Terrain Analysis

Using QGIS and SAGA

Terrain Analysis using QGIS and SAGA

Objective: To analyze the topography of a region with respect to its slope, aspect and curvature etc., using a Digital Elevation Model.

Software: SAGA GIS and Quantum GIS

Level: Intermediate

Time required: 3 Hours

Prerequisites and Geospatial Skills:

1. SAGA and QGIS should be installed on the computer.
2. Familiarity with basic operations in SAGA and QGIS is preferable.
3. An internet connection to fetch '*Profile Tool*' plugin.

Readings

1. Clarke, K. C. (1995). Chapter 13: Terrain Analysis. In Analytical and Computer Cartography (2nd ed., pp. 249-279). Prentice Hall. Retrieved from http://www.geog.ucsb.edu/~kclarke/AACC/_Chapter13.pdf

2. Aileen, B. (n.d.). Understanding curvature rasters. ArcGIS Resources. Retrieved from http://blogs.esri.com/esri/arcgis/2010/10/27/understanding-curvature-rasters/

3. Scottish Road Network Landslides Study: Implementation | Transport Scotland. (n.d.). Retrieved June 24, 2013, from http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j10107-07.htm
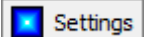
Tutorial Data: SRTM DEM downloaded from http://srtm.csi.cgiar.org has been supplied for this tutorial and can be downloaded here.

Introduction

While using raster data in the previous tutorials the images were limited to those describing the spectral properties of the land, however we also have raster datasets that describes the elevation of the land. The elevation values are stored in the form of a raster grid known as a *Digital Elevation Model* (DEM). The DEM pixel values indicate the height of the pixel above the defined vertical datum. Although the DEM itself describes just the elevation of the land surface, it can be used to derive many interesting and useful data products. These derivatives are used in almost every field and mostly in hydrological, visibility, ecology and morphological analyses.

DEMs are generated as a product of the satellites like ASTER, CartoSat P5, and the Shuttle Radar Topography Mission (SRTM). Often user may come across some areas with missing pixel values, these are referred to as 'holes' or 'sinks' in the data and are caused by anomalies during the data collection. To alleviate this problem there exist many algorithms which fill in these sinks by interpolating the elevation of neighboring pixels.

In this tutorial we will learn how to fill the sinks, prepare various products, and visualize DEM data by using both Quantum GIS and SAGA GIS.

1. Launch SAGA and open the filled DEM image in SAGA by clicking the *'Load'* button. Navigate to the DEM file, select it and click *'Open'* (File types should be set to 'All files' to view the DEM).

2. The DEM will be imported into the *Data* tab list. Double click on it to open in a *Map* window as shown above by changing the color ramp to grey scale. To change the color ramp from blue-yellow-red to black-white, click on the button from the *'Colors'* field in the tab. In the next popup window that opens select *'Presets'* button and choose *'Greyscale'* from the list. Click on '*OK*' and '*Okay*'. Now click on '*Apply*' in *Settings* tab.
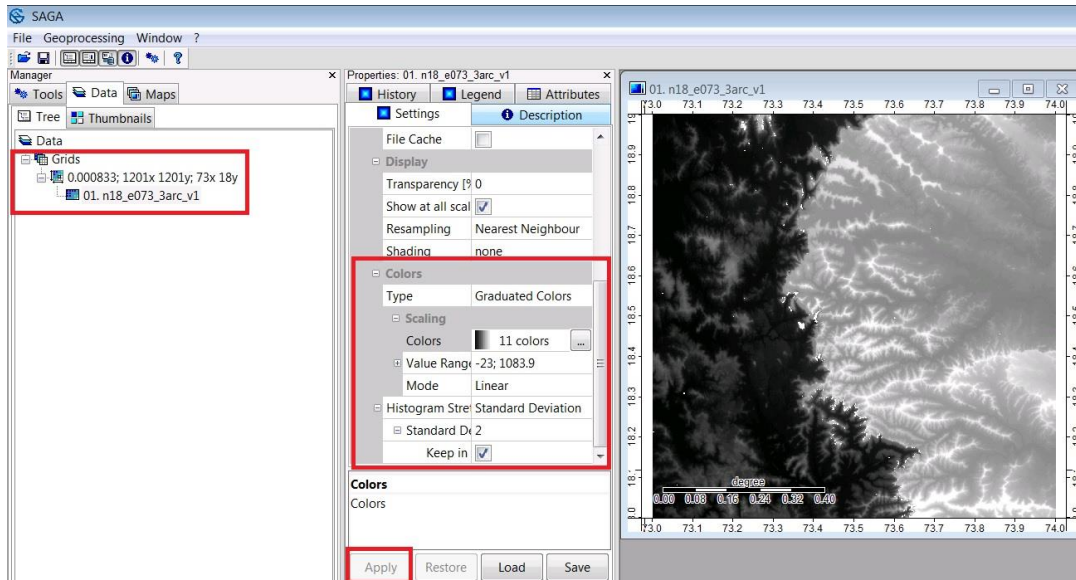
3. The white patches are the parts of the DEM without any data and generally referred as the holes or sinks which cause problems in analysis if they are not filled.

