Change Detection

Using SAGA

Tutorial ID: IGET_RS_012

content and to continue to offer high quality geospatial educational resources. For suggestions and feedback please visit www.iget.in.

Change Detection using SAGA

Objective: To detect and analyze the changes in land use and land cover of a region using post classified images from different time periods.

Software: SAGA

Level: Intermediate

Time required: 4 Hours

Prerequisites and Geospatial Skills:

1. SAGA should be installed on the computer.
2. Student must have completed exercise IGET_GIS_001, IGET_RS_007 and IGET_RS_008.
3. Familiarity with basic operations in SAGA is preferable.

Reading:

1. Campbell, J. B., & Wynne, R. H. (2011). Chapter 16: Change Detection (pp. 445 - 464), *Introduction to Remote Sensing, Fifth Edition*. Guilford Press.

Tutorial Data: This tutorial requires two classified images. You can download the data from the following link:

Link

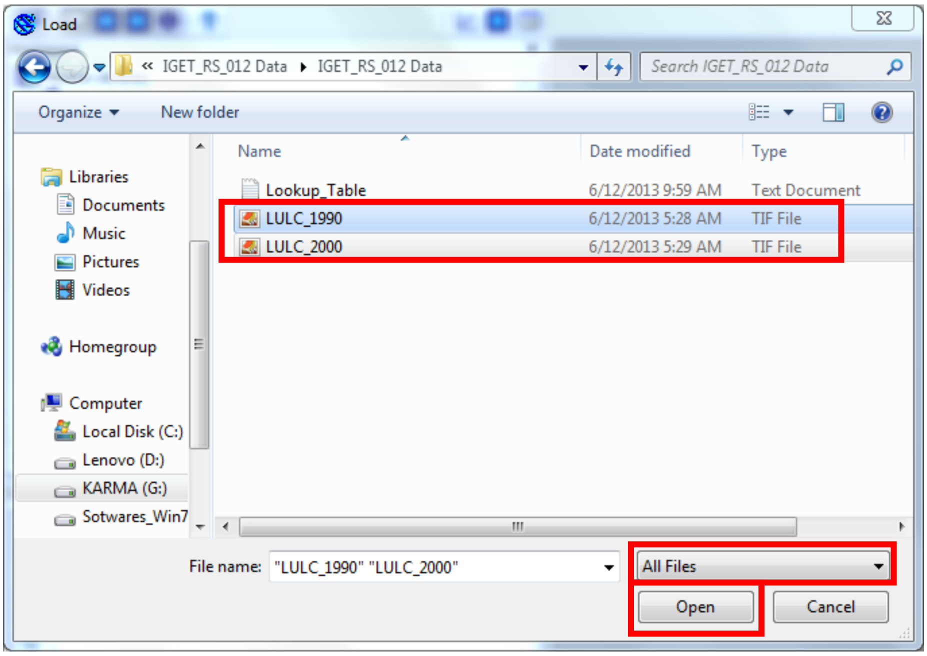
Data Reference: Wagner, P. D., Kumar, S., & Schneider, K. (2013). An assessment of land use change impacts on the water resources of the Mula and Mutha Rivers catchment upstream of Pune, India. *Hydrology and Earth System Sciences Discussions*, *10*(2), 1943-1985. doi:10.5194/hessd-10-1943-2013

Introduction

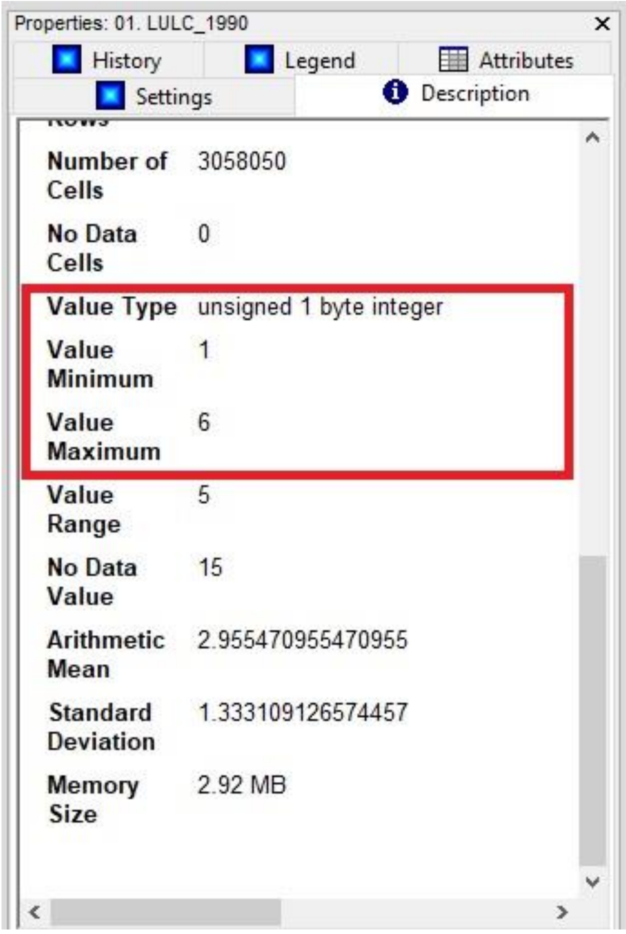
Change detection enables us to assess the gains and losses among various types of land use and land cover in a region over a period of time. Remote sensing data is widely used for change detection due its high temporal resolution, wide coverage and cost effectiveness over field surveys/inventories. Change detection can be used as diagnostic tool to understand the impact of anthropological effects on natural resources, which might further help us to prepare a sustainable planning measure to protect our environment. Change detection techniques are mainly of two types. The first one is *spectral change detection*, in this technique the unit of analysis is a pixel, a neighborhood, a multi temporal segment or a spectral class (Campbell & Wynne, 2011). One would require accurate radiometric, atmospheric and geometric corrections to be carried out before performing the spectral change detection. The second technique is *post-classification change detection*. It uses thematic maps (classified images) as inputs. It is a relatively easy and less accurate method compared to spectral change detection. In this tutorial we will learn how to perform *post-classification change detection* in SAGA.

