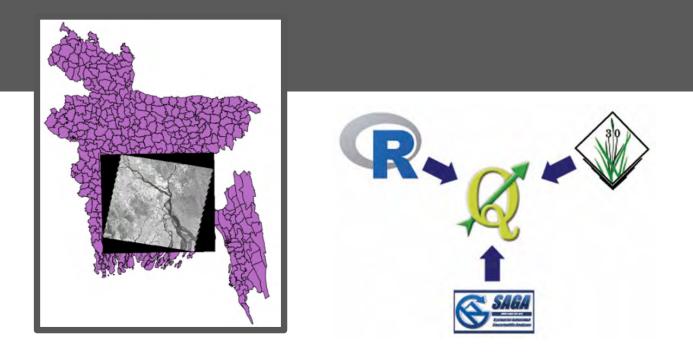




# Introduction to basic GIS and spatial analysis using QGIS:

## **Applications in Bangladesh**



Zia Uddin Ahmed Timothy J. Krupnik Mustafa Kamal



## Introduction to basic GIS and spatial analysis using QGIS:

### **Applications in Bangladesh**

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**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.

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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.



CSISA was established in 2009 to promote durable change at scale in South Asia's cerealbased 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.

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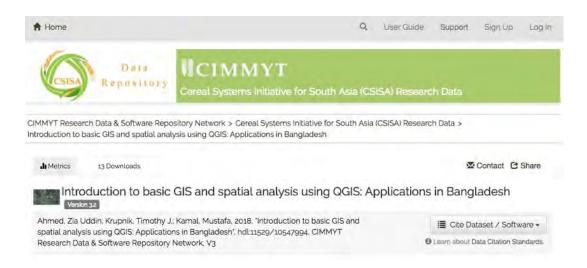




## Instructions before you begin using this set of learning modules

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:

I. Go to the following link by <u>clicking here</u>. 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 I: Downloading and Installation of 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.

- I. Click the
  - Windows Start button



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

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Manifold System 8.0 (32-	bit)
퉐 Create a System Repair D	lisc
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🕎 System	
🛃 Edit the system environn	nent variables
🛃 Restore system files and	settings from a restore point
Documents (488)	
1 system	
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🕖 🖓 🕨 Control Panel 🕨	System and Security 🕨 System			✓ ↓ Search Control Panel	
File Edit View Tools Help					
Control Panel Home	View basic information	about your computer			6
Device Manager	Windows edition				
Remote settings	Windows 7 Professional				
System protection		ft Corporation. All rights reserved.			
Advanced system settings	Service Pack 1	recorporation. An right reserved.			
	Get more features with a n	ew edition of Windows 7	64-bit	] 🙋	)
	System Rating:	7			
		7.3 Windows Experience Index			
	Processor:	Intel(R) Core(TM) i7-3930K CPU @ 3.20GHz 3.20 GHz			
	Installed memory (RAM):	64.0 GB			
	System type: Pen and Touch:	64-bit Operating System No Pen or Touch Input is available for this Display			
	Computer name, domain, and	workgroup settings			
	Computer name:	Zia-BigPC		Ghange s	settings
	Full computer name:	Zia-BigPC.CIMMYTBD.local			
See also	Computer description:				
Action Center	Domain:	CIMMYTBD.local			
Windows Update	Windows activation				
Performance Information and	Windows activation Windows is activated				
10015		1193-85170 Change product key		genu	ine

#### **Download QGIS Installers**

For installation of the latest version of OGIS please go to https://www.ggis.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:





I. Click Windows Start button

A statement of the QAD project     (+)	international design of the second se	
💓 <sup>22</sup> discover ogis for Users get involved documentation (	Egteh	1
A Free and Ope	GIS eographic Information System	
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2. Go to Control panel, then System, then System type

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😧 Asscover agus for users art involv	ED EDOCEMENTATION		togun -
	Download QGIS for your Platform		
	The current version is QGIS 2.2 and was miseased in February 2014		
	COD is available on Wadsel, WeOS X Uma and Analost		
	Sinny peckages (installers) for current statue version 2.2 can be downloaded here		
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	Download for Windows		
	For New Users		
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	GGLS Standalone Installer Version 2.2 (92 bit)	-	
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	10		
	For Advanced Users		
	A Coldeolil Remore Installer (22 bit)	-	
	ciūre		
	A OSGeodity Network Installer (64 ttt)		
	In the instance choose Desistop Express install and select QQIS to install		
	Download for Mac OS X	i	
	and the second se		
	Download for Linux	*	

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



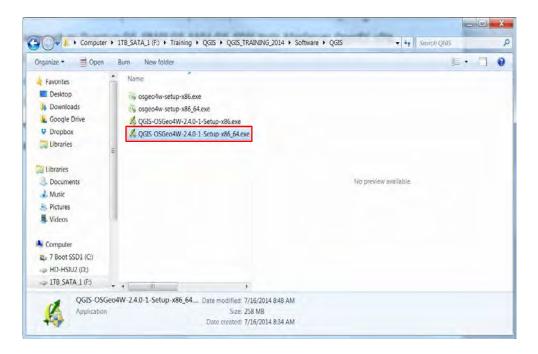


#### Installation of QGIS

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**

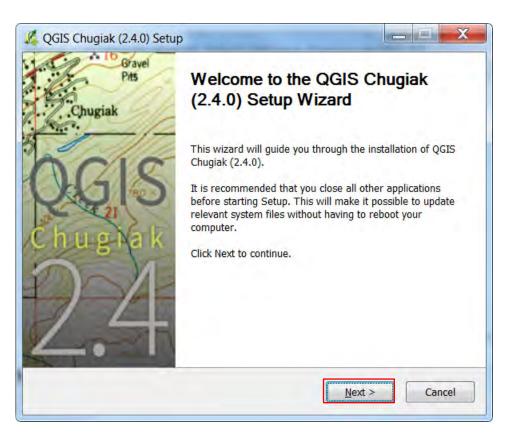
- I. To download the OSGeo4W installer click here.
- 2. Navigate to the directory where the downloaded **osgeo4w-setup-x86\_64.exe** installercan be found.
- 3. Right click on the installer and select Run as administrator.



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







icense Agreement		1
Please review the license terms befo	re installing QGIS Chugiak (2.4.0).	+4
Press Page Down to see the rest of t	he agreement.	
License overview:		*
1. QGIS 2. MrSID Raster Plugin for GDAL		111
3. SZIP compression library		
4. OGR FileGDB Driver		
5. ECW Raster Plugin for GDAL		
6. Oracle Instant Client		
ki dana		<b>T</b>
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agreement to install QGIS Chugiak (2	nent, click I Agree to continue. You must a	accept the
sgreement to install gots entigiat (2		
Isoft Install System v2,46		
		Cancel





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

QGIS Chugiak (2.4.0) Setup	
Choose Install Location	
Choose the folder in which to install QGI	S Chugiak (2.4.0).
Setup will install QGIS Chugiak (2.4.0) in click Browse and select another folder. C	n the following folder. To install in a different folder, Click Next to continue.
Destination Folder	
C:\Program Files\QGIS Chugiak	Browse
Space required: 1.2GB	
Space available: 45.2GB	

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.

Choose Components Choose which features of QGIS	5 Chugiak (2,4.0) you want to ins	stall. 🧳
Check the components you wa install. Click Install to start the	nt to install and uncheck the com installation.	ponents you don't want to
Select components to install:	QGIS North Carolina Data Set South Dakota (Spearfish) Alaska Data Set	Description Position your mouse over a component to see its description
Space required: 1.2GB	4 III F	
lisoft înstall System y2.46		





8. Click Finish

#### **Network Installer (for advanced users)**

- I. To download the OSGeo4W installer <u>click here</u>.
- 2. Navigate to the directory where the downloaded osgeo4w-setup-x86\_64.exe installer is exit.

Favorites	Name	Date modified	Туре	1	
E Desktop	E 💀 R_Packages	5/17/2014 2:11 PM	File folder		
Downloads	Firefox Setup Stub 29.0.exe	5/8/2014 11:19 AM	Application		
🔏 Google Drive	ocogleEarthSetup.exe	5/8/2014 2:34 PM	Application		
😌 Dropbox	🖗 osgeo4w-setup-x86.exe	5/17/2014 2:24 PM	Application		No preview available.
🥽 Libraries	🎉 osgeo4w-setup-x86_64.exe	5/17/2014 2:25 PM	Application		
🔚 Recent Places	🔀 R-3.1.0-win.exe	5/7/2014 2:18 PM	Application		
	😡 RStudio-0.98.507.dmg	5/17/2014 2:13 PM	DMG File	-	
🗃 Libraries	+ 4		<u>k</u> 19 19.	•	

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

This setup program is used for the initial installation of the OSGeo4W environment as well as all subsequent updates. Make sure to remember where you saved it. The pages that follow will guide you through the installation. Please note that OSGeo4W consists of a large number of packages spanning a wide variety of purposes. We only install a base set of packages by default. You can always run this program at any time in the future to add, remove, or upgrade packages as necessary. © Express Desktop Install © Express Web-GIS Install • Advanced Install	well as all subsequent updates. Make sure to remember where you saved it. The pages that follow will guide you through the installation. Please note that OSGeo4W consists of a large number of packages spanning a wide variety of purposes. We only install a base set of packages by default. You can always run this program at any time in the future to add, remove, or upgrade packages as	BS
The pages that follow will guide you through the installation. Please note that OSGeo4W consists of a large number of packages spanning a wide variety of purposes. We only install a base set of packages by default. You can always run this program at any time in the future to add, remove, or upgrade packages as necessary.	The pages that follow will guide you through the installation. Please note that OSGeo4W consists of a large number of packages spanning a wide variety of purposes. We only install a base set of packages by default. You can always run this program at any time in the future to add, remove, or upgrade packages as	
Express Web-GIS Install		
	🕐 Express Desktop Install	
	DExpress Web-GIS Install	





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

Choose	Download Source whether to install or download from the internet, or install from files in directory.
	<ul> <li>Install from Internet (downloaded files will be kept for future re-use)</li> </ul>
	© Download Without Installing
	Install from Local Directory
	< Back Next > Cancel

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

Select Root Install Directory Select the directory where you want to insta few installation parameters.	Il OSGeo4W. Also choose a	X
Root Directory		
CNOSGeo4W64		Browse
Install For All Users (RECOMMENDED) OSGeo4W will be available to all users of the system. Just Me OSGeo4W will only be available to the current user. Only select this if you lack Admin. privileges or you have specific needs.	Create icon on <u>D</u> esktop Add icon to <u>Start Menu</u>	
	< Back Nex	t> Cancel





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

Select Local Package Directory Select a directory where you want Setup downloads. The directory will be created	o to store the installation files it d if it does not already exist.		(E)
Local Package Directory			-
C/Users/zuahmed/Documents		Browse	)
Share and the			
Start menu name			
Start menu name OSGeo4W			

8. Select Direct Connection and click Next





Select Your Internet	Connection		13
Setup needs to know the appropriate settin	how you want it to connect to the internet. gs below.	Choose	C
O Direc	Connection		
	E5 Settings		
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101 Use	in tryini boxy.		
P	oxy <u>H</u> ost		
	Port 80		

9. Choose download site and click Next

Choose A Download Choose a site from t	Site nis list, or add your own sites to the list	(B)
Availa	ble Download Sites:	
http:/	//download.osgeo.org	
User URL:		Add

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





Search		Clear			ev i Curr 🔿 Exp	View Cat	egory
Category	New	B	S Size	Package			-
🗄 Web 😯 D	erault						

II. Click + (expand) and select packages to Install.

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Category	New	B S Size	Package	
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#### 12. Click Next





Select Package Select package					C
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Category	New	B	S	Size	Package
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	07.3.1-1	$\boxtimes$		358k	curl: The CURL HTTP/FTP library and commandline utility
	01.11.0-1	$\times$		5,413k	gdal: The GDAL/OGR library and commandline tools
	01.4.4-2	$\boxtimes$		601k	gpsbabel: GPS file conversion plus transfer to/from GPS u
	9.07-1	$\times$	nía	7,288k	gs: Ghostscript
	1.4.0-1	$\times$		847k	libgeotiff: The Libgeotiff library, commandline tools and sur
	9.2.4-1	$\times$		235k	libpq: The libpq library for accessing PostgreSQL + psql cc
	1.8.1-1	$\times$		36k	libspatialindex-devel: libspatialindexlinker libraries and inclu
	1.0.18-4	$\boxtimes$	nja	7,824k	msys: Minimal SYStem
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	0 2.7.5-1	$\boxtimes$		2,602k	python-tcltk: Python Tkinter and IDLE
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	0 1.0.7-10	$\boxtimes$	nía	379k	setup: OSGeo4W Installer/Updater
	01.0.1-2	$\times$		4k	shell: OSGeo4W Command Shell
	€ 2.0.10-1	$\boxtimes$		1,076k	swig: SWIG is a tool for OSGeo4W Packagers to build lar
🗉 Desktop 🕄	Install				
	<b>Q</b> 1.4.4-2	$\boxtimes$		586k	gpsbabelfe: GPSBabel GUI Frontend
*		0	-		
Hide obsolete p	packages				
	Concerne of the second s				

