Assessment of Spatiotemporal Changes in Vegetation Cover using NDVI in The Dangs District, Gujarat

Using SAGA GIS and Quantum GIS

Tutorial ID: IGET_CT_003

Assessment of Spatiotemporal changes in vegetation cover using NDVI in the Dangs district, Gujarat

Objective: To assess spatiotemporal changes in vegetation cover in the Dangs district, Gujarat

Software: SAGA, Quantum GIS

Level: Advanced

Time required: 3 Hours

Prerequisites and Geospatial Skills

1. SAGA and Quantum GIS should be installed on the computer and basic knowledge of it interface
2. Google Earth should be installed and Basic knowledge about the its interface
3. Should have completed all GIS and Remote sensing tutorials from the IGET portal.

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Reading

1. Interaction of EMR with earth's surface, http://www.geol-amu.org/notes/mw4-2-4.htm
2. NDVI, http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php

Data credit: Landsat data credit goes to EROS data center, USGS, Sioux Falls and the Dangs administrative boundary credit goes to GADM.

Introduction

The Dangs forest is a rich reserved forest existing in the state of Gujarat. In this tutorial we will assess the spatiotemporal changes of vegetation cover in the Dangs district of Gujarat. To accomplish this task we will use multispectral remote sensing data of Landsat 7 and 8 sensors. The advantage of using Landsat series data is, its long-term archive with medium spatial resolution with quite consistent spectral and radiometric resolution (Kantakumar, Kumar, & Schneider, 2016). Photosynthetically active vegetation absorbs red wavelength and scatters large portion of near-infrared wavelength of electromagnetic radiation falling on it. Unhealthy or dry vegetation reflects most of the red wavelength as compare to near-infrared wavelength. The Normalized Difference Vegetation Index (NDVI) is a numeric indictor that uses red and near-infrared wavelengths of electromagnetic spectrum to study the characteristics of the vegetation. It is one of the most commonly used vegetation index to measure and monitor vegetation cover. NDVI can be calculated per-pixel level using following formula.

$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}}$$

Where, ρ_{NIR} and ρ_{Red} are spectral reflectance of a pixel in near-infrared and red band respectively.

NDVI values vary from -1 to +1. Where -1 indicates no presence vegetation and +1 indicates presence dense healthy vegetation in the pixel. In remote sensing, the NDVI value of zero or less than zero represents water or bare soil. A forest with dense healthy vegetation cover might record a NDVI value above 0.6. However, the interpretation of multi-temporal NDVI values should be done with care. When our interest is to monitor the spatiotemporal changes in vegetation cover of an area over a certain period, the temporal images used in the study should pertain to same day or around the same day of the years. In this study we are using Landsat 7 and 8 images pertaining to 22-Nov-2002 and 12-Dec-2013 to assess the temporal change of vegetation cover in the Dangs district of Gujarat. The band specification of Landsat 7 and 8 are given below.

Landsat 7		
Band	Wavelength(mm)	Name
1	0.45-0.52	Blue
2	0.52-0.60	Green
3	0.63-0.69	Red
4	0.75-0.90	NIR
5	1.55-1.75	SNIR 1
6	10.4-12.5	Thermal
7	2.09-2.35	SNIR-2
8	0.52-0.9	Panchromatic

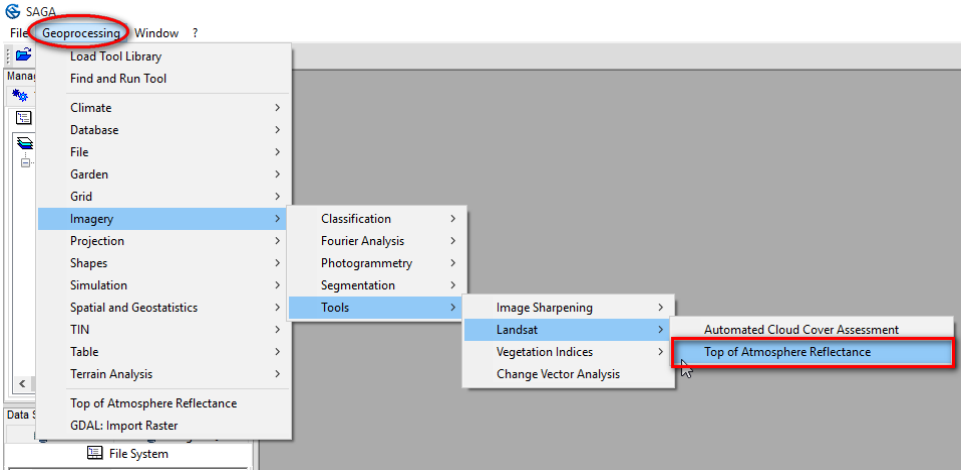
Landsat 8		
Band	Wavelength(mm)	Name
1	0.43-0.45	Coastal
2	0.45-0.51	Blue
3	0.53-0.59	Green
4	0.64-0.67	Red
5	0.85-0.88	NIR
6	1.57-1.65	SNIR 1
7	2.11-2.29	SNIR-2
8	0.50-0.68	Panchromatic
9	1.36-1.38	Cirrus
10	10.6-11.19	Thermal 1
11	11.5-12.51	Thermal 2

In order to calculate NDVI, we need to convert the Digital Number of *red* and *near-infrared* image bands to near ground spectral reflectance. However, for simplifying the tutorial we use *top of atmosphere spectral reflectance*.

