Hillshade in QGIS – The Algorithm and the Math

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Flow

1. Introduction to the Hillshade

2. Open source for DEM data

3. QGIS demo

1. Introduction

i. “Hillshade” is a technique where a lighting effect is added to a map based on elevation variations within the landscape.

ii. Hillshade provides a clearer picture of the topography by mimicking the sun’s effects (illumination, shading and shadows) on hills and canyons.

iii. The DEM (digital elevation model) layer shows the elevation of the terrain, but it can seem little abstract.
- The DEM contains all the 3D information about the terrain, but it does not look like a 3D object.
- To get a better impression of the terrain, we calculate a *hillshade*, which is a raster that maps the terrain using light and shadow to create a 3D-looking image.

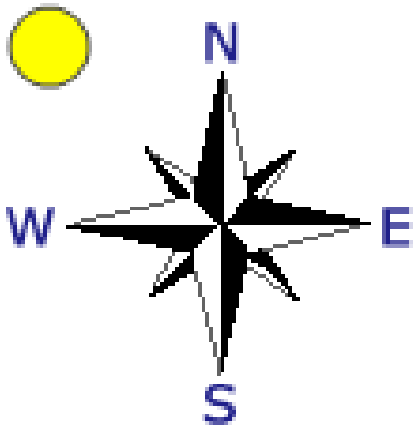
iv. The Hillshade tool obtains the hypothetical illumination of a surface by determining illumination values for each cell in a raster.
- It does this by setting a position for a hypothetical light source and calculating the illumination values of each cell in relation to neighboring cells.
- It can enhance the visualization of a surface for analysis or graphical display
- By default, shadow and light are shades of gray associated with integers from 0 to 255 (increasing from black to white).

2. Inputs for the hillshade algorithm

The primary factor when creating a hillshade map for any particular location is the location of the sun in the sky.

1. **Azimuth**

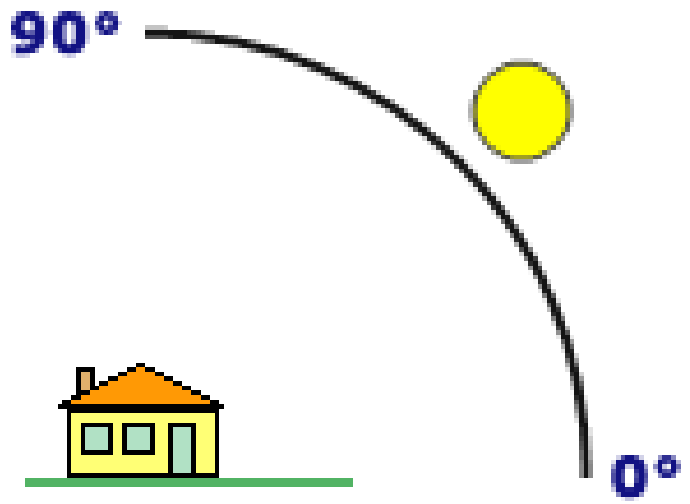
The azimuth is the angular direction of the sun, measured from north in clockwise degrees from 0 to 360. An azimuth of 90 degrees is east. The default azimuth is 315 degrees (NW).