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

OSGeo4W Setup	
Progress This page displays the progress of the download or installation.	E
Downloading	
gdal-filegdb-1.10.1-4.bt from http://download.osgeo.org/osgeo	
Connecting	
Package:	





🎯 OSGeo4	W Setup - Agreement of Restrictive Package	
	Non-Open Source License Agreements	Ì
	Please review the license terms of the following packages and indicate acceptance of it's terms: Free OpenGL Utility Toolkit (freeglut)	
	Freeglut Copyright	
	Freeglut code without an explicit copyright is covered by the following copyright:	
	Copyright (c) 1999-2000 Pawel W. Olszta. All Rights Reserved. Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies or substantial portions of the Software.	
	The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.	
	THE SOFTWARE IS PROVIDED "AS IS". WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL PAWEL W. OLSZTA BE LIABLE FOR ANY CLAIM. DAMAGES OR OTHER LIABILITY. WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE. ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.	
	Except as contained in this notice, the name of Pawel W. Olszta shall not be used in advertising or otherwise to promote the sale, use or other dealings in this Software without prior written authorization from Pawel W. Olszta.	
	I agreed with above license terms	int
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Please wait, download and Installation will take several minutes, especially if you have slow internet.

	p	
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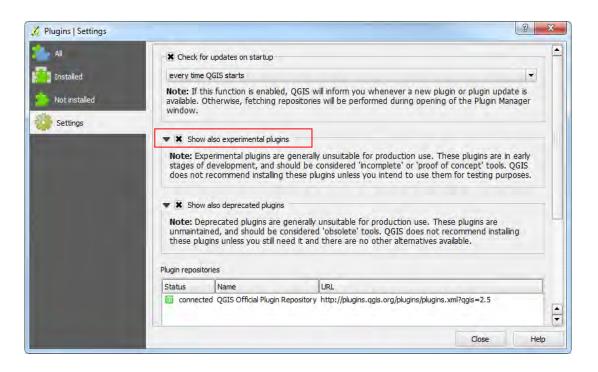




#### I4. Click Finish

#### 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 geoinformatics 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:

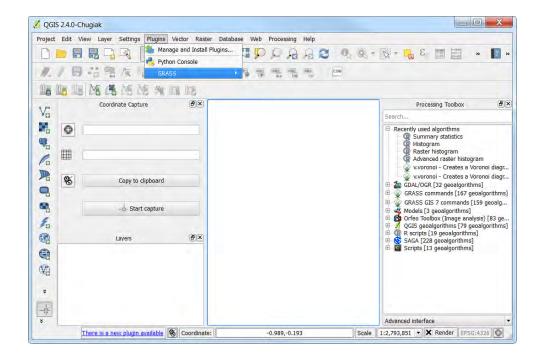
#### PLUGINS --> MANAGER AND INSTALL PLUGINS --> NOT INSTALLED MENU

You can also activate and deactivate the plugins in the *Installed* tab of the Plugin Manager.





All	Search	
Installed Not installed	<ul> <li>PointsToPaths</li> <li>PointsToPaths</li> <li>PostGIS Search</li> <li>PostGIS Topology Editor</li> <li>postgisQueryBuilder</li> <li>Postgres 91 plus Auditor</li> <li>PPConverter</li> <li>prepair</li> <li>Processing</li> <li>Processing UWGEOM Provider</li> <li>Profile tool</li> <li>PS Time Series Viewer</li> <li>pyArchInt</li> <li>pyUPVBib</li> <li>QChainage</li> <li>QCOnsolidate</li> <li>QGIS Cloud Plugin</li> <li>QGIS Cloud Plugin</li> <li>QGIS View Connector</li> </ul>	This plugin is experimental Processing Permaclim provider Expose Permaclim algorithms to Processing. Tags: permaclim,processing More info: homepage tracker code repository Author: Riccardo Lemmi (for Faunalia) Available version: 0.4 (in QGIS Official Plugin Repository
	🐈 qgis2leaf	Upgrade all Install plugin



#### 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/

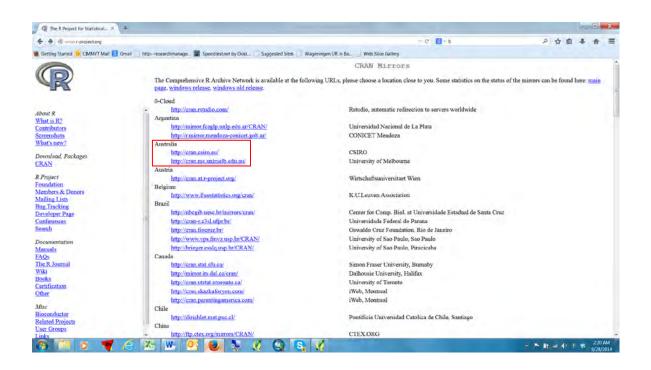




🖉 🕀 The R Project for Statistical. 🔅 🕴 C - R + + E www.r.projectorg Cetting Started () CIMMYT Mail 🔡 Gmail en UR in Ba. D Web Si The R Project for Statistical Computing PCA 5 VIPI ٠ . .. that is R? Carbok? ٩. Agiculue What's new? (1-3) 80% . Download, Packages RAN R Project Foundation Members & Donors Mailing Lists Bug Tracking Daveloper Page Conferences Search Getting Started Marmals EAQ8 The R Journal Wiki R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To <u>download R</u>, please choose your preferred CRAN mimor.
 If you have quantizen about R like how to download and install the software, or what the hoense terms are, please read our <u>movem to frequently usked questions</u> before you send in menial. Books Certifi News Mise Bioconductor Related Project X- W-.....

#### 2. Click CRAN for download Packages

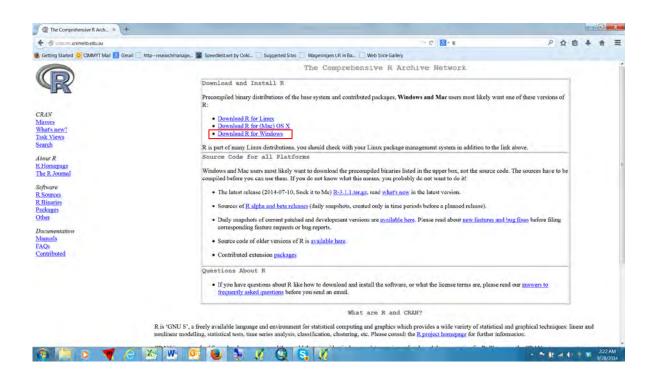
3. Select any CRAN Mirrors from the closest location on the globe proximal to your location







4. Select Download R for windows



5. Click base or install R for the first time

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	R for Win	dows					
	Subdirectories:						
CRAN Mirrors What's new? Task Views Search Abour R R Homesses The R Journal Safware R Binaries Packages Other Documentation Manuals EAQs Contributed	build rectories:           tase         Binaries for base distribution (managed by Duncan Murdoch). This           contrib         Binaries of contributed packages (managed by Uwe Ligges). Ther           windows services and corresponding environment and make varia         Tools to build R and R packages (managed by Duncan Murdoch).           Rmols         Tools to build R and R packages (managed by Duncan Murdoch).           plase do not submit binaries to CRAN. Package developers might want to contact Duncan Murdoch You may also want to read the R FAQ and R for Windows FAQ.           Note: CRAN does some checks on these binaries for viruses, but cannot give guarantees. Use the not submit also the second sec	e is also information on <u>third party software</u> available for CI bles. This is what you want to build your own packages on Wind ch or Uwe Ligges directly in case of questions / suggestions	ows, o		îndow	s bina	ries.





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

The Comprehensive R Arch × +	6				-	6	x
• Consider-projectorg	= C 🔯 * Soogie	p	\$	Đ	+	ŧ	Ξ
	R-3.1.1 for Windows (32/64 bit)						
	Download R 3.1.1 for Windows (\$4 megabytes, 32/64 bit) Installation and other, instructions New features in this version						
CRAN Mirrors	NET REAGES IN LOS VERION						
What's new? Task Views	If you want to double-check that the package you have downloaded exactly matches the package distributed by R, you can compare the mdSoum of the or need a version of mdSsum for windows: both graphical and command line versions are available.	exe to the	true	finger	print.	You v	vill
Search	Frequently asked questions						
About R <u>R Homepage</u> The R Journal	How do I install R when using Windows Vista?     How do Lupdate packages in my previous version of R?     Should I run 32-bit or 54-bit R?						
Software R Sources	Please see the R FAQ for general information about R and the R Windows FAQ for Windows-specific information.						
R Binaries Packages	Other builds						
Other Documentation Manuals	<ul> <li>Patches to this release are incorporated in the <u>repatched snapshot build</u>.</li> <li>A build of the development version (which will eventually become the next major release of R) is available in the <u>redevel snapshot build</u>.</li> <li><u>Previous releases</u></li> </ul>						
FAQs Contributed	Note to webmasters: A stable link which will redirect to the current Windows binary release is < <u>CRAN MIRROR</u> >bin/windows/base/release.htm.						
	Last change: 2014-07-10, by Duncan Murdoch						

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

#### Installation

- I. 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)



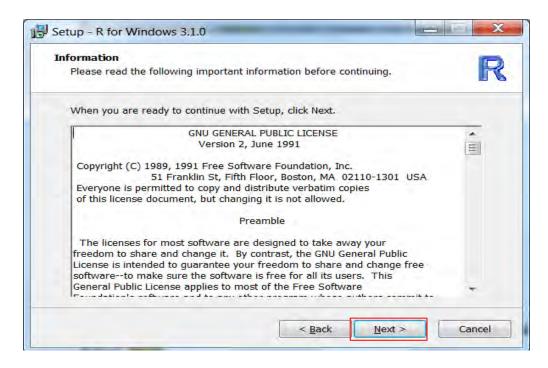




• GNU General Public License: click Next







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

Select Destination Location Where should R for Windows 3.1.1 be in	installed?
Setup will install R for Windows	s 3.1.1 into the following folder.
To continue, click Next. If you would like	e to select a different folder, click Browse.
C:\OSGeo4W64\bin\R-3.1.1	Browse
At least 1.2 MB of free disk space is req	juired.
At least 1.2 MB of free disk space is req	juired.

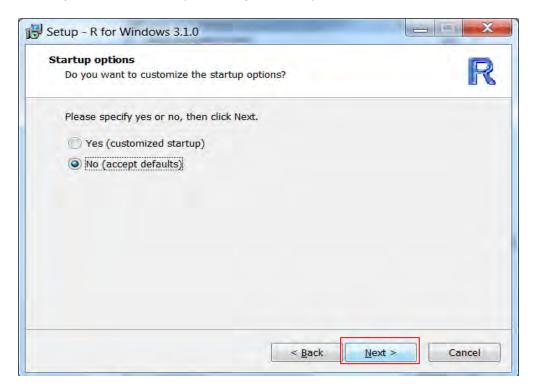
• Select Components: Select 64 or 32-bit according to your system, click Next





elect Components Which components should be inst	talled?
A concerne former former former	
Select the components you want install. Click Next when you are re	to install; clear the components you do not want to eady to continue.
64-bit User installation	
Core Files	63.7 MB
32-bit Files	13.4 MB
64-bit Files	15.4 MB
Message translations	7.0 MB
Current selection requires at leas	t 87.1 MB of disk space.

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



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





ollowing Start Menu folder. ent folder, click Browse.
ent folder, click Browse.
1
Browse
Next > Cano

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

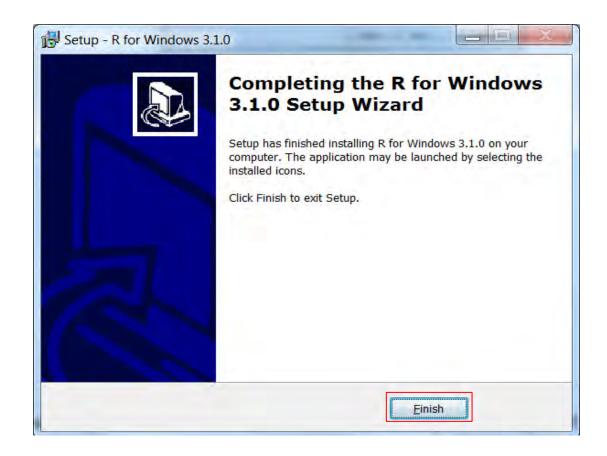
Select Additional Tasks		1
Which additional tasks should be	e performed?	
Select the additional tasks you w Windows 3.1.0, then click Next.	vould like Setup to perfor	m while installing R for
Additional icons:		
Create a <u>d</u> esktop icon		
Create a Quick Launch icon		
Registry entries:		
Save version number in reg	istry	
Associate R with .RData file:	s	

• Installation... (this again can take several minutes so please be patient)



Installing	
Please wait while Setup installs R for Windows 3.1.0 on your computer.	R
Extracting files	
	-
	_
ſ	Cancel

• 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. <u>Click here</u> 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"

R RGui	CRAN mirror
File Edit Misc Packages Windows Help	0-Cloud Argentina (La Plata) Argentina (Mendoza) Australia (Canberra)
Load package	Australia (Melbourne) Austria Belgium Brazil (BA)
Set CRAN mirror	Brazil (PR) II Brazil (RJ) Brazil (SP 1)
R R Console Select repositories	Brazil (SP 2) Canada (BC) Canada (NS) Canada (ON)
Install package(s)	Canada (QC 1) Canada (QC 2) Chile
R : Copyric Update packages or Statistical Computin	China (Beijing 1) China (Beijing 2) China (Hefei)
Version 2.1 Install package(s) from local zip files	China (Xiamen) Colombia (Bogota) Colombia (Cali) Denmark
R is free software and comes with ABSOLUTELY NO WARRANTY.	Ecuador France (Lyon 1) France (Lyon 2) France (Montpellier)
You are welcome to redistribute it under certain conditions.	France (Paris 1) France (Paris 2) Germany (Berlin)
Type 'license()' or 'licence()' for distribution details.	Germany (Bonn) Germany (Goettingen)
	Greece Hungary India Indonesia (Jakarta) Indonesia (Jember)
	OK Cancel

#### Installation from Internet:

- I. 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.

