



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

Using SAGA GIS and Quantum GIS



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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

- Interaction of EMR with earth's surface, <u>http://www.geol-amu.org/notes/mw4-2-4.htm</u>
 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 =	$\rho_{NIR} - \rho_{Red}$	Where,	$ ho_{\scriptscriptstyle NIR}$	and	$ ho_{Red}$	are	spec	ctral
	$ \rho_{NIR} + \rho_{Red} $	reflectan	ce of a	a pixel	in ne	ar-infra	ared	and
		red band	respec	ctively.				

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 changes of vegetation cover in the Dangs district of Gujarat. The band specification of Landsat 7 and 8 are given below.

Landsat 7						
Ban d	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 \rightarrow File \rightarrow GDAL/OGR \rightarrow GDAL: Import raster'.
- 2. Open Top of Atmospheric (TOA) reflectance module via, 'Geoprocessing \rightarrow Imagery \rightarrow Tools \rightarrow Landsat \rightarrow Top of Atmospheric reflectance'.

SAC	A						
File	Geoprocessing Window ?						
1 📂 🛛	Load Tool Library	- 1					
Mana	Find and Run Tool	1					
***	Climate	>					
	Database	>					
	File	>					
	Garden	->					
	Grid	\rightarrow					
	Imagery	>	Classification	>			
	Projection	>	Fourier Analysis	>			
	Shapes	>	Photogrammetry	>			
	Simulation	>	Segmentation	>			
	Spatial and Geostatistics	>	Tools	>	Image Sharpening	>	
	TIN	>			Landsat	>	Automated Cloud Cover Assessment
	Table	>			Vegetation Indices	>	Top of Atmosphere Reflectance
<	Terrain Analysis	>			Change Vector Analysis	_	W
Data	Top of Atmosphere Reflectance						
Duite	GDAL: Import Raster						
	🛄 File System						

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.

Top of Atmosphere Reflectance			23
 Data Objects Grids 			Okay
E Spectral	30; 1648x 1662y; 341216.726267x 2274291.427343y		Cancel
> DN Band10	<not set=""></not>		
> DN Band20	<not set=""></not>	_	
> DN Band30	01. Band3_L7_22Nov2002	=	Load
> DN Band40	02. Band4_L7_22Nov2002		
> DN Band50	<not set=""></not>		Jave
> DN Band70	<not set=""></not>		Defaults
< Reflectance Band30	<not set=""></not>		
< Reflectance Band40	<not set=""></not>		
Thermal	<not set=""></not>		
> DN Band61	<not set=""></not>		
> DN Band62	<not set=""></not>		
Panchromatic	<not set=""></not>		
> DN Band80	<not set=""></not>		
Options			

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**'.



> DN Rand70	< not cots	\$	
 Div Band 70 Constant on Decid 20 		^	Okay
< Reflectance Band30	< not set>		Cance
< Reflectance Band40	< not set>		Carree
DN Rand61	<not set=""></not>		
> DN Band62	< not set>		Load
	<not set=""></not>		2000
> DN Band80	<not set=""></not>		Save
Options			Defau
Metadata File			
Spacecraft Sensor	Landsat-7 ETM+		
Image Acquisition Date	2012-11-22		
Image Creation Date	2014-09-26		
Suns's Height	43.612456639999998		
At-Sensor Radiance			
Atmospheric Correction	uncorrected		
Rayleigh Scattering	0		
Solar Radiance	1		

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.

0000002 22000 33000 34000 35000 3000 000002 000002 000002 000002 000002 000002 000002 000002 000002 000002 000002 000002 000002 000002 00000 00000 000000		200 420 420 420 420	01000222 000000000000000000000000000000000000	200 4200 4200
Properties: 05. Band3_L7_22Nov2002 [Reflectance Settings ① Description I History	I Legend 🖽 Attributes	×	Properties: 01. Band3_L7_22Nov2002 Settings Description History Legend History Attributes	×
No Data Cells 0 Value Type 4 byte floating point n Value Minimum -0.0054196352139115 Value Maximum 0.35968104004859924 Value Range 0.36510067526251076 No Data Value 255 Arithmetic 0.08188910300147746 Mean 0.02916710503303156 Deviation Memory Size Memory Size 10.45 MB	umber 33 4 3	E	No Data Cells 0 Value Type unsigned 1 byte integer Value Minimum 6 Value Maximum 211 Value Range 205 No Data Value 255 Arithmetic 55.02289213195004 Mean 16.377007526899579 Deviation Memory Size 2.61 MB	A H
05. Band3_L7_22Nov2002 [Reflecta	ince] X346022.4437	756 Y228	Y2280313.288330 Z 0.087191	



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 \rightarrow Grid \rightarrow Calculus \rightarrow 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'.