4. These sinks/no data values can filled by interpolating the pixel values from the neighborhood pixels. To do this we use the 'Close Gaps with Stepwise Resampling' tool (Geoprocessing → Grid → Gaps → Close Gaps with Stepwise Resampling). Now fill the option as shown below and click 'Okay'.
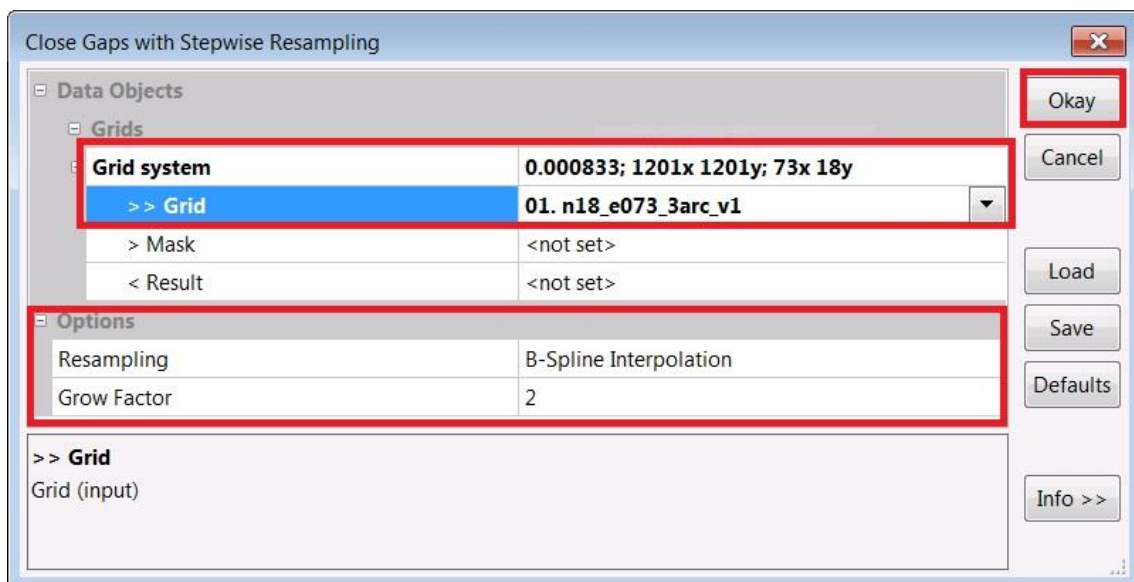

Note: Since we choose <not set> option under <Result. The changes will be stored to the original grid, i.e., 'n18_e073_3arc_v1'.
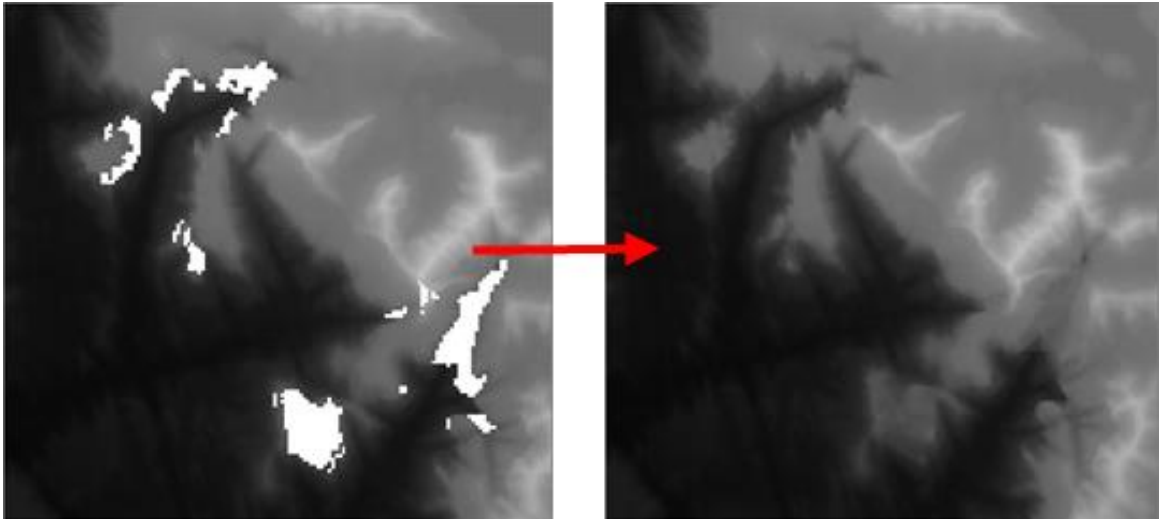
5. Now you can see that the gaps are filled by the estimated elevation values. Click the **ⓘ Description** tab under *Object Properties* section. This will display the metadata of the DEM, some part of which is displayed below.

Projection	Geographic Coordinate System [EPSG 4326]: WGS 84 [+proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs]
West	73
East	73.99999996000000
West-East	0.9999999599999967
South	18
North	18.999999960000000
South-North	0.9999999600000002
Cell Size	0.0008333333000000000

6. As you see, the DEM is in a *Geographic Coordinate System (GCS)*, which means its distance is measured in degrees (cell size is 0.0008333 degrees). Before carrying out any spatial analysis operations on the DEM, it will strongly suggest to convert it from a *Geographic Coordinate System* to a *Projected Coordinate System*.