🤌 Options   Rendering	A DOCUMENT OF A DOCUMENT	? ×
General	<ul> <li>Rendering behavior</li> <li>By default new layers added to the map should be displayed</li> <li>Use render caching where possible to speed up redraws</li> </ul>	
Rendering Canvas & Legend Map Tools Composer Digitizing	Render layers in parallel using many CPU cores       Max cores to use:       Image: CPU cores         Map update interval       250 ms       Image: CPU cores       Image: CPU cores <td>encies</td>	encies
GDAL CRS Locale	<ul> <li>Rendering quality</li> <li>Make lines appear less jagged at the expense of some drawing performance</li> <li>Rasters</li> <li>RGB band selection Red band 1 + Green band 2 + Blue band 3 + Contrast enhancement</li> </ul>	
1	Single band gray Stretch To MinMax  Multi band color (byte / band) No Stretch Multi band color (> byte / band) Stretch To MinMax Limits (minimum/maximum) Cumulative pixel count cut Cumulative pixel count cut limits 2.0  98.0  %	
	OK Cancel	Help

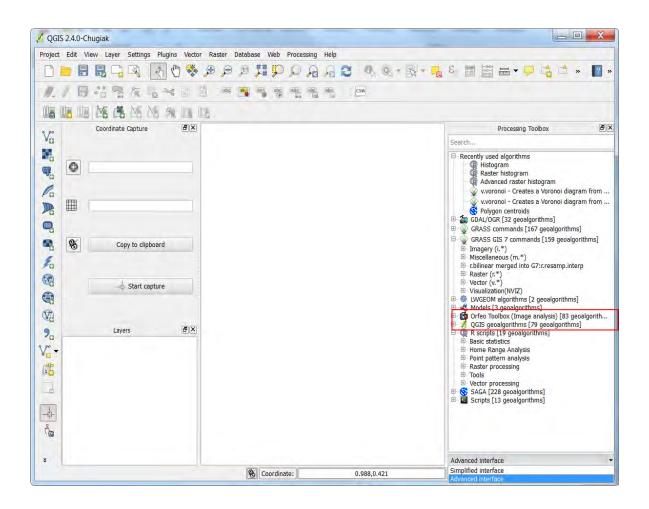
#### **Configuring the Processing Toolbox**

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



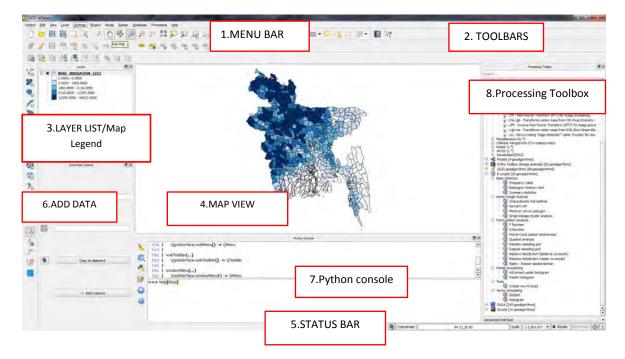
	Ture -
etting	Value
@ General	
4 Models	
Providers	
🗉 🚋 GDAL/OGR	
GRASS GIS 7 commands	
Activate	×
GRASS7 folder	C:\OSGeo4W64\apps\grass\grass-6.4.3
Log console output	×
Log execution commands	
Wsys folder	C:/OSGEO4~1/apps\msys
GRASS commands	
Activate	×
GRASS folder	C:\OSGeo4W64\apps\grass\grass-6.4.3
Log console output	×
Log execution commands	
Msys folder	C:/OSGEO4~1/apps\msys
UWGEOM algorithms	
Modeler-only tools	
Orfeo Toolbox (Image analysis)	
🖻 🕺 QGIS geoalgorithms	
R scripts	
@ Activate	×
R Scripts folder	C:\Users\ZAhmed\.qgis2\processing\rscript
R folder	C\OSGeo4W64\bin\R-3.1.1
R Use 64 bit version	×
🖻 😵 SAGA	
S Activate	×
Enable SAGA Import/Export optimizatio	
S Log console output	×
Log execution commands	×
TauDEM (hydrologic analysis)	
Tools for LiDAR data	
Scripts	





#### 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	
<b>Save</b>	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	
0 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
<sup>™</sup> 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
Radd 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
CRotate 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
PZoom 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
Soom 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	( fri+K	see Spatial Bookmarks	Attributes
Show Bookmarks	( fri+\niff+K	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
Radd MSSQL Spatial Layer	Ctrl+Shift+M	see label_mssql	Manage Layers
Radd Oracle GeoRaster		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
P₂Add 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
Bave 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			
(abe 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	Shortcut Reference	
🏶 Toolbox		see The toolbox	Toolbox
🔩Graphical Modeler		see The graphical modeler	
■History and Logs		see The history manager	
XOptions and configuration		see Configuring the processing framework	
₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽ ₽		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,  $\sqrt[p]{}^{Toggle}$  editing is not available. See sectionDigitizing and editing a GRASS vector layerfor 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 *Simmediately* 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*  $\star$  *Project Properties* or, you can select a project CRS clicking on the  $\bigcirc^{CRS \text{ status}}$  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 filebgs\_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:

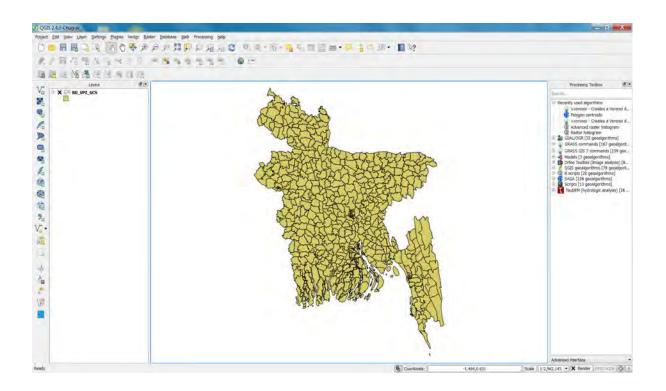
- I. First, launch **QGIS Desktop 2.4** from your desktop
- **2.** Click the **Add Vector Layer**  $\sqrt{2}$  lcon
- 3. or Click Layer on Menu bar and then Add Vector Layer V<sub>G</sub> (alternatively, this can also be chosen from your browser)
- 4. Select File from Source Type
- **5.** Select Encoding 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

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			Help

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







Style		Symbol layer type	Outlin	e: Simple line	
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	🚯 🔳 🔒 🖾 🔝 Save		Data defined proper	ties	
	Laver rendering			1	1
	Load Style Save A	s Default Rest	ore Default Style	Save Style	

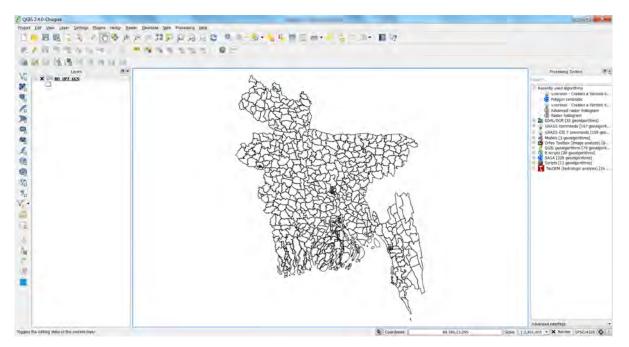
9. In the Layers menu to the left of the map viewer, right-click on

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).

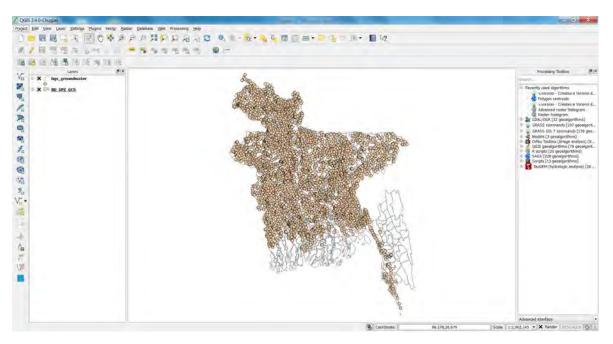
In this exercise, we will use *British Geological Survey Groundwater Quality* data for Bangladesh (http://www.bgs.ac.uk/research/groundwater/health/arsenic/Bangladesh/data.html) as CSV file. This CSV file contains the results of a geochemical survey of 3,534 boreholes from 61 of the 64 districts of Bangladesh.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

## Steps:

- I. Click Add Vector Layer Vallcon
- 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:







- 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  $\rightarrow$  Simple marker
- **II.** Then, choose Size I mm and Outline style No Pen, then click OK.
- **12.** Select Color ramp RdYIGn and check Invert
- **13.** Choose Classes 10 and Mode Quantile
- 14. Click Classify and then OK

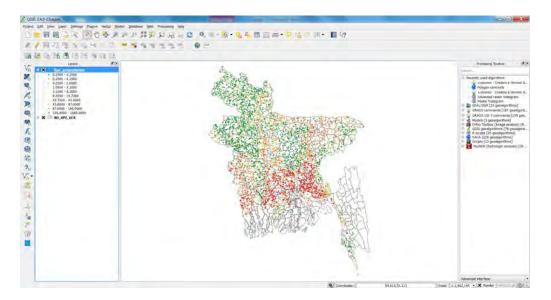
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				Advanced interface





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:

- I. Click Add Vector Layer Valle 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.shpand select PROPERTIES --> STYLE.
- 7. Change Single symbol to Categorized.
- 8. Then click **CLASSIFY** to display the road data.





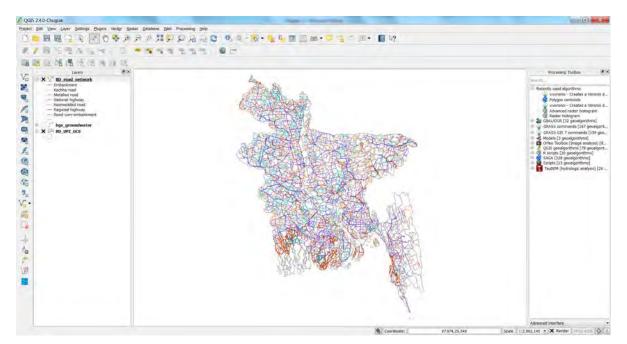
- 9. Select Colum "ROADCLASS" and Color ramp Random colors
- **10.** Click Classify and then, OK

General	2 Categorize	d 🔻							
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c Labels	Symbol	— c	hange		Color ramp	Random	colors		▼ Inve
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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:

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.

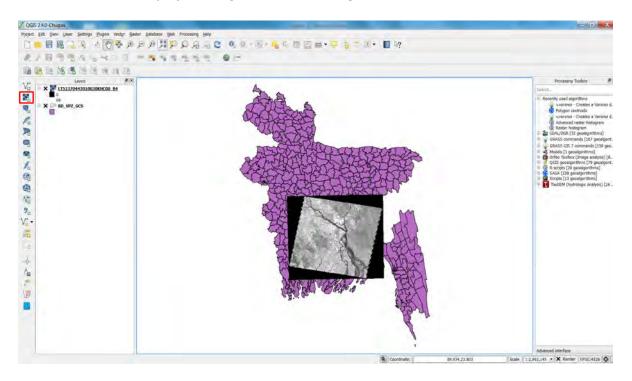
The resulting map should look roughly like the one below:

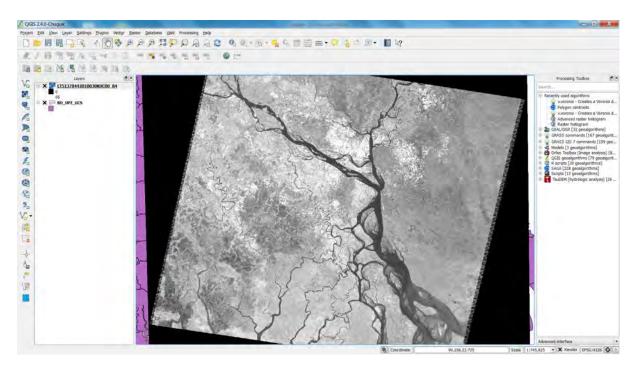
Use the tools for zooming in  $\mathbb{P}$  to increase the map scale and zoom in on the scene of southern Bangladesh and its rivers. Use the panning tool to move the map in the





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**<sup>52</sup> 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.