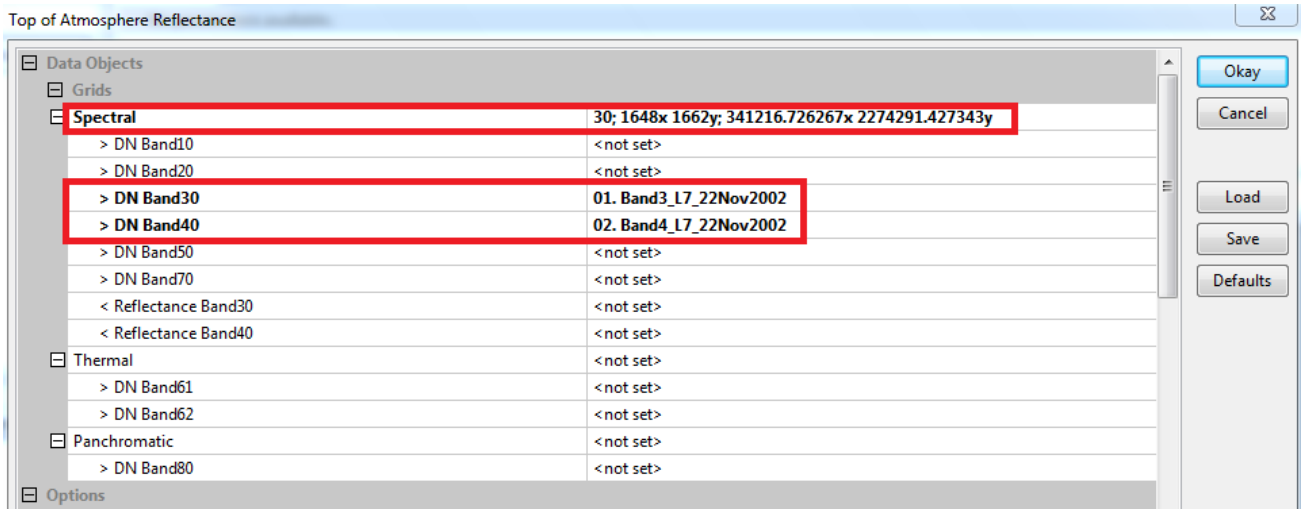
I. Landsat-7 DN to TOA Spectral reflectance

The conversion of DN number of Landsat-7 to Top of atmospheric reflectance is quite straight forward because of '*Top of Atmospheric reflectance*' module in SAGA GIS.

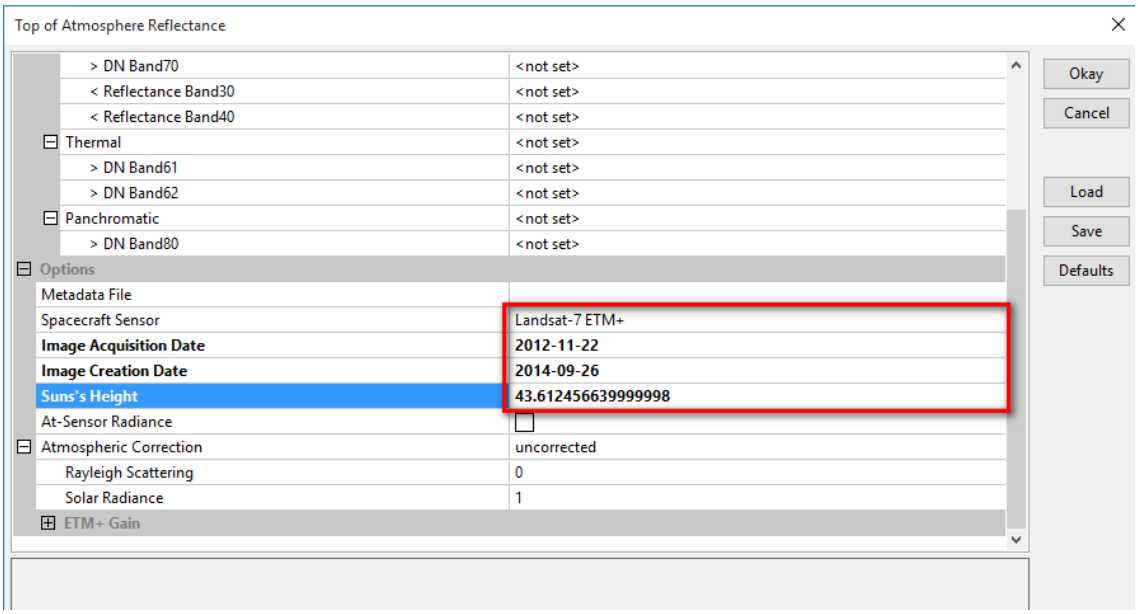
1. Open SAGA GIS and load '***Band3_L7_22Nov2002.TIF***' (red band) and '***Band4_L7_22Nov2002.TIF***' (NIR band) via, '*Geoprocessing → File → GDAL/OGR → GDAL: Import raster*'.
2. Open *Top of Atmospheric (TOA) reflectance* module via, '*Geoprocessing → Imagery → Tools → Landsat → Top of Atmospheric reflectance*'.