7. Open the *'Coordinate Transformation'* module via *Geoprocessing → Projection → Coordinate Transformation (Grid)*. In the module window, under *'Proj4 Parameters'*, change the *'Projected Coordinate System'* entry to **'WGS 84 / UTM Zone 43N'**. Enter the *'Grid System'* entries as shown below. Click on *'Okay'*.
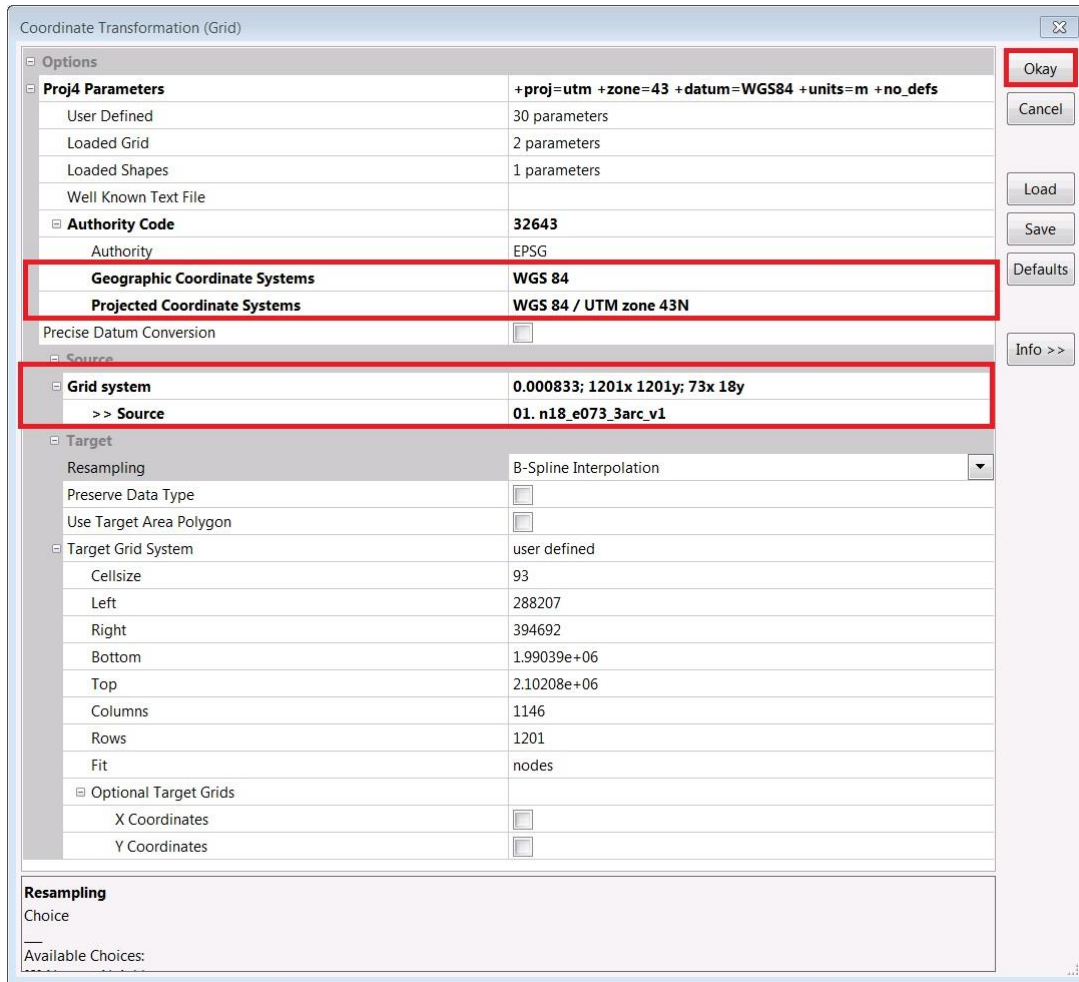
8. The reprojected DEM will now be placed in the *Data* list. It will now have a different set of descriptors. You can see the pixel size has been converted from 0.00083333 degrees to 93 meters .Open it in a new window and change the color ramp to *'Greyscale'* .
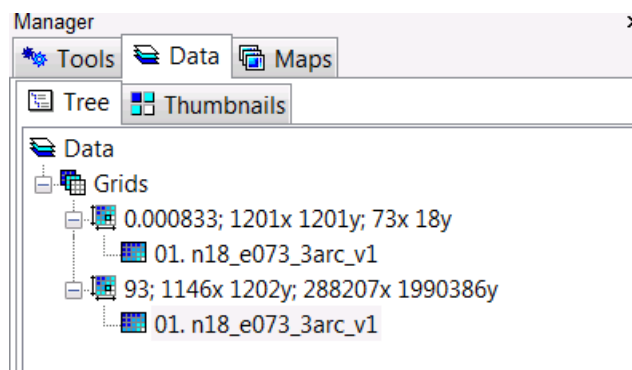