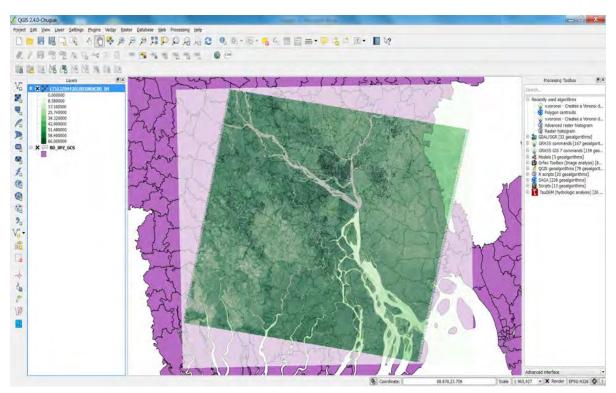
General	Global transparency	▼ No data value: not defined
Transparency	None 30% Full	Additional no data value
Pyramids	<ul> <li>Custom transparency options</li> </ul>	
🖂 Histogram	Transparency band	
	Transparent pixel list	
Metadata	From To Pe	ercent Transparent

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.

	LT51370442010030K	HC00_B4   Style	2 ×
General	<ul> <li>Band rendering</li> <li>Render type Sing</li> </ul>	leband pseudocolor 👻	Ī
Transparency	Band Color interpolation	Band 1 (Gray) 🔹	Generate new color map Greens ▼ Invert
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	Restore Default Style		Load Style Save Style ancel Apply Help







# 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

#### **P**ROJECT-->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 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**<sup>1</sup>:32645) and zone 46N (**EPSG**: 32646).

## Parameters of UTM zone 45 and 46N

UTM Zone 45N (EPSG:32645)

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", I, 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]]

#### UTM Zone 46N (EPSG:32646)

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", I, 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 I/f = 300.8017