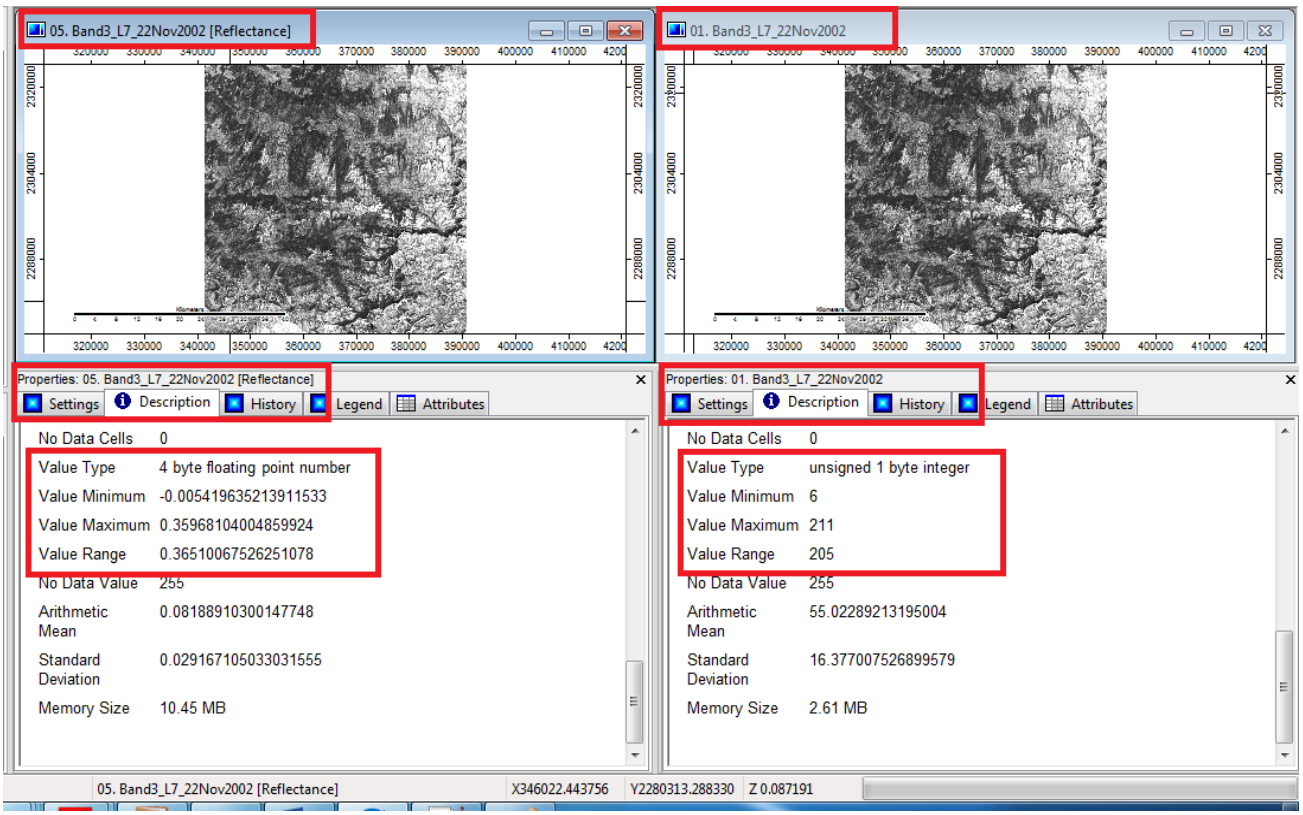
3. In the popup window, we will fill in the details to get reflectance for band 3 and 4 of Landsat-7 as shown in below snapshot.



4. Fill the other necessary details i.e, '*Spacecraft sensor, image acquisition date, Image creation date and sun's height*' as shown in below snapshot. You can find these details in the metadata file supplied to you. Click on '***Okay***'.



5. Open band 3 and band 4 of Landsat-7 before and after conversion to spectral reflectance in the *map viewer* with *grey color ramp* and explore the '*Description*' section in '*Properties*' window. The following figure showing the statistics of pixel values after and before conversion to TOA spectral reflectance.



II. Landsat-8 DN to TOA Spectral Reflectance

Since there is no Landsat-8 sensor specific algorithm exist in *Top of Atmospheric reflectance* module in SAGA GIS. We will convert the DNs of pixels in *Red* and *NIR* bands of Landsat-8 to *Top of Atmospheric spectral reflectance* manually. To accomplish this task we will use Raster calculator in SAGA GIS and Landsat-8 specific formulas. These formulas can be found at USGS Landsat-8 product website.

6. Load '***Band4_L8_12Dec2013.TIF***' (red band) and '***Band5_L8_12Dec2013.TIF***' (NIR band) into SAGA GIS.
7. First we will convert the DN values of red band i.e., '***Band4_L8_12Dec2013.TIF***' to '*Top of Atmosphere planetary reflectance without correction of sun angle*' by using following formula.

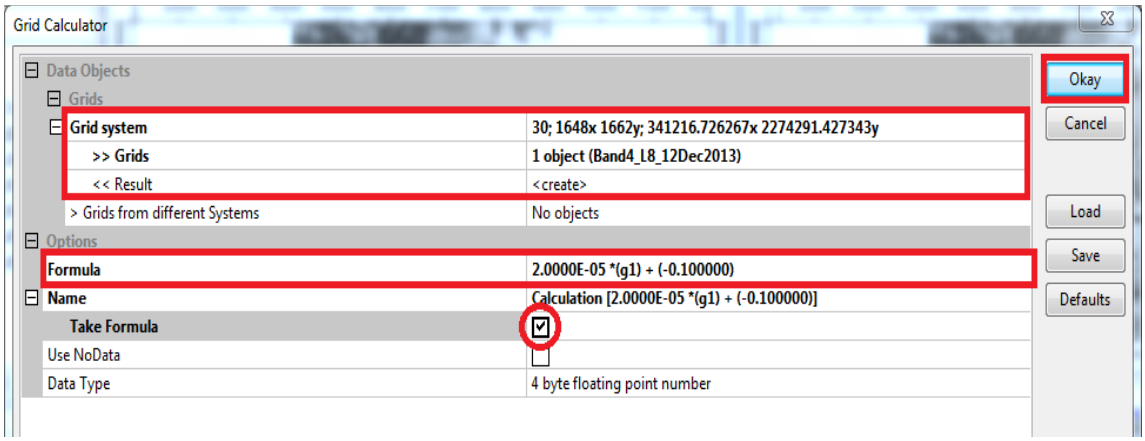
$$\rho\lambda' = M_p Q_{cal} + A_p$$

Where, $\rho\lambda'$ = TOA planetary reflectance, without correction for sun angle
M_p = Band-Specific Multiplicative rescaling factor from metadata
Q_{cal} = Quantized and calibrated standard product pixel value DN
A_p = Band-Specific additive rescaling factor from metadata

The values of M_p and A_p for band 4 and band 5 for our study area is extracted from the metadata and are presented in the following table.