In the tutorials 7 to 9 of IGET_RS series, we learnt how to create thematic maps from satellite images using different image classification techniques and how to assess their accuracy. These images serve as excellent visual guides to understanding the spatial distribution of the land use and land cover of a region. Furthermore, they can be used to calculate the actual spatial extent of different land classes at that point in time. However, a single land-use map may not be enough to identify areas where change is taking place. To see what changes have taken place to the landscape, it becomes necessary to have at least two land cover maps of a region at two points in time. Therefore, the procedure of '*Change Detection*' utilizes two or more such thematic images belong to different periods to track the changes that have taken place in the study region over the length of that period. This allows us to assess which land classes are gained, losses and remained the same over the period of time.

1. Import the thematic images in SAGA via the  ***Load*** button. Navigate to the folder containing the tutorial data and change the file type to '*All Files*'. Select the tiff files named '***LULC_1990***' and '***LULC_2000***', and click '*Open*'.



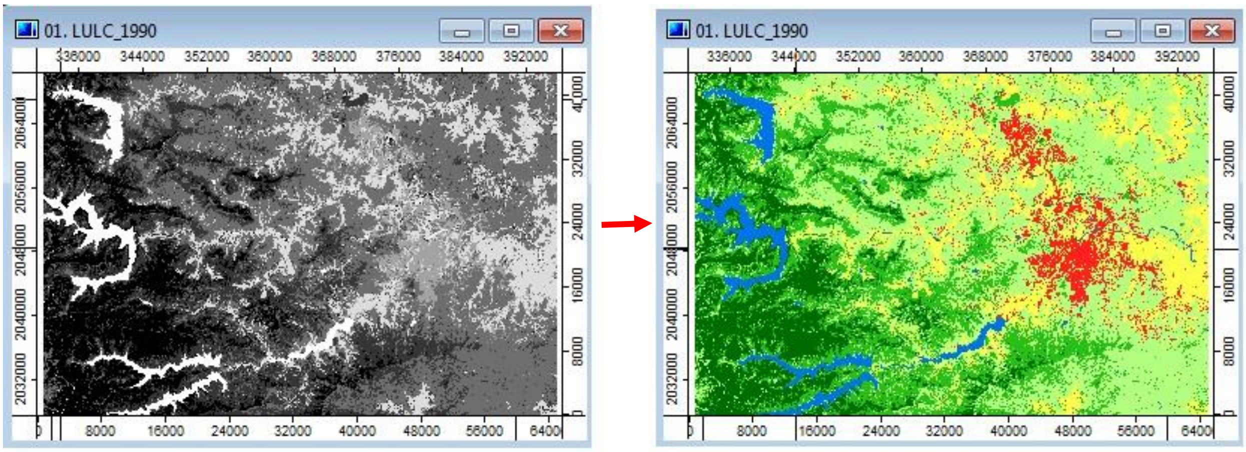
2. Select the image *'LULC_1990'* in the list under Data tab section, and click on the Description tab on the right. This displays the metadata of the image file. You will see that the *'Value Type'* is *'unsigned 1 byte integer'* and the values range from 1 to 6, this means that there are 6 land classes in this image.



3. Double click on the images to open them. They will appear in shades of grey. This is because the class numbers are being treated as pixel DN values. However that is not the case as this is a thematic image and each number represents a unique land class. We will use the lookup table that accompanies the .tif images to designate the appropriate class names.

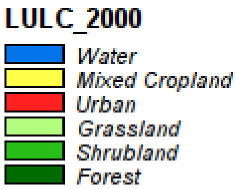
4. Click the Settings tab and change the 'Colors' type from '***Graduated Color***' to '***Classified***'. Select the '*Table*' field and click on the ... button.

5. In the table window that appears, click on the **'Load'** button and open the file **'Lookup_Table.txt'**. The colours and class names would have changed. Click '*Okay*' and then '*Apply*'.

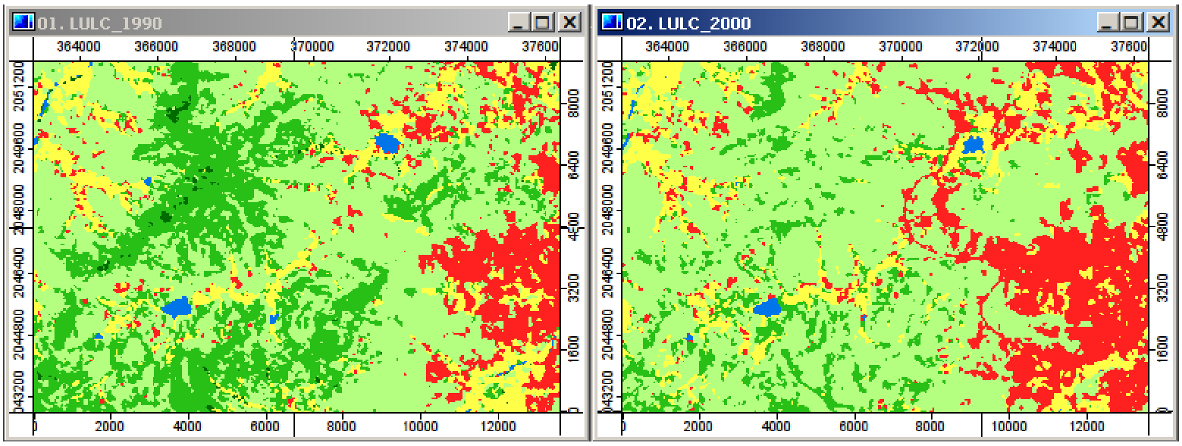


6. To do the same thing to the *'LULC_2000'* image simply right click on it and select *'Copy settings from other layer'*. In the window that pops up select *'LULC_1990'*. This will copy the class colours and names to this image.

7. Look at the  tab to see which land class each colour indicates. It will look like this:



8. Overlay the 'LULC_2000' image on the 'LULC_1990' image. Turn it on and off via the *'Maps'* tabs by double-clicking on it. This way, we can visually gauge the gains or losses of the land classes over the decade. *For example*: If we look at the west of Pune (Pashan), which is just right above to the centre of the image, we can see the 'Urban' class has increased due to the development of the Pune-Mumbai Bypass road and the built up area around it.