amete	ers
:	Seven Parameters
:	0
:	0
:	0
:	283.729 m
:	735.942 m
:	261.143 m
:	0 ррт
:	Transverse Mercator
:	0° N
:	90° E
:	-2,000,000 m
:	500000 m
:	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. **PRI:** 

```
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\ :

- I. 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* 

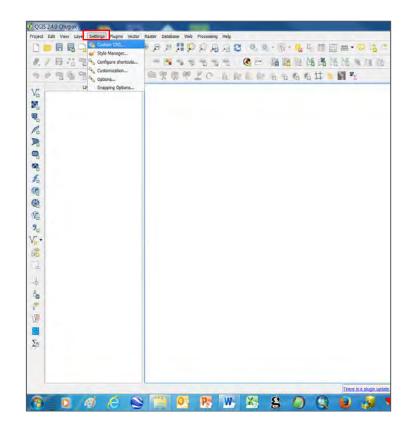
**Create a custom CRS** 

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)

- I. 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.







efine		
ou can define yo onform to the pr	our own custom Coordinate Reference System (CRS) here. The roj4 format for specifying a CRS.	e definition must
Name	Parameters	
new CRS		
Add new Cl	RS	Remove
		Remove
Add new Cl	RS EPSG_3106_BTM_D_GULSAN_NEW	Remove
	EPSG_3106_BTM_D_GULSAN_NEW	
Name: Parameters:	EPSG_3106_BTM_D_GULSAN_NEW	0000 +y_0=0
Name:	EPSG_3106_BTM_D_GULSAN_NEW +proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500 +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_dee	0000 +y_0=0
Name: Parameters: Copy existing CRS	EPSG_3106_BTM_D_GULSAN_NEW +proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500 +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_dee	0000 +y_0=0
Name: Parameters: Copy existing CRS	EPSG_3106_BTM_D_GULSAN_NEW +proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500 +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_dee	0000 +y_0=0
Name: Parameters: Copy existing CRS st	EPSG_3106_BTM_D_GULSAN_NEW +proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500 +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_de	1000 +y_0=0 fs coordinate where both
Name: Parameters: Copy existing CRS st se the text boxe le lat/long and ti	EPSG_3106_BTM_D_GULSAN_NEW +proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500 +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_de	1000 +y_0=0 fs coordinate where both
Name: Parameters: Copy existing CRS st se the text boxe lat/long and ti alculate button t	EPSG_3106_BTM_D_GULSAN_NEW +proj=tmerc +lat_0=0 +lon_0=90 +k=0.9996 +x_0=500 +a=637726.345 +b=6356075.11314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_de es below to test the CRS definition you are creating. Enter a c the transformed result are known (for example by reading off	1000 +y_0=0 fs coordinate where both
Name: Parameters: Copy existing CRS st se the text boxe lat/long and ti alculate button t	EPSG_3106_BTM_D_GULSAN_NEW  EPSG_3106_BTM_D_GULSAN_NEW  +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_de es below to test the CRS definition you are creating. Enter a c the transformed result are known (for example by reading off to see if the CRS definition you are creating is accurate.	0000 +y_0=0 fs coordinate where both a map). Then press th
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Name: Parameters: Copy existing CRS st se the text boxe lat/long and ti alculate button t Geographic orth	EPSG_3106_BTM_D_GULSAN_NEW  EPSG_3106_BTM_D_GULSAN_NEW  +a=6377276.345 +b=6356075.41314024 +towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_de es below to test the CRS definition you are creating. Enter a c the transformed result are known (for example by reading off to see if the CRS definition you are creating is accurate.	0000 +y_0=0 fs coordinate where both a map). Then press th

# 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.

- I. If you have not done so already, launch QGIS Desktop 2.4.0 from your desktop
- 2. Click M 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 Systemheader under Properties. The example below shows that the layer projection is *Geographic coordinate system* and the datum is WGS84.





Chuqiak	🖋 Layer Properties - BD_Upazila   Metadata	0
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	×	Cencel Apply Heb

# 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 M 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
- Scroll down in the Coordinate reference system of world section of the Coordinate Reference SystemSelector window, and select EPSG\_3106\_BTM\_D\_GULSAN\_NEW fromUser defined Coordinate Systems(this may take time for you to find, but be patient).
- 6. Next, click OK.
- 7. Then Click OK again.





Format ESRI Shapefile			Select the coordinate reference system for the vect the layer coordinate reference system.	tor file. The data points will be transformed fro
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WGS 84	Brow	se	Filter	
			Recently used coordinate reference systems	
Encoding	UTF-8		Coordinate Reference System	Authority ID
Save only selected features Skip attribute creation Add saved file to map			Gulshan 303 / Bangladesh Transverse Mercat World_Mercator Gulshan 303 / Bangladesh Transverse Mercat WGS 84	EPSG:54004
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				OK Cancel Help

# 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 system our custom CRS (EPSG\_3106\_BTM\_D\_GULSAN\_NEW).

## Checking the Coordinate Reference System

- I. 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.
- 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 Systemheader under Properties. The projection of this raster is Geographic coordinate systemand the datum is WGS84.



Projection of a Single Raster:

- I. 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 alight OK
  - and click OK
- 5. Click OK again and then, Close

butch mode (for processing	g whole directory)		Recently used coordinate reference systems	
Input file	srtm_55_08 🔻	Select	Coordinate Reference Syster Authority ID	
Output file	1_55_08_BTM.tif	Select	Gulshan 303 / Banglades EPSG:3106	
			Gulshan 303 / Banglades, EPSG:3106 World Mercator EPSG:54004	
X Source SRS	EPSG:4326	Select	Gulshan 303 / Banglades EPSG:3106	
			Gulshan 303 / Banglades EPSG:3106	
X Target SRS	+proj=tmerc +la	Select	Gulshan 303 / Banglades EPSG:3106	
			WGS 84 EPSG:4326 EPSG 3106 BTM D GUL USER:100002	
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			+towgs84=283.7,735.9,261.1,0,0,0,0 +units=m +no_	defs
-b=6356075.41314024				

# Batch Projection of Multiple Rasters:

- I. 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**.



 $\swarrow \Leftrightarrow \bigcirc \Leftrightarrow \diamondsuit$ 

nput directory	/STRM_90_GCS	Select
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K <u>T</u> arget SRS	roj=tmerc +lat_(	Select
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# 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:

- I. 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:

- I. First, launch **QGIS Desktop 2.4** from your desktop
- 2. Click the Add Delimited Text **P**lcon
- 3. or Click Layer on Menu bar and then Add Delimited Text **7**
- Click Browse and Open GPS\_COORDINATES.csv from MODULE\_05/Datasub-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



ave	er nan	ne GPS_COO	ORDINATES				Encoding UTF-8	
-	forma		CSV (comma se	parated values)	Custom delimiters	🗇 Regular	expression delimite	r
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	ID	Longitude	Latitude					-
1	1	89.93148	23.15284					
2	2	89.94341	23.14496					
3	3	89.95217	23.13665					· •
4	4	89.91119	23.12582					
5	5	89.91818	23.11487					
6	6	89.91481	23.10481					
7	7	89.76470	23.10402					
8	8	89,73163	23.09081					

# Load soil attribute data (with no geometry)

## Steps:

- I. Click the Add Delimited Text **?** Icon
- 2. or Click Layer on Menu bar and then Add Delimited Text ?..
- 3. Click browse and select Data.csv from MODULE\_05 \Datasub-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



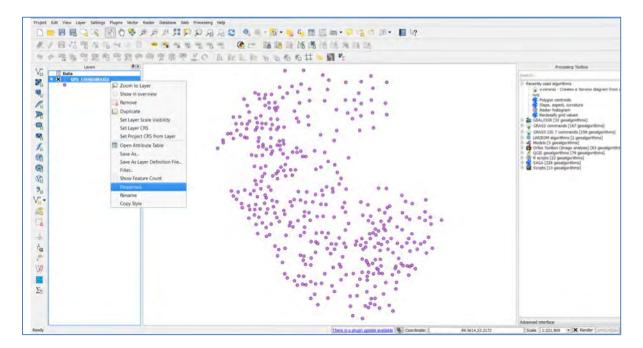


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1	1			Gopalganj Sadar			6.6	0.5	39.8	1010	0.4	7	150	0.2	8.6	271	19.2		14	Gopalganj-Khulna
2	2			Gopalganj Sadar	1.62.80.62.67		2.5	0.3	38.8	100	0.1	4	92	0.3	2.5	2.8	16.4	10.00	14	Gopalganj-Khulna
3	3	DHAKA	GOPALGANJ	Gopalganj Sadar	Pourasabha	8.4	2.6	0.3	35.3	2.8	0.1	8	75	0.3	4.2	2	9.8	0.4	14	Gopalganj-Khulna
4	4	DHAKA	GOPALGANJ	Gopalganj Sadar	Pourasabha	8.4	1.4	0.2	38.5	4	0.1	7	18	0.3	1.5	11	33	0.3	14	Gopalganj-Khulna
-	5	DHAKA	GOPALGANJ	Gopalganj Sadar	Pourasabha	7.1	2.5	0.6	38.8	6.3	0.3	15	86	0.9	5.2	30	23.4	0.5	12	Low Ganges River
5	6	DHAKA	GOPALGANJ	Gopalganj Sadar	Pourasabha	8.4	1.4	0.3	56.5	4.3	0.1	5	95	0.1	1.4	11	32.2	0.4	12	Low Ganges River
_	7	DHAKA	GOPALGANJ	Gopalganj Sadar	Pourasabha	7	1.4	0.3	39.5	4	0.2	7	8	0.4	1.5	10	30	0.3	12	Low Ganges River
5 6 7	1		CODALCANI	Gonalgani Sadar	Pourasabha	79	27	n 4	20.3	3.8	0.1	7	6	0.6	4 2	3	92	<u>n 4</u>	12	Low Gannes River

# Join soil data with GPS data

# Steps:

I. 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

General	Join layer	Join field	arget field Memory cad	he		
Style		2	Add vector jo	oin 💡	×	
be Labels						
Fields			loin layer	Data		
Display			loin field	ID	-	
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Joins		3	X Cache join la	yer in virtual memo	vity	
			_	ite index on join fie		
Metadata						
			-	OK Ci	ancel	
	Load Si		Save As Default	Restore Default St	yle Save Style	

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.

1										
	ID V	Longitude	Latitude	DIV	DIST	UPZ	UNION	PH	SOM	
	1	89.93148445	23.15284214	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	6.5	6.6	
	2	89.9111925	23.12582403	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	7.9	2.5	
	3	89.9181795	23.11486808	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	8.4	2.6	_
	4	89.91480947	23.10480957	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	8.4	1.4	
-	5	89.76470227	23.10401959	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	7.1	2.5	
	6	89.73163443	23.09080815	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	8.4	1.4	
	7	89.74346304	23.09392534	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	7	1.4	_
-	8	89.75353849	23.08665041	DHAKA	GOPALGANJ	Gopalganj Sa	Pourasabha	7.9	2.7	
Ē	1					- 1 +			1	4)

# Save as GPS\_CORDINATES layer file to a point shape file

- I. 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.

ormat ESRI Shapefile			Select the coordinate reference system transformed from the layer coordinate re	
ave as jonj_Data/GOLPALGAN	J_DIST_BD_BTM.shp E	Browse		
RS Project CRS				
WGS 84	E	Browse	Filter	
	(and the second		Recently used coordinate reference	systems
incoding	UTF-8		Coordinate Reference System	Authority ID
Save only selected features			World_Mercator	EPSG:54004
Skip attribute creation			Gulshan 303 / Bangladesh Transver	
Add saved file to map			Gulshan 303 / Bangladesh Transver	
Symbology export	No symbology	-	WGS 84 Gulshan 303 / Bangladesh Transver.	EPSG:4326
Scale	1:50000		EPSG 3106 BTM D GULSAN NEW	
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West 89.67488	East 90,10249		Coordinate Reference System	Authority ID
South 22.	8322		Geographic Coordinate S.	
Layer extent	Map view extent.		EPSG 3106 BTM D GULSAN	USER:100002
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Layer Options			Selected CRS: EPSG_3106_BTM_D_GL	JLSAN_NEW
Custom Options			+proj=tmerc +lat_0=0 +lon_0=90 +k=0 +a=6377276.345 +b=6356075.4131402 +units=m +no defs	





# Module 6: Working with Tabular data

In this module, you will learn:

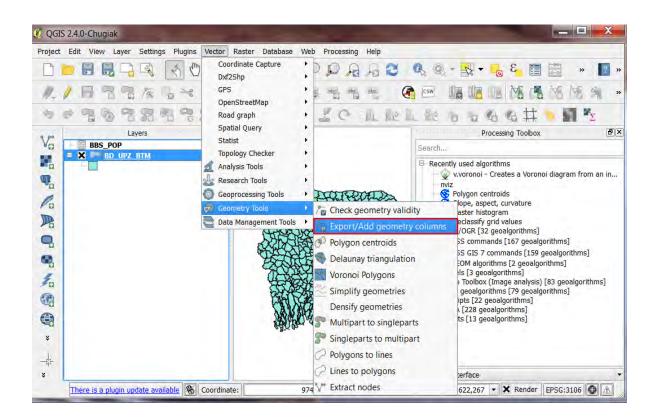