	Band 4	Band 5
M_p	2.0000E-05	-0.100000
A_p	2.0000E-05	-0.100000

8. Now we will use grid calculator '*Geoprocessing → Grid → Calculus → Grid Calculator*' to compute *Top of Atmosphere planetary reflectance without correction of sun angle* ($\rho\lambda'$)
9. In the *Grid calculator* window input the details of '***Band4_L8_12Dec2013.TIF***' as shown below snapshot. Make sure to keep '*Results*' as '***<create>***'. Write '***2.0000E-05 *(g1) + (-0.100000)***' in '*Formula*' and ensure that '*Take Formula*' is checked in and Click '***Okay***'.



10. After successful execution of *grid calculator* module, you can see '***Calculation [2.0000E-05 *(g1) + (-0.100000)]***' grid under *Data Tree* tab of '*Manager*'. Rename it as '***Band4_L8_12Dec2013 [UC Reflectance]***' using '*Properties*' window.
11. Similarly compute *Top of Atmosphere planetary reflectance without correction of sun angle* ($\rho\lambda'$) for '***Band5_L8_12Dec2013*** and rename it as '***Band5_L8_12Dec2013 [UC Reflectance]***'.

12. *Top of Atmosphere reflectance* with correction for the sun angle can be calculated by using below formula.

$$\rho\lambda = \frac{\rho\lambda\prime}{\cos(\theta sZ)} = \frac{\rho\lambda\prime}{\sin(\theta sE)}$$

Where,

$\rho\lambda'$ = TOA planetary reflectance
θsZ= Local Solar Zenith Angle
θsE= Local Sun Elevation angle from Metadata
$\theta sZ = 90^{\circ} - \theta sE$

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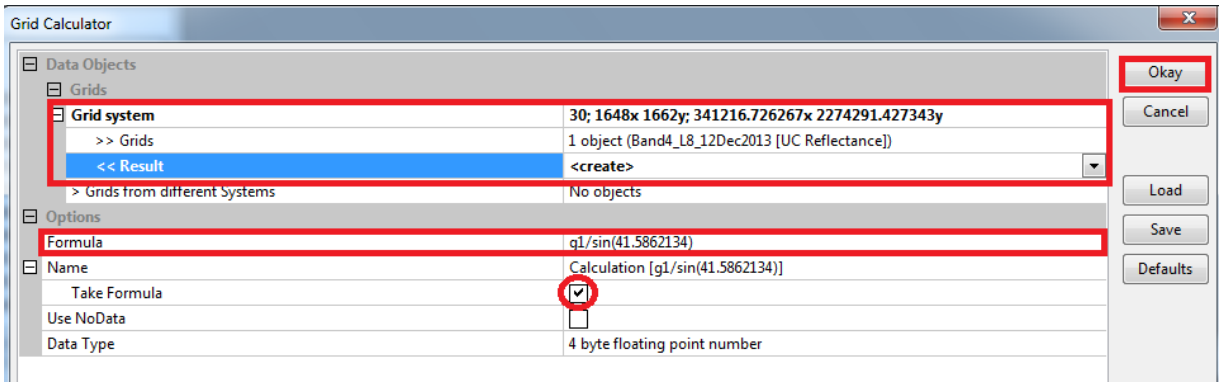
13. Open *Grid calculator,* select '*Grid system*' and '*Grid*' of '***Band4_L8_12Dec2013 [UC Reflectance]***'. Make sure to keep '*Results*' as '***<create>***'. Write '***g1/sin(41.5862134)***' in '*Formula*' and ensure that '*Take Formula*' is checked in and Click '***Okay***'.

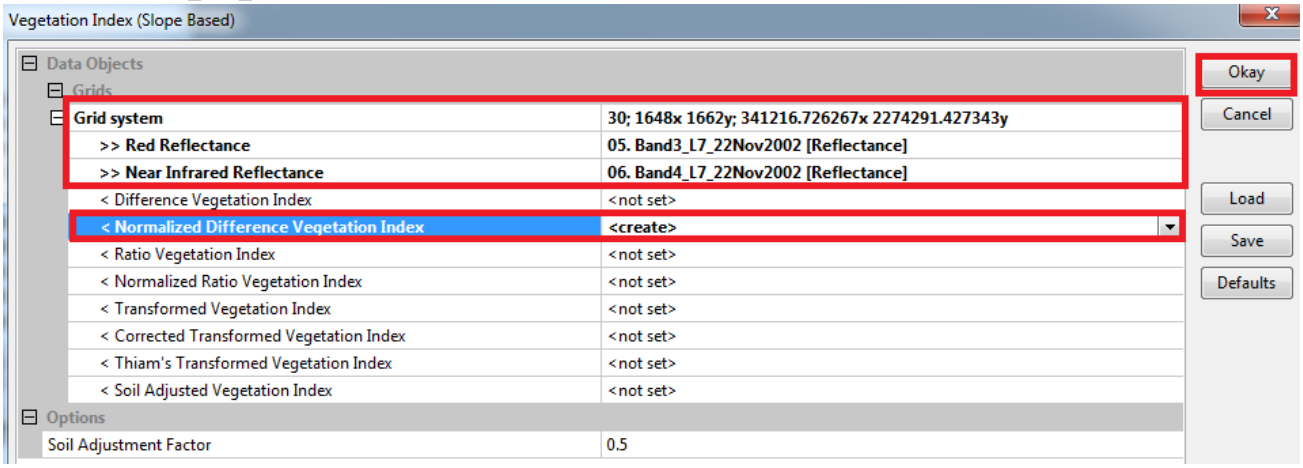


14. Rename the '***Calculation [g1/sin(41.5862134)]***' file to '***Band4_L8_12Dec2013 [Reflectance]***'.
15. Similarly repeat the steps 13 and 14 to create *Top of Atmosphere reflectance* image of NIR band of Landsat-8 with name '***Band5_L8_12Dec2013 [Reflectance]***'.

