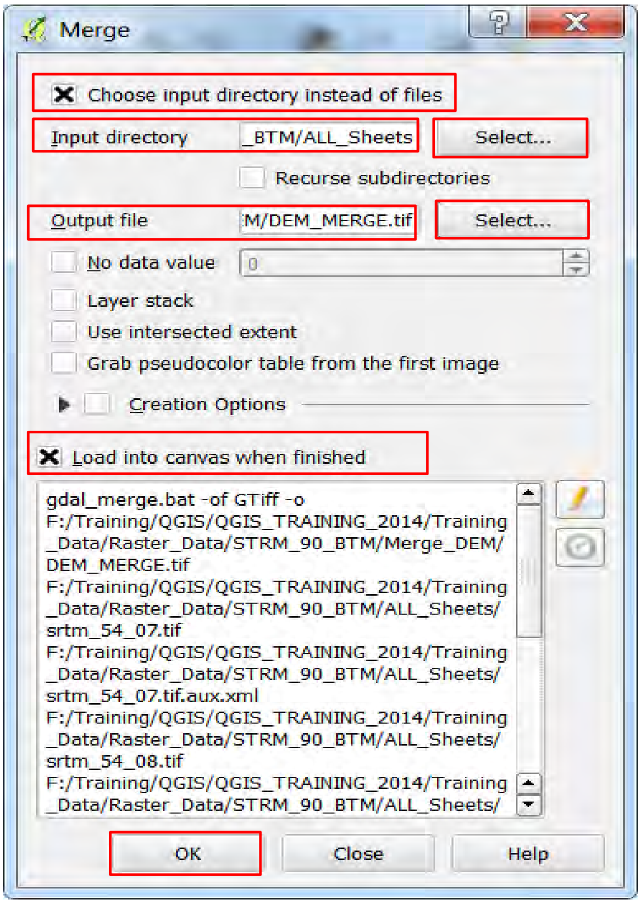
1. Four DEM raster in ALL_SHEETS_DEM_GCS sub-directory of MODULE_03/Data
2. Country boundary of Bangladesh

Merge

In this exercise, we will choose the directory (ALL_Sheets_DEM_GCS) from MODULE_03/Data folder to merge all sheets in this directory to create a seamless raster using the built-in batch processing capability in QGIS.

1. Click on the menu item Raster -> Miscellaneous-> Merge
2. Check Choose input directory instead of file

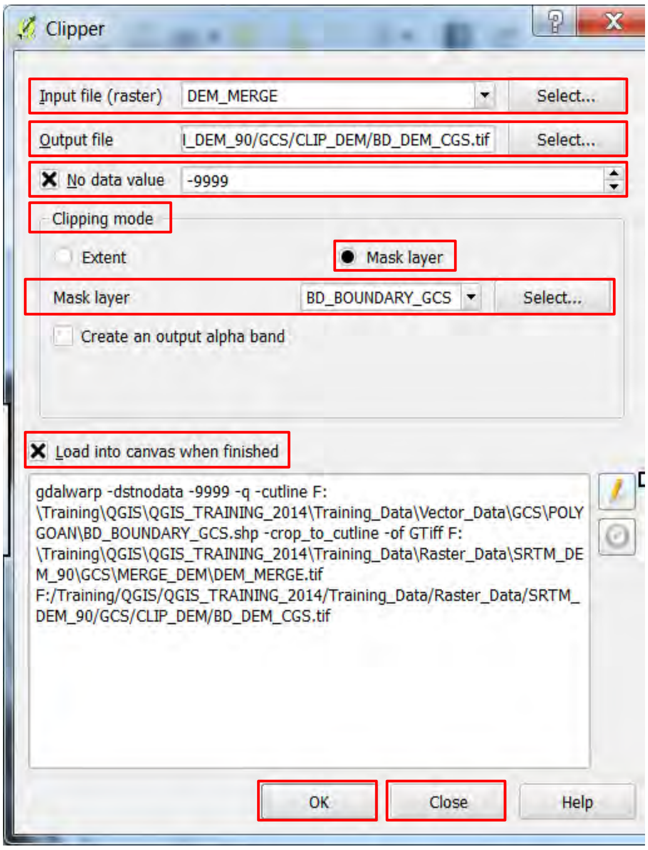


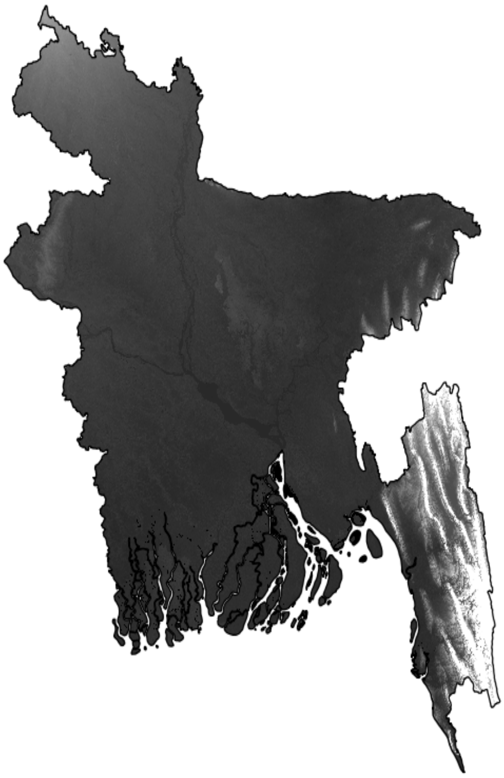


3. Select the ALL_Sheets_DEM_GCS folder as an Input directory from ~\MODULE_03/Data
4. Select **DEM_MERGE_GCS.tif** as an Output file
5. Check Load into canvas when finished
6. Click OK and then, Close

Clip

1. Open ***DEM_MERGE_GCS.TIF raster***and ***BD_BOUNDARY_GCS.shp***on the QGIS canvas. This step overlays vector data on raster data.
2. Click on the menu item Raster -> Extraction-> Clipper
3. Select **DEM_MERGE_GCS** as an Input file (raster) and **BD_DEM_GCS** as an Output file in .tif format
4. Next, change No data value to -9999 (The aspect value -9999 is generally used as the 'nodata' value to indicate use of an undefined aspect in areas lacking variation in topography, with slope=0. This will be clarified in Module 9)
5. Select Mask layer as Clipping mode and Select **BD_BOUNDARY_GCS** as a Mask layer
6. Click OK and then Close

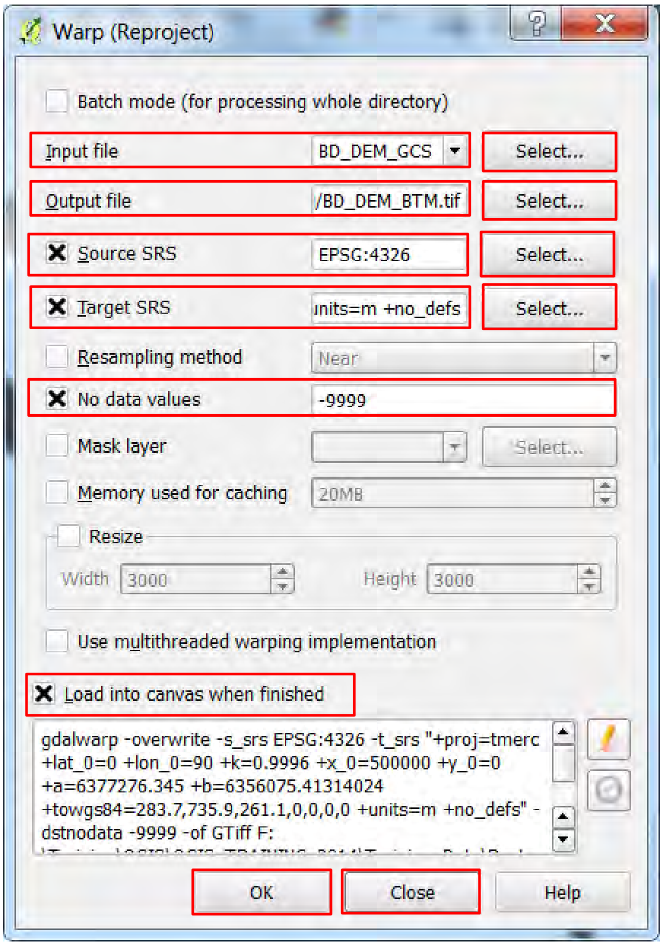




Re-projection

The digital elevation model, or DEM, obtained in the last step is not yet suitable as an input for digital terrain modeling (e.g.*Slope, Aspect, Curvature,* etc. are incorrect). This is because while its elevation values are in meters, cell size of the rasters is not expressed in meters (this is because that layer uses a CRS with geographic coordinates). Because of these issues, a re-projection is needed. To reproject a raster layer, the *Warp (reproject)* algorithm can be used again. We reproject into a CRS with meters as units, so we can then correctly all spatial analysis function.

1. Click the **Add raster layer** button and select the file ***BD_DEM_GCS.tif***
2. Click **Raster->Projection->Warp(Repoject)**



3. Define Output file as **BD_DEM_BTM** and file type **GeoTIFF**
4. **EPSG:4326** will be popping up as **Source SRS**
5. Check Target SRS and Select **EPSG_3106_BTM_D_GULSAN_NEW** as Target SRS
   and click OK
6. No data value as -9999, and Load into canvas when finished
7. Click OK again and then, Close. Note that processing may take some time.

Module 9: Terrain Analysis

Terrain analysis or land surface analysis is a process that describes terrain, for example it's roughness, altitude, etc., quantitatively. Such analysis can be very useful in assessing land suitability for agriculture, construction, roads, or in designing irrigation schemes, and other land use features. They are also very important in site selection. The following terrain parameters will be computed from DEM data using standalone QGIS software, as well as **GRASS and SAGA plugins in QGIS.** In this module, you will learn how to create the following DEM derived terrain rasters using these commands:

1. Hillshade
2. Slope
3. Aspect
4. Color relief
5. Terrain Ruggedness Index (TRI)
6. Topographic Position Index (TPI)
7. Roughness
8. Curvature

The following data is needed for this exercise and is located in: *~\MODULE_09\ Data* directory:

1. *Elevation raster of Bangladesh (BD_DEM_BTM.tif)*
2. *Shape file of four hilly districts (HILLY_AREA_BTM.shp)*

Processing of DEM data

Before terrain analysis, we have to create a DEM raster for four hill tract districts from DEM data of Bangladesh by clipping it with the **HILLY_AREA_BTM** shape file. This will isolate the terrain area of interest for the study we will do in this module, ending with the creation of a new, isolated raster file.

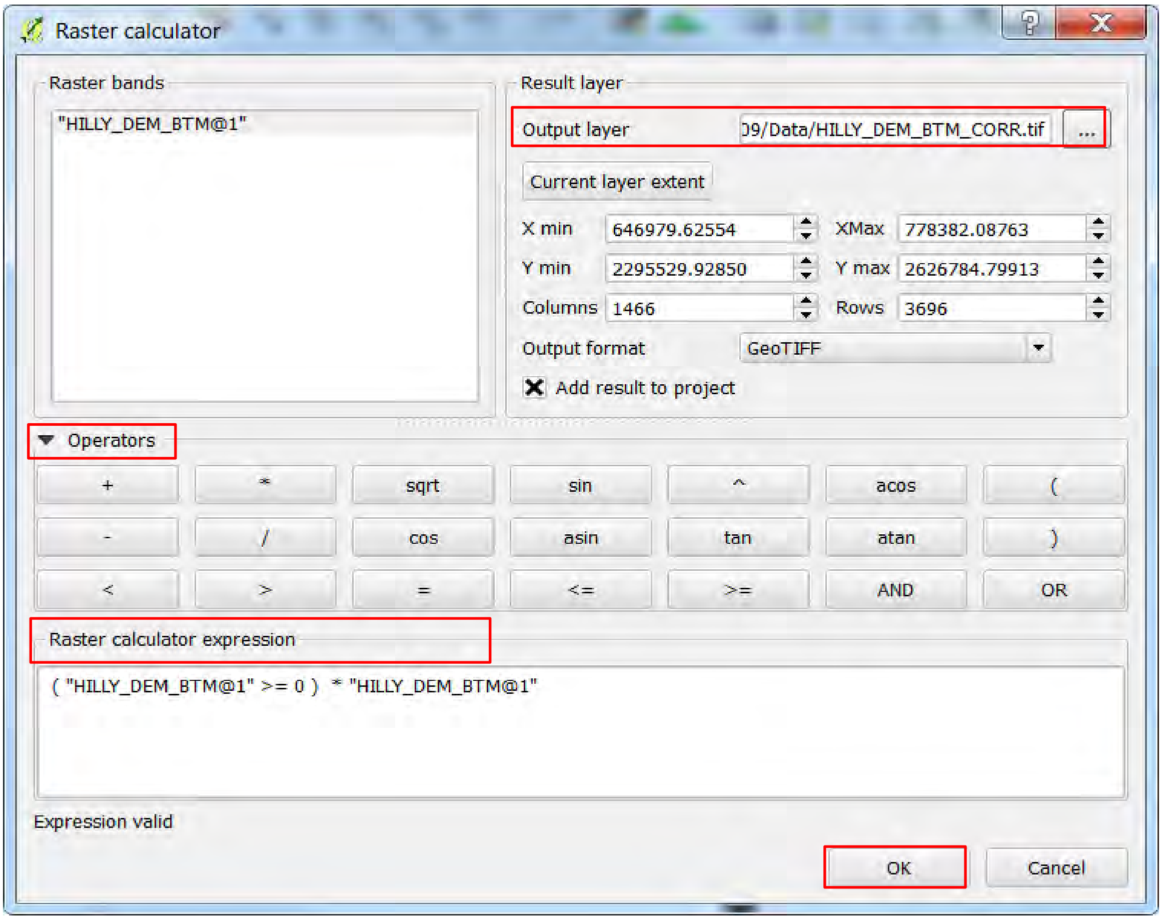
1. Open BD_***DEM_BTM.tif*** raster and **HILLY_AREA_BTM.*shp***
2. Click on the menu item Raster -> Extraction-> Clipper
3. Select **BD_DEM_BTM** as an Input file (raster) and add **HILLY_AREA_BTM.tif** as an Output file
4. No data value as -9999
5. Select Mask layer as Clipping mode and Select **HILLY_AREA_BTM** as a Mask layer
6. Click OK and then Close

After clipping, open Metadata tab in Layer Properties for HILLY_DEM_BTM. You will notice that Pixel size is 89.6 x 89.6. This means each cell represents a 89.6 by 89.6 meter area. When switching to the Style tab in Layer Properties, you will also notice that the minimum value reads and the max value. For terrain analysis, we have to first select the grid cells where we have elevations ranging from above sea level to mountaintops. This means excluding the negative values. You can use the raster calculator to create a mask and apply it to your raster all in one step.x

The expression looks like this:(HILLY_DEM_BTM@1 >= 0) * HILLY_DEM_BTM @1

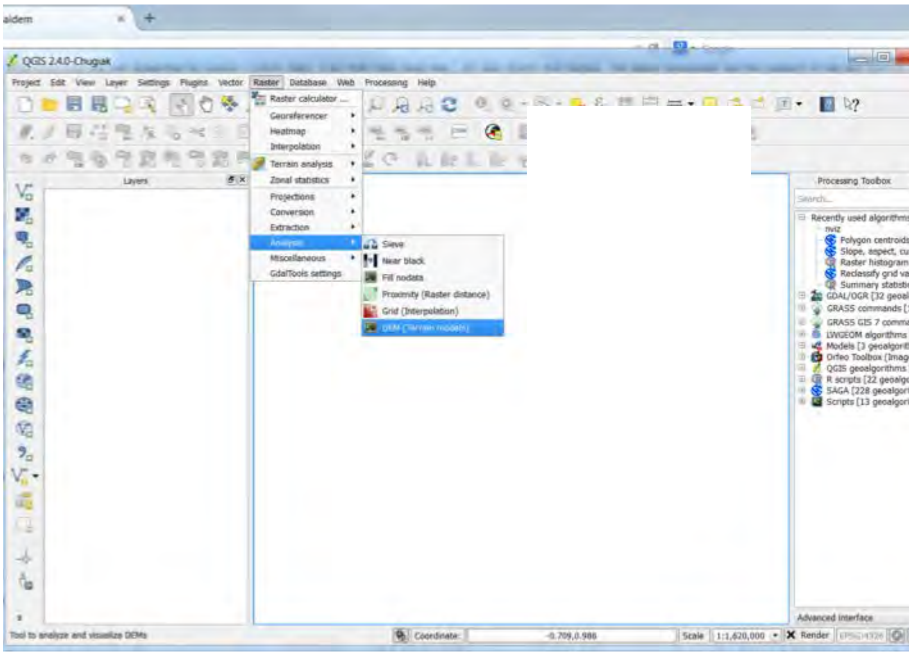
The first part of the expression in parentheses effectively says: for every cell greater than orequal to zero, set its value to 1, otherwise set it to 0. This creates the mask as you go along. For the second part of the expression, the raster is multiplied (**HILLY_DEM_BTM @1**) by the mask values. This sets every cell with an elevation less than zero to zero. When you click OK, the calculator will create a new raster with the mask applied. Here is how to do this.

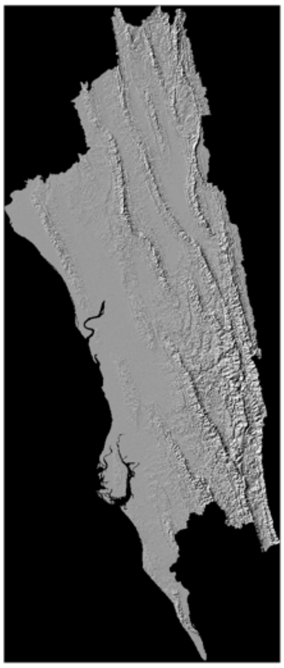
1. Click the **Add raster layer** button and select the file ***HILLY_DEM_BTM.TIF***
2. Click on the menu item *Raster ‣ Raster Calculator*
3. Write (HILLY_DEM_BTM@1 >= 0) * HILLY_DEM_BTM @1 expression in Raster calculator expression window
4. Set the Output layer as **HILLY_DEM_BTM_CORR.tif**
5. Then click OK



Terrain Analysis in QGIS

In QGIS, select Raster> Analysis>DEM (Terrain Model) The below figure shows the QGIS terrain model analysis tool menu, which is a fairly straightforward tool which allows us to perform six types of raster based terrain analysis techniques, including **hillshade, slope, aspect color relief, terrain ruggedness index (TRI), topographic position index**.





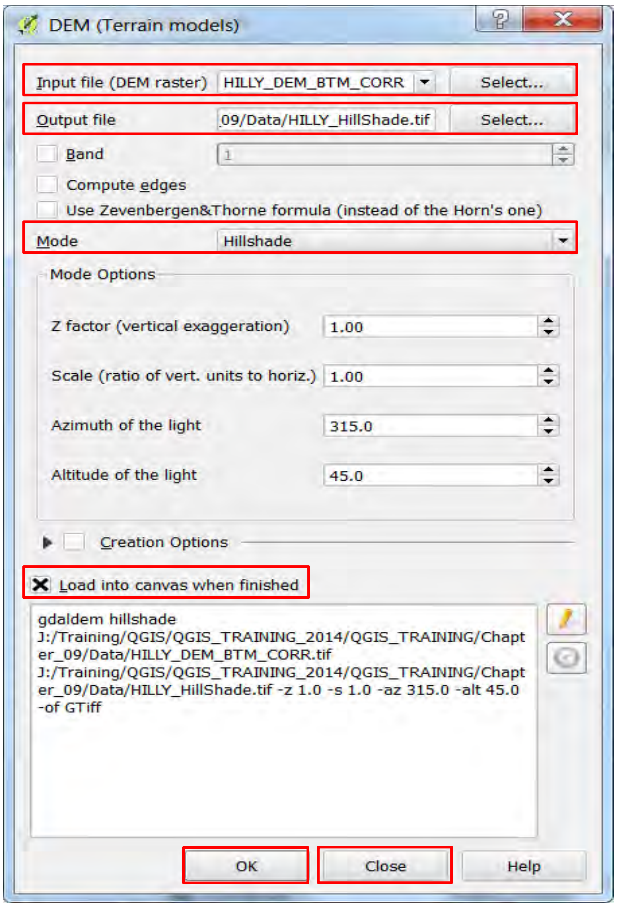
Hillshade

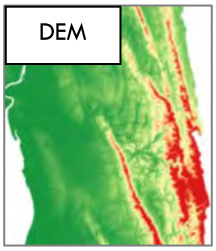
The hypothetical illumination of a surface according to a specified azimuth and altitude of the sun. Hillshading creates a three-dimensional effect that provides a sense of visual relief for cartography, and a relative measure of incident light for analysis. It is very useful for visualizing the terrain. You can optionally specify the azimuth and altitude of the light source, a vertical exaggeration factor and a scaling factor to account for differences between vertical and horizontal units.