- how to calculate polygon area
- use the field calculator
- join attribute data with polygons
- generate simple statistics of a vector field
- select a polygon using an expression

# 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

Input vector layer		
BD_UPZ_BTM		
Calculate using	Broject CBC	_
calculate using	Project CRS	_
X Save to new shapefi	le	
	LUPZ_BTM_GEO.shp Brows	se

**II. Looking at the attribute table, BD\_UPZ\_BTM\_GEO** now has two addition column titles **Area** (sq.m) and **Perimeter.** 

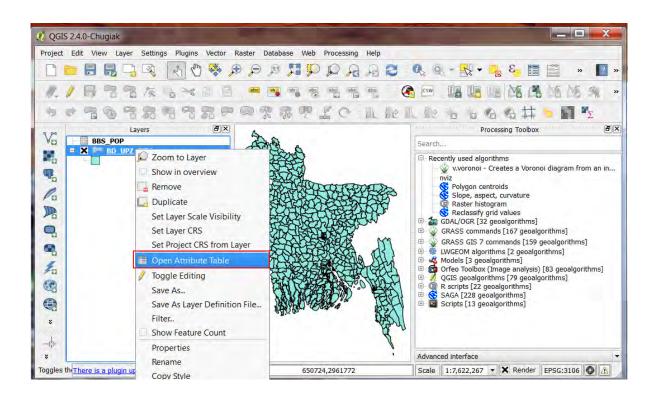
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-	ID 🗸	DIVISION	DISTRICT	UPAZILA	BBS_DIV	BBS_DIST	BBS_UPZ	AREA	PERIMETER
0	1	Barisal	Barguna	Amtali	10	1004	100409	512400693.52	194370.455950
1	2	Barisal	Barguna	Bamna	10	1004	100419	87074537.351	65197.103904
2	3	Barisal	Barguna	Barguan	10	1004	100428	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

# **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.



 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**

📝 📑 🐁 😰 📓 🏵 🗊 🗈 🚛 🔛 Field Calculator								
	7 CI	DIVISION	DISTRICT	UPAZILA	BBS_DIV	BBS_DIST	BBS_UF	
0	1	Barisal	Barguna	Amtali	10	1004	100409	
1	2	Barisal	Barguna	Bamna	10	1004	100419	
2	3	Barisal	Barguna	Barguan	10	1004	100428	
3	4	Barisal	Barguna	Betagi	10	1004	100447	
4	5	Barisal	Barguna	Patharghata	10	1004	100485	
5	6	Barisal	Barisal	Agailjhara	10	1006	100602	

- 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





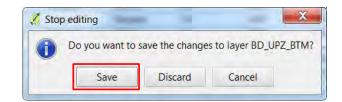
- 5. From the Function list select Geometry-> \$area and double click it
- 6. In Expression windows, divide \$area by 1000000 (the number of meters in a km<sup>2</sup>) and then click OK.
- 7. A new field named AreaSqKm will be created in attribute table of existing BD\_UPZ\_BTM layer.

Only update 0 selected features	
Create a new field	Update existing field
Output field name AreaSqKm	
Output field type Decimal number (real)	• D
Output field width 10 🍦 Precision 0	<del>\$</del> 1
Function list	Selected function help
Search	Sarea function
E Color	Returns the area size of the current feature.
Geometry	Syntax
sgeometry	
\$area	Şarea
Slength \$perimeter	Arguments
\$x	➡ None
Operators	
N N N N N N N	
	2
Expression	
\$area / 100000	

	ID Ŧ	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
5	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
0	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.

- I. Click Add Delimited Text **P** lcon
- 2. or Click Layer on Menu bar and then Add Delimited Text 况
- 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

File Name F:/Training/QGIS/QGIS_TRAINING_2014/Training_Data/Tabuler_Data/BBS_POP.csv							Brows	Browse	
Layer name BBS_POP Encoding U							Encoding UTF-8		
File	format	• C	SV (comm	a separate	d values)	Custom delimiters	Regular expression delimiter		
-iel	d options	× Ir	im fields	Discar	d empty field	ds Decimal separator is comma			
	metry defini er settings		oint coordin se spatial in			Well known text (WKT)	No geometry (attribute only t     Watch file	able)	
		Us	se spatial i		RURPOP				
	er settings	Us	se spatial i	ndex	RURPOP 248994			able)	
.aye	er settings BBS_UPZ	Us Тотнон	e spatial i	ndex HOHPOL	A CONTRACTOR OF				

Join Census Population data with Upazila Layer





- I. 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.

🖌 Layer Properties -	Layer Properties - BD_UPZ_BTM   Joins				oin	2	x
General	Join layer	Join field Targe	et fie	🥖 Add vector jo			
🥡 Style				Join layer	BBS	_POP	Ŧ
abc Labels				Join field	BBS	_UPZ	-
Fields				Target field	DDC	UPZ	
Rendering							
🢭 Display				Cache join la			
Actions				Create attribu	ite index or	n join field	
Joins					ОК	Cance	
Diagrams		10					
Metadata	Load Style	Save As D	erau				
		-		OK Cancel	A	pply	Help

## **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 I.
- 5. From Function list select Fields and values
- 6. Divide "BBS\_ POP\_TOTPOP" by "AreaSqKm" in Expression windows

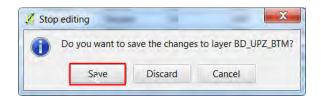
7. Then, click OK





Create a new field Output field name PopPer Dutput field type Decimal number (real) Output field width 10 Precision	D Update existing field
Function list	Selected function help
Search UPA ZILA BBS_DIV BBS_DIST BBS_UPZ AreaSqKm BBS_POP_TOTHOH BBS_POP_TOTPOP BBS_POP_HOHPOL BBS_POP_RURPOP BCRecent (fieldcalc)	Field Double click to add field name to expression string. Right-Click on field name to open context menu concels unlike leading patients Field values Load values all unique 10 samples
Operators     = + - / * ^ II (     Expression     "BBS_POP_TOTPOP" / "AreaSqKm"	)

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



## **Visualization of Population Density**

- I. 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



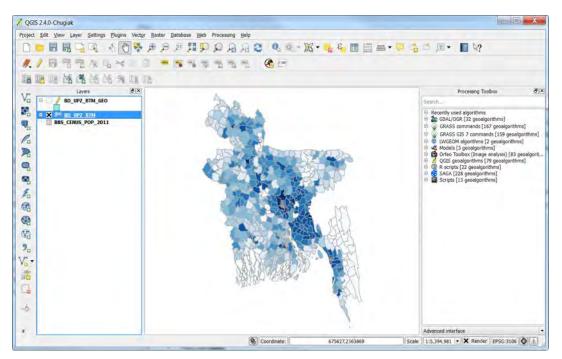


General	👔 Graduate	+					
Style	Column P	opPer		•	3		
Labels	Symbol		Ch	ange		Classes 10	-
Fields	Color ramp	Blues	Ŧ	Invert		Mode Quant	ile (Equal Count)
Rendering Display Actions Joins Diagrams	Symbol	70.6600 81.3000 91.7600 99.6000	Label 0.0000 - 54.7 54.7000 - 70. 70.6600 - 81. 81.3000 - 91. 91.7600 - 99. 99.6000 - 112 112.7800 - 12	6600 3000 7600 6000 2.7800 80.2600			
Metadata	Classify	Add class	Delet	ie l	Delete all		Advanced
	Layer transp Layer blendir	arency	) Normal		Feature blendin	g mode Normal	0

🕺 Symbol selector	2 ×	🕺 Select Color	X
Fill Simple fill	Symbol layer type Simple fill  Colors Fill  Border  Fill style Solid  Border style Solid  Border style Solid Line  Border style Border  Colors fill  Colors fill  Colors fill  Colors fill  Color  Colors fill  Color  Colo	Basic colors	Hug: 0   Bed: 167  Sat: 0  Green: 167  Jol: 167  Blye: 167  Alpha channel: 255
	OK. Cancel		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:

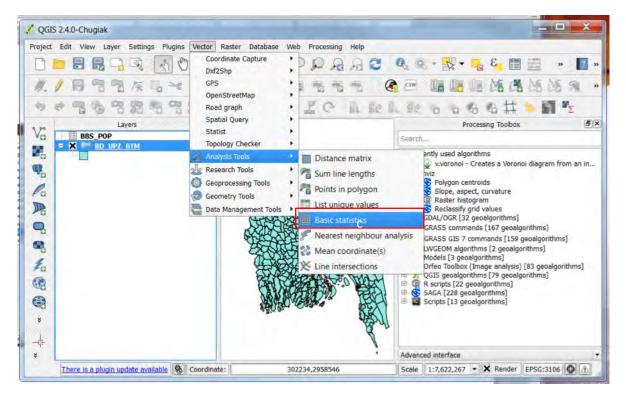
## **Simple Statistics of a Vector Field**

#### **Option I:**

- I. Select VECTOR-->ANALYSIS TOOL> BASICS STATISTICS
- 2. Select BD\_UPZ\_BTM as Input Vector Layer
- 3. PerPop as Target field
- 4. Select OK







nput Vector Layer		
BD_UPZ_BTM		*
Use only selected features		
arget <mark>f</mark> ield		
PopPer		•
itatistics output		
Parameter	Value	•
Mean	2272.15673624	Ī
StdDev	5596.6645081	
Sum	1197426.6	
Min	19.4	
Max	66660.8	
N	527.0	
cv	2.4631507232	
Number of unique values	521	Ŧ
Press Ctrl+C to copy results to the	he clipboard	





## **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)

- I. 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.

💋 Plugins   Not installed (257)	? ×
All Search Statist	<u>ସ</u>
Installed	y Statis Statist Calculate and show statistics for a field Calculate and show statistics for a field Calcul
	Close Help

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

- I. 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.





Input vector layer: BD_UPZ_BTM			Frequency distribution
Use only selec	ted features		500
Target field:	PopPer	÷	400 -
Enable statisti Statistics output:	cs for text fields		300
Parameter	Value		<sup>o</sup> 200 -
Unique values	521	Т	100 -
Minimum v	19.400000		
Maximum v	66660.800000		0000 2000 3000 4000 5000 5000 0000
Range	66641.400000		PopPer
Sum	1197426.600000		O O + C Ase plot as PNG file
Mean value	2272.156736		
Median value	997.700000	÷	Xmin 0.00 CRefresh

## **Option 3:**

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

- I. In the **Processing**  $\rightarrow$  **Toolbox**, select R-scripts -->Basic statistics  $\rightarrow$ 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.



Parameters	Log	Help	_				
Layer							
BD_UPZ_BT	M [EPSG:	3106]	С			•	9
Field							
PopPer			C				÷
R Console O	utput						
F:/Training/	QGIS/QGI	IS_TRAINI	NG_201	4/Output,	/PopDensit	y.html	
F:/Training/	QGIS/QGI	IS_TRAINI	ING_201	4/Output,	/PopDensit	y.html	
F:/Training/	QGIS/QGI	IS_TRAINI	NG_201	4/Output,	/PopDensit	y.html	

R Console O PopPer Sum: 1197426.600 Count: 527.000	
Unique values: 521.000 Minimum value: 19.400 Maximum value: 66660.800 Range: 66641.400 Mean value: 2272.157 Median value: 997.700 Standard deviation: 5601.982	Close

# 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).

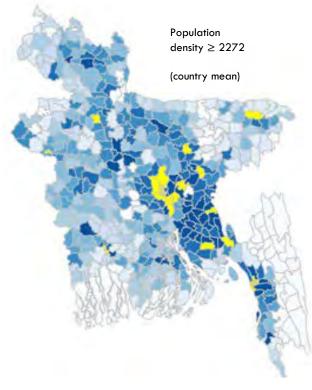




- 1. Right click on **BD\_UPZ\_BTM.shp**, select Open Attribute Table
- 2. Click Select by expression
- 3. From the Function list, select Fields and Values
- 4. Double click PerPop, type >=2272 in **Expression** window and
- **5.** Click Select and then, click Close.
- 6. The newly assigned yellow color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

#### Select by expression

	a 8	🔏 Select b	by expression -	BD_UPZ_BTM	and the lite	-	? ×			
п	DT	Function list	-	S	elected function	elp		BBS_UPZ	AreaSqKm	Po
	1 B	Search		11	Field			)0409	512.4	
	2 B							)0419	87.1	
-	3 Bi	ID			Double click to ad	ld field nan	ne to	)0428	316.5	
	4 B		ISION	1	expression string			10447	151.2	
	5 B		ZILA		ield values	d norma to	anan nontaut	0485	235.6	
	6 B		DIV		iela values			)0602	162.7	
	7 B		DIST					)0603	154.0	
	8 B		UPZ	145				)0607	366.6	
	9 B	Area	aSqKm	01				)0610	135.2	
	10 B	Pop	Per					)0651	274.9	
0	11 B	B Recent	(Selection)	÷ 10	ad values al	unique	10 samples	)0632	141.8	
1	12 B	• Operator	-					)0636	213.5	
2	13 B	♥ Operator	15					0662	324.7	
3	14 B	= +	- / -	^ II (	)			)0669	209.9	
4	15 B	Expression-						00694	247.8	
5	16 B	(Inc. a)	an mal					)0918	330.0	
6	17 B	"PopPer" >	=2272					)0921	227.0	
7	18 B	Output previ	ew: 0					)0925	658.3	
8	19 B				E c	elect 💌	Close	)0929	153.2	
9	20 B				- S	elect 1	Close	)0954	289.6	
0	21 Ba	risal	Bhola	Manpura	10	1	009	100965	146.9	
1	22 Ba	risal	Bhola	Tazumuddi	n 10	1	009	100991	200.3	
	23 Ba	risal	Jhalokati	Jhalokati	10	1	042	104240	185.0	
2										1







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.

Format ESRI Shapefile		
Save as pr_Data/BTM/POLYGO		
CRS Layer CRS		]•
han 303 / Bangladesi	h Transverse Mercator Browse	
Encoding	UTF-8	1
X Save only selected feature	!S	
Skip attribute creation		
Add saved file to map	Chestron and the	~
Symbology export	No symbology 👻	-
Scale	1:50000	1
<ul> <li>Extent (current: layer)</li> </ul>	0	1
North 46	637.449317456	
West 306.85349086253	East 3382.0876300894	
South 76	700,637349276	
Layer extent	Map view extent.	
Datasource Options		1
▼ Layer Options		1
<ul> <li>Custom Options</li> </ul>		1





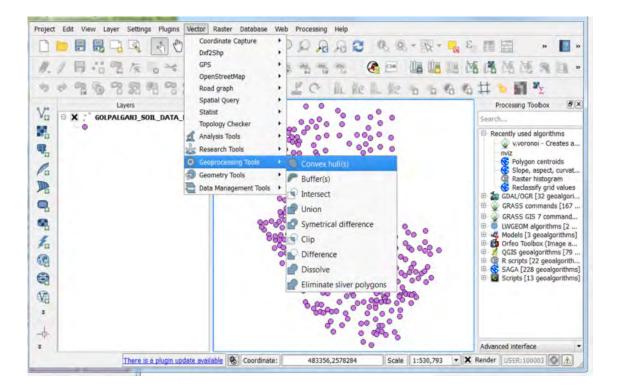
## Module 7: Working with Vector Data

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 Valler
- 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)
- **II.** Then click **Open**
- 12. Click Vector -> Geoprocessing Tools -> Convex hull (s)

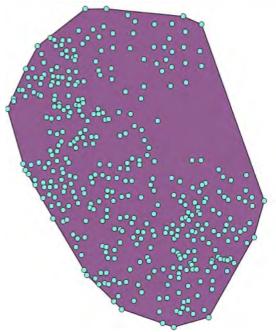


- 13. Check Create single minimum convex hull
- 14. Browse to the directory (~MODULE\_07\Data) and save as GOPAL\_CONVEX\_HULL. shp
- 15. Click Add result to canvas (if not already clicked)
- 16. Click OK and Close





+
Browse
-
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

- I. First, load GOPALGANJ\_DIST\_BD\_BTM.shpandBD\_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.





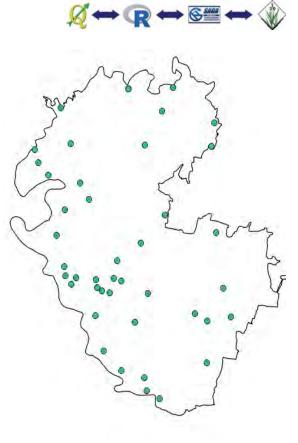
🔏 Clip	
Input vector layer	w mar
BD_ROAD_BTM	A. C.
Use only selected features Clip layer	the t
GOLPALGANJ_DIST_BD_BTM	SPEns.
Use only selected features	& Marin