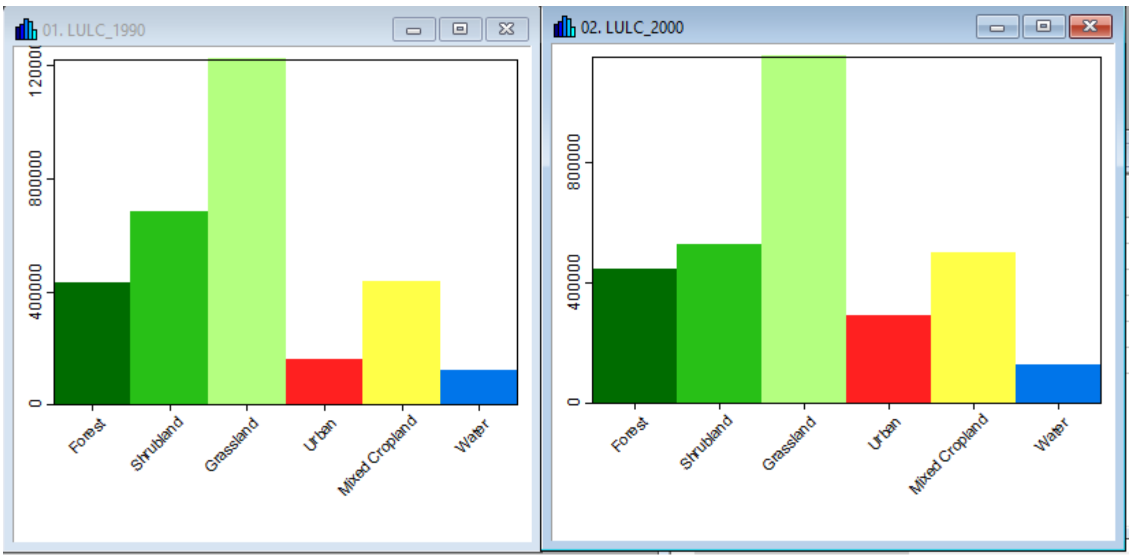


Question 1: Which land class got converted to Grassland in the above region?

Question 2: Is there any other part of Pune that has expanded significantly?

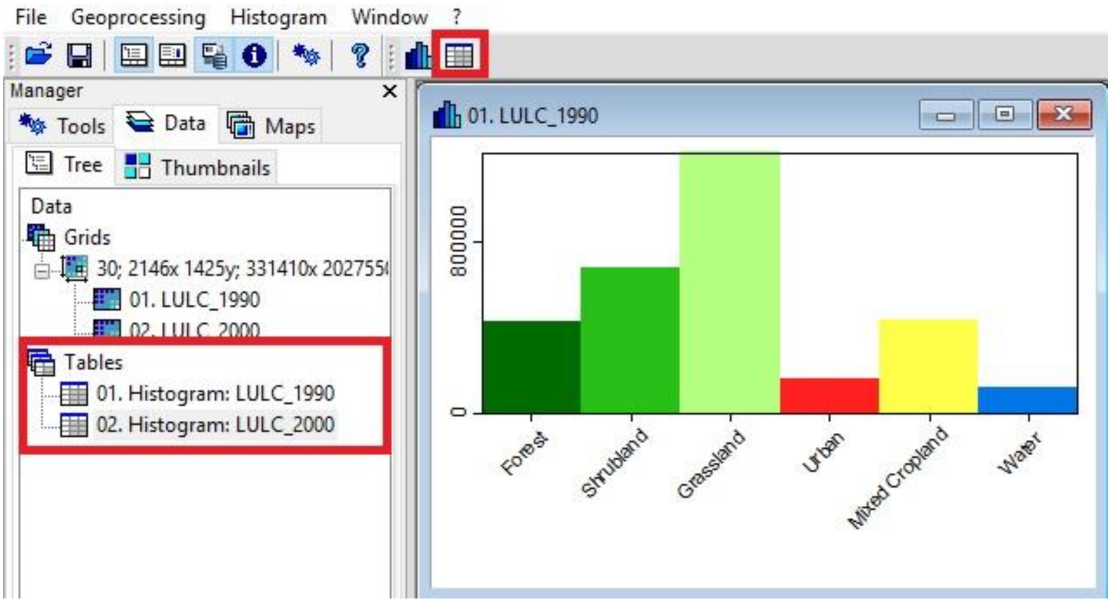
9. Another way to look at the images is in a side-by-side comparison (As seen above). Load the *'LULC_2000'* image in another map window. Select the map window and via the *'Map'* menu, check (*Map → Synchronize map Extents*). When this option is checked, this current map window will control the viewing extent of the other window. If you'd like the other map to use this feature as well then select it and check the same option from the menu.

10. The advantage of a georeferenced map over an ordinary map is that spatial measurements can be carried out on them easily. Let us take a look at the distribution of classes in the map using a histogram *(Go to the Data tab → select the Land use Map → Right-click → Histogram)*. This will create a histogram of the classes in the current image. Do this for both images and place them side by side.



11. These histograms give us an idea of the relative distribution of classes within each image. However, to compare the land class distribution across images we need to have a single histogram containing all the class values. This can be done by converting the histograms into tables and then joining them.

12. Select the *'Histogram map of LULC 1990'* and then click on the *'Convert to Table'* button in the toolbar above. Do this for the *'LULC_2000'* window as well.



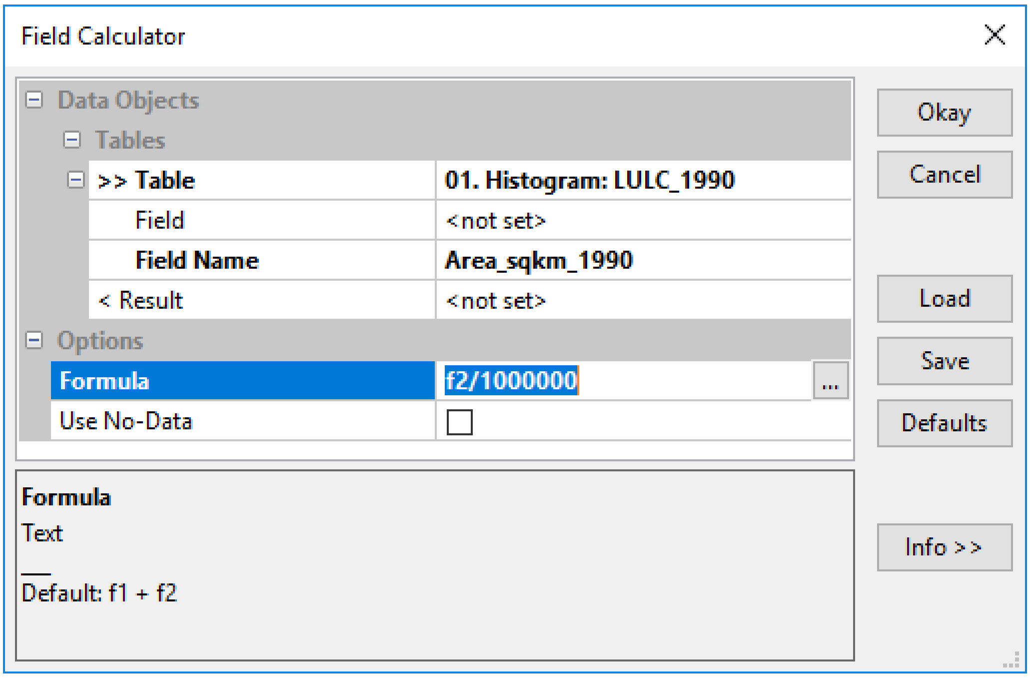
13. Two tables will appear in the *Data* tab list. *Double-click* on them to open. If the column is too small, expand it by holding left mouse bottom and dragging the border between two columns.