9. We are now ready to run a set of basic operations on the DEM via *Geoprocessing → Terrain Analysis → Morphometry → Slope, Aspect, Curvature*. In this window, enter the current *'Grid sytem'* and *'Elevation'* as reprojected DEM and select the options as

shown below to generate slope, aspect and curvature products. It might take a while depending your computer speed.
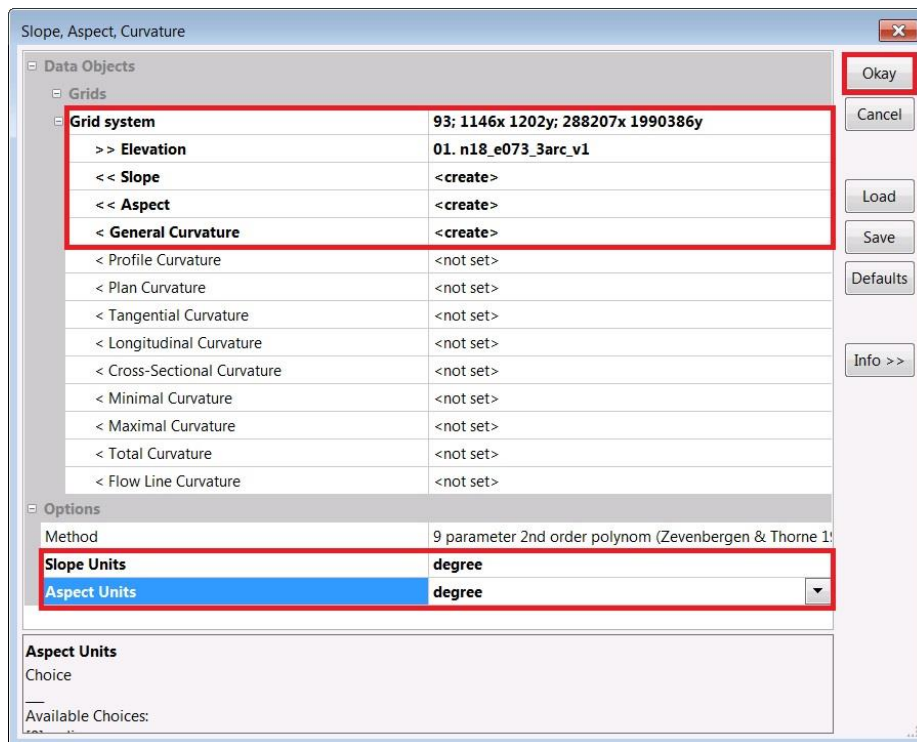
10. **Slope** is change in elevation per unit distance. The slope can be expressed either in degrees or percentage. This module calculates the slope in degrees. Slope is most commonly used product of terrain analysis in almost all fields of human activity, planning transportation networks and hydrology. Double click on '*Slope*' layer under *Data* tab to open in new map window.
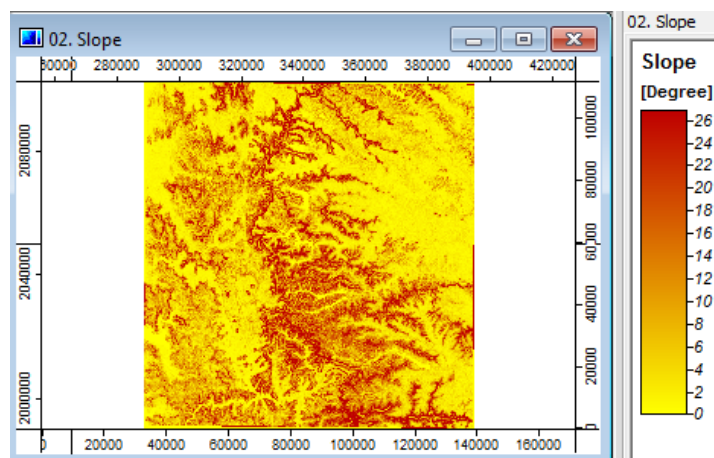

11. **Aspect** is the compass direction of the slope and its value measured in degrees. It affects the direction in which water flows. It is a widely used product of terrain analysis in fields of ecology, hydrology and green energy projects like solar energy and wind mills. Open '*Aspect*' map in new window, it looks like below figure.
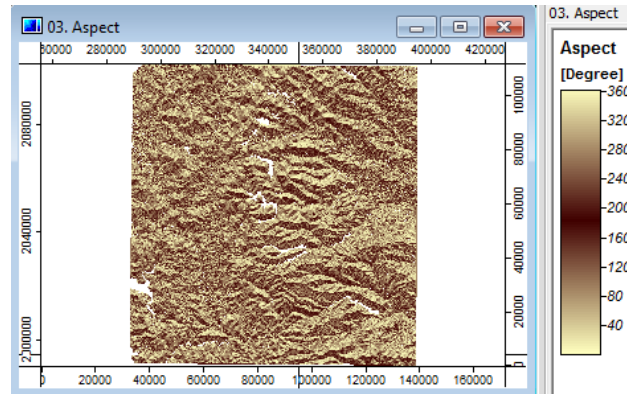
Task 3: How slope and Aspect helps in planning of transportation routes?