Output shapefile	Stell toto
	State
ng_Data/Gopalgonj_Data/GOPAL_ROAD.shp Browse	NY MAR
X Add result to canvas	Stor -
0% OK Close	and the

#### **Point layer**

- I. 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



🦸 Clip	2 X
Input vector layer	
BGS_groundwater_BTM	-
Use only selected features	
Clip layer	
GOLPALGANJ_DIST_BD_BTM	•
Use only selected features	
Output shapefile	
ning_Data/Gopalgonj_Data/GOPAL_BGS.shp	Browse
X Add result to canvas	
0% OK	Close



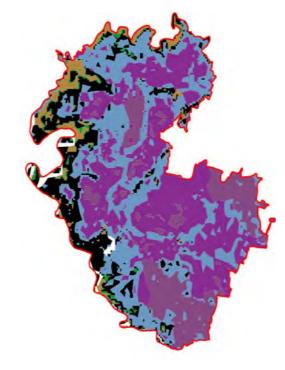
## Polygons

- I. 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.





Input vector layer BD_LandType_GCS Use only selected features Clip layer GOLPALGANJ_DIST_BD_BTM Use only selected features	
Use only selected features Clip layer GOLPALGANJ_DIST_BD_BTM	
Clip layer GOLPALGANJ_DIST_BD_BTM	•
GOLPALGANJ_DIST_BD_BTM	
Use only selected features	+
Output shapefile	
Data/Gopalgonj_Data/GOPAL_LandType.shp Brow	vse
X Add result to canvas	
0% OK Clo	se



#### **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.

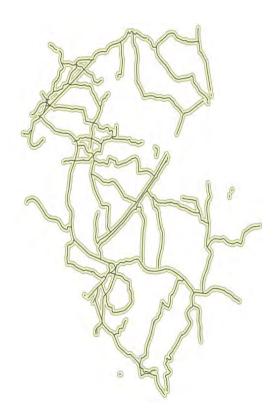
#### **Buffering of Polylines**

- I. 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





🔏 Buffer(s)	₽ X
Input vector layer	
GOPAL_ROAD	
Use only selected feature	s
Segments to approximate	5
Buffer distance	400
Buffer distance field	
	Ŧ
X Dissolve buffer results	
Output shapefile	
llgonj_Data/GOPAL_ROAD_40	00_BUFFER.shp Browse
X Add result to canvas	
0%	OK Close



## **Buffering of Point layers**

- I. 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.

- I. 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.







💋 Dissolve		P X	Ama
Input vector layer			and a
BD_DIST_BTM			~ )
Use only selected feat	ures		Same and
Dissolve field			L and
Dissolve all		*	J my
Output shapefile			S SM
ctor_Data/BTM/POLYGON	BD_BOUNARY.shp	Browse	T. A. C.
X Add result to canvas			ANA (SERVICE)
0%	ОК	Close	Rain Ber . Carton

## **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.

- I. 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.





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#### 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).

- I. 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\



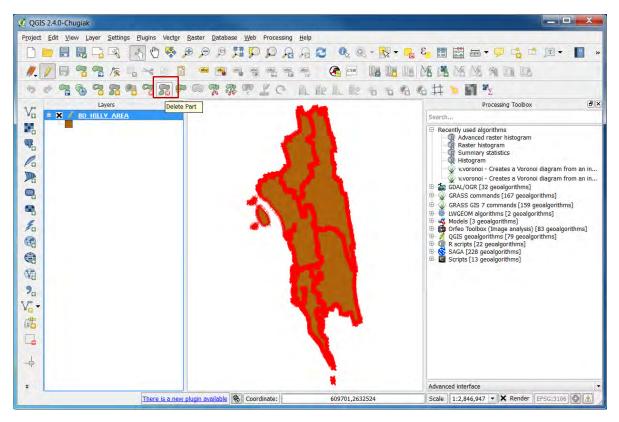
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# Polygon Editing

- I. 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.











## 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-digitalelevation-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:

- I. 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:

- I. 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.

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

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- 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** rasterand **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



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#### **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 reprojection 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.

- I. Click the Add raster layer button Rand select the file BD\_DEM\_GCS.tif
- 2. Click Raster->Projection->Warp(Repoject)





Input file	BD_DEM_GCS ▼	Select
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- 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:

- I. 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:  $\sim$ \MODULE\_09\ Data\ directory:

- I. 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.

- I. 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@I >= 0) \* HILLY\_DEM\_BTM @I

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 **M** 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

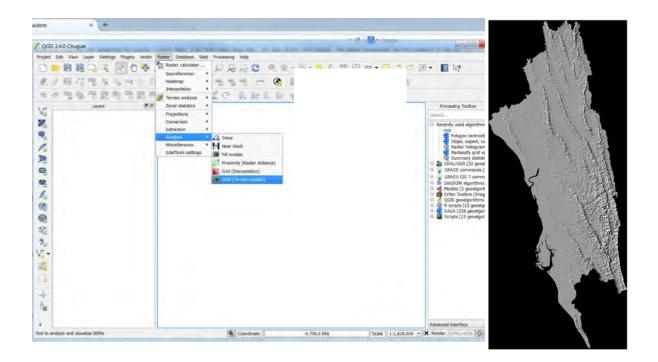
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## **Terrain Analysis in QGIS**

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.

- I. 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. Select 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.

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#### 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.

I. Click the Add raster layer button and select the file HILLY\_DEM\_BTM\_CORR.tif
- 97 -



- 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.

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#### 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.

- I. 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.

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## Color relief

Color relief helps differentiate topography more clearly, by providing a 3-band (RGB) or 4band (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.

- I. 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

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## **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  $\leq$  -8 m as valley bottoms, cells with *TPI* values  $\geq$  8 m as ridgelines, and cells with *TPI* values between - 8 and + 8m and slope < 6<sup>0</sup> as gentle slopes or slope  $\geq$  6<sup>0</sup> and *TPI* values between - 8 and + 8m as steep slopes (Dickson and Beier, 2007)<sup>1</sup>.

- I. 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.

DEM (Terrain models)      Input file (DEM raster) HILLY_DEM_BTM_CORR      Sel	ect
Qutput file         apter_09/Data/HILLY_TPI.tif         Selection           Band         1         1         1           Compute edges         1         1         1	ect
Mode TPI (Topographic Position Index) Mode Options Creation Options Load into canvas when finished	
gdaldem TPI J: \Training\QGIS\QGIS_TRAINING_2014\QGIS_TRAINING\Chap _09\Data\HILLY_DEM_BTM_CORR.tif J:/Training/QGIS/QGIS_TRAINING_2014/QGIS_TRAINING/Cha er_09/Data/HILLY_TPI.tif -of GTiff	
OK Close	Help

<sup>&</sup>lt;sup>1</sup> 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.

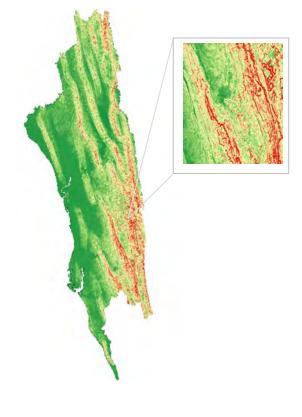


### **Topographic Ruggedness Indices (TRI)**

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.

- I. 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.

Input file (DEM raster)	HILLY_DEM_BTM_CORR   Select
<u>D</u> utput file	apter_09/Data/HILLY_TRI.tif Select
<u>B</u> and Compute <u>e</u> dges	[ <u>i</u>
Mode	TRI (Terrain Ruggedness Index)
Load into canvas wh gdaldem TRI J:	
Training\QGIS\QGIS_1 _09\Data\HILLY_DEM_E	_TRAINING_2014/QGIS_TRAINING/Chapt





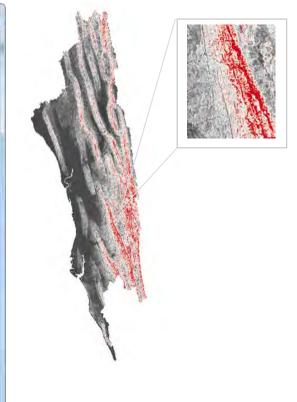


#### Roughness

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.

- I. 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.

	HILLY_DEM_BTM_CORR V	Select
<u>O</u> utput file	r_09/Data/HILLY_ROUGH.tif	Select
<u>B</u> and Compute <u>e</u> dges	1	4
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gdaldem roughness J: \Training\QGIS\QGIS_T _09\Data\HILLY_DEM_B		6
J:/Training/QGIS/QGIS er_09/Data/HILLY_ROU		NG/Chapt —







## 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 Switch Activate and Enable SAGA Import/Export optimization to ON and click OK.

Search,,.		
Setting	Value	-
🐵 🥥 GRASS commands		
🐵 🐵 LWGEOM algorithms		
🐵 🥰 Modeler-only tools		
🐵 🚯 Orfeo Toolbox (Image analysis)		
🐵 🕺 QGIS geoalgorithms		
R scripts		
🖻 😵 SAGA		
S Activate	×	
Senable SAGA Import/Export optimizations	×	
S Log console output	×	
Security Commands	×	
TauDEM (hydrologic analysis)		
- C Activate	×	
T MPICH2/OpenMPI bin directory		
T Number of MPI parallel processes to use	2	
TauDEM command line tools folder		6
Tools for LiDAR data		

- I. 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





Processing Toobox	Slope, aspect, curvature	
Search	Parameters Log	Run as batch pro
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QGIS geoalgorithms [79 geoalgorithms]	[hilly_dem_btm_cory [EPSG:3106]	•
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De Table - Tools		
Terrain Analysis - Channels		
B Terrain Analysis - Hydrology		
Terrain Analysis - Lighting		
Terrain Analysis - Morphometry		
S Convergence index		
S Convergence index (search radius)		
Curvature classification		
<ul> <li>S Diurnal anisotropic heating</li> </ul>		
S Downslope distance gradient		
<ul> <li>Effective air flow heights</li> </ul>		
K Hypsometry		
Mass balance index		
Morphometric protection index		
Multiresolution index of valley bottom flatness (m.		
Real area calculation		
Relative heights and slope positions		
Slope, aspect, carvatore		
Surface specific points		

6. Save to file

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

7. Check all Open output file after running algorithm

Terrain ruggedness index (tri) Topographic position index (tp

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.

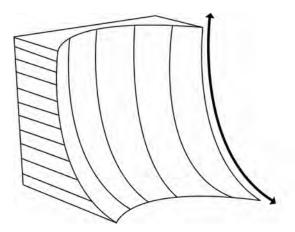


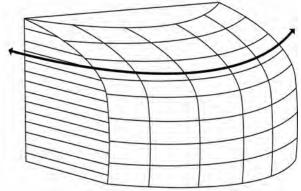


A *Profile curve* is conversely a vertical measurement of the change of a slope. Positive values indicate convexity, while negative values represent concave profiles.

#### **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 I - 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

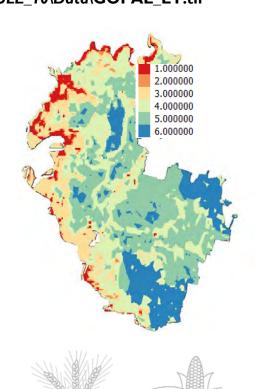
## **Convert a vector to raster**

- I. 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]
- IO. Cell size:
- II. Grid:

90.000 Save to file ~\MODULE\_10\Data\GOPAL\_LT.tif

12. Click Run

Shapes to grid		
Parameters Log Help		
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it_m		
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Method for Lines		
[0] thin		
Preferred Target God Type		
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X Open output file after running algorithm		
U%		
	Run	Clo





## Extract grid values to point shape file

- I. 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

Parameters Log Help		GORAL_DEM [E			
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Grids 0 elements selected Interpolation			Can	cel	
[0] Nearest Neighbor 🔹					
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## **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.

- I. 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





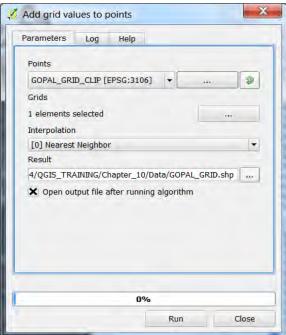
8. By clicking OK, we clip **GOPAL\_GRID** with **GOLPALGANJ\_DIST\_BD\_BTM** and create a new point layer (**GOPAL\_GRID\_CLIP**) using SAGA geo-processing tools (SAGA->Shape->Cut shapes layer)

Area	Parameters Log Help
	Vector layer to cut
<ul> <li>Input Boundary Layer</li> </ul>	GOPAL_GRID [EPSG:3106] 🦻
GOLPALGANJ_DIST_BD_BTM	Method
State Par	[0] completely contained
Input Coordinates	Cutting polygons
X Min Y Min	GOLPALGANJ_DIST_BD_BTM [USER:100000] ▼ 🦻
	Result
X Max Y Max	5_2014/QGIS_TRAINING/Chapter_10/Data/GOPAL_GRID_CLIP.shp
Grid Spacing	Open output file after running algorithm Extent
Use this point spacing 90.0000	[Save to temporary file]
Use this number of points 1	Open output file after running algorithm
Initial inset from corner (LH side) 45,0000	
Dutput Shapefile	
INING/Chapter_10/Data/GOPAL_GRID.shp Browse	0%
Add result to canvas	Run Close

- 9. Expand SAGA ->Shapes-Grid in Processing Toolbox
- **10.** Click on Add grid values to points
- II. Points: GOPAL\_GRID\_CLIP
- 12. Grids: CheckGOPAL\_DEM click OK
- 13. Interpolation: [0] Nearest Neighbor
- I4. 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	<b>TPI</b> Values	Slope Class	Slope value