01. Histogram: LULC_1990

	CLASS	AREA	COUNT	CUMUL	NAME	MIN	CENTER	MAX
1	1	388927800	432142	432142	Forest	1	1	1
2	2	613643400	681826	1113968	Shrubland	2	2	2
3	3	1097923500	1219915	2333883	Grassland	3	3	3
4	4	146548800	162832	2496715	Urban	4	4	4
5	5	393201900	436891	2933606	Mixed Croplan	5	5	5
6	6	111996900	124441	3058047	Water	6	6	6

14. The field titled *'AREA'* describes the area of each land class in square metres. This becomes inconvenient at small scale maps (Those maps cover large areas, where we deal with hundreds or thousands of square kilometres). The conversion of area can be done by using

'table calculator tool' with a conversion parameter *'1 m^2=1/1,000,000 km^2'*, open the table calculator (*Geoprocessing → Table → Calculus → Field Calculator).*



15. Set the window entries as shown above. They are explained below.

    >>Table: This is the name of the table for which the calculation has to be done. From the dropdown menu select **'01. Histogram: LULC_1990'**.

    Field Name: If the entry *'Field'* is ***'[not set]'*** then this will the name of the new field. We will call the new field ***'Area_sqkm_1990'***, type it over field name.

    Field: This decides which field the results will be placed in. Select one from the dropdown menu. If it is ***'[not set]'*** it will create a new field titled by the *'Field Name'* entry. This time we will keep it as ***'[not set]'***.

    Formula: This is the calculation to be performed on *'AREA'* field which is third on table (f1, f2, f3… are being the first, second, third…etc fields). Change the default formula to ***'f2/1000000'*** since we are converting *'AREA'* from square metres to square kilometres.

    Result: This points to which table the result will be placed in. ***'[create]'*** will create a new table. Keep this as ***'[not set]'*** to append the result to the current table.

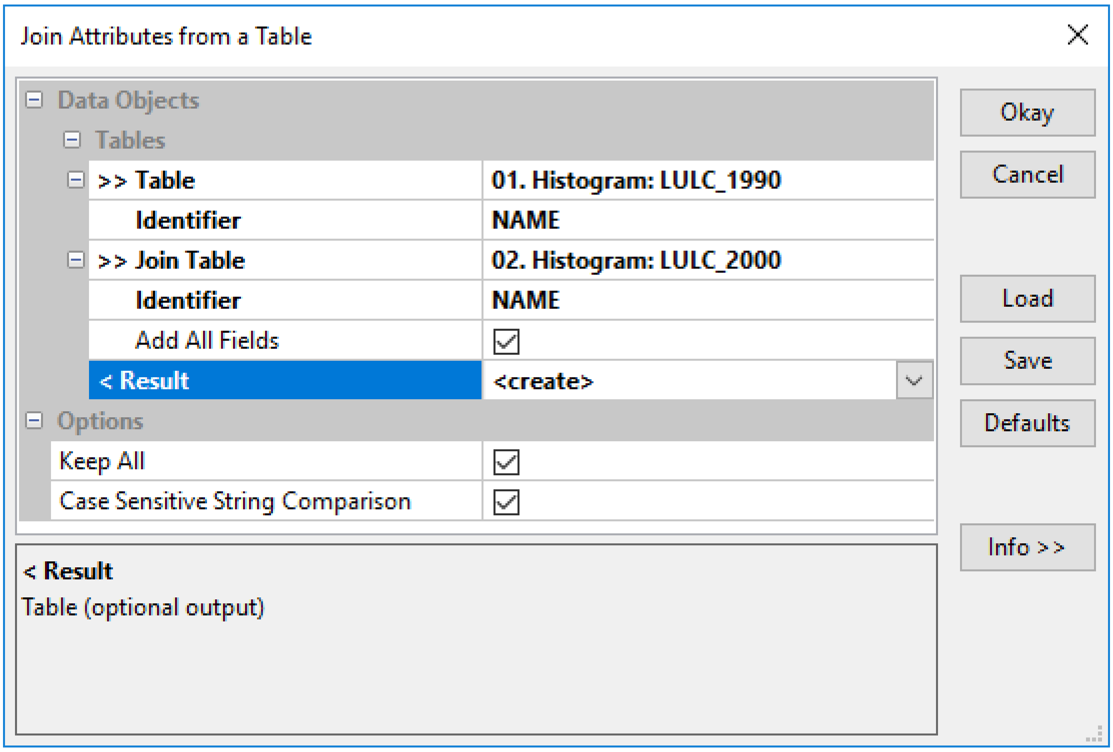
    Now click on ***'okay'*** to finish.

16. Open the table ***'01. Histogram: LULC_1990'*** again. The new field will be seen attached at the end. Repeat the *step 14 to 15* for the table ***'02. Histogram: LULC_2000'***

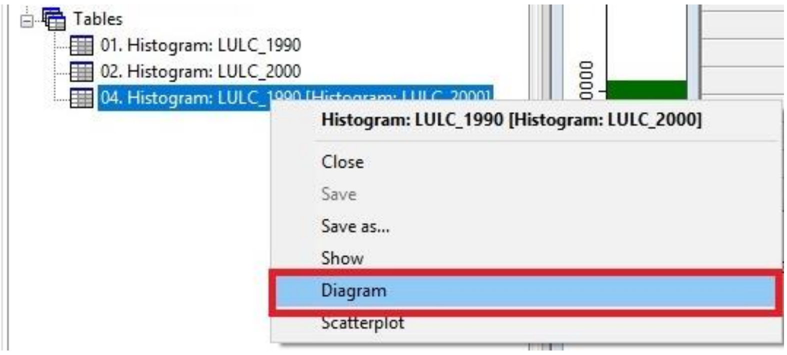
01. Histogram: LULC_1990

	CLASS	AREA	COUNT	CUMUL	NAME	MIN	CENTER	MAX	Area_sqkm_1990
1	1	388927800	432142	432142	Forest	1	1	1	388.9278
2	2	613643400	681826	1113968	Shrubland	2	2	2	613.6434
3	3	1097923500	1219915	2333883	Grassland	3	3	3	1097.9235
4	4	146548800	162832	2496715	Urban	4	4	4	146.5488
5	5	393201900	436891	2933606	Mixed Croplan	5	5	5	393.2019
6	6	111996900	124441	3058047	Water	6	6	6	111.9969