12. **General Curvature** is the change in slope per unit distance. It is a very helpful measure to understand the surface water flow. Therefore it is widely used in the field of hydrology. The pixels with positive curvature indicate the flow dispersal and negative values indicates the flow accumulation. Open the 'Curvature' layer in new map and change its color ramp to 'Greyscale'.
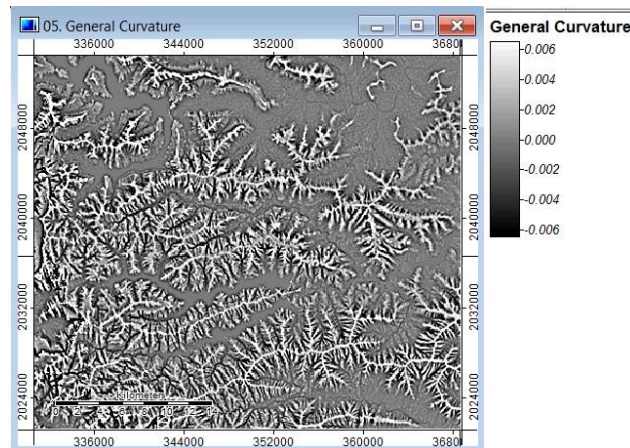

13. Another useful derivative of the DEM is the *Analytical Hillshading* module. It is a shaded relief raster provides a better visualization experience of the terrain. Open it via *Geoprocessing → Terrain Analysis → Lighting → Analytical Hillshading.* Set the Grid System and '>>Elevation' entries to the reprojected DEM. Leave the rest of the values as the defaults and click 'Okay'.
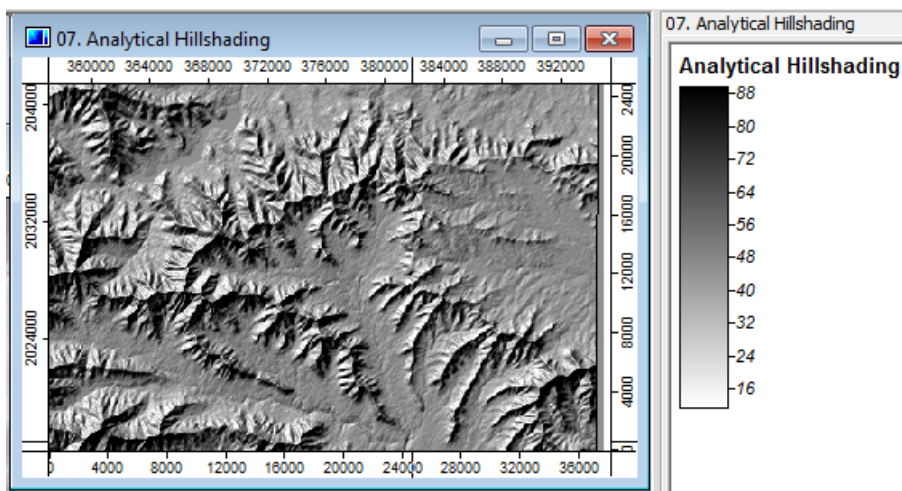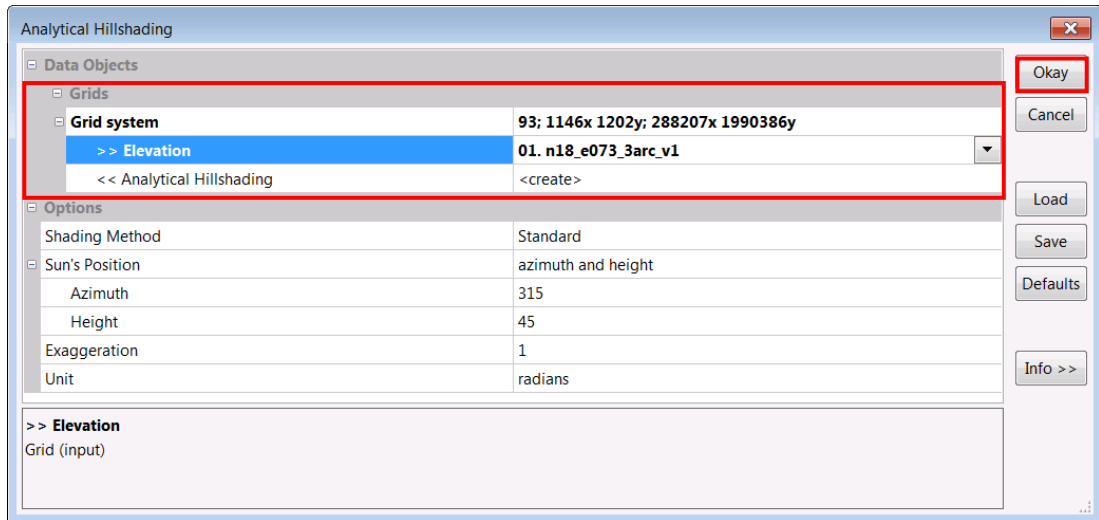
This simulates the shadow effect from a light source originating from the North West (315 degree) direction at an angle of 45 degrees from the horizontal plane.