Calculator	1 N N	×
Data Objects		Okay
E Grid system	30; 1648x 1662y; 341216.726267x 2274291.427343y	Cancel
>> Grids	1 object (Band4_L8_12Dec2013)	
<< Result	<create></create>	
> Grids from different Systems	No objects	Load
Options		Save
Formula	2.0000E-05 *(g1) + (-0.100000)	Jave
Name	Calculation [2.0000E-05 *(g1) + (-0.100000)]	Defaults
Take Formula		
Use NoData		
Data Type	4 byte floating point number	

- 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.

$$\rho\lambda = \frac{\rho\lambda'}{\cos\left(\theta s Z\right)} = \frac{\rho\lambda'}{\sin(\theta s E)}$$

Where,

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

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'.

Grid Calculator		— X
Data Objects Grids		Okay
Grid system >> Grids	30; 1648x 1662y; 341216.726267x 2274291.427343y 1 object (Band4_L8_12Dec2013 [UC Reflectance])	Cancel
<< Result	<create></create>	▼ Load
Options	in open	Save
Formula Name	q1/sin(41.5862134) Calculation [g1/sin(41.5862134)]	Defaults
Take Formula Use NoData		
Data Type	4 byte floating point number	



- 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 \rightarrow Imagery \rightarrow Tools \rightarrow Vegetation Indices \rightarrow 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*'.

Vegetation Index (Slope Based)		×			
Data Objects Grids		Okay			
E Grid system 30; 1648x 1662y; 341216.726267x 2274291.427343y					
>> Red Reflectance	05. Band3_L7_22Nov2002 [Reflectance]				
>> Near Infrared Reflectance	06. Band4_L7_22Nov2002 [Reflectance]				
< Difference Vegetation Index	<not set=""></not>	Load			
< Normalized Difference Vegetation Index	<create></create>	Cauca			
< Ratio Vegetation Index	<not set=""></not>	Save			
< Normalized Ratio Vegetation Index	<not set=""></not>	Defaults			
< Transformed Vegetation Index	<not set=""></not>				
< Corrected Transformed Vegetation Index	<not set=""></not>				
< Thiam's Transformed Vegetation Index	<not set=""></not>				
< Soil Adjusted Vegetation Index	<not set=""></not>				
Options					
Soil Adjustment Factor	0.5				

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 \rightarrow File \rightarrow GDAL/OGR \rightarrow OGR : Import Vector Data'.
- 20. Open 'Clip grids with polygon' tool via, 'Geoprocessing \rightarrow Shapes \rightarrow Grid \rightarrow Spatial Extent \rightarrow 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'.



Clip Grid with Polygon		×
Data Objects		Okay
E Grid system >> Input	30; 1648x 1662y; 341216.726267x 2274291.427343y 2 objects (NDVI_L7_22NOV2002, NDVI_L8_12dec2013)	Cancel
Shapes >> Polygons	01. The_Dangs_UTM43N	Load
Options Exclude No-Data Area		Save Defaults

- 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	New
range	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**'.



Properties: 01. DANG_NDVI_L7_22NOV2002						
📕 History 📃 Leg		gend 🔛 Attributes		Attributes		
	💌 Set	tings		Des	cription	
⊡ Ор	tions					
Ξ	General					
	Name		DANG_N	DVI_L7_	22NOV2002	
	Descriptio	n				
Ŧ	No Data		-99999; -9	99999		
	Show Leg	end	✓			
	Unit					
	Z-Factor		1			
	Show Cell Values					
	Memory H	landling	Normal	Normal		
Ξ	Display					
	Transparency [%]		0			
Show at		l scales	✓			
	Interpolation		None			
	Colors					
Туре			Lookup T	able	-	
	Looku	p Table	Single Sy	mbol		
Table		Lookup T	Lookup Table			
		Discrete (Discrete Colors			
		Graduate	d Coloi	s		
		Shade				
		RGB Over	rlay			
		RGB				
A	pply	Restore	Loa	d	Save	

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

\square	Colors		
	Туре	Lookup Table	
	Lookup Table		
	Table	(columns: 5, rows: 4)	

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.



'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'.

COLO				
	R NAME	DESCRIPTION	MINIMUM	MAXIMUM
1	No vegetation	No vegetation	-1.000000	0.200000
2	Less dense vegetation	Less dense veg	0.200000	0.400000
3	Moderatly dense vegetation	Moderatly den	0.400000	0.600000
4	Dense healthy vegetation	Dence healthy	0.00000	

- 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 \rightarrow Imagery \rightarrow Classification \rightarrow 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**'.

Change	Detection		x
🖻 Da	ta Objects		Okay
	Grids		
E	Grid system	30; 1647x 1661y; 341216.726267x 2274291.427343y	Cancel
	>> Initial State	01. DANG_NDVI_L7_22NOV2002	
	> Look-up Table	<not set=""></not>	I
	□ >> Final State	02. DANG_NDVI_L8_12dec2013	Load
	> Look-up Table	<not set=""></not>	
	<< Changes	<create></create>	Jave
Ξ	Tables		Defaults
	<< Changes	<create></create>	
	Output as	cells	
🖂 Ор	tions		
Re	port Unchanged Classes		

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.