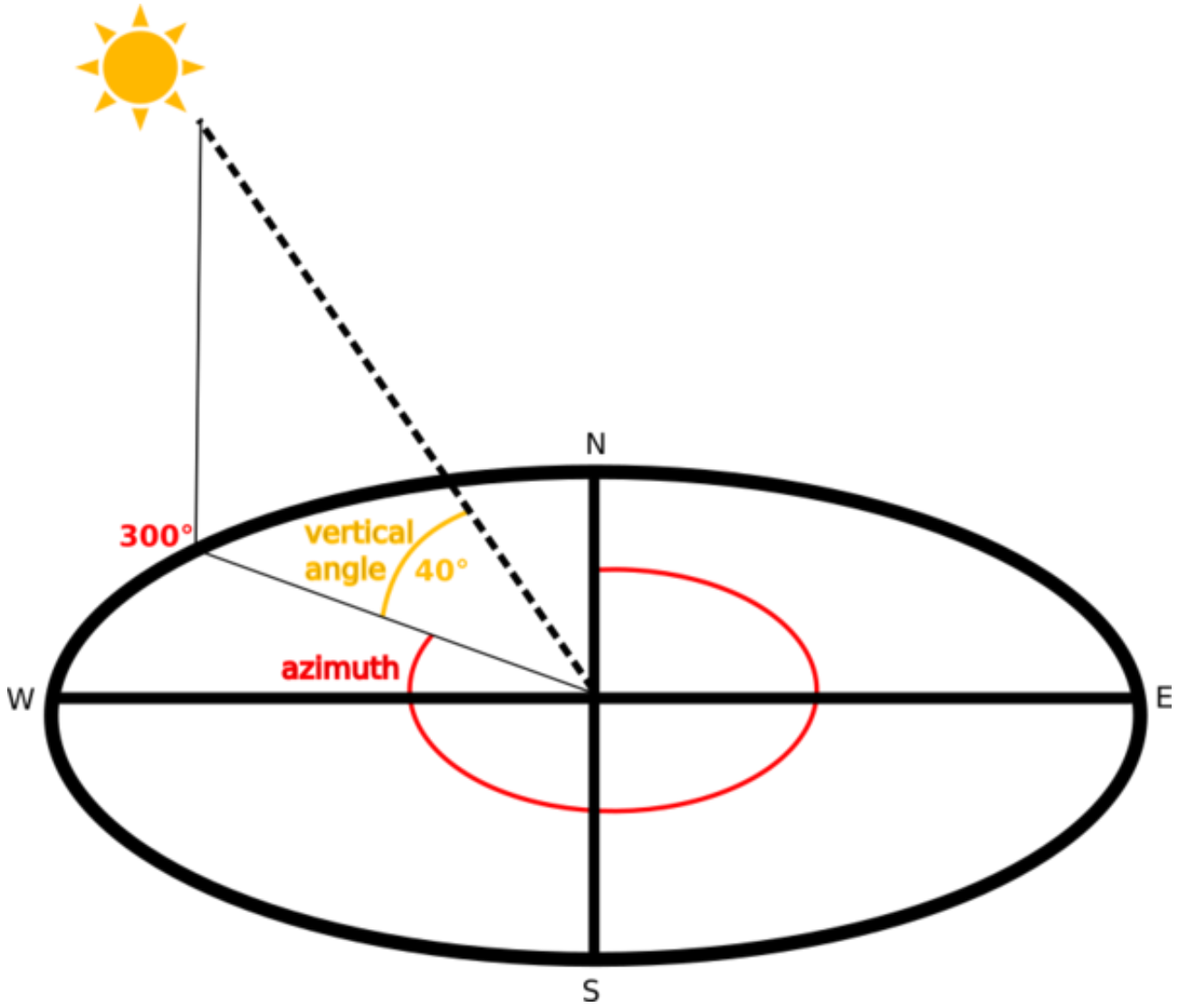
2. Inputs…

2. Altitude

The altitude is the slope or angle of the illumination source above the horizon. The units are in degrees, from 0 (on the horizon) to 90 (overhead). The default is 45 degrees.



1. Inputs…



2. Inputs…

3. The “Z” factor

- Since the Hillshade algorithm needs linear units to perform the function, it assumes that the linear unit of measurement (X,Y) is the same as the height unit of measurement (Z).
- The problem occurs when the linear units for the geographic coordinate system are different than the Z units for the DEM, like decimal degrees (which will vary across the extent of the data set depending on latitude), with a Z unit in meters or feet.
- When Z unit is different from X and Y units, the Z factor can be used to adjust.
  - If Z unit is identical to X and Y units, then the Z factor is 1 which denotes no scaling.
  - If X and Y units are in meters, whereas Z unit is feet, as 1 feet = 0.3048 meter, then Z factor is 0.3048 to convert the feet into meter.