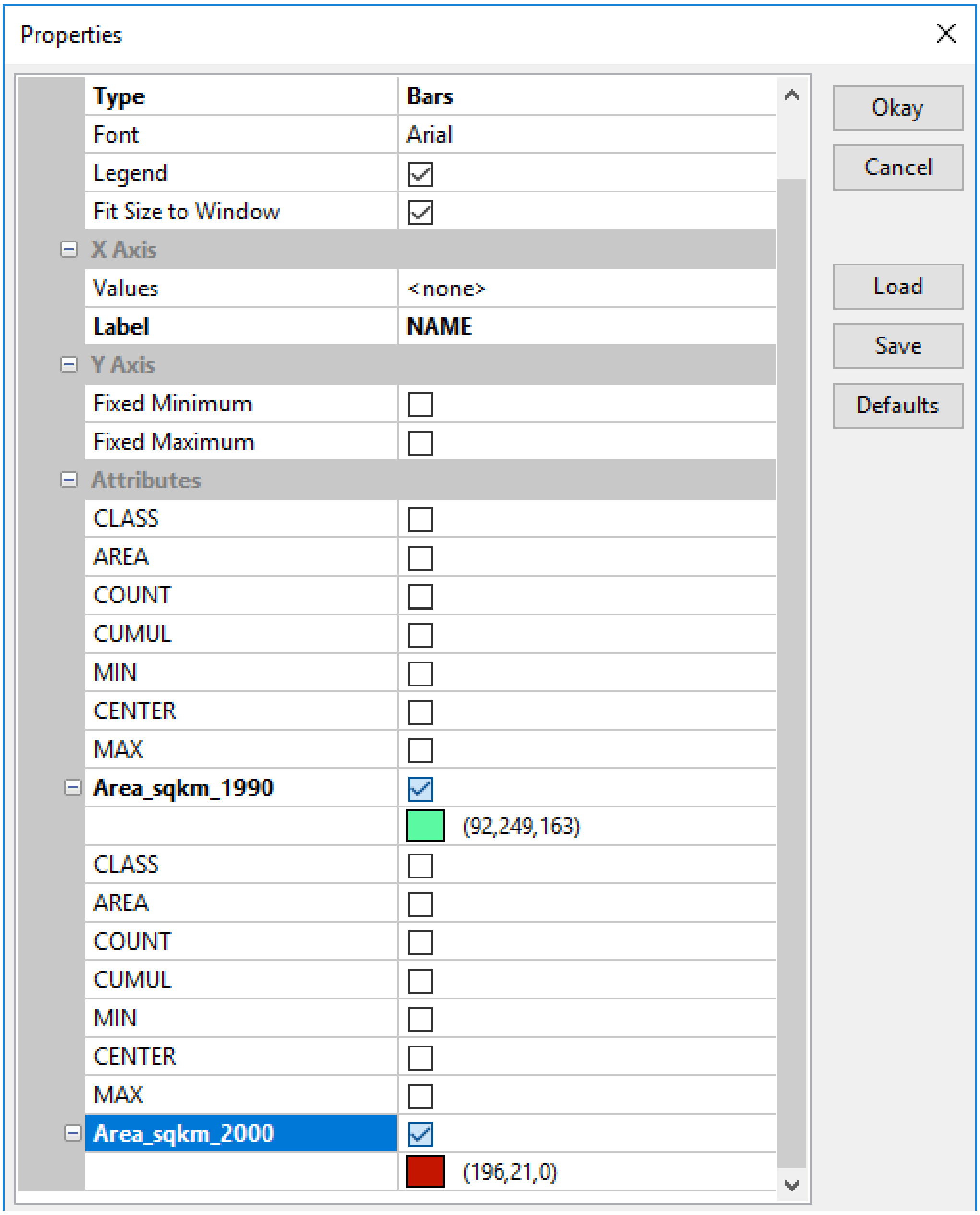
17. We now open *'Geoprocessing → Tables → Tools → Join Attributes from a Table'*. Set the *'Table* 'entry as ***'01. Histogram: LULC_1990'*** and the *'Join Table'* entry as ***'02. Histogram: LULC_2000'***. The *Identifiers* are the fields to be used as the common link. Set them both to ***'NAME'***. To create a new table select ***'[create]'*** from the *'Result'* dropdown menu. Now click on ***'Okay'***.

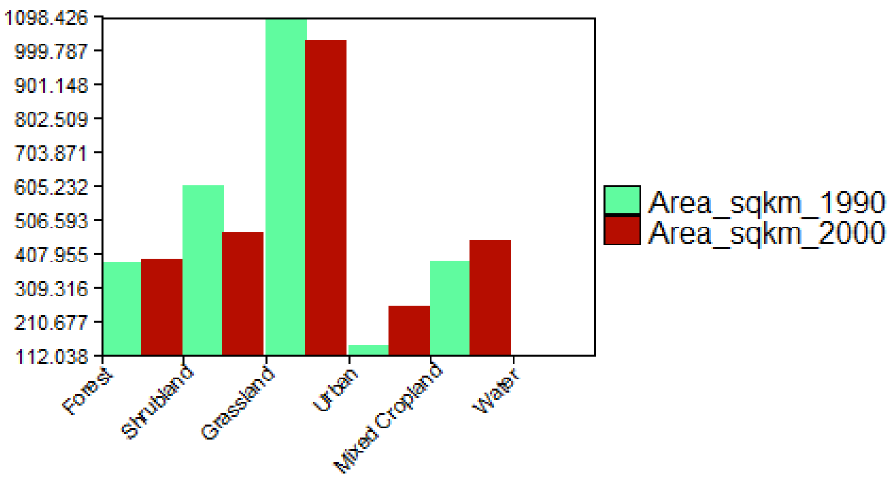


18. The resulting table will have fields from both tables. We can now create a histogram comparing the areas of the two images. Right-click on the table and select ***'Diagram'***.