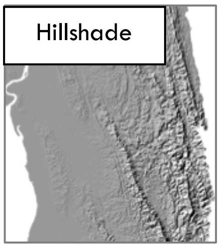
1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Click on the menu item *Raster ‣ Analysis ‣ DEM (Terrain models)*.
3. In the dialog that appears, make sure that the Input file is the *DEM* layer.
4. Set the Output file to HillShade.tif
5. S**elect Mode as Hillshade**
6. Check the box next to Load into canvas *when finished*.
7. You may leave all the other options unchanged.
8. Click OK to generate the hillshade.
9. When it tells you that processing is completed, click OKon the message to get rid of it. Click *Close* on the main DEM (Terrain models) dialog.
10. Your result should look like the image to the right.

A hillshade can provide very useful information about the pattern of shadow cast by sunlight at a given time of day. It can also be used simply to improve the appearance of the map. Note that you can also change the transparency of the HillShade and other raster layers.

1. Go to *Layer properties* then click style, from render type dropdown menu select singleband pseudo color then click classify then click ok.
2. Hide all the layers except the DEM and **hillshade** layers.
3. Click and drag the *DEM* to be beneath the hillshade layer in the *Layers list. Control rendering order* (beneath the list) on the bottom of your window should be checked as well.
4. Set the hillshade layer to be transparent.
5. Open its *Layer Properties* and go to the *Transparency* tab.
6. Set the *Global transparency* to 50%:
7. Click *OK* on the *Layer Properties* dialog.





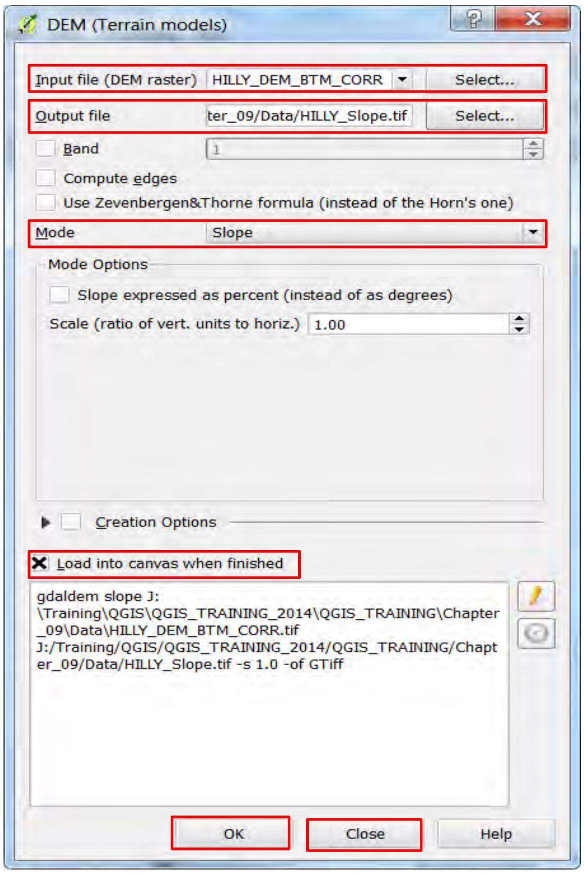


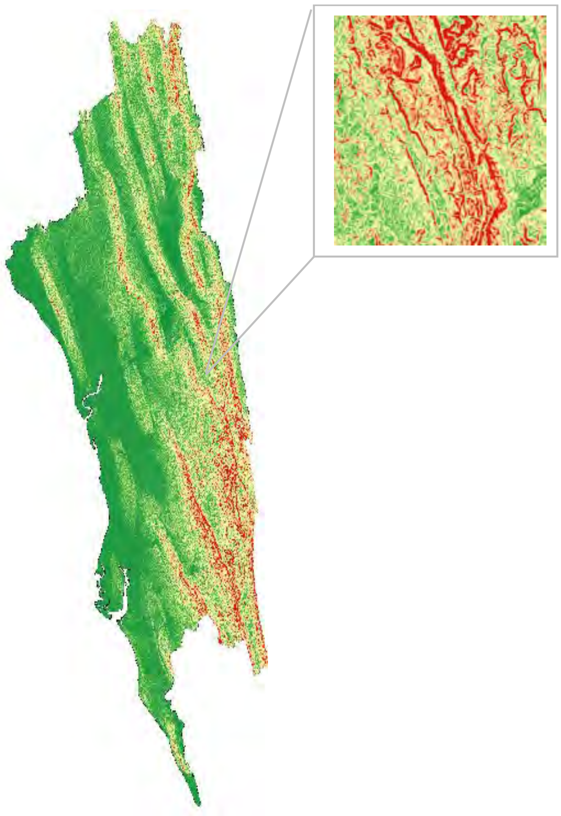
Slope

Slope is the incline and steepness of a surface. Slope can be measured in degrees from horizontal (0–90), or percent slope (which is the rise divided by the run, multiplied by 100). A slope of 30 and 45 degrees equals 58 and 100 percent slope, respectively. As slope angle approaches vertical (90 degrees), the percent slope approaches infinity. The slope for a cell in a raster is the steepest slope of a plane defined by the cell and its eight surrounding neighbors. Here we will clarify how slope can be depicted with your raster data.

1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**

2. Click on the menu item *Raster* ‣ *Analysis* ‣ *DEM (Terrain models)*.
3. In the dialog that appears, ensure that the Input file is the *DEM* layer.
4. Set the Output file to HILLY_Slope.tif
5. **Select Mode as Slope**
6. Check the box next to Load into canvas *when finished*.
7. You can leave all the other options unchanged (though note that you also have the option of indicating the type of slope value you want: **degrees or percent slope**)
8. Click OK and Close after generating the slope map in degree.



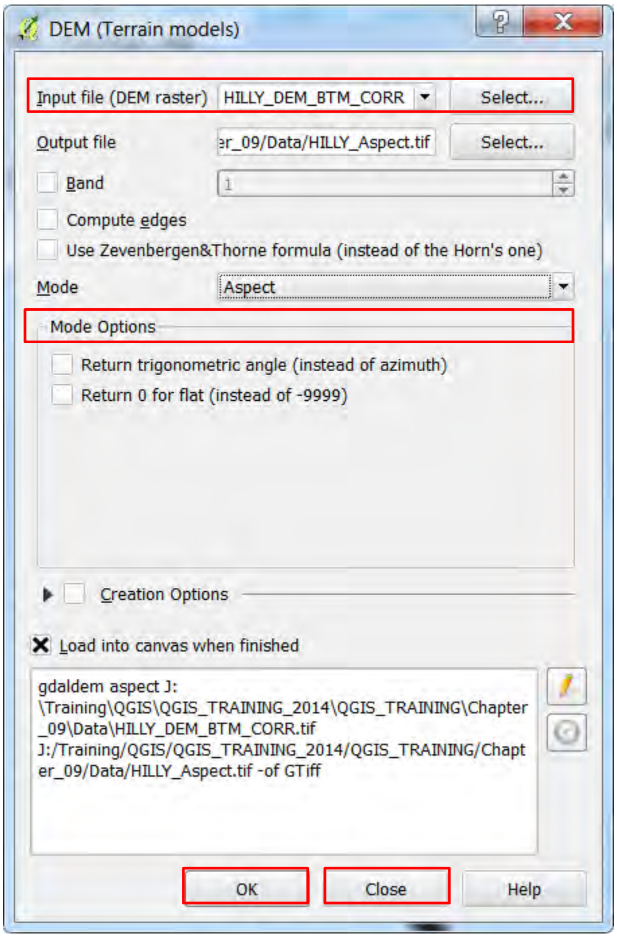


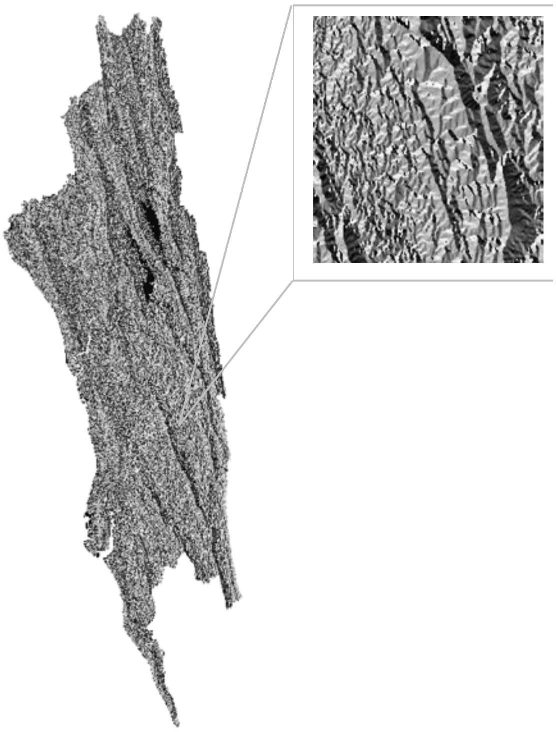
Aspect

The compass direction that a slope faces is most commonly measured from degrees north. The Aspect command provides a 32-bit float raster that ranges from 0° and 360°. This represents the azimuth (the angular distance from the north to south point of the horizon that can be transversed by a vertical circle that intersects the horizon, which represents the direction of an object from the observer) that slopes are facing. In other words, 0° means that the slope is facing North, 90° indicates East, 180° indicates a Southward facing, and 270° is to the west. This however requires that the top of your input raster is north oriented, as most are. Values found in between these ranges assume a mixture of cardinal directions, ex. 250 indicates a hillside with a Southeast facing aspect. The aspect value -9999 is generally used as the 'nodata' value to indicate use of an undefined aspect in areas lacking variation in topography, with slope=0. You can also make use of the legend to indicate the appropriate aspect for each hillside in your study area. The legend permits you to identify North (~ 0 or

360 degrees), South (~ 180 degrees), East (~270 degrees) or West (~90 degrees) facing slopes.

1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Click on the menu item *Raster* ‣ *Analysis* ‣ *DEM (Terrain models)*
3. In the dialog that appears, ensure that the Input file is the *DEM* layer
4. Set the Output file to HILLY_Aspect.tif
5. **Select Mode as Aspect**
6. Check the box next to Load into canvas *when finished*
7. You may leave all the other options unchanged
8. Click OK and Close after generating the aspect map.

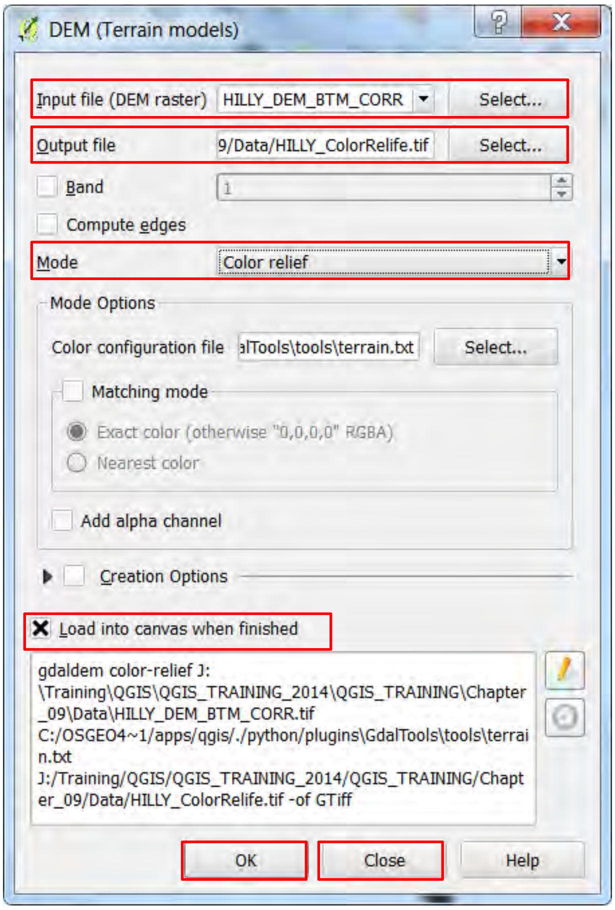


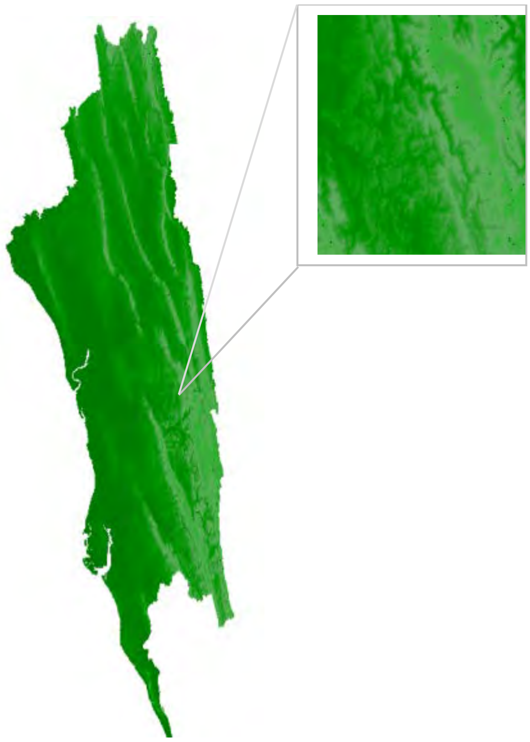


Color relief

Color relief helps differentiate topography more clearly, by providing a 3-band (RGB) or 4-band (RGBA) raster with values that is computed a color configuration file and also an elevation file. The configuration file is based on text, and includes expressions of the association between various elevation values and the color that is of interest to the user. QGIS's default settings will automatically provide elevation values that are well blended, making a nicely colored DEM that is easy to understand. Here is how to turn your DEM into a color relief.

1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Click on the menu item *Raster* ‣ *Analysis* ‣ *DEM (Terrain models)*
3. In the dialog that appears, ensure that the Input file is the *DEM* layer
4. Set the Output file to HILLY_ColorRelief.tif
5. Select **Mode as Color relief**
6. Check the box next to Load into canvas *when finished*
7. You may leave all the other options unchanged
8. Click OK and Close after generating the Color Relief map

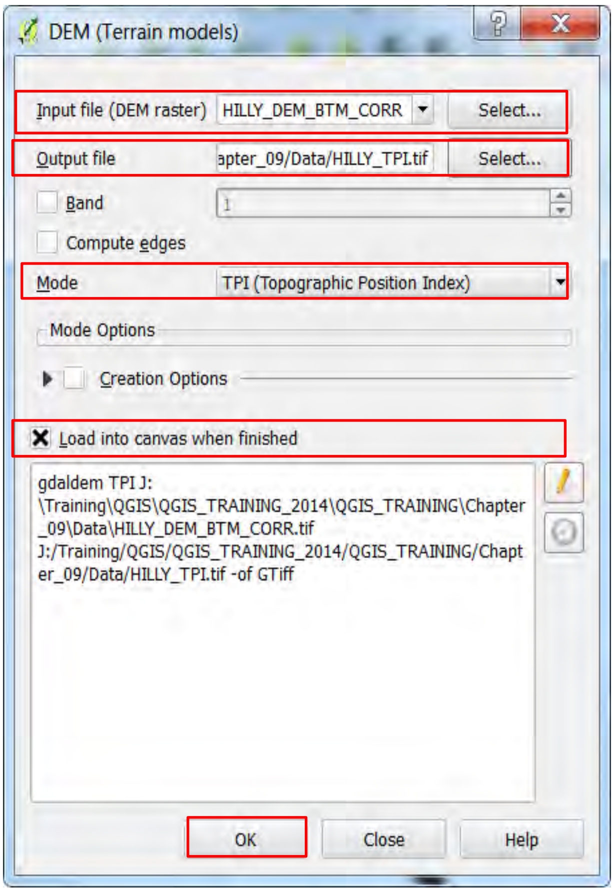


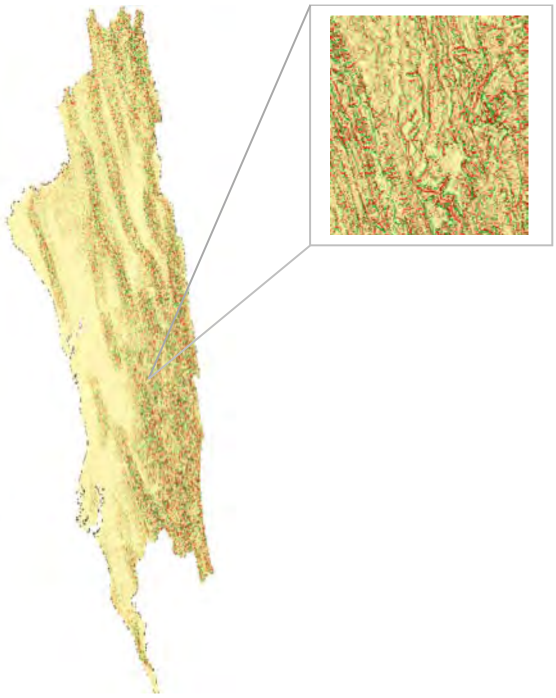


Topographic Position Indices (TPI)

Topographic Position Index (TPI) is defined as the difference between a central pixel and the mean of its surrounding cells. The **TPI**are calculated at each cell of the DEM by calculating the difference between the elevation of the cell and the mean elevation calculated for all cells of a moving rectangular window centered on the cell of interest. Positive TPI values represent locations that are higher than the average of their surroundings, as defined by the neighborhood (**ridges**). Negative TPI values represent locations that are lower than their surroundings (**valleys**). TPI values near zero are either flat areas (where the slope is near zero) or areas of constant slope (where the slope of the point is significantly greater than zero). Topographic position is an inherently scale-dependent phenomenon. TPI was generally second most important predictive variable after elevation. With the combination with slope raster, we can define cells with *TPI* values ≤ -8 m as valley bottoms, cells with *TPI* values ≥ 8 m as ridgelines, and cells with *TPI* values between - 8 and + 8m and slope < 6^0 as gentle slopes or slope ≥ 6^0 and *TPI* values between - 8 and + 8m as steep slopes (Dickson and Beier, 2007)[1].

1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Click on the menu item *Raster ‣ Analysis ‣ DEM (Terrain models)*.
3. In the dialog that appears, ensure that the Input file is the *DEM* layer.
4. Set the Output file to HILLY_TPI .tif
5. Select **Mode as TPI (Topographic Position Index)**
6. Check the box next to Load into canvas *when finished*.
7. You may leave all the other options unchanged
8. Click OK and Close after generating the TIP map.