2. Inputs…

```
(1)  Hillshade = 255.0 * ((cos(Zenith_rad) * cos(Slope_rad)) +
                 (sin(Zenith_rad) * sin(Slope_rad) * cos(Azimuth_rad - Aspect_rad)))
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(2)  Zenith_deg = 90.0 - Altitude
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(3)  Zenith_rad = Zenith_deg * pi / 180.0
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(4)  Azimuth_math = 360.0 - Azimuth + 90.0
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(6)  Azimuth_rad = Azimuth_math * pi / 180.0
```

2. Inputs…

Percent Slope = (Rise ÷ Run) × 100 = 15 ÷ 125 × 100 = 12 %

Degree of Slope = arctan (Rise ÷ Run) = 6.85 degrees

Rise: ΔZ = 15 ft

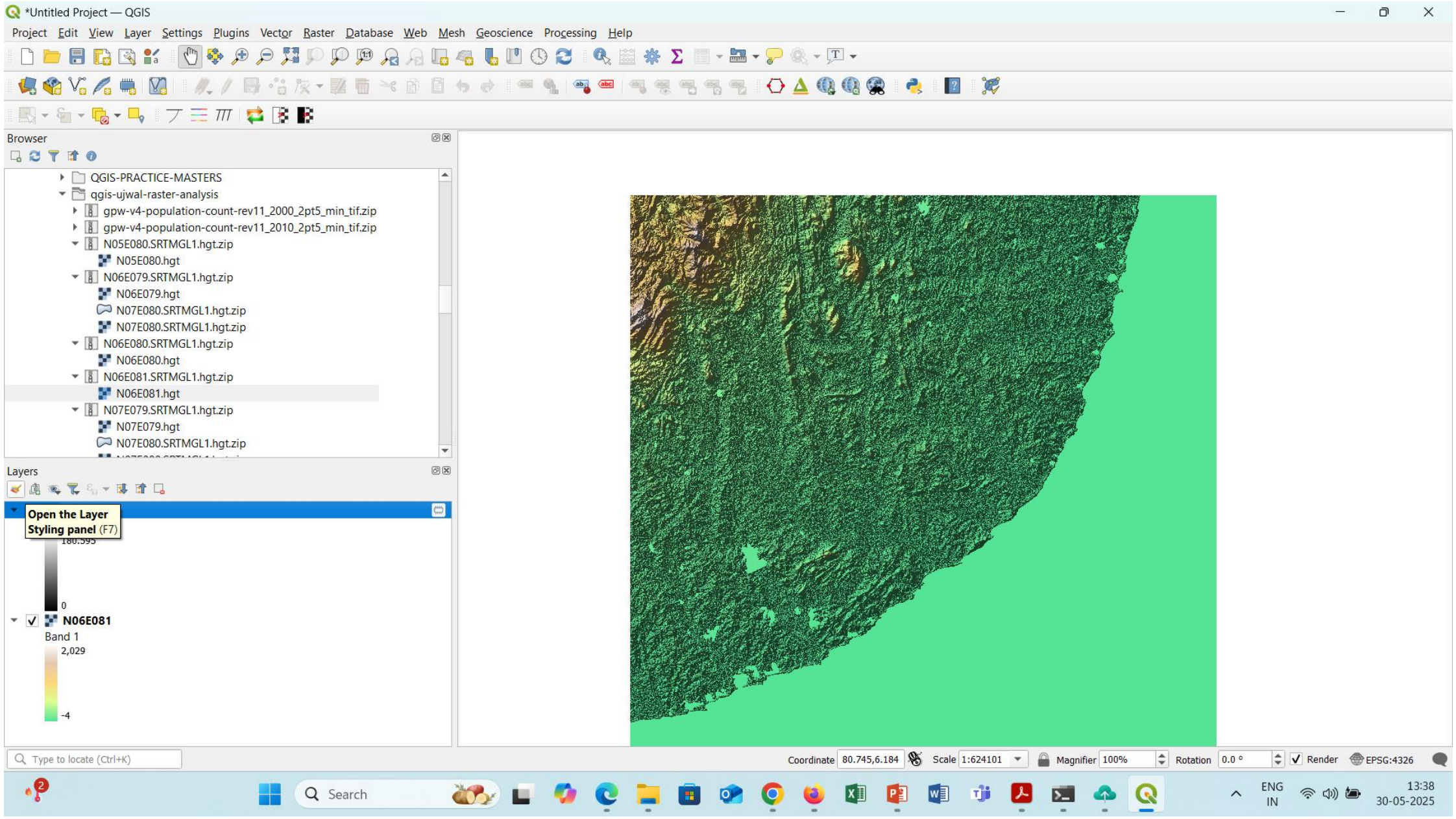
Run: ΔX = 125 ft

2. Open Source data for DEM

i. https://dwtkns.com/srtm30m/

ii. QGIS demo

Hillshade output of the south-eastern portion of Sri Lankan island



Thanks