19. In the *Properties* window, change the *'Display Type'* to ***'Bars'*** and the *'Label'* value to ***'NAME'***. From the *'Attributes'* section, check the options for ***'Area_sqkm_1990'*** and ***Area_sqkm_2000'***. You can change the colours if you like. Click ***'Okay'***. The resulting graph will look like below:


Properties
Type
Bars
Font
Arial
Legend
Fit Size to Window
X Axis
Values
<none>
Label
NAME
Y Axis
Fixed Minimum
Fixed Maximum
Attributes
CLASS
AREA
COUNT
CUMUL
MIN
CENTER
MAX
Area_sqkm_1990
(92,249,163)
CLASS
AREA
COUNT
CUMUL
MIN
CENTER
MAX
Area_sqkm_2000
(196,21,0)
Okay
Cancel
Load
Save
Defaults

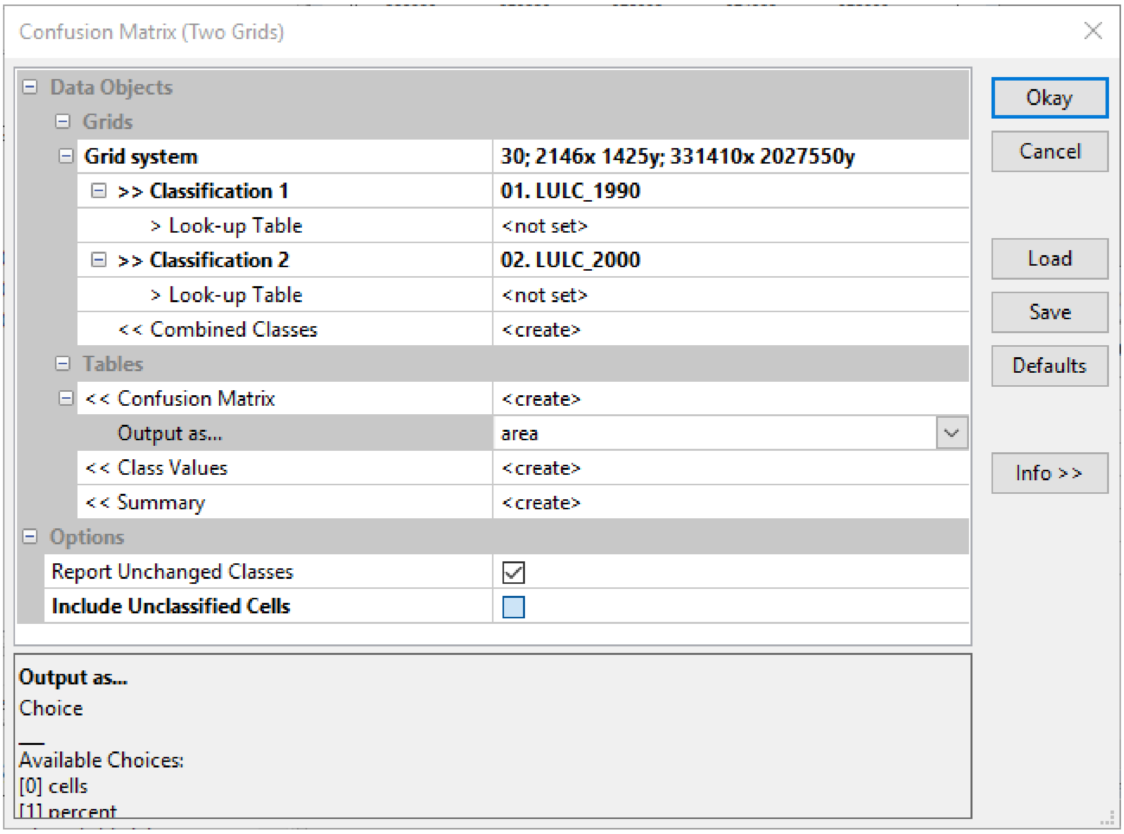

1098.426
999.787
901.148
802.509
703.871
605.232
506.593
407.955
309.316
210.677
112.038
Forest
Shrubland
Grassland
Urban
Mixed Cropland
Water
Area_sqkm_1990
Area_sqkm_2000

Here the histogram shows the increase or decrease in area of each class over a decade.

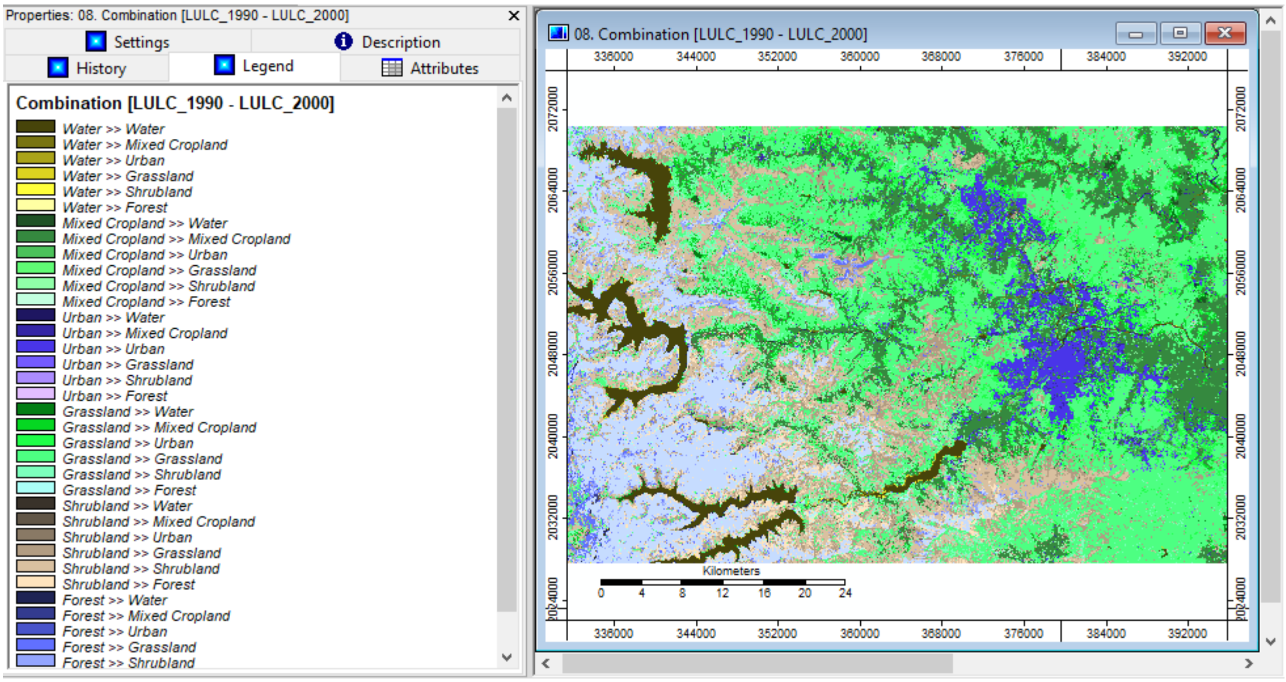
Question 3: Which class shows the highest increase?