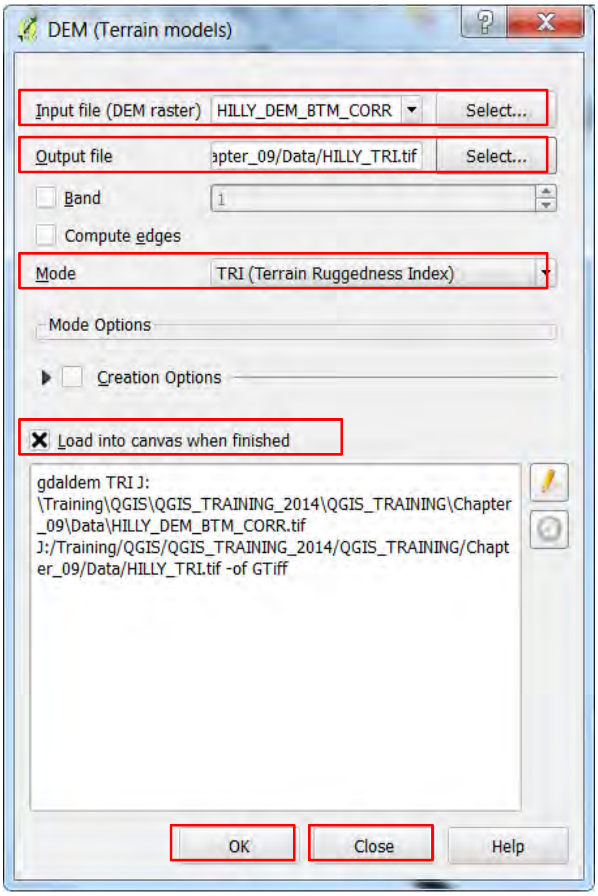


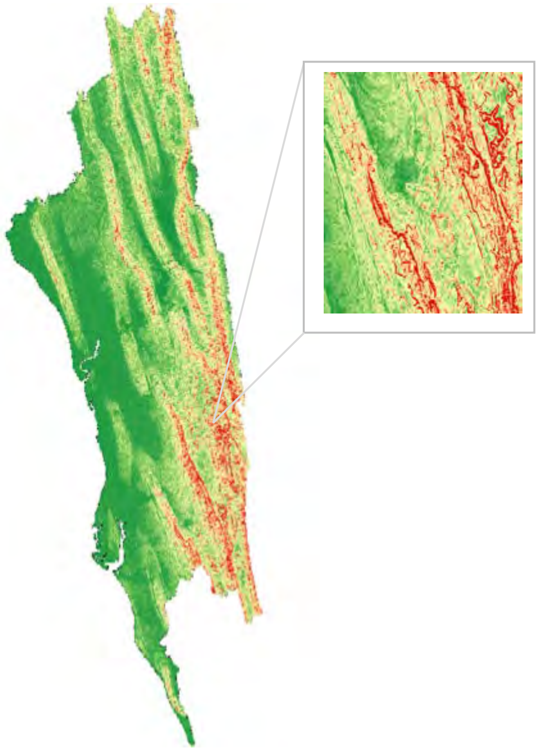
[1] Dickson, B.G., Beier, P., 2006. Quantifying the influence of topographic position on cougar (*Puma concolor*) movement in southern California, USA. Journal of Zoology 271, 270-277.

Topographic Ruggedness Indices (TRI)

The Terrain Ruggedness Index (TRI) can be clarified as the mean difference between a central pixel and its surrounding cells. Using this tool, terrain heterogeneity (variation) can be calculated. This provides a relative measure of elevational changes between a specified grid cell and neighbors. The TRI is useful for analyzing what environments might be suited to particular crops or species which may be sensitive to particular sloped environments, or for assessing the potential flow of soil during erosion events, and so on.

1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Click on the menu item *Raster* ‣ *Analysis* ‣ *DEM (Terrain models)*.
3. In the dialog that appears, ensure that the Input file is the *DEM* layer.
4. Set the Output file to HILLY_TRI .tif
5. Select **Mode as TRI (Topographic Ruggedness Index)**
6. Check the box next to Load into canvas *when finished*.
7. You may leave all the other options unchanged
8. Click OK and Close after generating the TRI map.

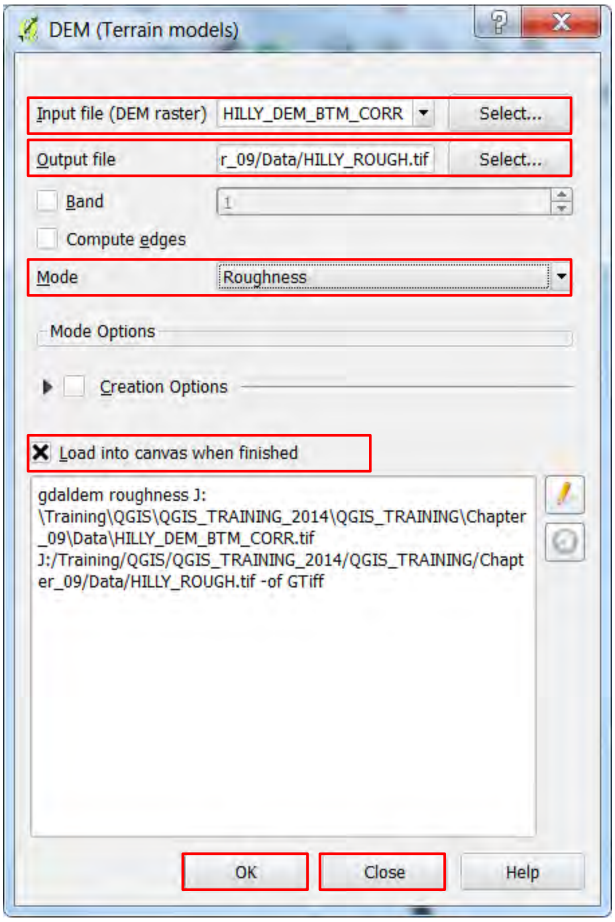


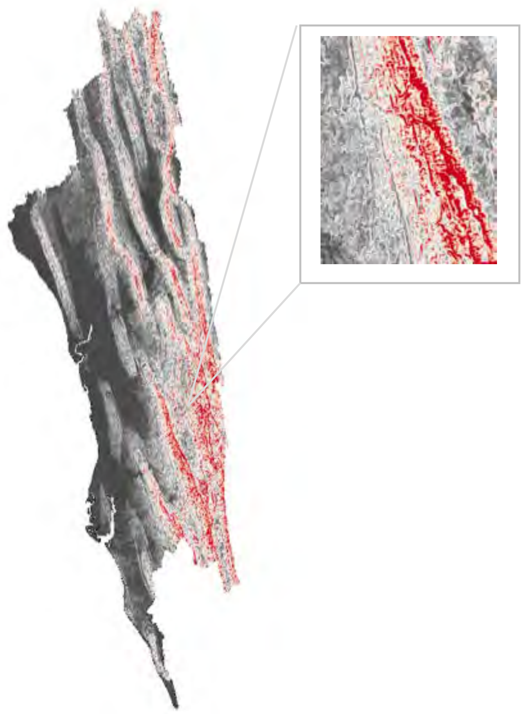


Roughness

When comparing among the differences in cells in a raster and a central pixel, you are making a comparison of roughness. This is useful for helping to determine the overall variation and frequency of change in elevation in a DEM, or particular selected parts of a DEM.

1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Click on the menu item *Raster ‣ Analysis ‣ DEM (Terrain models)*.
3. In the dialog that appears, ensure that the Input file is the *DEM* layer.
4. Set the Output file to HILLY_ROUGH .tif
5. Select **Mode as Roughness**
6. Check the box next to Load into canvas *when finished*.
7. You may leave all the other options unchanged
8. Click OK and Close after generating the roughness map.

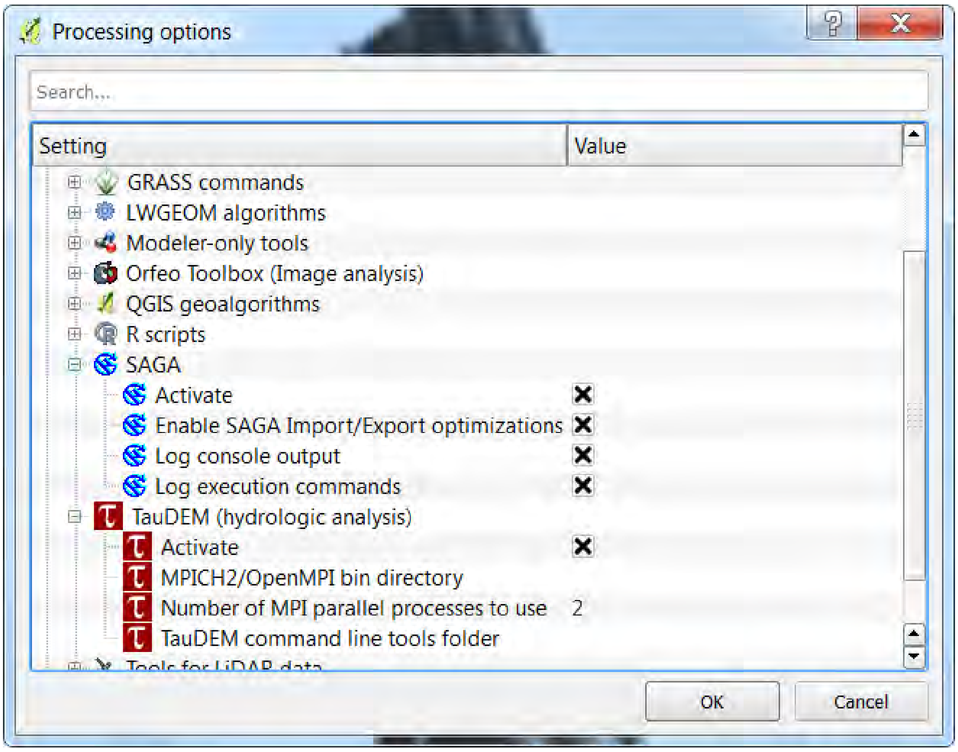




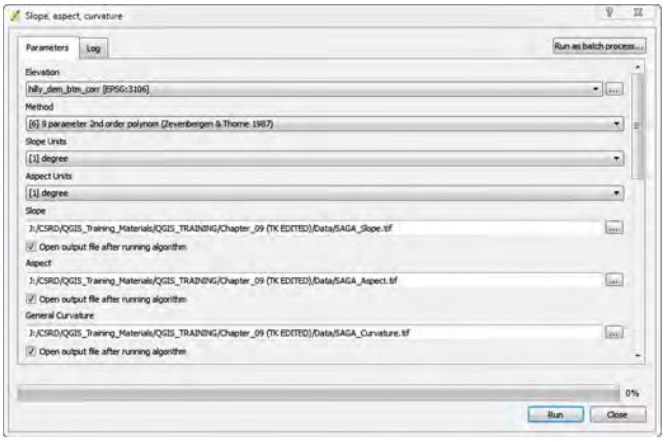
Terrain Analysis using SAGA plugin in QGIS

SAGA (System for Automated Geoscientific Analyses) **GIS** is a free and open source geographic information system used for editing spatial data. Initially developed by scientists at the University of Göttingen in Germany, SAGA, like QGIS, is being continually developed and updated by a community of GIS users. and click OK.

Before using SAGA commands in QGIS, you need to activate SAGA following way:
PROCESSING --> OPTIONS AND CONFIGURATION --> PROVIDERS Expand**SAGA**
Switch Activate and Enable SAGA Import/Export optimization to ON and click OK.



1. Click the **Add raster layer** button and select the file **HILLY_DEM_BTM_CORR.tif**
2. Expand SAGA ->Terrain Analysis – Morphometry in the Processing Toolbox (you may have to select this option from the menu to load this window)
3. Click on Slope, aspect, curvature
4. Elevation: HILLY_DEM_BTM_CORR
5. Method: [5] Fit 2.Degree Polynom



6. Save to file

   Slope: ~/MODULE_09/Data/SAGA_Slope
   Aspect: ~/MODULE_09/Data/SAGA_Aspect
   Curvature: ~/MODULE_09/Data/SAGA_Curvature
   Plan Curvature: ~/MODULE_09/Data/SAGA_PlanCurvature
   Profile Curvature: ~/MODULE_09/Data/SAGA_ProfileCurvature

7. Check all Open output file after running algorithm
8. Click Run

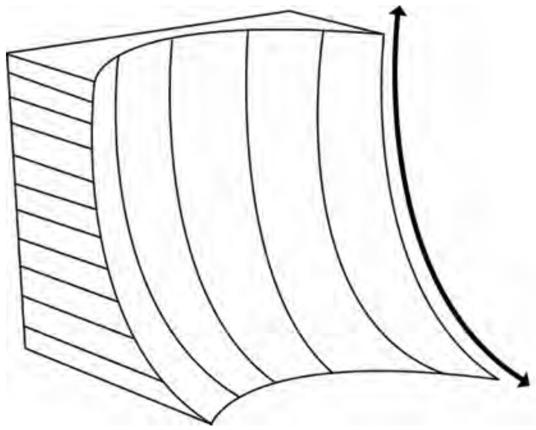
Curvature

Curvature is the change in the degree of slope for a given distance on that slope. It is a very helpful measure to understand the surface water flow through a landscape, and can be used in part to help design an irrigation scheme, for example. It is widely used by hydrological scientists. When interpreting data from a curve, any positive values indicate a convex (upward bulging) slope, while negative values correspond to a convex (downward facing) curve. The first is like a dinner bowl sanding correctly on a table, the latter is like a bowl that has been flipped over and is facing down. Any pixels observed that show positive curvature indicate the potential for liquid flow dispersal away from a central area, while and negative values indicate accumulation. In combination, convex and concave surfaces approximate actual topography.

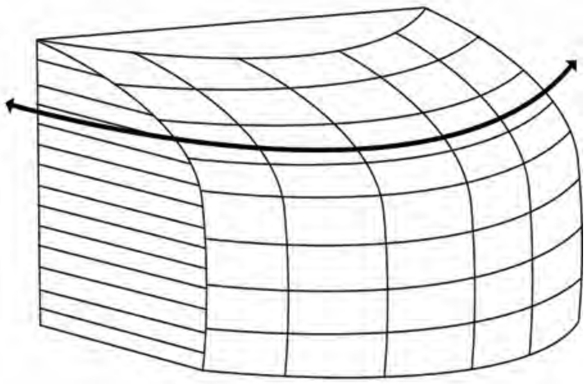
A *Plan curve* is the measurement of the rate at which a horizontal curve changes. Positive and negative values respectively indicate divergence and convergence of a particular slope. Highlight a divergent slope, negative values a convergent slope.

A *Profile curve* is conversely a vertical measurement of the change of a slope. Positive values indicate convexity, while negative values represent concave profiles.

Plan curvature



Profile curvature



Module 10: Spatial Analysis

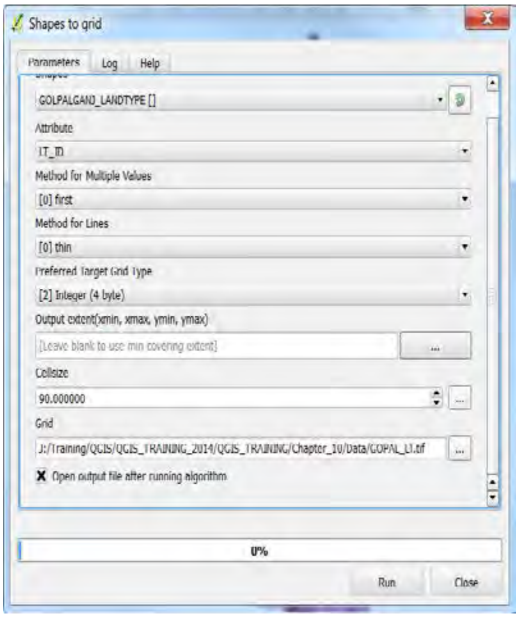
By examining locations, attributes, and relationships between and of features of spatial data, we conduct spatial analysis. The analytical process proceeds by overlaying layers and using many of the tools and techniques you have learned in module 1 – 9. The result of an analysis is usually the summary or extraction of new data from spatial information. In thismodule, we will cover the following analytical processes:

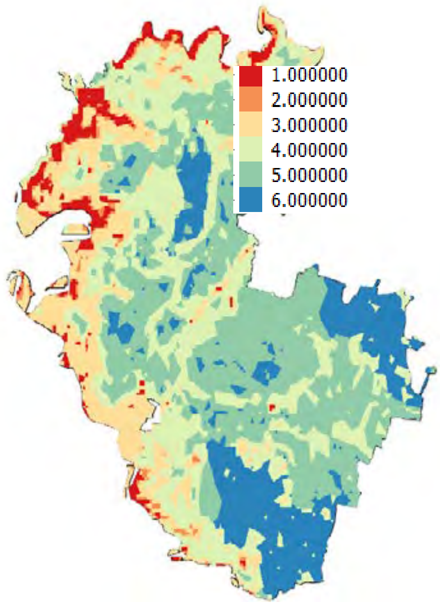
1. Conversion of vector to raster data
2. Extraction of grid values to point shape files
3. Conversion of raster to point data
4. Reclassification processes
5. Overlaying raster data
6. Analyzing zonal statistics

The data for these exercises are located on at: *~\MODULE_10\Data*

Convert a vector to raster

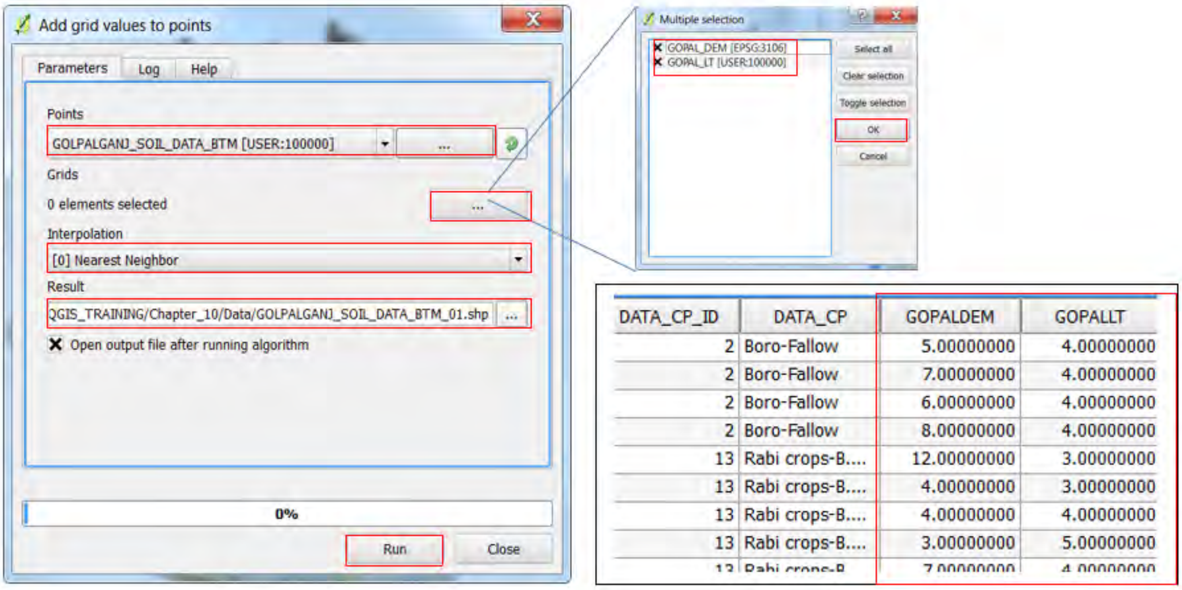
1. Open QGIS Desktop 2.4.0.
2. Add the GOLPALGANJ_LANDTYPE vector layer to QGIS Desktop using the Add vectorbutton
3. Expand SAGA ->Grid-Gridding in Processing Toolbox
4. Click on Shape to grid
5. Shapes: **GOLPALGANJ_LANDTYPE**
6. Attribute: LT_ID
7. Method for Lines: [0] first
8. Method for Lines: [0] thin
9. Preferred Target Grid Type: [2] Integer [4 byte]
10. Cell size: 90.000
11. Grid: Save to file ***~\MODULE_10\Data\GOPAL_LT.tif***
12. Click Run





Extract grid values to point shape file

1. Open QGIS Desktop 2.4.0.
2. Add the **GOLPALGANJ_SOIL_DATA_BTM** point layer and **GOPAL_DEM** and **GOPAL_LT** raster layers in QGIS Desktop
3. Expand SAGA ->Shapes-Grid in Processing Toolbox
4. Click on Add grid values to points
5. Points: **GOLPALGANJ_SOIL_DATA_BTM**
6. Grids: **CheckGOPAL_DEM and GOPAL_LT and** click OK
7. Interpolation: [0] Nearest Neighbor (this is a form of non-parametric pattern recognition used in classification and regression)
8. Result: Save to file ***~\MODULE_10\Data*** **GOLPALGANJ_SOIL_DATA_BTM_01.shp**
9. Click Run