III. NDVI calculation

In this section we will compute the NDVI of the study area using the TOA spectral reflectance bands created in above sections and *Vegetation Index (Slope based)* module in SAGA GIS.

16. Open *Vegetation Index (Slope based)* module via., '*Geoprocessing → Imagery → Tools → Vegetation Indices → Vegetation Index (Slope based)*'
17. Now input the Landsat-7 TOA reflectance bands as shown below snapshot and select '***<Create>***' infront of '*Normalized Difference Vegetation Index*' to create NDVI of Landsat-7 pertain to 22-Nov-2002**.** Rename the NDVI output to '***NDVI_L7_22NOV2002***'.

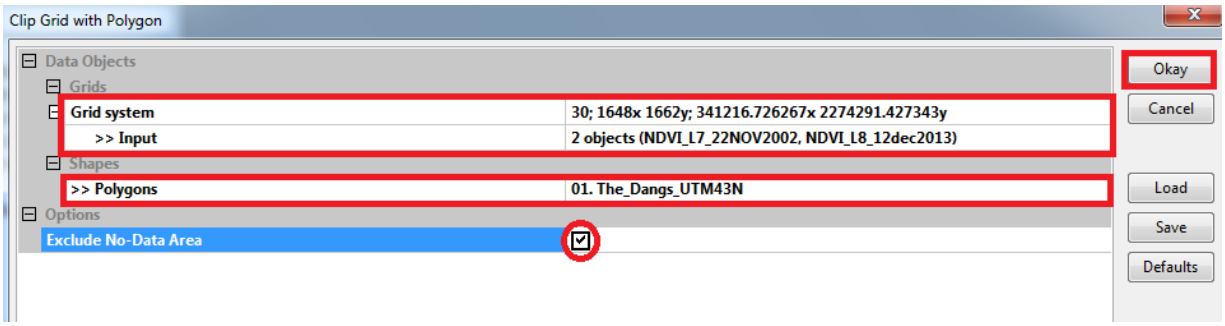


18. Similarly calculate NDVI image of Landsat-8 pertain to 12-Dec-2013 and rename NDVI image to '***NDVI_L8_12dec2013***'.

IV. Clipping of NDVI images

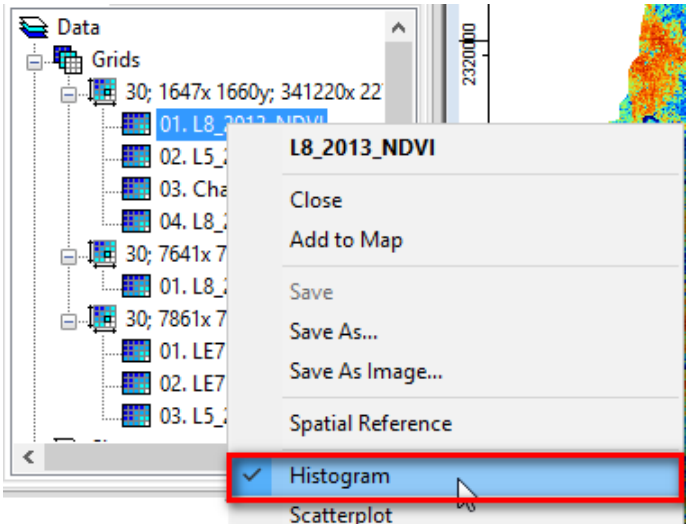
In this section we will clip the NDVI images to the study area using the administrative boundary of the Dangs district.

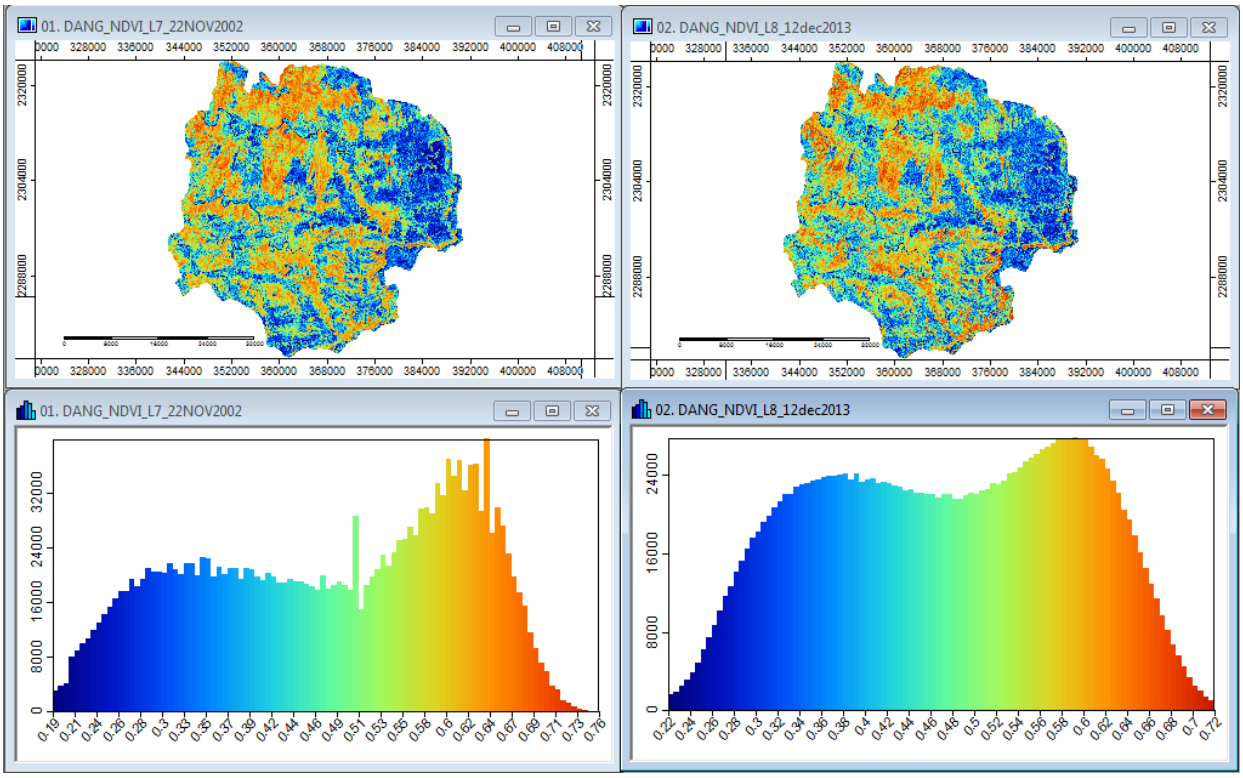
19. Import the boundary shape file of the Dangs district i.e, '***The_Dangs_UTM43N.shp***' via, '*Geoprocessing → File → GDAL/OGR → OGR : Import Vector Data*'.
20. Open '*Clip grids with polygon*' tool via, '*Geoprocessing → Shapes → Grid → Spatial Extent → Clip grids with polygon*.
21. In the popup window, select the '*grid system*' of NDVI images under '*Grids*' select both the NDVI images i.e., '***NDVI_L7_22NOV2002*** and ***NDVI_L8_12dec2013***. Select '***The_Dangs_UTM43N'*** as input polygon and make sure to *check* '***Exclude No-Data Area***' and Click '***Okay***'.