20. This visual interpretation gives us a good idea about the change in the land cover in terms of just area, i.e., quantitative values. However, to map the location of change and the individual transitions, we will use the *'Change Detection'* module. Open it via the menu (*Geoprocessing → Imagery → Classification → Confusion Matrix(Two Grids)'*).

21. In the module window, fill in the details of the table as shown below and click on *'Okay'*.

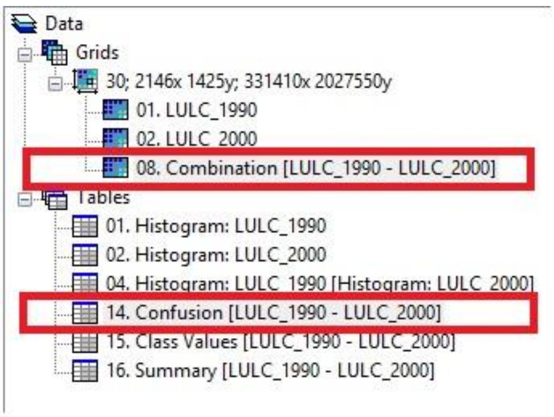


22. The newly created change map will appear in the *'Data'* list. It will have the class changes indicated by colour. For example, in this case, the changes from Shrub land are in different shades of blue while those from the Grassland class are shades of dull yellow.



23. The *Legend* tab serves as a good guide for the colour scheme, but the differentiating between classes might get tricky. One way around this is to select the *'Changes'* layer and place the mouse over a pixel to get the class name, it will appear in the *Status Bar* below.

24. The ***'Combinations [LULC_1990 - LULC_2000]'*** image is accompanied by a table i.e., ***'Confusion [LULC_1990 - LULC_2000]'*** which lists out the changes in a cross tabular form. It compares the classes of the first image with those of the second. Open the table by double clicking on it. To fit the values to column, right-click on the title in the *'Confusion'* table and select ***'Fit Column Sizes'***.



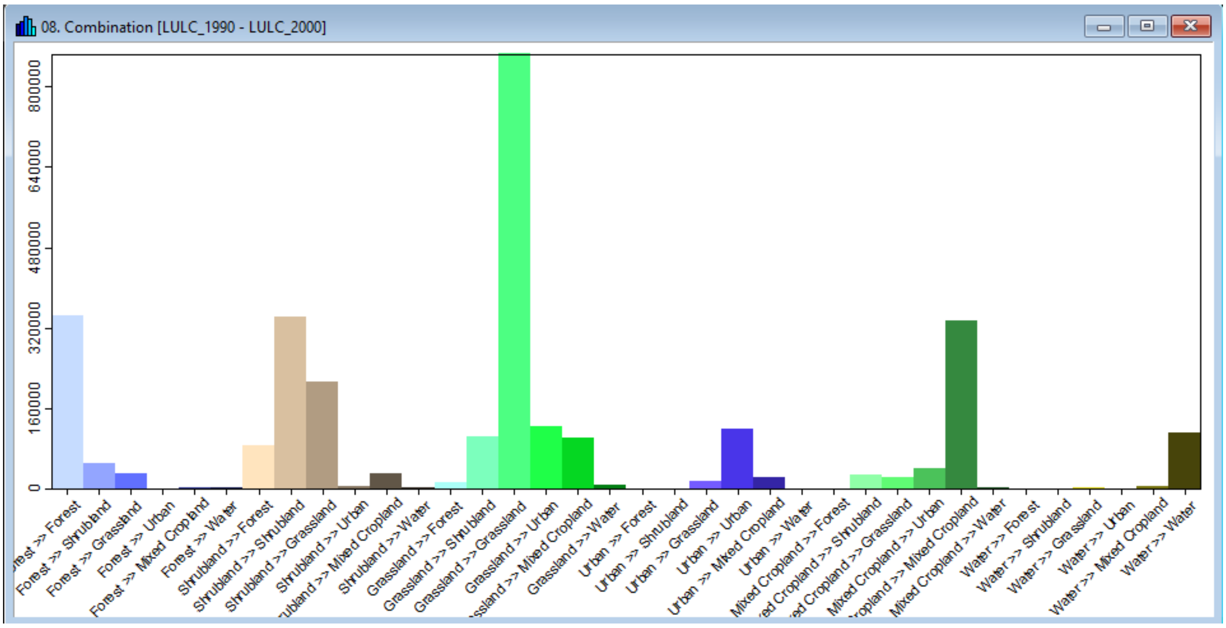
25. This matrix gives us the area of change for each class transition. The row wise classes are the first image (LULC_1990) and the columns are of the second image (LULC_2000).