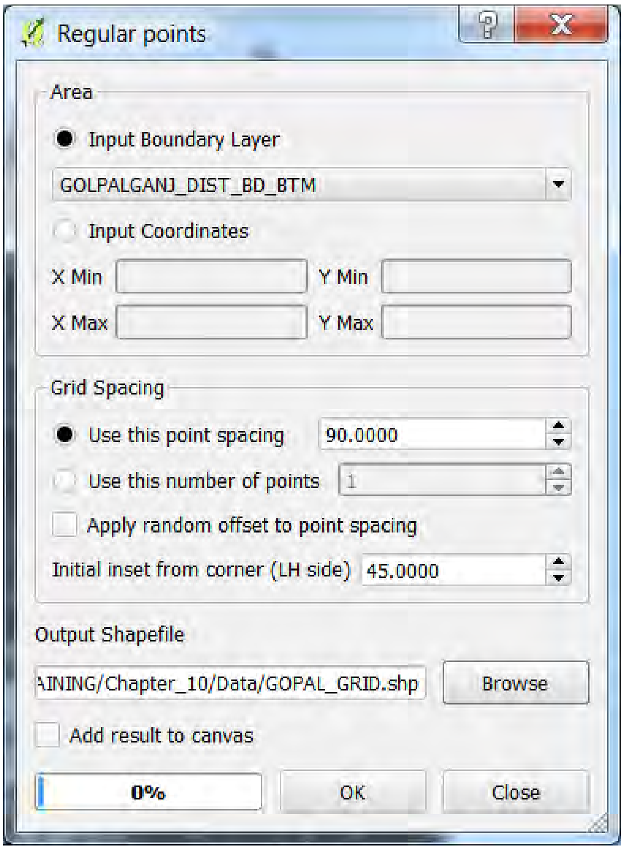


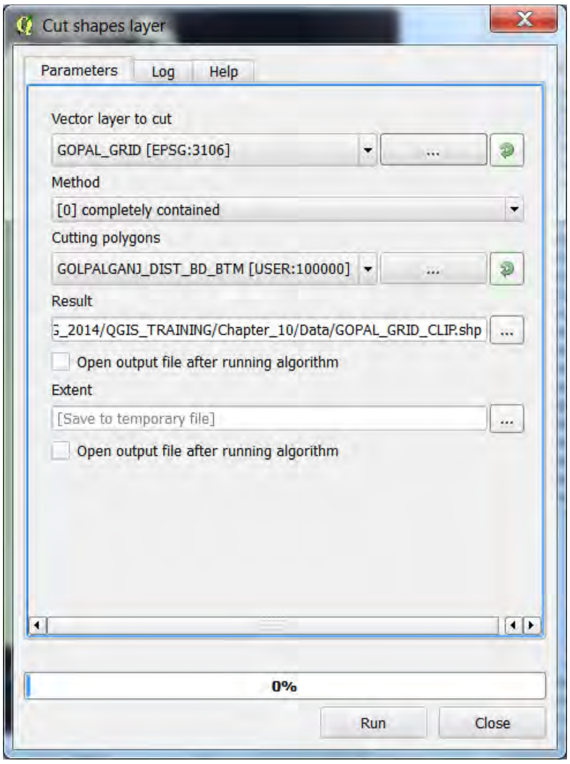
Convert raster to point data

How can a regular grid of points and/or sample a raster dataset manipulated to extract the individual pixel values? This is a very basic form of raster to vector point conversion.

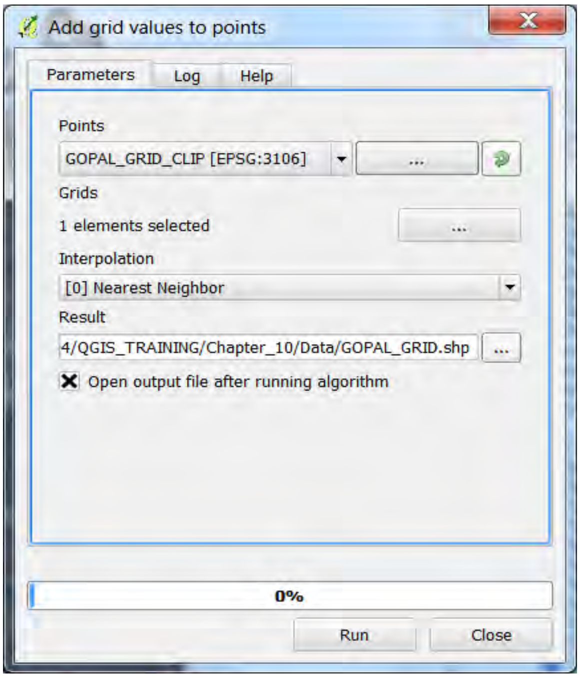
1. Open QGIS Desktop 2.4.0.
2. Add the **GOPAL_DEM** raster (.tif file) and GOLPALGANJ_DIST_BD_BTM vector layers to QGIS canvas
3. Select Vector > Research Tools > Regular Points
4. If necessary, change the Input Boundary Layer set to **GOPAL_DEM**.
5. In the Grid Spacing section set the point spacing value to 90 as that is the size of our raster pixels
6. In order to make the regular points fall within the center of each pixel we will add an offset of half our pixel size, i.e. (90 / 2) = 250. Set the Initial inset from corner (LH side) value to 15.
7. Click the Browse button for Output Shapefile, navigate to ***~\MODULE_10\Data***and save the file as **GOPAL_GRID.shp** click OK or Save

8. By clicking OK, we clip **GOPAL_GRID** with **GOLPALGANJ_DIST_BD_BTM** and create a new point layer (**GOPAL_GRID_CLIP**) using SAGA geo-processing tools (SAGA->Shape->Cut shapes layer)





9. Expand SAGA ->Shapes-Grid in Processing Toolbox
10. Click on Add grid values to points
11. Points: **GOPAL_GRID_CLIP**
12. Grids: **CheckGOPAL_DEM** click OK
13. Interpolation: [0] Nearest Neighbor
14. Result: Save to file ~***MODULE_10\Data*** **GOPAL_GRID.shp** and overwrite GOPAL_GRID
15. Click Run



Reclassification

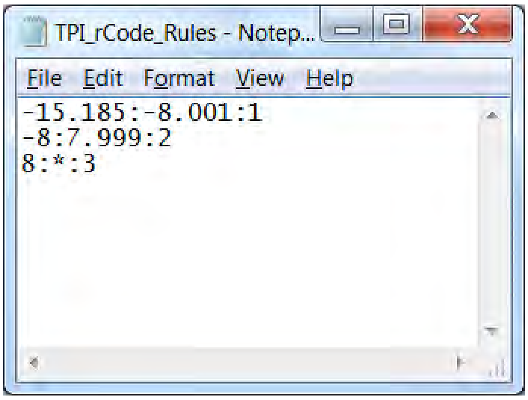
Based on the analyses above, we will now work with the slope and Topographic Position Index(TPI) data to reclassify them in a way that permits meaningful, clear interpretation. This kind of raster reclassification will aggregate data into useful categories as follows:

TPI Class	TPI Values	Slope Class	Slope value
1	≤ -8 m	1	< 6°
2	- 8 to + 8 m	2	≥ 6°
3	≤ -8 m		

After you have reclassified the slope and TPI data, we will work to recombine them to identify valley bottoms (TPI ≤ -8 m), ridgelines (TPI ≤ -8 m), gentle hill slopes (TPI= - 8 to + 8 m and slope < 6^{0}) and steep hill slopes (TPI = - 8 to + 8 m and slope ≥ 6°).

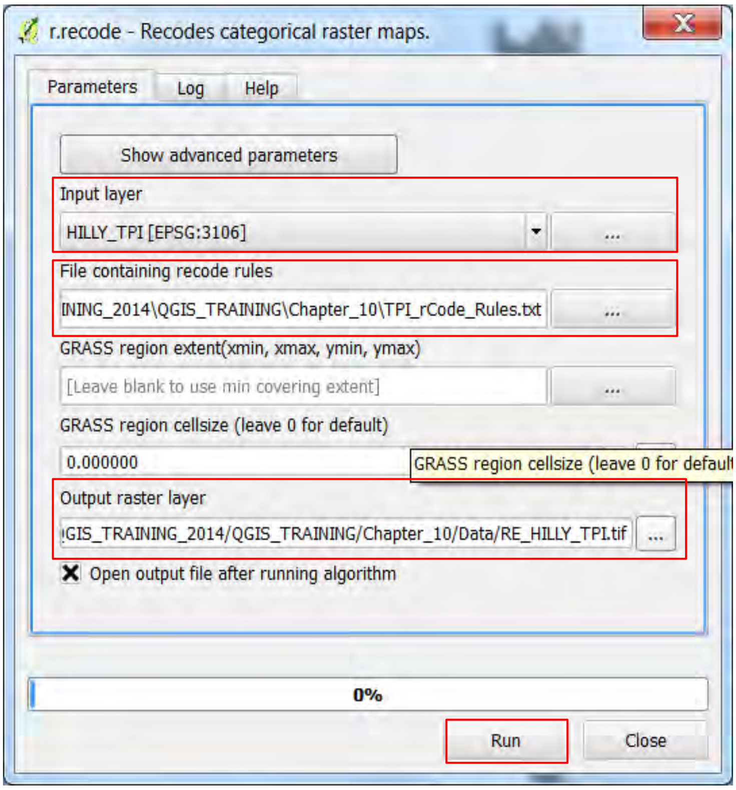
Reclassify TPI raster

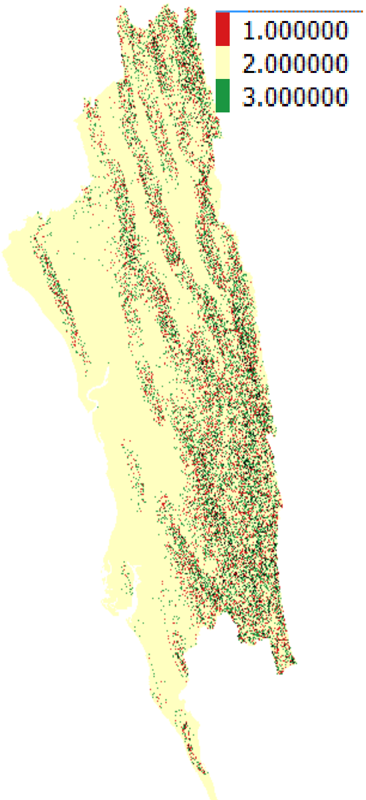
1. Load HILLY_TPI raster in QGIS canvas
2. Now, we will create a text file that contains a set of classification rules that we use to classify the TPI rasters.
   a. Open NotePad or a similar text editor and create a text file in the format below:



   b. The first line tells QGIS to recode cells with TPI values < -8.0 m with a new value of 1
   c. Cells with TPI values from - 8 and + 8m will receive a new value of 2 and
   d. Those cells with values ≥ 8 m will receive a new value for non-range cells (*) of 3
   e. Save the text file to the ~MODULE_10 folder and name it TPI_rRecode_Rules.txt.

3. From the menu bar choose Processing Toolbox. Expand the GRASS commands toolset Raster (r.*) r.recode - Recodes categorical raster maps.
   a. Set the Input layer to HILLY_TPI.
   b. Navigate to the **~\MODULE_10\DATA** and select the **TPI_rRecode_Rules.txt** as the File containing recode rules.
   c. Name the output file **RE_HILLY_TPI.tif**
   d. Click Run.

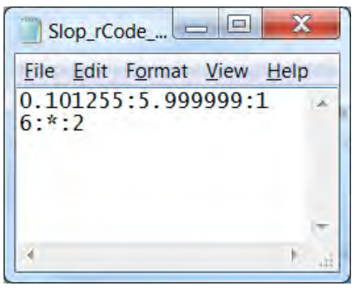




Reclassify Slope raster

1. Load the Slope raster into your QGIS canvas
2. Like the TPI raster above, we will now create a text file that contains the classification rules that we use to classify Slope rasters

   a. The first line tells QGIS to recode cells with Slope values < 6.0 ° m with a new value of 1 ° m
   b. Those cells with values≥ 6° mwill receive a new value of 2° m.
   c. Save the text file to the ~\MODULE_10 folder and name it Slope_rRecode_Rules.txt.

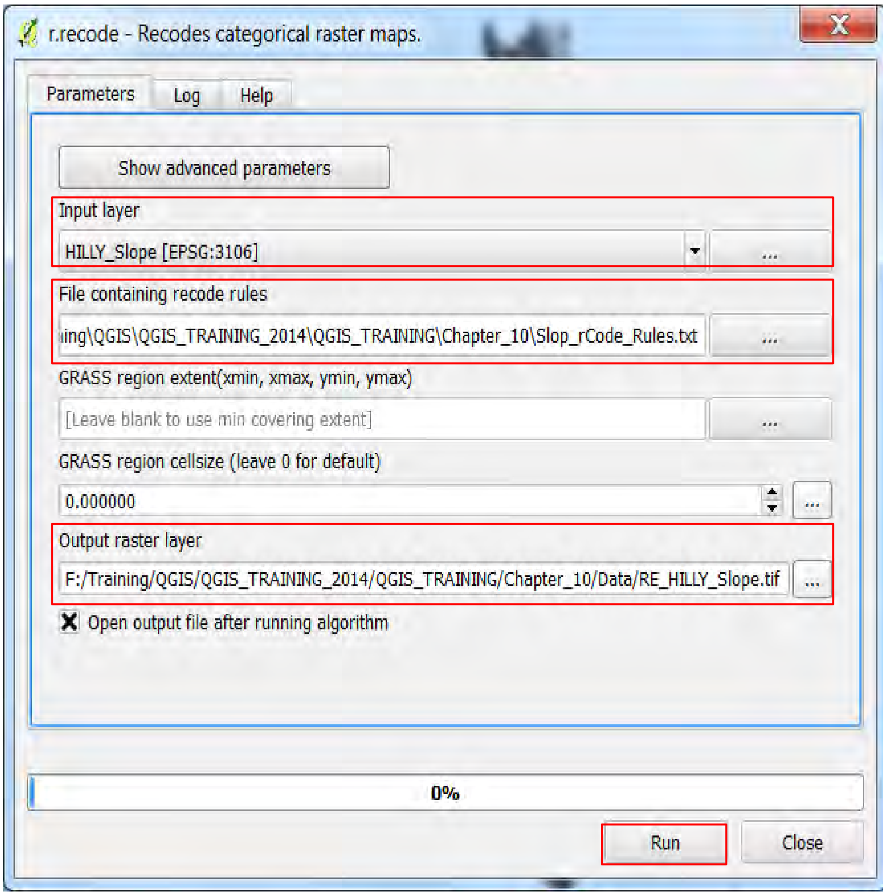


3. From the menu bar, next choose Processing Toolbox. Expand the GRASS commands toolset Raster (r.*) r.recode - Recodes categorical raster maps.

   a. Set the Input layer to HILLY_Slope.
   b. Navigate to the:

   ~**MODULE_10\DATA** and select the **Slope_rRecode_Rules.txt** as the File containing recode rules.

   c. Name the output file **RE_HILLY_Slope.tif**
   d. Click Run.



Raster Overlay

After reclassification of the slope and TPI data, we will now work to combine them to identify valley bottoms (TPI ≤ -8° m), ridgelines (TPI ≤ -8 m), gentle hill slopes (TPI= - 8° to + 8° m and slope < 6° m) and steep hill slopes (TPI= - 8 to + 8° m and slope ≥ 6° m).

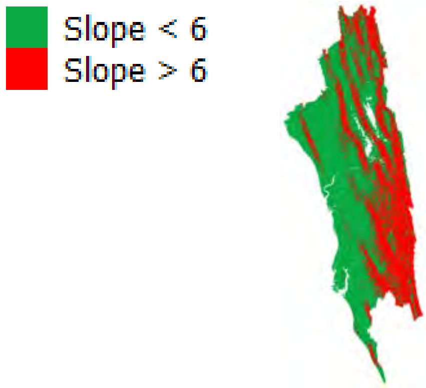
In this next step, you will learn how to use the Raster Calculator to combine the reclassified slope and TPI data. This tool permits the user to combine raster datasets and produce new outputs for further analysis. Raster datasets can be added, subtracted, multiplied and divided in a process known as raster algebra.

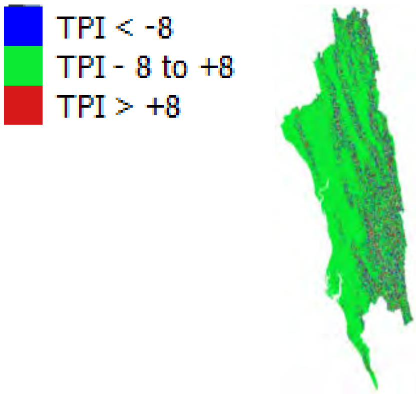
The expression looks like this:(("RE_HILLY_TPI@1" = 2) * "RE_HILLY_Slope@1") + "RE_HILLY_TPI@1"

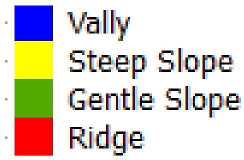
The above code can be understood as the following set of instructions. For every cell having a TPI class 2 that indicates a range from - 8° to + 8° m), reset this value to 1, otherwise reset it to 0, which creates a new mask. The second segment of the code indicates that this raster will be multiplied by the resulting mask values. In the last part of the code, QGIS will add "RE_HILLY_TPI@1" to the corresponding mask layer build a new raster with four selected Land form classes. This process is accomplished as follows:

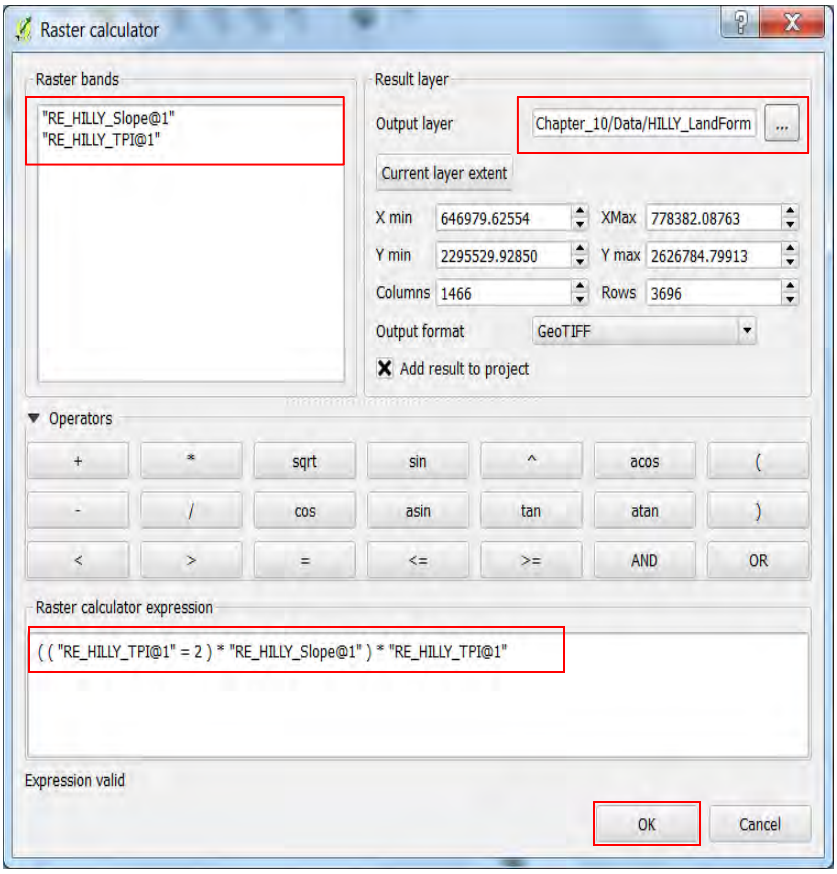
1. Load **RE_HILLY_TPI** and **RE_HILLY_Slope** raster in QGIS canvas
2. Click on the menu item *Raster* ‣ *Raster Calculator*