14. To understand how these derivatives relate to each other, we can lay them side-by-side. From the *Window* menu select *'Tile Vertically'* (You can also close the *'Object Properties'* module on the right to make place for the windows). This will arrange them neatly like tiles ensuring there is no overlap. Next, select one of the map windows and via the *Map* menu, click *'Synchronize Map extents'*. This will set all the maps to the same extent as that window.
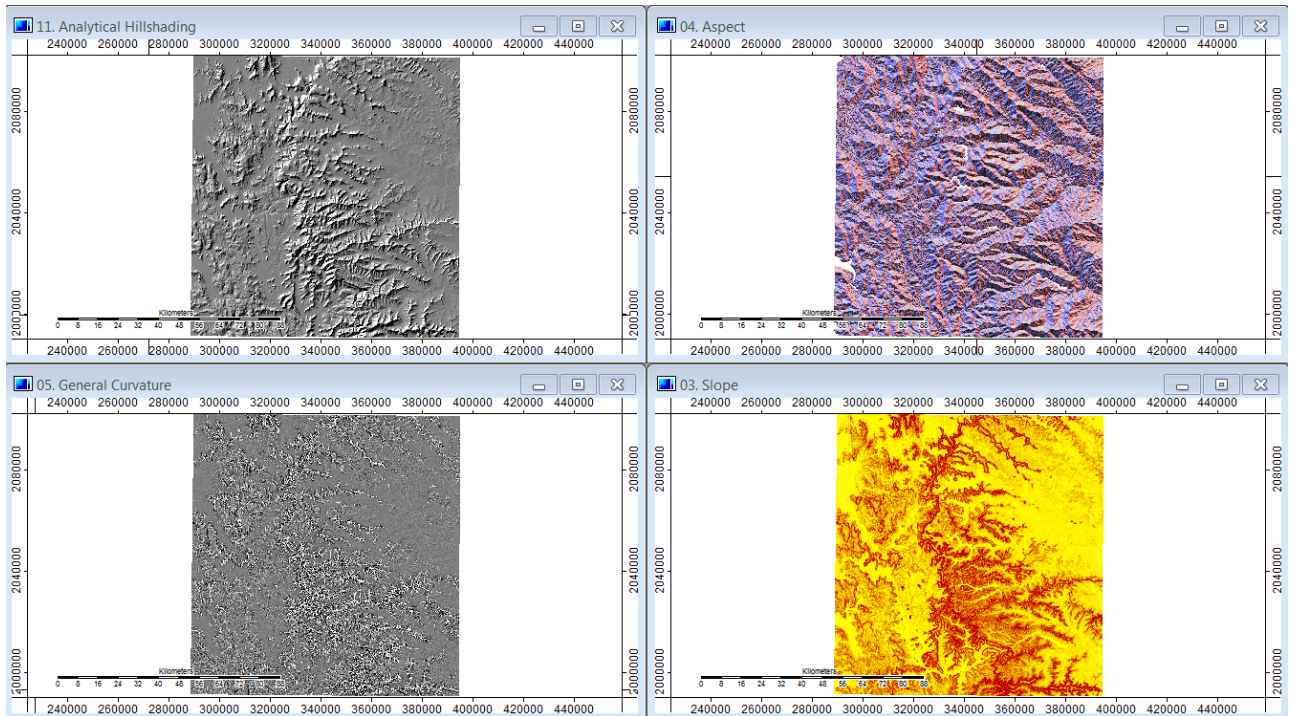
15. Another interesting tool to use is the Landform Classification. This classifies the terrain into different landforms. The pixels are classified based on their relative position and elevation with respect to the surrounding pixels. Open it via *Geoprocessing → Terrain Analysis → Terrain Classification→ TPI Based Landform Classification.*