22. Rename the clipped NDVI images of 2002 and 2013 to '***DANG_NDVI_L7_22NOV2002***' and '***DANG_NDVI_L8_12dec2013***'.

23. Open both clipped NDVI images side by side for comparison. You can change the colour ramp if required for better understanding. Check the Histogram for both NDVI images to ensure that the calculated NDVI values are within [-1 to +1] range. To compute Histogram *right click* on the layer of interest and click on '***Histogram***'.





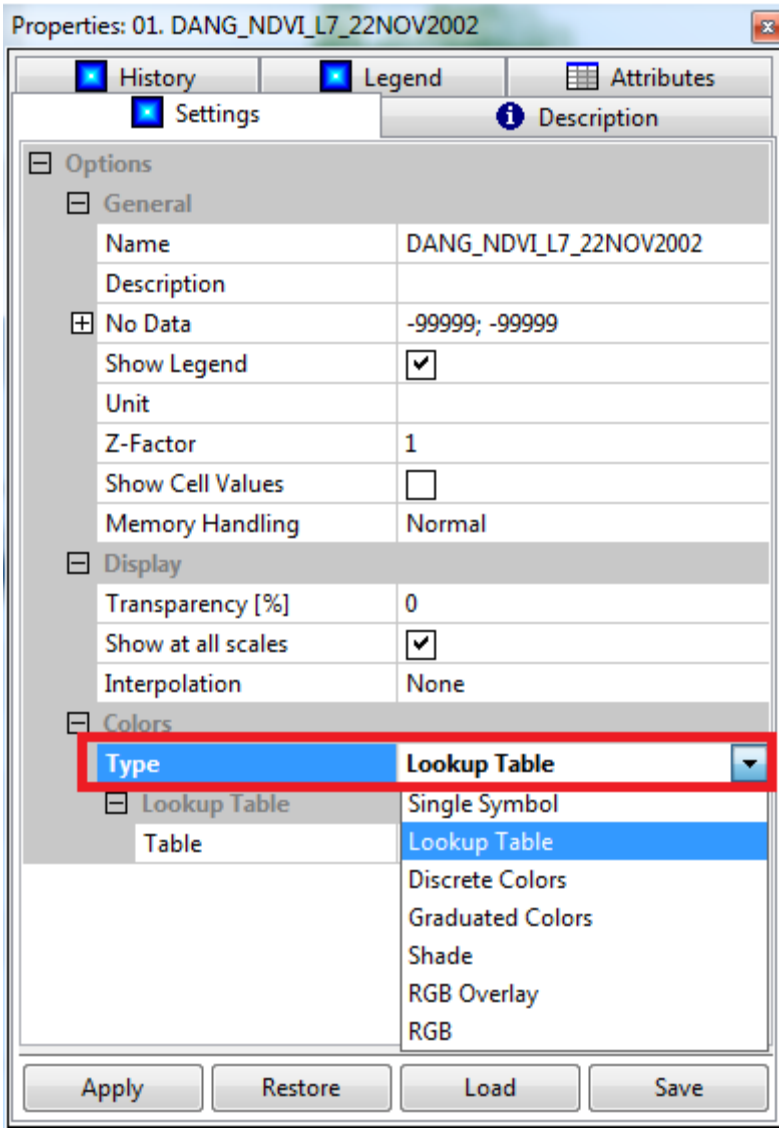
V. Spatiotemporal change detection

Inorder to quantify the spatiotemporal changes in vegetation cover in the Dangs district, we will classify both NDVI images of 2002 and 2013 into four similar classes and then will carry out change detection. To classify both the images we will edit the look up table of the images.

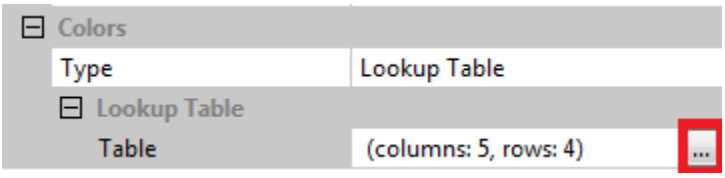
Class range	New Values
>0.2	1
0.2-0.4	2
0.4-0.6	3
0.6-1.0	4

Note: This classification is mainly done based on site specific requirements and purpose of the study. Here we used a simplest classification scheme.

24. Goto the '***Properties window***' of '*DANG_NDVI_L7_22NOV2002*' image, In '**Settings**' tab Select '***Lookup table***' option using drop down menu in '***colors***' section under '***Type***'.