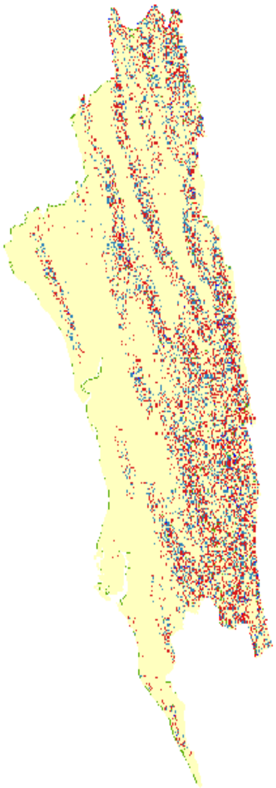
3. Write above expression in Raster calculator expression window
4. In the **Result layer** section, name the output layer ~**MODULE_10\DATA\HILLY_LandForm.tif**
5. Then click OK







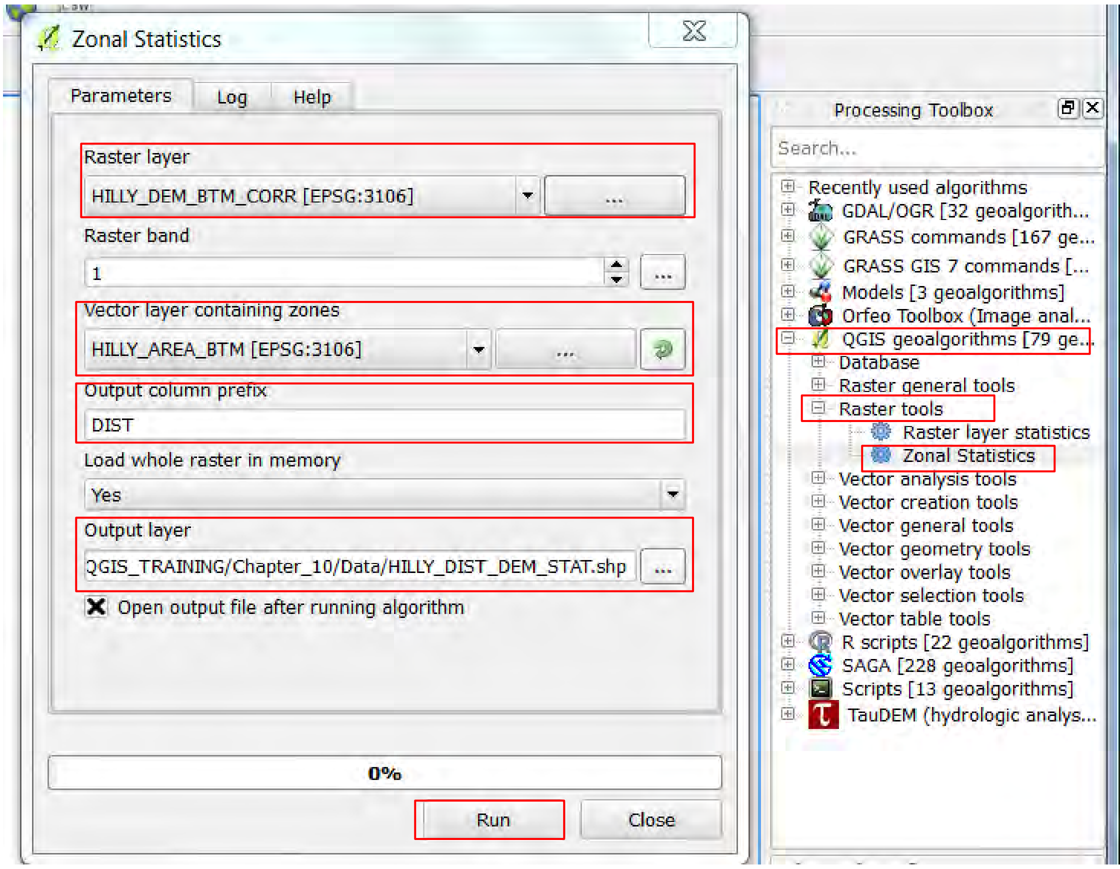


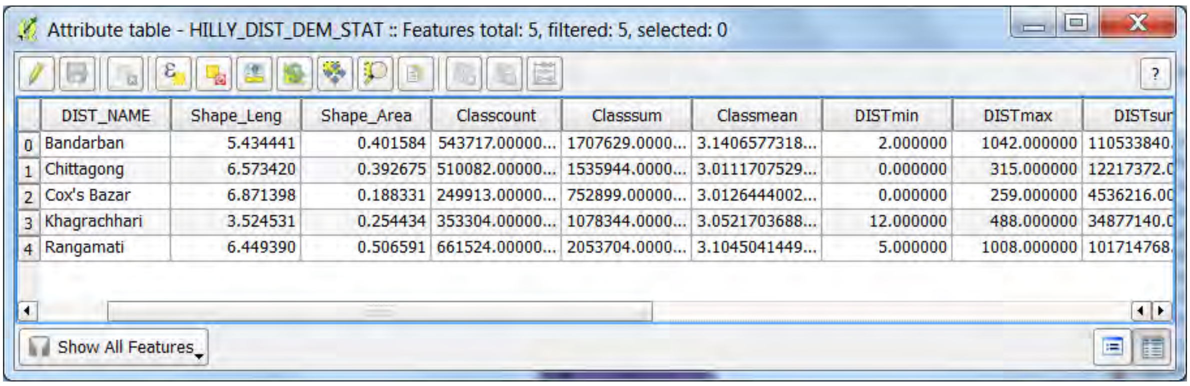


Zonal statistics

The zonal statistics function summarizes values of a selected raster within the zones that can be found in another raster or vector dataset. The function reports the resulting data in tabular form or as a vector layer file. In this exercise, we will calculate descriptive elevation statistics for four districts of hilly areas (zones) in Bangladesh using the Zonal statistics tool in QGIS.

1. Open QGIS Desktop 2.4.0.
2. Add the **HILLY_DEM_BTM_CORR.tif** raster and **HILLY_AREA_BTM.shp polygon** layers to QGIS Desktop.
3. Expand QGIS geoalgorithms –>Raster tools in the Processing Toolbox
4. Click on Zonal Statistics
5. Raster layers: **HILLY_DEM_BTM_CORR.tif**
6. Vector layer containing zones: **HILLY_AREA_BTM.shp**
7. Output column prefix:DIST
8. Output layer: Save to file ***~\MODULE_10\Data*** **HILL_DIST_DEM_STAT.shp**
9. Click Run




Attribute table - HILLY_DIST_DEM_STAT :: Features total: 5, filtered: 5, selected: 0

	DIST_NAME	Shape_Leng	Shape_Area	Classcount	Classsum	Classmean	DISTmin	DISTmax	DISTsur
0	Bandarban	5.434441	0.401584	543717.00000...	1707629.0000...	3.1406577318...	2.000000	1042.000000	110533840.
1	Chittagong	6.573420	0.392675	510082.00000...	1535944.0000...	3.0111707529...	0.000000	315.000000	12217372.0
2	Cox's Bazar	6.871398	0.188331	249913.00000...	752899.00000...	3.0126444002...	0.000000	259.000000	4536216.00
3	Khagrachhari	3.524531	0.254434	353304.00000...	1078344.0000...	3.0521703688...	12.000000	488.000000	34877140.0
4	Rangamati	6.449390	0.506591	661524.00000...	2053704.0000...	3.1045041449...	5.000000	1008.000000	101714768.

Show All Features

Module 11: Georeferencing Google Earth Imagery

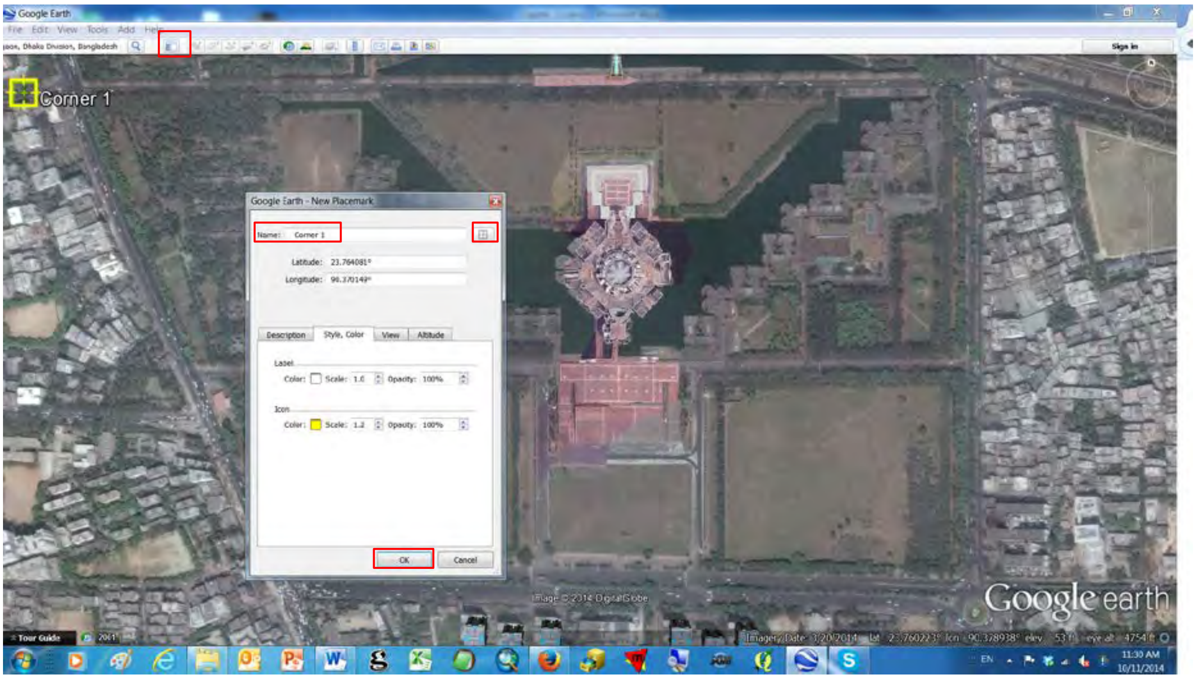
Google Earth is a free program offered by the Google company that provides relatively high-resolution satellite images online, which are updated on a regular basis. All imagery is open source, with relatively good coverage. Where you are unable to access higher resolution or proprietary satellite imagery, Google Earth offers a useful alternative. In this tutorial, we will explain how you can obtain satellite imagery from Google Earth, and then export it and geo-reference the image so that you can make maps or conduct further spatial analysis. We will also explain how to use the clipping tool in QGIS to trim the raster imagery you will download from Google Earth. To complete this tutorial you must have a copy of Google Earth desktop application installed on your computer, and also have an active internet connection. Google Earth can be downloaded here: https://www.google.com/earth/resources. Be sure to download the most recent version of the software.

Obtaining the Google Earth Satellite Imagery

Before you can georeference an image downloaded from Google Earth in QGIS, it is important to first set a few ground control points that have known coordinates. Without doing this, it is impossible to georeferenced the image for further spatial analysis. In this learning session, you will locate and indicate four basic ground control points, representing the lower left, lower right, upper left and upper right corners of the satellite image downloaded from Google Earth).

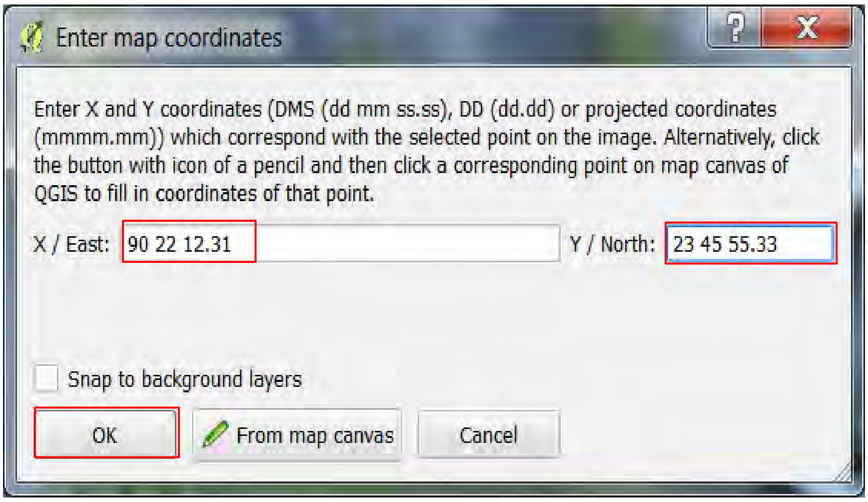
1. Open the Google Earth. IF you are not familiar with how to use Google Earth, it operates similarly to QGIS or other GIS applications. Tutorials on its use can nonetheless be located here:https://www.google.com/earth/resources
2. On the right side of the screen in the toolbar area, uncheck any borders and labels as well as roads or boundaries as they may make the satellite image difficult to see and read.
3. In the search bar, type **Tajgaon, Dhaka Division, Bangladesh** and then click the Search button.
4. Zoom into the area of the National Parliament building.
5. Click the Add place mark button. In the Name field, enter "Corner 1". After giving the name, click on the place mark icon button on the right of the field. Next look at the icon selection window. There will be a bull's-eye mark, which you will place your curser on and then click OK.
6. Now look for the Style toolbar. Select the, color tab set the opacity of labels to 0%. This will hide the label so the screen and satellite image is easily visible. Nowdrag the place mark icon to the uppermost left corner of the image, stopping wherever you would like to delineate the boundary that will be the cut off of your satellite image.
7. Use the same process for the other corners of the image, which you will label appropriately as corner 2, 3, and 4. When completed, you will have set up four ground control points around the edges of the National Parliament area, delineating the portion of the satellite image you will then extract.
8. When you are ready, position your curser the top left hand corner of Google Earth, and select File > Save > Save Image. Give the image the title 'Dhaka.jpg'.
9. If you have been working in fill screen mode, next press F11 to disable full screen mode so you can see multiple programs and windows. Take a moment to note in an

excel spreadsheet the latitude and longitude values the four ground control points for 'Dhaka.jpg' that you just selected. Next, save the spreadsheet as **Control_point.xls**. Next, right click on the Corner 1 place mark you set earlier, and select properties. Go back to your spreadsheet, and copy the Longitude value and paste it into the X column of your spreadsheet, then copy the Latitude value and do the same. QGIS Georeferencing requires that locations be entered in X, Y pairs, which is why we have advised this step. Repeat this process until you have X, Y pairs stored in Excel for all four-place markers.

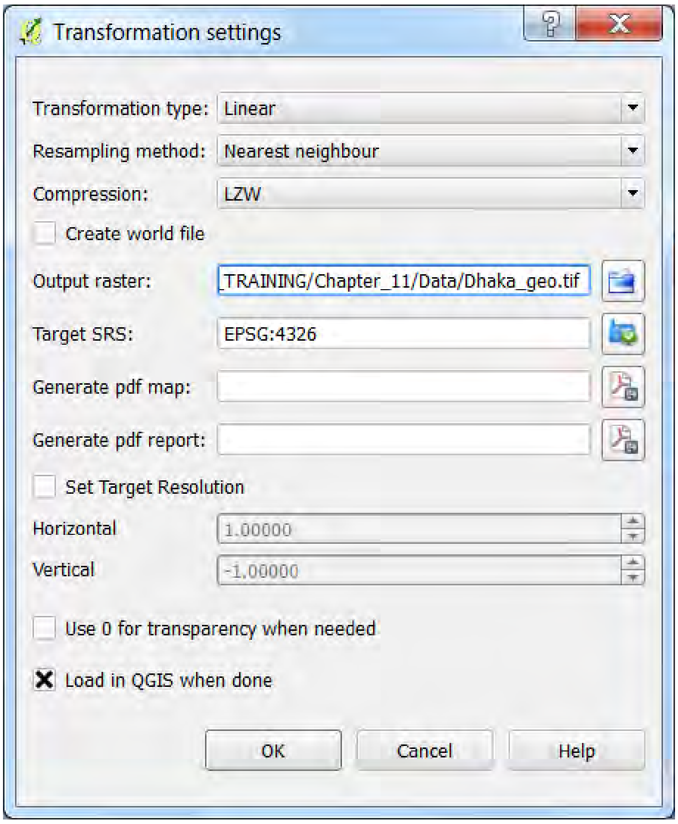


Georeferencing your image in QGIS

1. Open QGIS
2. Go to Raster->Georeferencer-> Georeferencer plugin
3. Click the "Open raster"  icon to import your recently created satellite image.
4. Now find your way to **Dhaka.jpg** on your computer, select it, and click Open. The image will then appear in the dialog box so you can work with it in QGIS.
5. Click on the zoom in tool and draw a box zoom around the Corner 1 bull's-eye that you will see.
6. You will now georeferenced the image in QGIS. Click the Add Point button and click precisely in the center of the bull's-eye. A pop-up window will then appear; that you can add your X and Y coordinates to.
7. Using your spreadsheet as a guide, type or copy-paste the values for the lower left bull's-eye. It is important that you use the precise format that QGIS understands, so your latitude and longitude values should look roughly like X: 90 22 12.31, and Y: 23 45 55.33. After you complete adding the coordinate values for Corner 1, you will see the record appear in the GCP table below your satellite imagery in the Georeferencer window of QGIS, as seen below.



8. Click OK to accept the changes you made.
9. Zoom out. Next, recreate the same steps but by entering the three other ground control points until your image is fully georeferenced.
10. Once you have added all of the ground control points (remember, you can also add more than four if you wish), select Settings > Transformation settings. We will be keeping the default options of Linear transformation type, Nearest neighbor resampling method and compression LZW
11. Once done, click on the output raster icon and find your way to the directory in which you saved your original satellite imagery from Google Earth. Save the new file from QGIS in the same folder, but with the name Dhaka_geo.tif.
12. For a target SRS , we suggest that you use the EPSG: 4326 coordinate system. This is the WGS 84 global Latitude and Longitude projection.
13. It is important that you assure that the checkbox is enabled to Load in QGIS. When you are done with this step, click OK so save the transformation settings.
14. In addition, remember to save your ground control points. This can be accomplished by clicking Save GCP points as, and then save the ground control points into a file called Dhaka.jpg
15. We are now ready to start georeferencing, click on the play button in the top left hand corner of the Georeferencer window. Once the process is complete, you will see your satellite imagery load in the main QGIS mapping area.



Clipping the Raster Image

You will now learn how to clip the raster image you just created, so you can work with it in refined form.

1. In QGIS, select Raster > Extraction > Clipper
2. Select and drag a box around edges of the reduced image where you want it to be clipped.
3. Click the select button, and then save the output file as Dhaka_geo_clip.tif
4. Don't bother to change the rest of the default settings. You can simply leave them as they are, and click OK
5. When you have finished the above, add the new raster layer and disable Dhaka_geo.tif by deselecting it.
6. Dhaka_geo_clip.tif should now be visible. It should be a clean, crisp image that is the size you want, and that is georeferenced.This new image can be used as a new background layer or on-screen digitization, and can be subjected to additional spatial analyses.