16. Set the '*Grid System*' and '*Elevation*' to the reprojected DEM and keep the rest of the options as their default values. Click '*Okay*'. This will create the classified map of the landforms as shown below.
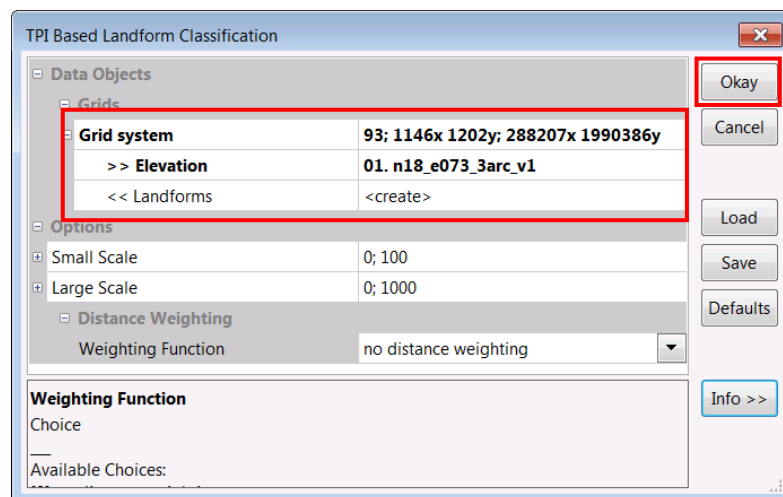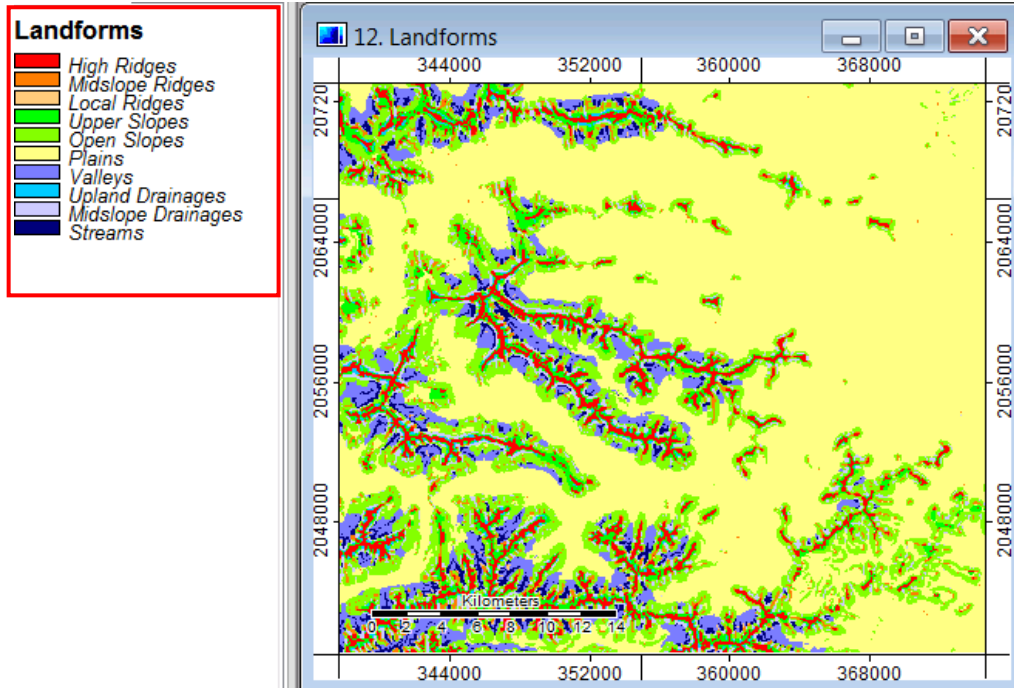
17. Right-click on the layer under *Data* tab to select *'Histogram'*. This will show the area distribution of different landforms.
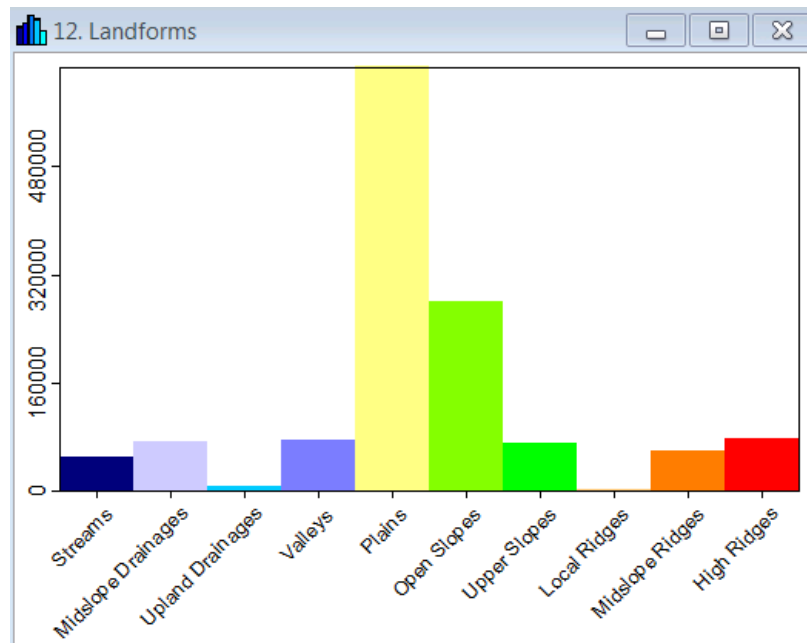
18. We will now view the DEM in 3D to more comprehensively visualize the topography. Open the DEM in a new map window, and overlay the *'Analytical Hillshading'* layer on top of it. If you closed the *'Object Properties'* module then open it via the menu *Window → Show Object Properties.* Change the *'Transparency'* value of the *'Analytical Hillshading'* layer to *'60'*.
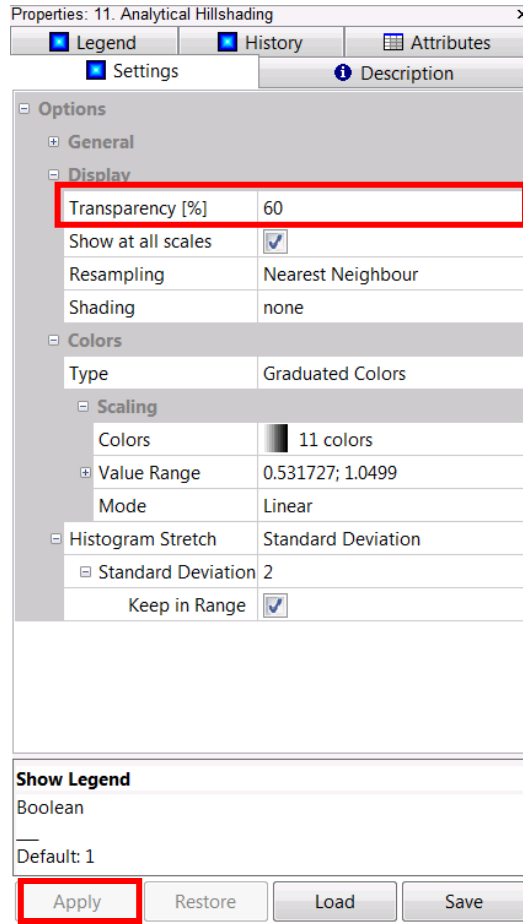
19. Select the map window and click the 〔3D〕 'Show 3D View' button. Set the 'Grid System' and '>>Elevation' to the projected DEM layer. Click 'Okay'. This will open the layer in the 3D-view window.
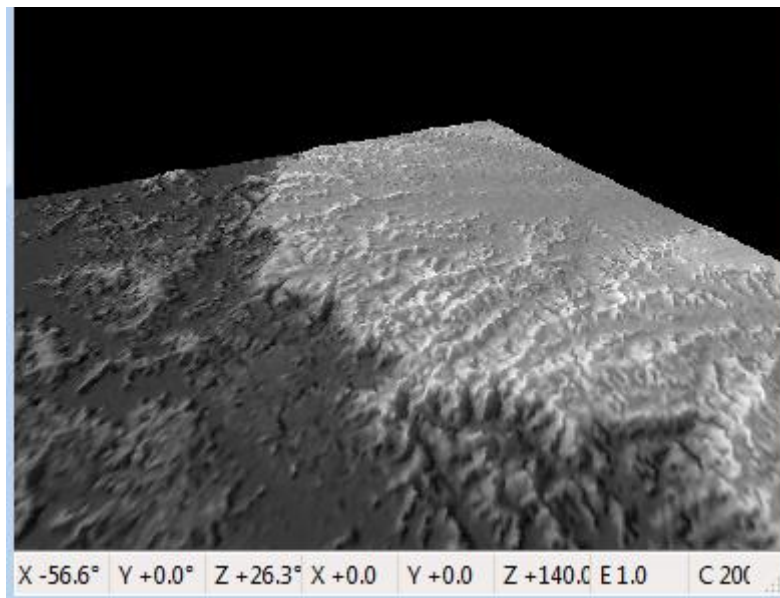