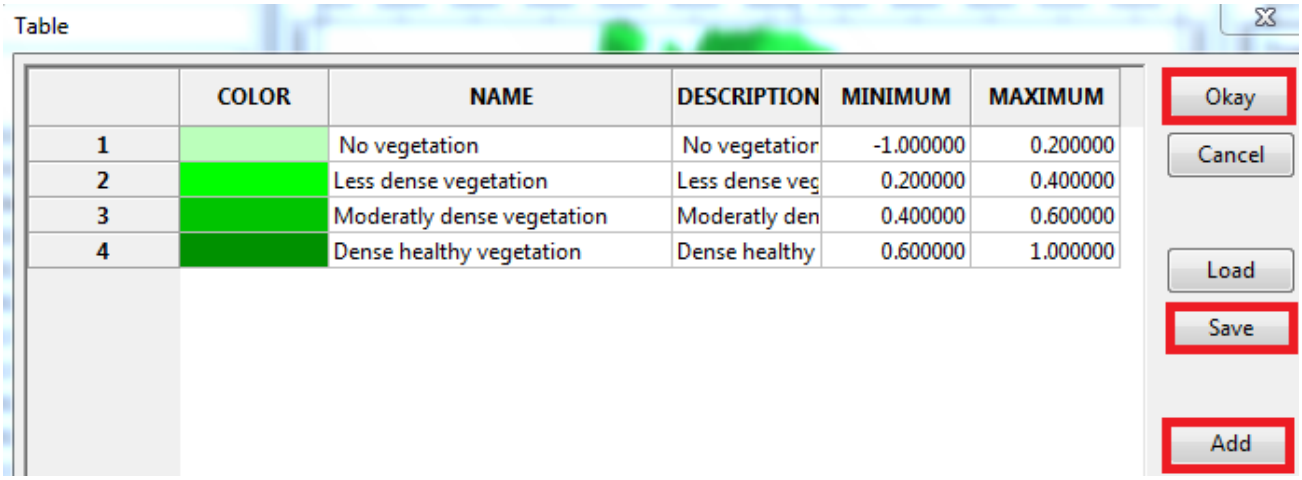


25. To create a lookup table. Click on the ... tab infront of '***Table***' under '*Lookup Table*' section.

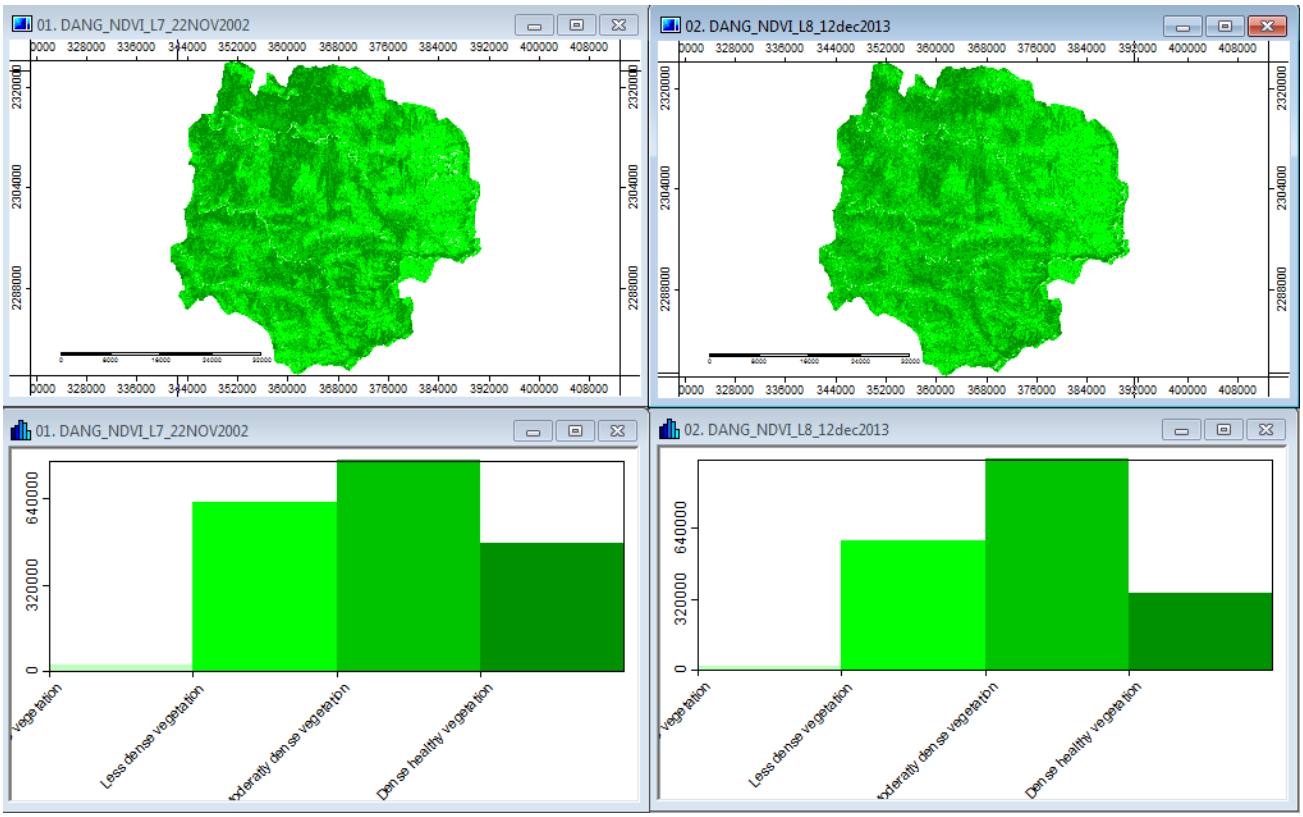


26. In the popup window of '*Table*'. Add two more rows to the existing table to make it with four rows using ***Add*** button Add on the right strip of the window. Now we will add the values with appropriate color scheme and description as given in the screen shot below.