Module 12: Creating a New Vector Dataset

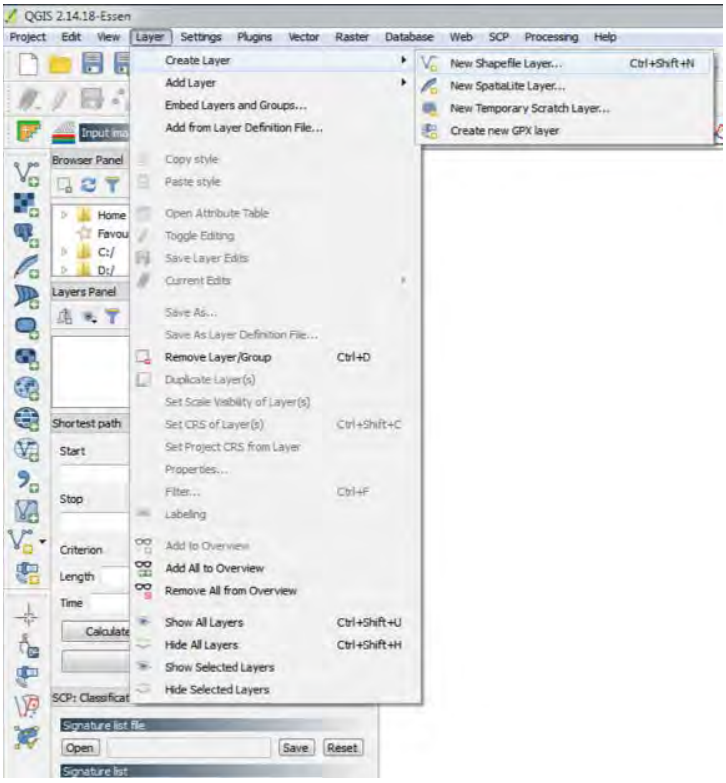
All data has to be sourced from somewhere. For most common geospatial applications, data can usually be found online or in open-access databases. However, the more particular and specialized your project, the less likely it is that data will easily be available. In these cases, you will may need to create your own new data from existing datasets, maps, images, or other sources. The goal for this module is to create a new vector dataset. This will provide background on how to create data that you can use for additional analyses.

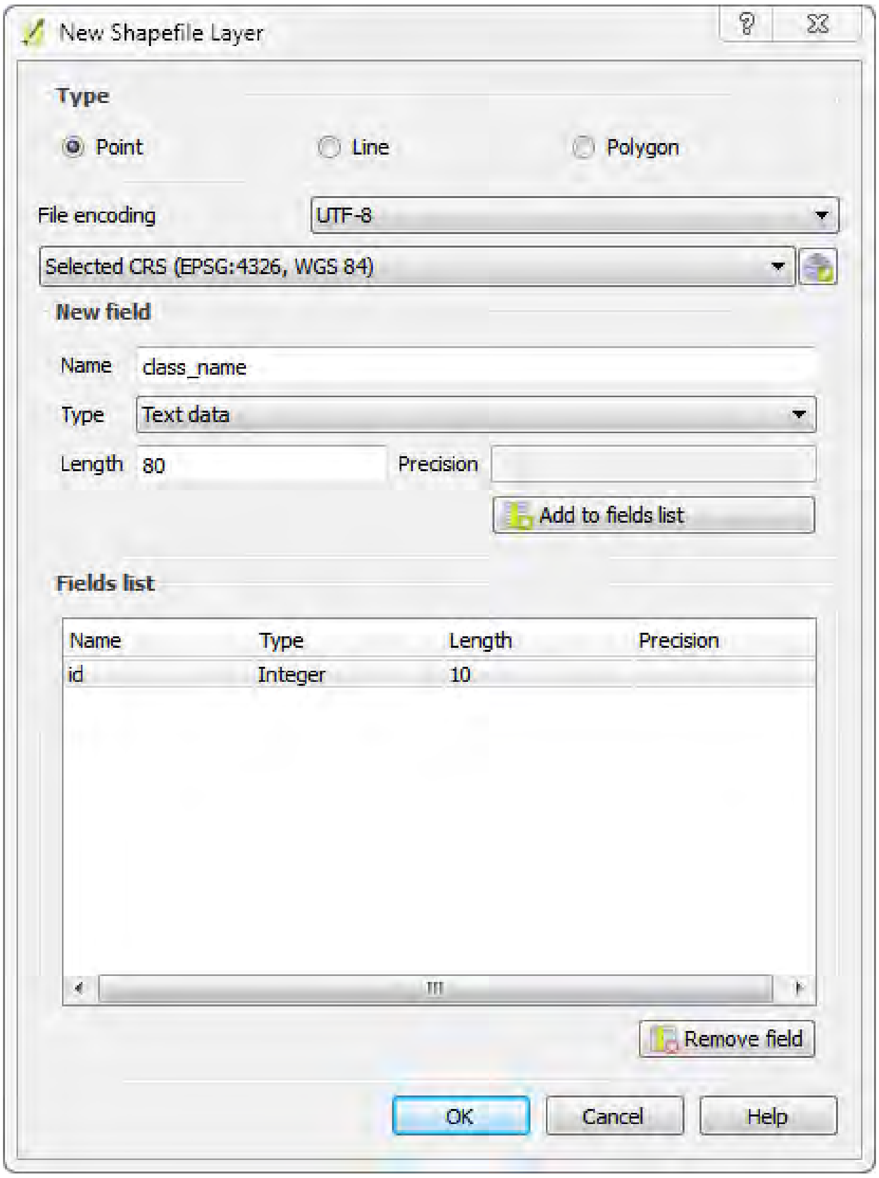
The Layer Creation Dialog

Before you can add new vector data, you need a vector dataset to add it to. In our case, you will begin by creating a new vector dataset entirely, rather than editing an existing dataset as you have in previous modules. Therefore, you will need to start by defining your own new dataset.

First, you will need to open the New Vector Layer dialog that will allow you to define a new layer.

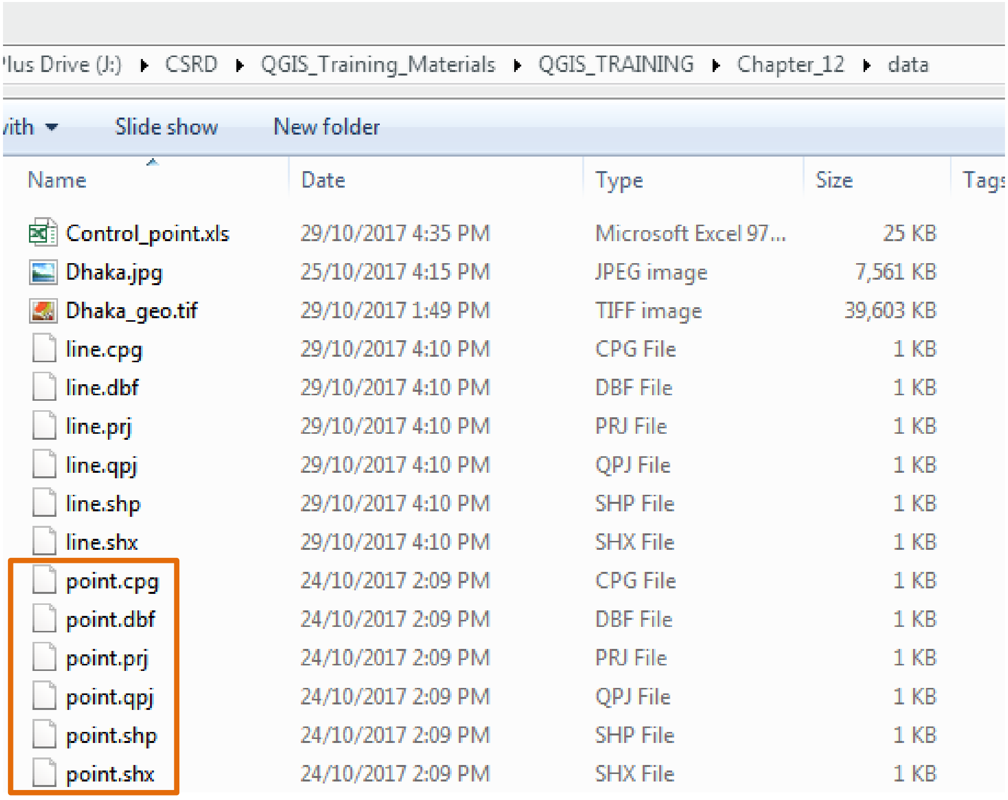
1. First, launch **QGIS Desktop 2.4** from your desktop
2. Click **Layer -> New -> New Shapefile Layer**





1. Click Point radio button from Type section of the New Shapefile Later window
2. Then under **file encoding** drop-down menu select file encoding **UTF-8**
3. Type class name in the name field
4. Keep **textdata** in type field
5. Leave length and precision at their default settings
6. Click 'Add to fields list'
7. Click 'ok'
8. 'Save layer as' window popup and save the shapefile as point in data directory of the Module 12 directory.

This will create a point shapefile. In order to create a line or polygon, please select the line or polygon radio button from the type field of new shapefile window accordingly.



'lus Drive (J:) ▸ CSRD ▸ QGIS_Training_Materials ▸ QGIS_TRAINING ▸ Chapter_12 ▸ data

/ith ▾ Slide show New folder

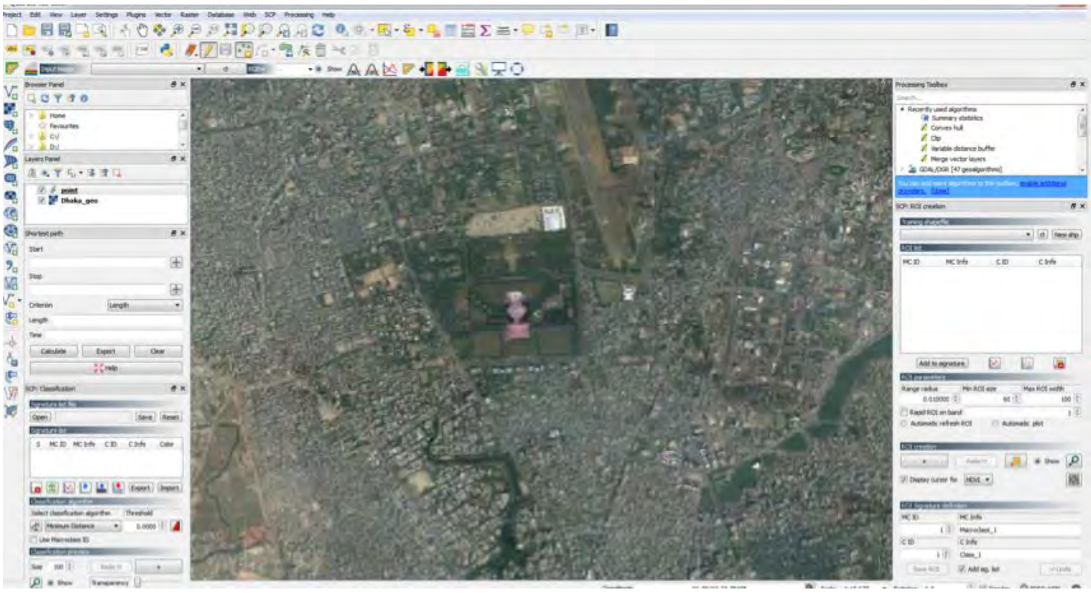
Name	Date	Type	Size	Tags
Control_point.xls	29/10/2017 4:35 PM	Microsoft Excel 97...	25 KB	
Dhaka.jpg	25/10/2017 4:15 PM	JPEG image	7,561 KB	
Dhaka_geo.tif	29/10/2017 1:49 PM	TIFF image	39,603 KB	
line.cpg	29/10/2017 4:10 PM	CPG File	1 KB	
line.dbf	29/10/2017 4:10 PM	DBF File	1 KB	
line.prj	29/10/2017 4:10 PM	PRJ File	1 KB	
line.qpj	29/10/2017 4:10 PM	QPJ File	1 KB	
line.shp	29/10/2017 4:10 PM	SHP File	1 KB	
line.shx	29/10/2017 4:10 PM	SHX File	1 KB	
point.cpg	24/10/2017 2:09 PM	CPG File	1 KB	
point.dbf	24/10/2017 2:09 PM	DBF File	1 KB	
point.prj	24/10/2017 2:09 PM	PRJ File	1 KB	
point.qpj	24/10/2017 2:09 PM	QPJ File	1 KB	
point.shp	24/10/2017 2:09 PM	SHP File	1 KB	
point.shx	24/10/2017 2:09 PM	SHX File	1 KB	

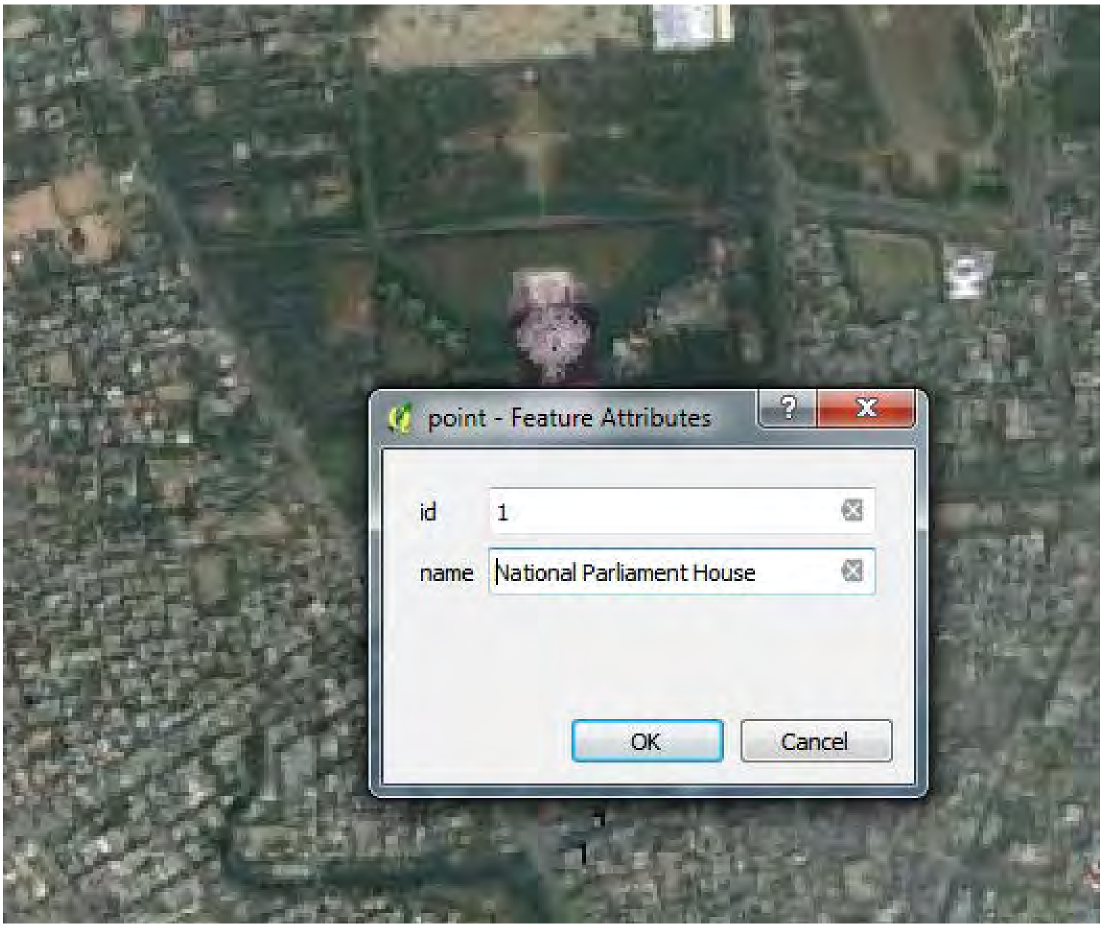
Getting started with digitizing

In order to digitize point feature, please follow the next steps:

1. Open Dhaka_geo.tif and point.shp from **~MODULE_12\DATA** folder.
2. Click the **ToggleEditing** button from the Digitizing toolbar

3. Now click on the **AddFeature** button from the Digitizing toolbar
4. Zoom to a specific part of the image. In this example, we will focus on the Bangladesh Parliament building, as shown below then click on it once.



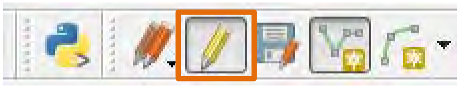


5. After clicking a popup window of attribute table will appear, Type 1 in the id field and National Parliament House in the name field.
6. A point has now been added after this attribute entry.

7. You can also add several additional points of interest throughout the image as you choose.
8. Now click on the Save Layer Edits button to save your editing, and then on the Toggle Editing button to close editing mode.

Digitizing linear features

1. Create a line shapefile following the poitn shapefile creation steps except choosing line radio button from Type section of the New Shapefile Later window.
2. 'Save layer as' window popup and save the shapefile as **line** in data directory of the Module 12 directory.



3. Click the Toggle Editing button from the Digitizing toolbar

4. Now click on the Add Feature button from the Digitizing toolbar, as shown below.
5. Zoom to specific part of the image, i.e. Green road as shown below.
6. Click and insert a node for the starting point of the linear feature. Next, continue clicking along the road until your mouse curser reaches the end of the road. After inserting end point, right click to finish your sketch of this linear feature.
7. The atribute table will appear when you finish this. Add the identification for this feature by adding the road name, or the name of any other feature you choose to inlclude. This will add the linear feature in the form of a line shapefile.
8. Now click on the Save Layer Edits button to save editing and the Toggle Editing button to close editing mode.

Adding polygon features

1. Create a polygon shapefile following the poitn shapefile creation steps except choosing **Polygon**radio button from Type section of the New Shapefile Later window.
2. 'Save layer as' window popup and save the shapefile as **polygon** in data directory of the Module 12 directory.
3. Click the Toggle Editing button from the Digitizing toolbar

4. Now click on the Add Feature button from the Digitizing toolbar, as shown below:

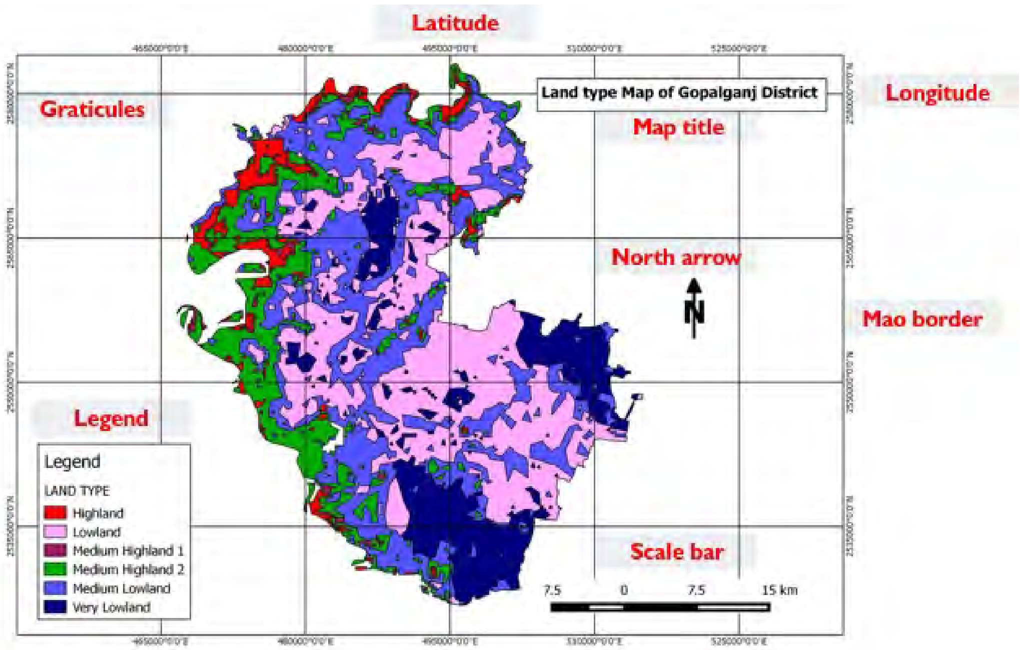
5. Click and insert a node for the starting point of your polygon feature and continue clicking along the edge of the waterbody (Hatir Jhil) until the temporary polygon mathes the edges of the waterbody in the image. After inserting the end point, right click to finish your polygon representation of the waterbody.
6. The atribute table will popup when you do this. Add the identification for this feature by adding the waterbody name, or the name of any other feature you choose to inlclude. This will add the polygon feature in the form of a polygon shapefile.
7. Now click on the Save Layer Edits button to save your polygon. Finally, click on Toggle Editing button to close editing mode.

It is important to decide which kind of dataset you want at this stage. Each different vector layer type is "built differently" (i.e. point, line, polygon) in the background, so once you've created the layer, you can't change its type. Once you have made your first vector layers, you can add more features using each type shapefiles you learned how to create. An example of a more detailed set of line and polygon vector files is shown below in the following figure.