20. Click and drag the image. It will rotate around an axis in the direction in which you pull it. The controls for the viewing angle and distance can be found in the tool bar above. Play around with these controls to get used to handling the layer (place the

mouse cursor over each one to see what each one does).

21. You might find that if you look at the terrain from a lateral view, it appears slightly flat. It makes it more difficult to make out the elevation differences. To fix this, use the *F1* and *F2* keys to decrease or increase the exaggeration of the terrain. An image when viewed with some exaggeration can make it easier to identify the landforms.
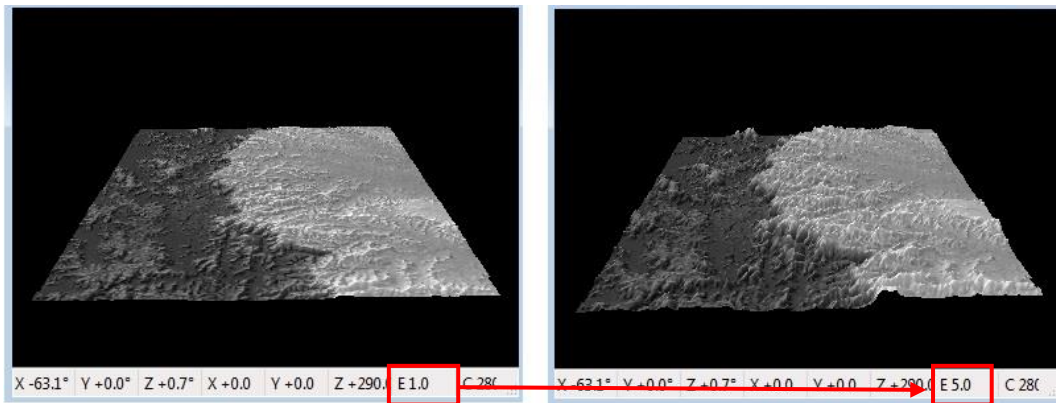
22. Save this as an image via the menu *3D View → Save as Image.* In the window that opens enter a name and format for the image and click '*Save*' . A window will open showing the image size. Click '*Okay*' if you want to keep this size. In the image below the original dimensions was 384 x 239 (it may vary). The dimensions have been changed to 1600 x 1000

23. The image will be just as it appears in the 3d View window.
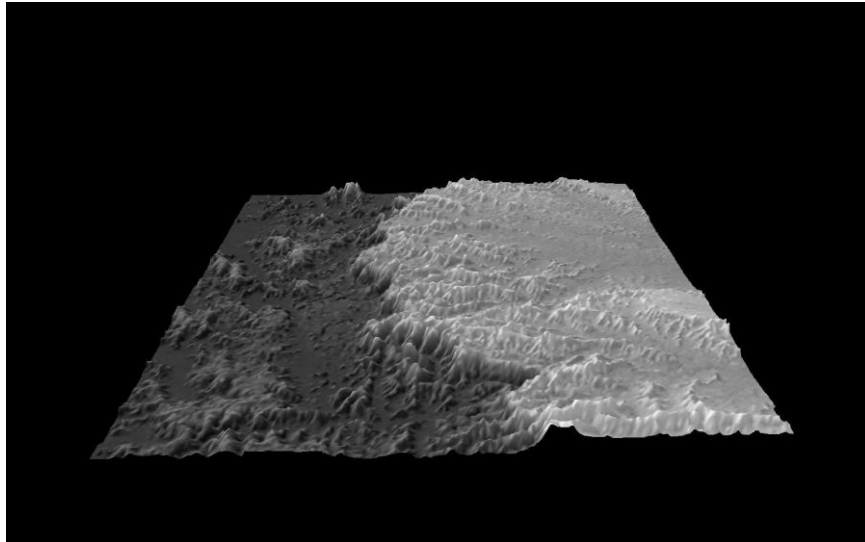
24. Close the Project and save the entire modified layers in a desired location.

Task 4: Prepare overlay maps of *Hillshade* in combinations with different *Curvature* layers and describe the patterns and feature that you observed.