27. '***Save***' the lookup table in an appropriate folder to use for classifying the NDVI image of 2013. Once settings done as shown in below snapshot click '***Okay***'.

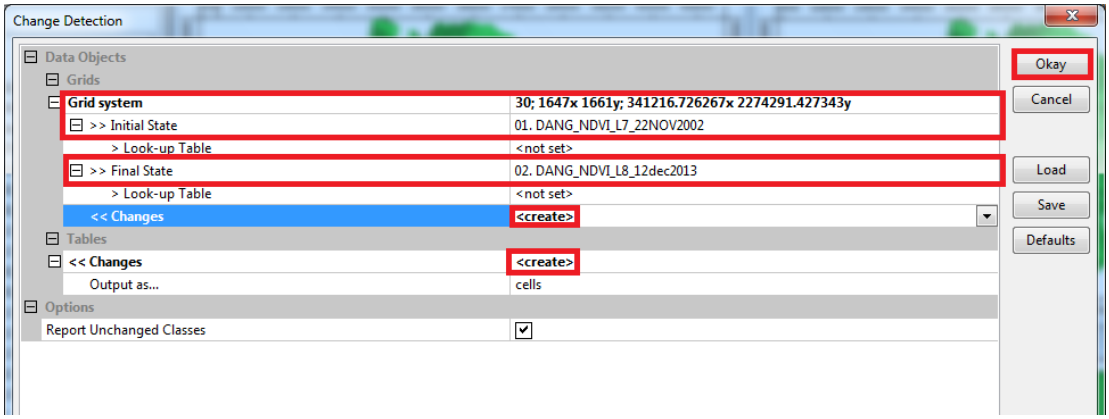


28. After click *Okay* will be redirected to the main window of *Properties*. Click '***Apply***' for setting to be saved for corresponding image.
29. Repeat the similar procedure for '*DANG_NDVI_L8_12DEC2013*' image. Here you can directly load the saved lookup table in *step 27*.
30. Open both the classified NDVI images of 2001 and 2013 along with their corresponding histogram.

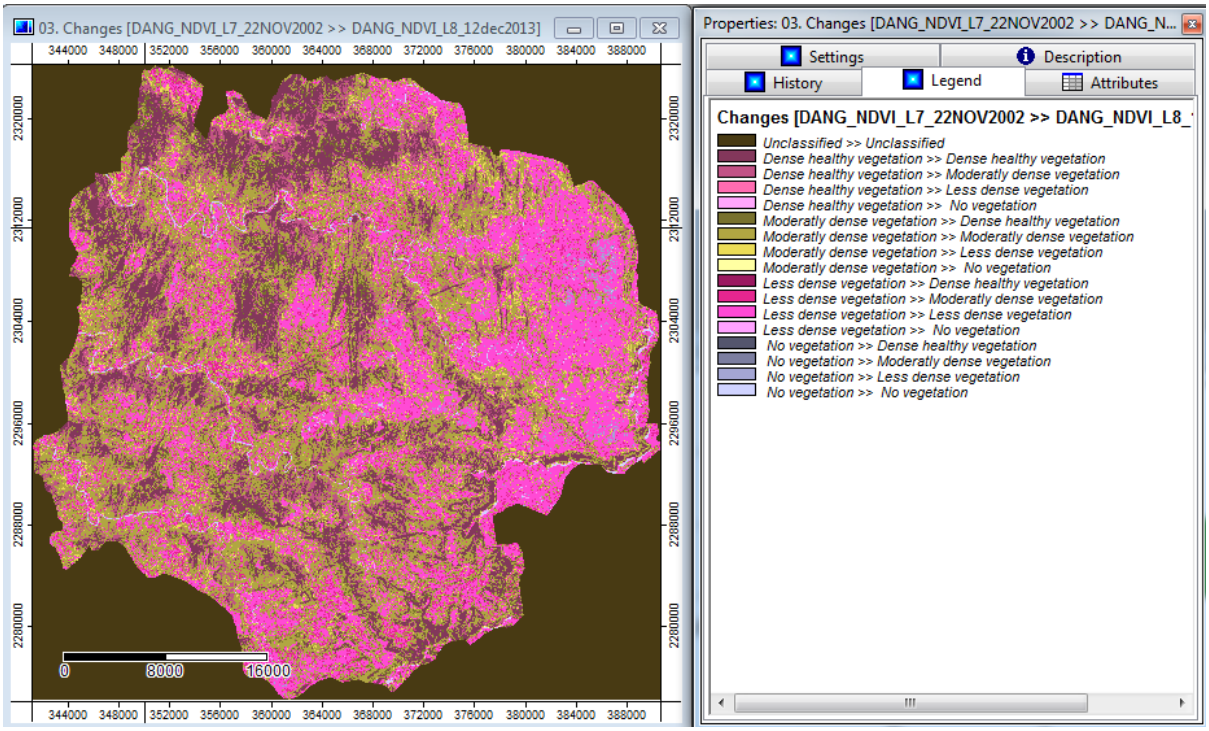


31. The changes can be clearly seen through the histogram itself. To quantify the transitions took place, we will perform change detection analysis via., *'Geoprocessing → Imagery → Classification → Change detection'*.

    In popup window of *change detection*, select the *'Grid system'* of the NDVI images of the Dangs district. *'DANG_NDVI_L7_22NOV2002'* image as *Initial state* and *'DANG_NDVI_L8_12DEC2013'* image as *Final State*. Ensure that the *'Changes'* is set to ***'<create>'.*** Once everything is done as shown in below snapshot, click ***'Okay'***.



32. Open the newly created change detection image along with the legend. It shows the spatiotemporal changes in vegetation cover in the Dangs district of Gujarat.



33. Refer *'IGET_RS_012: Change Detection'* tutorial from the IGET portal for information more analyzing tools and options.