Module 13: Map Production in QGIS

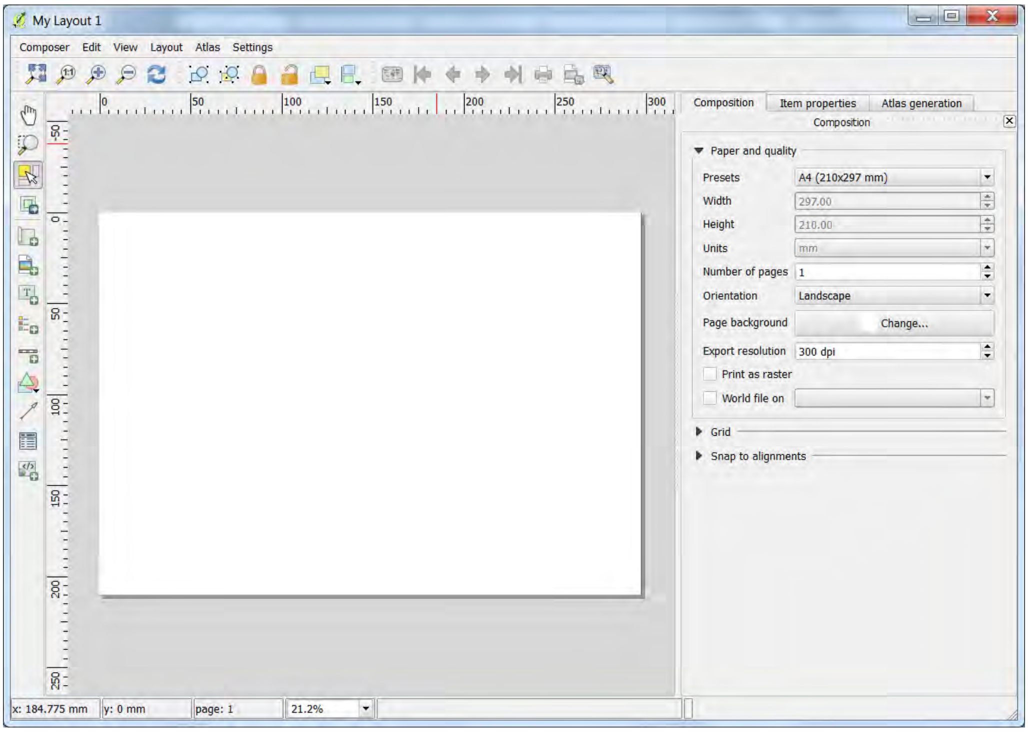
Congratulations! You have made it to the last learning module in this QGIS educational training. This module will bring together the skills you have learned so you can make a map in QGIS to represent your work. The production of maps involves the process of arranging map elements on surface in such a way that, even without many words, numbers, or additional information, an ordinary person can read the map and understand clearly most of the information in the map. While maps are often produced with no specific audience in mind, some maps are highly technical and for specific specialists in specific fields. But again, the purpose of most maps is to clearly communicate. Any map you make therefore has to be efficient in communicating spatial data to a wide audience, or even to a specialized technical audience. Most maps have the following components, which you will need to think about in making your map.

- Title of the map
- Map body, including all elements
- Legend giving a title to the map or any additional components or symbols
- North arrow, so the reader of the map can orient themselves
- Scale bar to indicate distance
- Acknowledgements (if any)
- Graticules, which are parallel lines that represent latitude and longitude, so the map can be considered in a georeferenced format



The Map/Print Composer

To make maps in QGIS, you will use the print composer window. It is in this window that you will create, layout, and print all maps with their corresponding elements. The print composer is relatively versatile, and can be used to align, change the size of, group, and arrange all of the elements you want in your map. The print composer is also the place where you will be able to adjust the properties of your layout. You can also export images in a variety of different formats from the print composer. When carefully saved, you can open the layout again to continue to work on it. Note that the tool is a bit touchy and takes some time to learn how to efficiently make effective maps. Be patient and persevere in your learning, as it will have great rewards. The print composer is shown below.

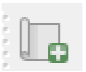
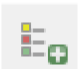
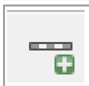
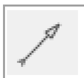
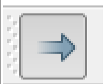


You will notice that the print composer has four important tabs. They are summarized below

- The first tab is the *Composition* tab. It is used to set the size of the paper you will print on, orient your map, and change the quality if what you will print onto paper. This tab also allows you to activate a grid that your image can be 'snapped' (positioned) to at a resolution of your choice. You can also modify the number of pages you might expect to print or layout your map on.
- The second tab is the*Item Properties* tab. This tab is used to show the properties of an element that you can select in the map itself. To use the *item properties* tab, Click the Select/Move item icon and choose an element (e.g. legend, scale, compass, etc.) on the canvas. Watch as information about that element appears for editing.
- The third tab is particularly useful. The *Atlas generation* tab will generate an atlas. It also grants you access to the atlas, which will help you to make more creative and clear maps.

- The last of the tabs is the *Command history* tab, which is hidden by default. When enabled, this tab displays historical accounting of each step and change that has been made to the map while working in the print composite. By reviewing this history, you can use a simple a mouse click undo and redo layout steps, which is very useful for correcting errors and changing the map.

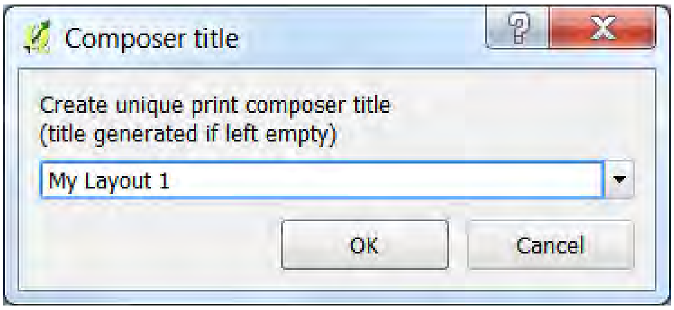
Now have a look at the icons across on the left hand size of your print composer window. The table below reviews what some of the icons you see mean, and indicates what they do.

Display Icon	**Function**
	**Add New Map** icon is used to add a new element to your map. It is however very important to note that if you change a map in a QGIS project, it does not automatically update the same map that you have added to you print composer, as we shall see later. Additional steps are needed to do this.
	**Add Image** allows is used when you want to add a picture image to your map. Images include compasses, or logos, or other media you think will be of use.
	**Add New Label**. This is used when you want to add new text at a location of your choice on the map.
	**Add New Legend** is for adding a legend, which will conform to the active layer in the QGIS window.
	**Add New Scale Bar** is a self-explanatory button that adds new scales to your map to measure length.
	**Add Ellipse/Triangle/Rectangle** is used to when you are interested to add a shape to your map. Use of shapes can enhance maps in many ways, ultimately to make the map look more attractive.
	**Add Arrow** is used to draw an arrow on the map. Arrows are useful to call the reader's attention to a particular element of the map.
	**Select / Move Item** allows us to move choose and move the elements that you add to the This is the map layout tool.With this tool selected, you can right -click on an element to lock its position.

Load Print Composer

You will now learn how to work with print composer and make a map.

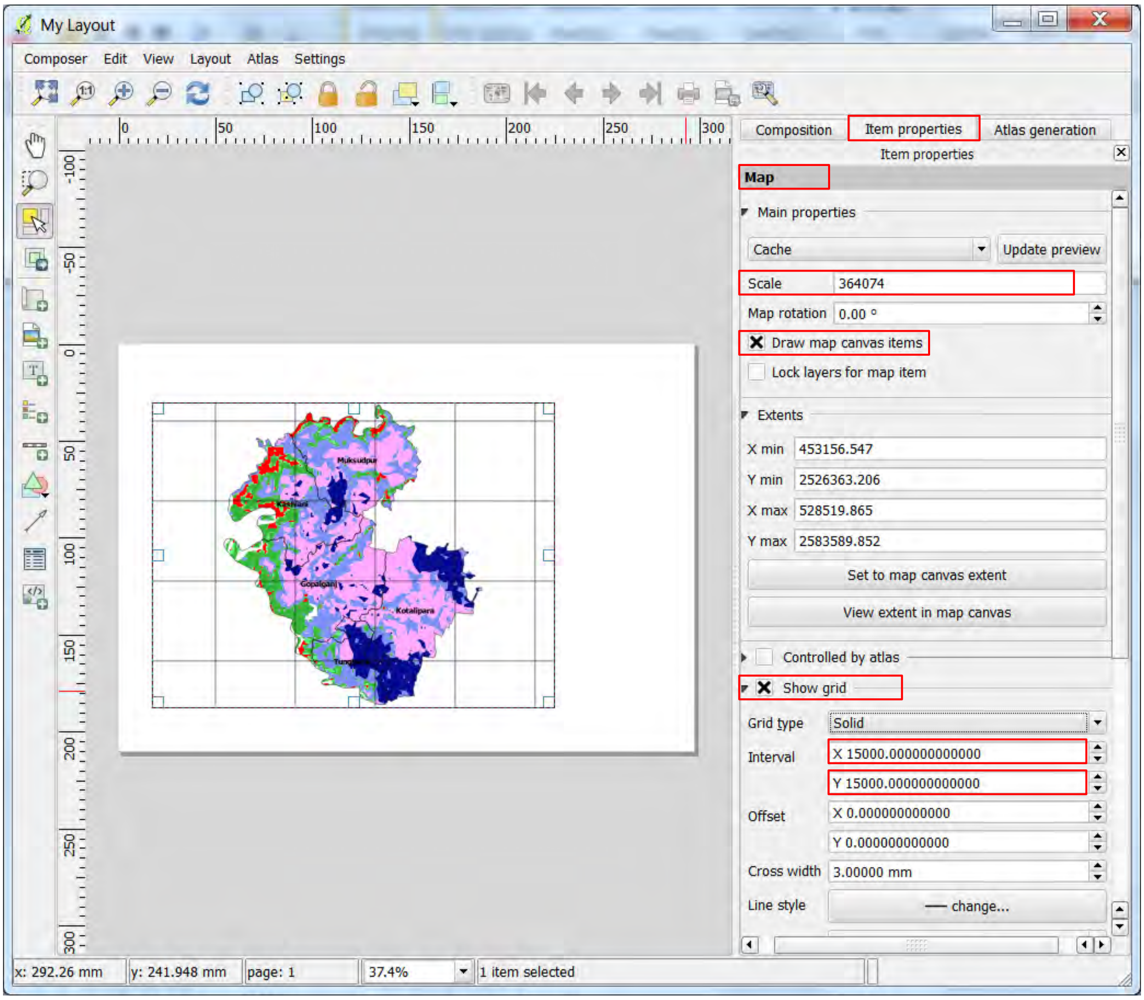
1. Open QGIS Project Module12 (~\MODULE_12\Data)
2. Change any of the colors on the map or symbols to your liking
3. Click the New Print Composer icon or choose *File ‣ New Print Composer*. This action will prompt you to give your map a unique title of your choice.



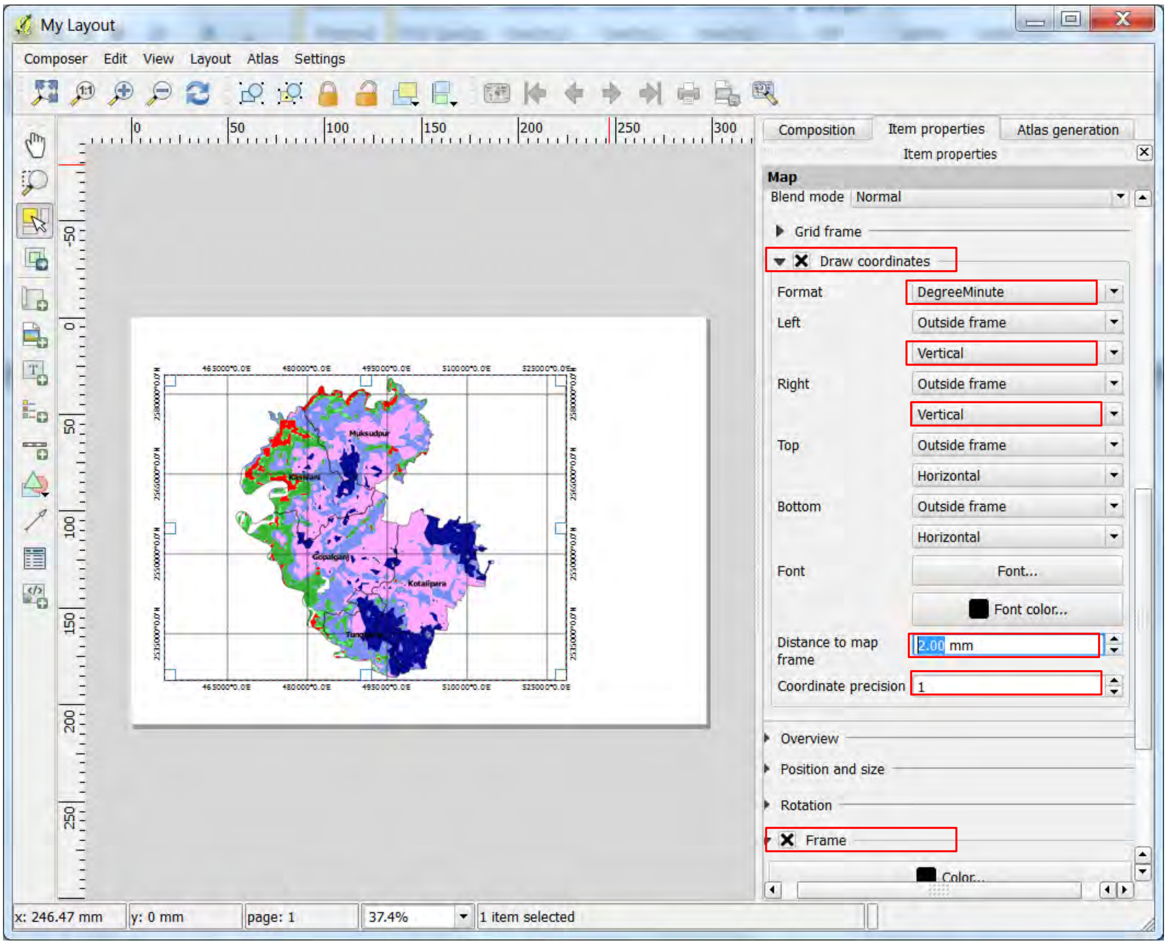
4. Once you have given a name you like, click OK, then a composer window will load on your screen

Add your map

1. Looking at the Print Composer window, find and click on the *Add new map* icon
2. Once you have done that, click and drag your mouse across the screen. This creates a box.
3. Once you have done that, click and drag your mouse across the screen. This creates a box.
4. Take a moment to look at your map. If you are dissatisfied with how it is placed in your print composer, drag the corners of the map to change its size. You can also drag the entire element around the canvas and reposition it as you like.
5. *Go to the Composition* tab. Feel free to experiment with changing page numbers, size, orientation, layout qualities, and so on, until you feel comfortable with this tool.
6. Once you have learned how to use the above tab, navigate to click on "Item Properties". You will find it in the right panel.
7. Take some additional time to learn how to edit and change the *Scale and press Enter when you are done*. You'll see that the scale (zoom level) of the map element changes. A scale of about 1:36500 is more or less appropriate for this project.
8. To accomplish this, check Draw map canvas items. In the Map, check Show grid, and in the interval field, enter X = 15000 and Y 15000.

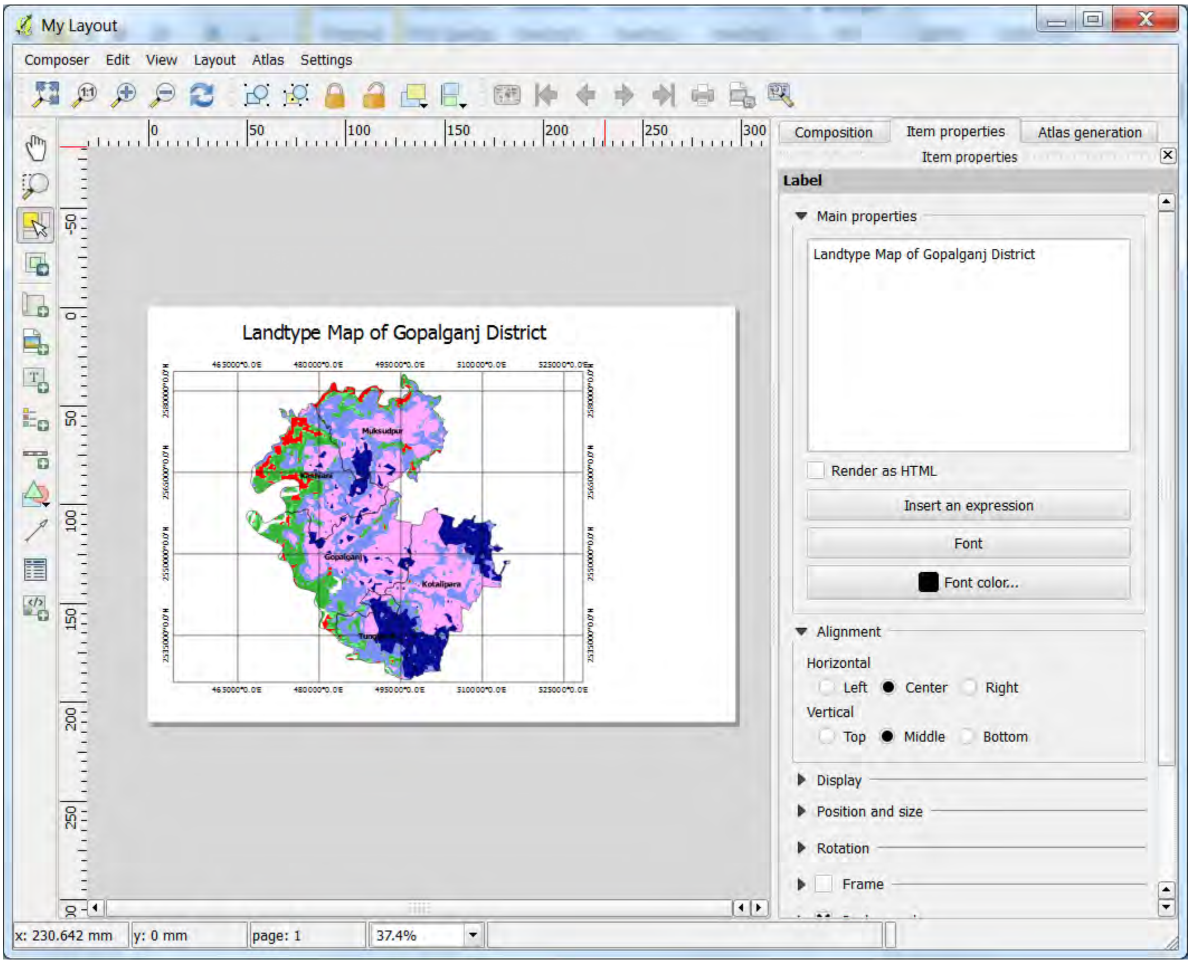


9. Next check Draw coordinates
10. Select the format: DegreeMinute
11. On the left: Select outside frame and Vertical
12. Do the same for the right
13. Change your font size 12 or any size of your choosing.
14. Set the distance to the map frame (experiment with what looks good to you, but we suggest starting with 2 mm)
15. Set coordinate precision to 1
16. You can next add a frame to your map by clicking 'box' next to *Frame*. Here you can also change and set the frame color and line thickness to your preferences.