Class			
Ι	≤ -8 m	I	< 6
2	- 8 to + 8 m	2	≥ 6 <sup>°</sup>
3	≤ <b>-8</b> m		

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

## **Reclassify TPI raster**

- I. 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:

<u>File Edit Format View Help</u>	0
-15.185:-8.001:1 -8:7.999:2 8:*:3	

- b. The first line tells QGIS to recode cells with TPI values < -8.0 m with a new value of I
- c. Cells with TPI values from 8 and + 8m will receive a new value of 2 and
- d. Those cells with values  $\geq 8$  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.

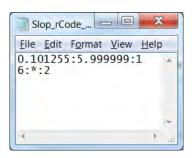
arameters Log Help			2.000
Show advanced param	neters		
Input layer			
HILLY_TPI [EPSG:3106]	+		
File containing recode rules			
INING_2014\QGIS_TRAINING\C	Chapter_10\TPI_rCode_Rules.txt		
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[Leave blank to use min cover	ring extent]		
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X Open output file after runn	ing algorithm		J. K.
	0%		

## **Reclassify Slope raster**

- I. 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  $^\circ$  m with a new value of 1  $^\circ$  m
  - **b.** Those cells with values  $\ge 6^\circ$  mwill receive a new value of  $2^\circ$  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.



- | | | -



Input layer HILLY_Slope [EPSG:3106] • File containing recode rules ing\QGIS\QGIS_TRAINING_2014\QGIS_TRAINING\Chapter_10\Slop_rCode_Rules.txt GRASS region extent(xmin, xmax, ymin, ymax) [Leave blank to use min covering extent] GRASS region cellsize (leave 0 for default) 0.00000 • Output raster layer F:/Training/QGIS/QGIS_TRAINING_2014/QGIS_TRAINING/Chapter_10/Data/RE_HILLY_Slope.tif Y Open output file after running algorithm	
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X Open output file after running algorithm	
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## **Raster Overlay**

After reclassification of the slope and TPI data, we will now work to combine them to identify valley bottoms (TPI  $\leq$  -8° m), ridgelines (TPI  $\leq$  -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  $\geq$  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@I" = 2) \* "RE\_HILLY\_Slope@I") + "RE\_HILLY\_TPI@I"

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 -  $8^{\circ}$  to +  $8^{\circ}$  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:

- I. 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

🚺 📃 TPI - 8 t	o +8		Vally Steep Slope Gentle Slope Ridge
	TPI - 8 t	TPI < -8 TPI - 8 to +8 TPI > +8	TPI - 8 to +8 TPI > +8

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## **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.

- I. 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

Parameters Log Help	Processing Toolbox
Raster layer	Search
HILLY_DEM_BTM_CORR [EPSG:3106]	Recently used algorithms     GDAL/OGR [32 geoalgorith
Raster band	GRASS commands [167 ge.
1	🖲 👻 GRASS GIS 7 commands [
Vector layer containing zones	Models [3 geoalgorithms]     Models [3 geoalgorithms]     Models [3 geoalgorithms]
HILLY_AREA_BTM [EPSG:3106] +	QGIS geoalgorithms [79 ge
Output column prefix	Raster general tools
DIST	🖃 Raster tools
Load whole raster in memory	Zonal Statistics
Yes 👻	Vector analysis tools     Vector creation tools
Output layer	Vector general tools
QGIS_TRAINING/Chapter_10/Data/HILLY_DIST_DEM_STAT.shp	Vector geometry tools     Vector overlay tools
X Open output file after running algorithm	Vector selection tools     Vector table tools     Vector table tools     R scripts [22 geoalgorithms]     SAGA [228 geoalgorithms]     Scripts [13 geoalgorithms]     TauDEM (hydrologic analyse)
0%	
Run Close	

	DIST_NAME	Shape_Leng	Shape_Area	Classcount	Classsum	Classmean	DISTmin	DISTmax	DISTsu
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.
2	Cox's Bazar	6.871398	0.188331	249913.00000	752899.00000	3.0126444002	0.000000	259.000000	4536216.0
3	Khagrachhari	3.524531	0.254434	353304.00000	1078344.0000	3.0521703688	12.000000	488.000000	34877140.
4	Rangamati	6.449390	0.506591	661524.00000	2053704.0000	3.1045041449	5.000000	1008.000000	101714768



## Module 11: Georeferencing Google Earth Imagery

Google Earth is a free program offered by the Google company that provides relatively highresolution 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 georeference 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.

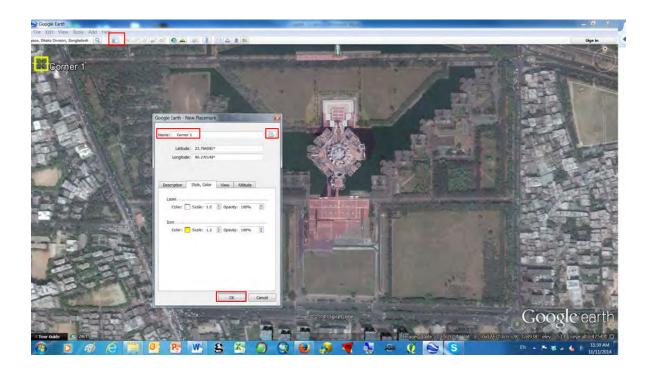
## **Obtaining the Google Earth Satellite Imagery**

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).

- I. 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 I". 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 FII 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 I 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

- I. 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 I 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.





(mmmm.mm)) which	nates (DMS (dd mm ss o correspond with the s of a pencil and then clic ates of that point.	elected point on	the image. Al	ternatively, click
X / East: 90 22 12.3	1		Y / North: 2	3 45 55.33
Snap to backgrou	ind layers <b>?</b> From map canvas	Cancel		

- 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 rin 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.





Transformation type:	Linear
Resampling method:	Nearest neighbour
Compression:	LZW -
Create world file	
Output raster:	TRAINING/Chapter_11/Data/Dhaka_geo.tif
Target SRS:	EPSG:4326
Generate pdf map:	
Generate pdf report:	2
Set Target Resolut	tion
Horizontal	1.00000
Vertical	-1.00000
Use 0 for transpar	n done

## **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.

- I. 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

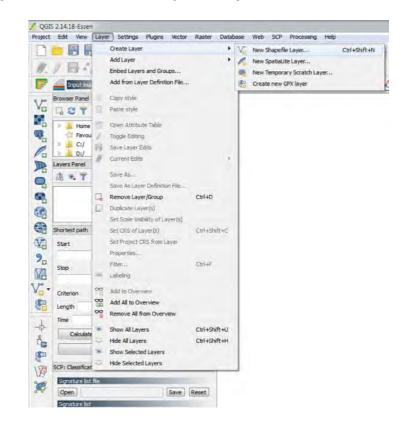
All data has to be sourced from somewhere. For most common geospatial applications, data can usually be found online or in open-access databases. However, the more particular and specialized your project, the less likely it is that data will easily be available. In these cases, you will may need to create 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







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Туре					
Poir	nt	ΟL	ine	Polygon	
ile encod	ing	UTF-	8		
Selected	CRS (EPSO	5:4326, WGS 84	4)	•	đ
New fie	ld				
Name	dass_na	me			-
Туре	Text data	3			1
Length	80		Precision		1
				Add to fields list	1
-					
Mamo		Tune	Length	Precision	П
Name id		Type Integer	Length 10	Precision	
id			10		
1000				Precision	-

- I. 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.





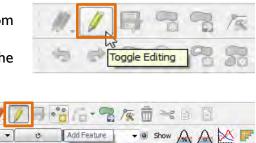
th 🔻 Slide show	New folder			
Name	Date	Туре	Size	Tag
Control_point.xls	29/10/2017 4:35 PM	Microsoft Excel 97	25 KB	
🔄 Dhaka.jpg	25/10/2017 4:15 PM	JPEG image	7,561 KB	
🌉 Dhaka_geo.tif	29/10/2017 1:49 PM	TIFF image	39,603 KB	
line.cpg	29/10/2017 4:10 PM	CPG File	1 KB	
line.dbf	29/10/2017 4:10 PM	DBF 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:

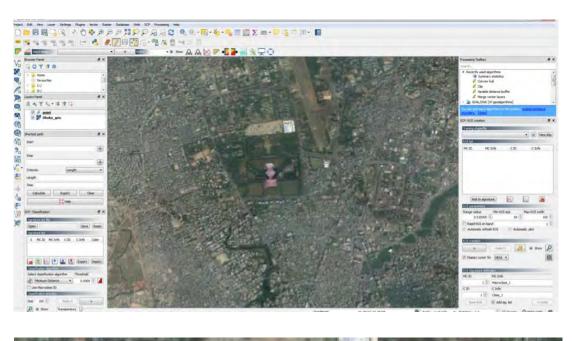
- Open Dhaka\_geo.tif and point.shp from ~MODULE\_12\DATA folder.
- 2. Click the **ToggleEditing** button from the Digitizing toolbar
- 3. Now click on the **AddFeature** button from the Digitizing toolbar
- **4.** Zoom to a specific part of the image. In this example, we will focus on the

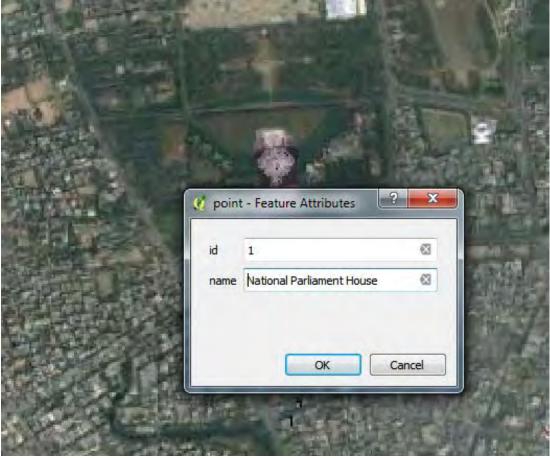
Bangladesh Parliament building, as shown below then click on it once.











- **5.** After clicking a popup window of attribute table will appear, Type I 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**

- I. 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



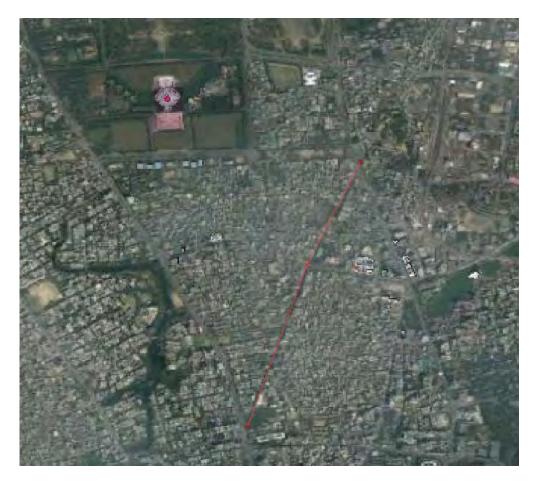
Now click on the Add Feature button from the

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.



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#### 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:

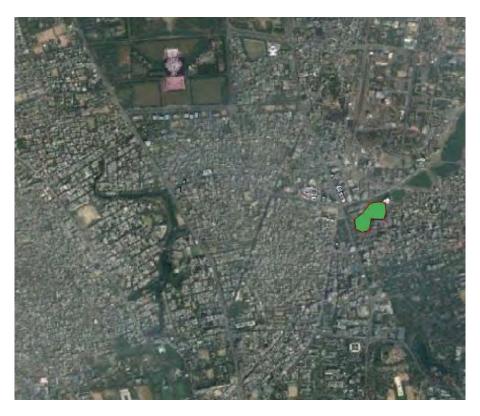


- 5. Click and insert a node for the starting point of your polygon feature and continue clicking along the edge of the waterbody (Hatir Jhil) until the temporary polygon mathes the edges of the waterbody in the image. After inserting the end point, right click to finish your polygon representation of 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.



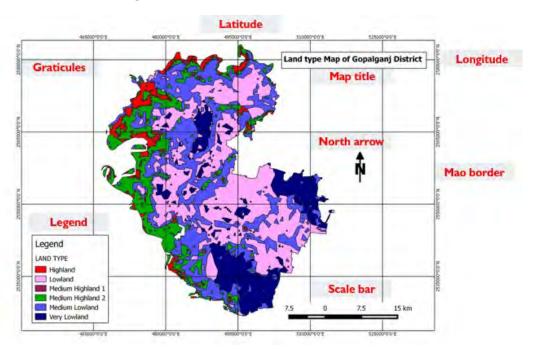




## Module 13: Map Production in QGIS

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.

nposer Edit View Layout Atlas Settings			
1 🗩 🗩 😂 🖄 🖉 🤮 🚰 🖳 🗒 🔶 🔶 🔶 🔍 👘 🛸 🔍 👘			
0         100         150         200         250         1900           0         5         5         5         5         5         5	, Composition Ite	m properties Atlas gene Composition	eration
	<ul> <li>Paper and qualit</li> </ul>	y	
13	Presets	A4 (210x297 mm)	•
	Width	297.00	*
0.	Height	210.00	*
	Units	mm	*
	Number of pages	1	1
	Orientation	Landscape	-
1001	Page background	Change	
8	Export resolution	300 dpi	-
	Print as raster		
8 <u>-</u>	World file on		*
	▶ Grid		
1	Snap to alignme	nts	
150			
3			
3			

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.						
<b>.</b>	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.						
Т	<b>Add New Label</b> . This is used when you want to add new text at a location of your choice on the map.						
E.	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.						
1	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.						
	<b>Select / Move Item</b> 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.

- I. Open QGIS Project Module I2 (~\MODULE\_I2\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.





🔏 Composer title			
Create unique print con (title generated if left e			
My Layout 1		*	
	ОК	Cancel	

**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.



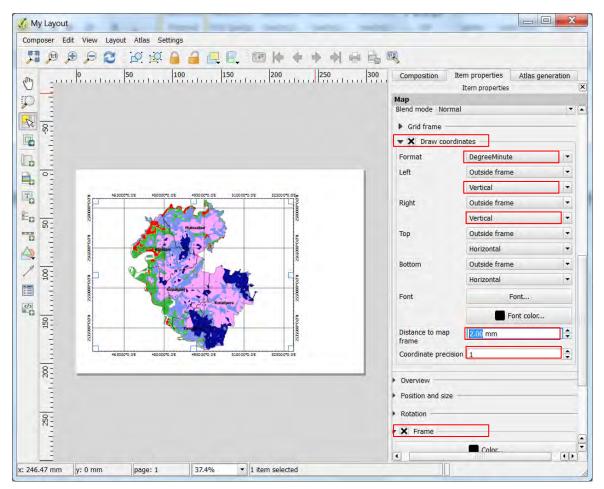


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- 9. Next check Draw coordinates
- **10.** Select the format: DegreeMinute
- II. On the left: Select outside frame and Vertical
- **12.** Do the same for the right
- **13.** Change your font size 12 or any size of your choosing.
- **14.** Set the distance 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.





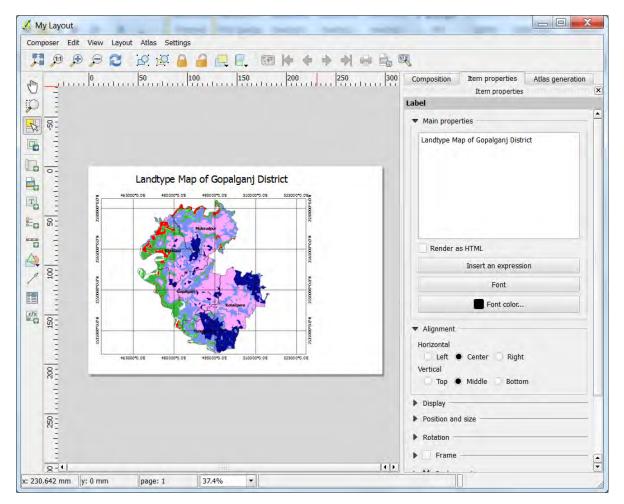


## Give your map a title

- 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 The 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"





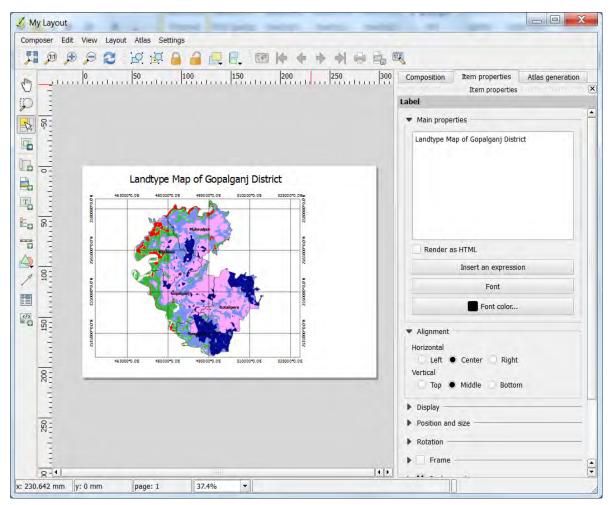


## Add a Scale Bar

- 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:





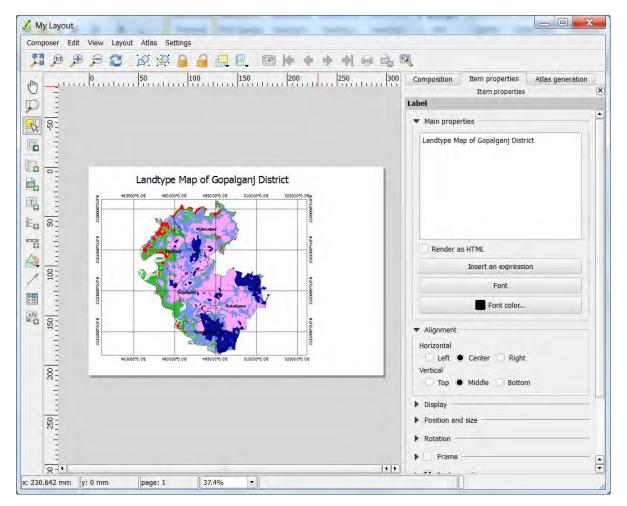


## Add a Legend

- I. In order to add a legend to your map, first click on the *Add legend* button, which looks like this:
- 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.

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#### 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 <u>https://grass.osgeo.org/</u>.

#### 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 <u>https://www.google.com/earth/</u>.

#### **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

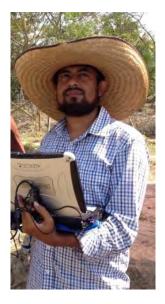


## Zia Uddin Ahmed

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

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