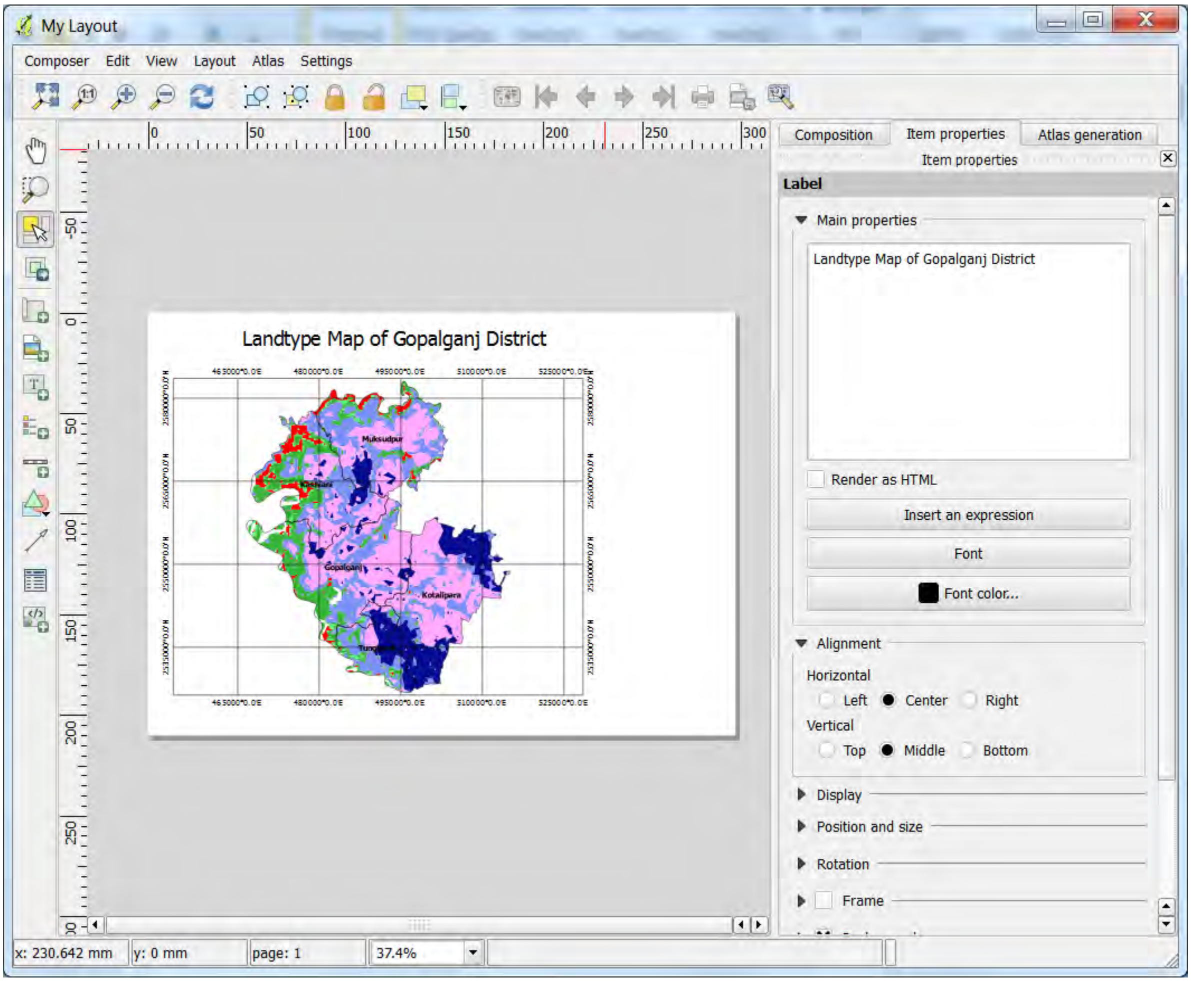
Give your map a title

1. Each map needs a good title to orient the map-reader. To add a title, click on the *Add new label* button, which looks like  this:
2. Adjust the size of the element to your choosing. The actual text and details of the style and font elements are shown to the right.
3. Click the *Font* button and change the text size to 36 (or any size you prefer). Experiment with making it bold, italic, or any style you choose. Change the alignment to the center of the map (horizontal and vertical) to position the title correctly. Lastly, add the type "**Landtype Map of Gopalganj District**"



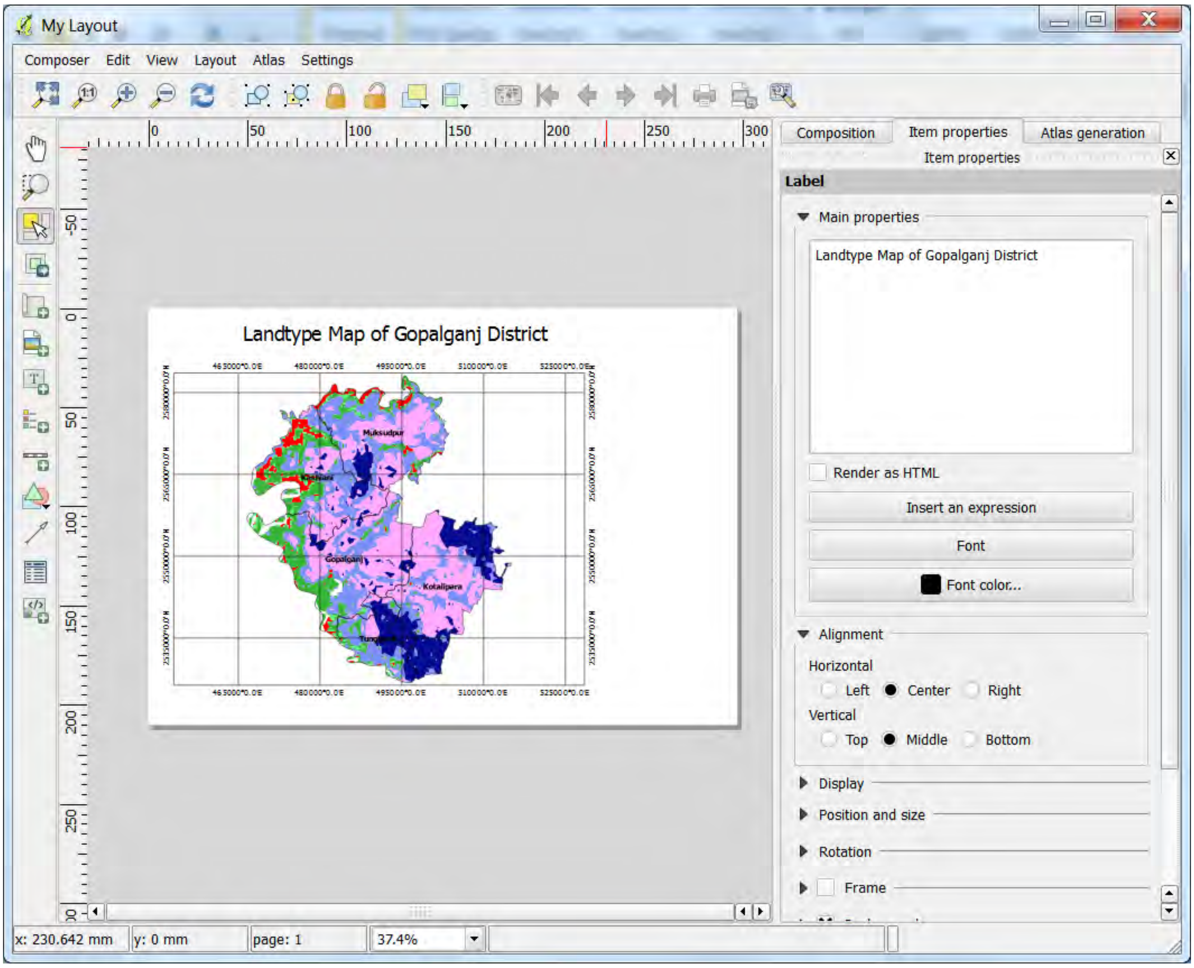
Add a Scale Bar

1. Scale bars are crucial for giving the reader perspective on the size of the map, and to measure distances. Click on the *Add scale bar* button.
2. Using your mouse, click and draw the new scale bar element on your map. Many people prefer to place their scale on the left corner of your map layout, though you can choose to put it anywhere you prefer.
3. You will next learn how to adjust the scrollbar options on your map. Since our project is in a PCS (Projected Coordinate System), all of the measurements in the map will appear in the metric system. Please enter the following information in the scale bar options to create a standard quality scale bar, as follows:



Add a Legend

1. In order to add a legend to your map, first click on the *Add legend* button, which looks like this:
2. Next draw a box  in the area where you wish to see the legend appear in your map. This will usually be one of the areas with blank space. After drawing the box, you will see a legend with appear with all relevant symbols for the map elements in it.
3. What if you want to change the legend? You can do this by looking at the panel on the right, and clicking *Legend items*. You cannot make use of the edit button to change the names and other features on the legend, including the font, font size, and so on. If you want to add or remove items from the legend, use the + and – buttons, respectively.



Printing the Map

- When you are done, you can print the map. Simply click on the *Print* button, which looks like the symbol to the right, and follow the instructions.. 
- Maps can be saved in a variety of formats, including PNG images. 
- Maps can also be saved as portable document viewers (PDFs), which many prefer for emailing and printing, etc. 

Glossary of keywords

Azimuth
The angular distance from the north to south point of the horizon that can be transversed by a vertical circle that intersects the horizon, which represents the direction of an object from the observer.

Buffer (or buffering)
Buffering creates an envelope of space around selected features in source layer or file. For this reason, buffers are sometimes referred to as a zone of a specified distance around a polygon, line, or point features. Buffering is often used for proximity analysis.

Clipping
Action that creates a new shape based on the input layer's area, that is overlapped by a clipping layer. Not to be confused with intersection.

Color ramp
A specified range of colors that change depending on the value of measured data, used to display gradients on a map.

Convex hull
A convex hull takes the outer border nodes from a vector shape (which you will recall may consist of points, lines or polygons) and uses them to develop a polygon of the minimum sized area that surrounds all features in the dataset, but that also avoids any concave angles.

Comma separated values (CSV)
A text delimited file. See 'Text delimited'.

Curvature
The change in the degree of slope for a given distance on that slope.

Digital elevation model (DEM)
A three dimensional representation of a portion of the surface of the earth, represented in QGIS using terrain data represented usually by points that correspond to different elevations.
Numerous kinds of DEMs exist.

Digitizing
The process of converting images into digital form that permits computer processing.

Dissolve
Separation of overlapping areas in the same layer.

Ellipsoid
In GIS, a regular oval shape, as a two dimensional representation of the globe as a spheroid.

EPSG code
A geodetic parameter dataset made up of coordinate reference systems (CRSs) that is widely available online.

Field calculator
A tool for automatically calculating the area of a polygon.

Geographic coordinate system (GCS)
The earth is not a perfect sphere, despite being often depicted as such. Because of this, different spheroid representations of the earth exist. Geographic coordinate systems use latitude and longitude to measure and indicate locations on the globe, defined as a function of direction and distance from a center point. Where representations of the globe however differ, so will the central point from which coordinate systems are measured. This complicates use of different coordinate systems, especially when they are to be compared, or data in one system is imported into a GIS basal layer that uses a different system. This often requires transformation of the coordinate system to assure alignment in the workspace.

Geographic Resources Analysis Support System (GRASS)
GRASS is an open-source GIS software suite with a high degree of flexibility, allowing the user to process images, make maps, perform spatial analysis. The GRASS GIS homepage is https://grass.osgeo.org/.

Georeference
To mark a location by tagging it with latitude and longitude values.

Google Earth
Google earth is a freely available online virtual map of the globe and GIS. The homepage for Google Earth is https://www.google.com/earth/.

Graphical User Interface (GUI)
A computer format that allows the user to interact with the computer through visual indicators (e.g., menus, buttons, windows, fields). GUI formats contrast with the user having to type code.

Graticule
Networks of lines that when combined represent latitude and longitudes, as represented in a map.

Ground Control Point(s)
These are locations on the globe that have been delineated to geo-reference satellite derived data precisely. These points have been accurately surveyed and are commonly used to correct for elevation differences in observed measurements, and for other purposes to improve spatial accuracy.

Interpolation
The process of constructing new point data by relying on the range of discrete points available in a given dataset.

Layer
Layer signifies different levels of information (for example shape files) that are arranged sequentially in a geographical information system for viewing and spatial analysis.

Nearest Neighbor
An algorithm that interpolates adjacent elements to fill in surfaces with information.

One-dimensional lines
See 'polyline'.

Pan / Panning
To switch view between windows or images on a computer.

Profile-curve
A vertical measurement of the change of a slope over a given distance. Positive values indicate convexity, while negative values represent concave profiles.

Plan curve
Measurement of the rate at which a horizontal curve changes. Positive and negative values, respectively indicate divergence and convergence of a particular slope.

Plugin
Software that can be added or 'plugged in' to another piece of software.

Point
See 'Zero dimensional point'.

Point layer
A shapefile or layer that displays point data.

Point shapefile
Shapefile used to geo-locate and describe point features such as villages or cities.

Polygon
Polygons are two-dimensional geographical features covering a portion of the earth's surface, for example forests, lakes, administrative boundaries, farmers' fields, or any other organizational unit the user defines. Polygons are important because their area and perimeter can be measured.

Polyline
One-dimensional lines, also called polylines, are used to represent geographical features like rivers, roads, railroads, trails, and topographic lines. Note that these features are linear in nature and do not have area like polygons. Hence they can measure distance.

Progress bar
Located in the status bar, the progress bar shows progress of rendering as each layer is drawn to the map view.

Projected coordinate system
Cartesian (X and Y coordinates) approaches are used to define locations in projected coordinate systems, which consider the global as a flat, two dimensional surface based on a flattened representation of a sphere on a flat plane, with geographical coordinate systems. This approach is useful where accurate distance, angle, and area measurements are needed. The term 'projection' is often used interchangeably with projected coordinate systems.

Raster (and Raster Data)
A particular type of geographical model. Using a grid format, it covers the space of each cell, the smallest measurement unit in the in the grid, aligning it with a measured geographical feature in this location. Combined into a matrix, a raster is a grid of cells.

Raster (and Raster Data)
A particular type of geographical model. Using a grid format, it covers the space of each cell, the smallest measurement unit in the in the grid, aligning it with a measured geographical feature in this location. Combined into a matrix, a raster is a grid of cells.

Raster algebra
The process of adding, subtracting, multiplying, or dividing data within raster files to create new outputs.

Raster reclassification
The process of aggregating data values into specified data categories.

Re-project (re-projection)
To change the geographic coordinate system of a particular layer into another one.

Roughness
When comparing among the differences in cells in a raster and a central pixel, you are making a comparison of roughness. This is useful for helping to determine the overall variation and frequency of change in elevation in a DEM, or particular selected parts of a DEM.

Scene
Captured path image from a satellite or other aerial survey instrument.

Shape file
A popular geospatial vector data format for geographic information system GIS software. It is developed and regulated by ESRI as an open specification for data interoperability among ESRI and other GIS software products. A "shapefile" is actually a set of several files. Three individual files are needed to store the core data that comprises a shapefile: .shp (shape format; the feature geometry), .shx (shape index format; a positional index of the feature geometry to allow seeking forwards and backwards quickly), and .dbf (attribute format; columnar attributes for each shape, in dBase IV format). The actual shapefile relates specifically to .shp files, but alone are incomplete for distribution, as the other supporting files are required.

Slope
Slope is the incline and steepness of a surface.

Shuttle Radar Topographic Mission (SRTM)
An international research collaboration that utilized satellite derived radar data to produce digital elevation models (DEMs) and to catalogue topographical information.

Status bar
The status bar shows you your current position in map coordinates (e.g. meters or decimal degrees) as the mouse pointer is moved across the map view.

System for Automated Geoscientific Analyses (SAGA)
A free and open source geographic information system used for editing spatial data.

Terrain Ruggedness Index (TRI)
The mean difference between a central pixel and its surrounding cells.

Text delimited
A data storage file in which each line of the file represents a different entry separated by a delimiter. This allows data fields of any length that the user might want. In QGIS, text delimited file is an attribute table. Each separate column has a separate and defined data character, and each row is independent. The first row references column names.

Toggle
To switch between two modes, choices, or windows, or keys on a computer.

Vector
In vector data models, geographical features are represented using lines, points, and polygons. Vector models conversely store date with discrete edges and boundaries, for example district or division boundaries, country borders, road and river networks, etc.

Z-ordering
In the map layer, Z-ordering means that layers listed nearer the top of the legend are drawn over layers listed lower down in the legend.

Zero-dimensional point
Considering mathematics, a zero-dimensional point is an abstraction of an object that can be represented by latitude and longitude coordinates. Representative of geographical features like wells, soil sampling locations, and so on,, that can be best expressed by a single reference point. These points confer the least information about these file types, and are best to represent geographical data that are very small scale and with limited area.

Zonal statistics
The zonal statistics function summarizes values of a selected raster within the zones that can be found in another raster or vector dataset. The function reports the resulting data in tabular form or as a vector layer file.

Zoom
To smoothly transition from a long-distance view to a close-up view, or vice versa, on a computer.

About the authors

Zia Uddin Ahmed

Dr. Ahmed has over 20 years of work experience in environmental modeling and data analysis. His Areas of expertise include (1) data mining, (2) geographic information systems (GIS), remote/proximal sensing, and geostatistics (3) linear/non-linear model, mixed effect model, multivariate statistics and machine learning and (4) database management. He is currently a Research Associate Professor and database and visualization specialist at the University of Buffalo's Research and Education in Energy, Environment and Water (RENEW) Initiative. He holds a PhD in Soil Science from Cornell University. Before RENEW, he worked for the International Maize and Wheat Improvement Center (CIMMYT) as a Remote Sensing Scientist in Bangladesh. Before CIMMYT, Dr. Ahmed also worked for the Bangladesh Rice Research Institute (BRRI) and Cornell University.

Timothy J. Krupnik

Dr. Timothy Krupnik is a Research Scientist and Systems Agronomist with the International Maize and Wheat Improvement Center's (CIMMYT) Sustainable Intensification Program. He leads a portfolio of applied research projects across South and South-East Asia that deliver evidence-based knowledge and activities to improve the sustainability and resilience of smallholder farming systems considering agronomic, ecological, and socioeconomic objectives, methods, and indicators. With core expertise in systems agronomy and interests spanning socio-ecological systems analysis, climate services, and science communication and extension, Timothy prioritizes integrative, interdisciplinary, and multi-scale research. He also serves as the overall CSISA coordinator for Bangladesh. Prior to CIMMYT, Timothy was affiliated with the Africa Rice Center and researched the agronomic, environmental and socioeconomic consequences of water-saving irrigation technologies in West Africa. He has also worked in East Africa and the Caribbean consulting for donor agencies and NGOs.

Mustafa Kamal

Mustafa Kamal is a GIS and Remote Sensing professional with the International Maize and Wheat Improvement Center's (CIMMYT) Sustainable Intensification Program. He has more than 8 years of working experience and specializes in the effective and efficient use of geospatial data applications across disciplines. With a background in urban and rural planning and disaster management, he is expert in the use of GIS, Remote Sensing (Optical, SAR, Thermal), Unmanned Aerial Vehicle (UAV) technologies, and machine learning algorithms for pixel and object based image analysis. He is also interested in land use and land cover classification using machine learning methods applied to remotely sensed data. Mustafa is passionate about using cutting edge remote sensing science to provide a better understanding of the complex relationships between crop performance and environmental change, while providing useful information and advisories for farmers.

Introduction to basic GIS and spatial analysis using QGIS: Applications in Bangladesh

This book provides a set of learning modules introducing young scientists and researchers to Geographic Information Systems (GIS) and spatial analysis using the open-source QGIS platform, and complementary R, SAGA and GRASS Platforms. The modules can be used for self-directed learning or to teach courses. Practical exercises that utilize spatial data for Bangladesh are included, and all required spatial data can be downloaded from an open-source website. The modules provide an overview of GIS, spatial data visualization techniques, and exercises in working with Global Positioning System (GPS) data, tabular, and raster data. Students will also learn terrain and spatial analysis, and also how to do georeferencing Google Earth image with QGIS and to develop new vector datasets and digitizing. Exercises on how to produce aesthetically pleasing and informative maps are also included. By the time students complete working with these modules, they should be proficient in QGIS and spatial data analysis, and able to continue using these tools on an individual basis without considerable extra coaching.

CIMMYT
International Maize and Wheat Improvement Center

CIMMYT- Bangladesh
House 10/B, Road 53, Gulshan 2, Dhaka 1212
Tel (Land/Fax): +880 2 9896676, +880 2 9894278
Post: P.O. No. 6057, Gulshan, Dhaka 1212, Bangladesh