14. Confusion [LULC_1990 - LULC_2000]

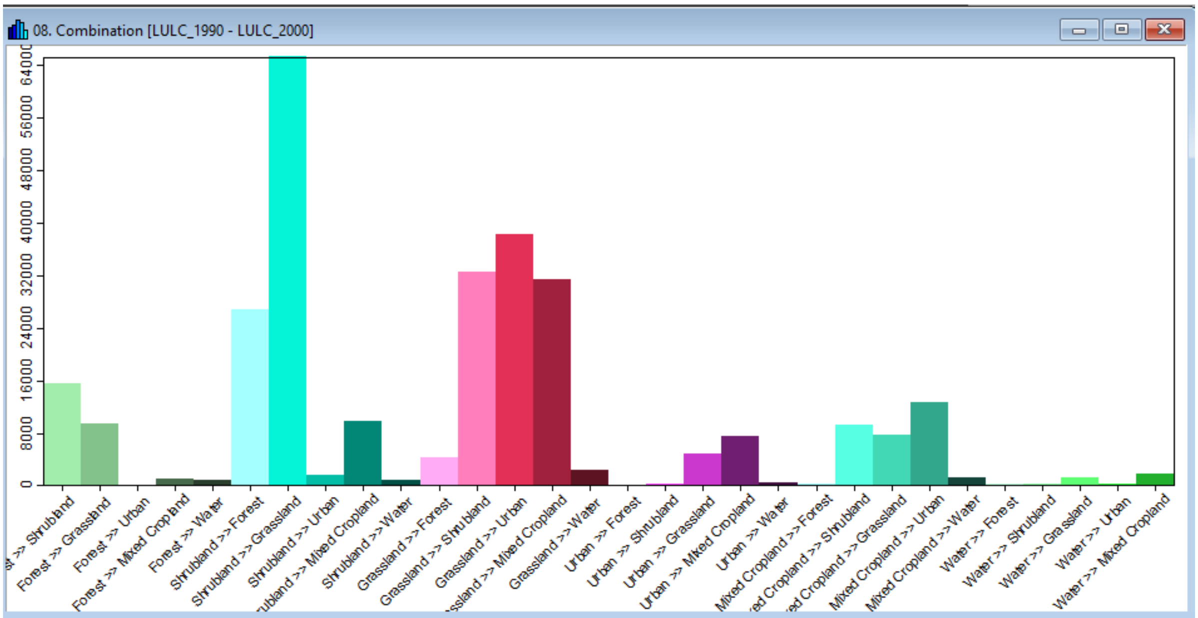
2000		Name	Forest	Shrubland	Grassland	Urban	Mixed Cropland	Water	SumUser	AccUser
1990	1	Forest	301586400	45661500	27731700	201600	2856600	2570400	380608200	79.23802
	2	Shrubland	77828400	301003200	188552700	4533300	28953900	2406600	603278100	49.894601
	3	Grassland	12549600	95566500	739404900	111776400	91141200	6868800	1057307400	69.932822
	4	Urban	9000	903600	14018400	107433900	22029300	1628100	146022300	73.573625
	5	Mixed Cropland	597600	27106200	22541400	37403100	294480900	3579300	385708500	76.348045
	6	Water	812700	999000	3593700	571500	5089500	100711800	111778200	90.09968
	7	SumProd	393383700	471240000	995842800	261919800	444551400	117765000		
	8	AccProd	76.664691	63.874714	74.249159	41.017861	66.242261	85.519297		

26. Take the above table, for example. The table shows the area of *Grassland converted to Urban class* as 111776400m². This translates to about 112km².

27. The transition areas can also be compared using a histogram. We can view this by right-clicking on the '*Combinations[LULC_1990 - LULC_2000]*' image under '*Data*' tab and selecting '*Histogram*'.



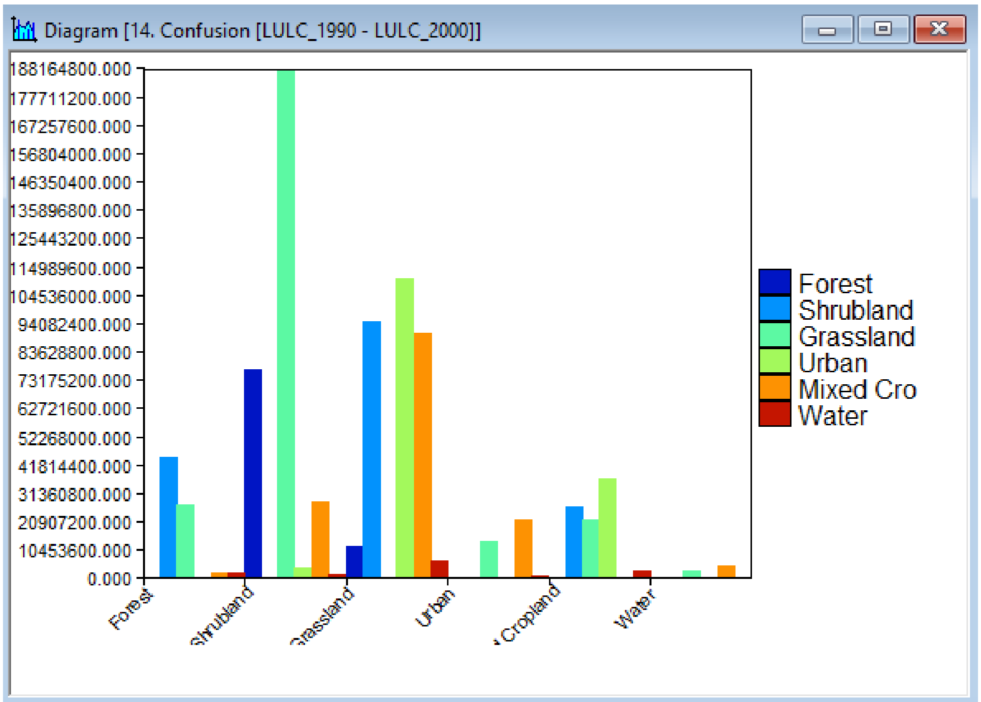
28. As seen above, the unchanged classes have the highest values, for example: the Shrubland transitions, the '*Shrubland>>Shrubland*' transition has the highest value. We can remove these by going back to the '*Confusion Matrix(Two Grids)*' module and unchecking '*Report Unchanged Classes*' and then click '*Okay*'.



29. The unchanged classes will have been removed. As you can see the colours have also changed. This is because SAGA generates a new set of random colours every time you make a new result.

Question 4: Can you tell which land class the Urban growth infringed upon most?

30. To set the histogram colours to be class-wise, right-click on the ***'Confusion [LULC_1990 - LULC_2000]'*** table and select *'Diagram'*. In the pop up window, set the *'Display Type'* as ***'Bars'***, and the X Axis *'Label'* to ***'Name'***. From the *'Attributes'* check all the classes and click *'Okay'*.



31. This second histogram has the transitions coloured according to the class of the final state (LULC_2000).

    Question 5: You can notice *Urban* land use is converted in to *Grassland* and *Mixed Crop land*! Would this be the real case? Can you explain why this transition exists?

32. Transition data can be viewed in another way. Select the first histogram window, i.e., '*Combination [LULC_1990 >> LULC_2000]*' and click the ***'Show Table'*** button on the toolbar above. This will create new table titled ***'Histogram: Combination [LULC_1990>>LULC_2000)'***. This displays the transitions as a list of classes.

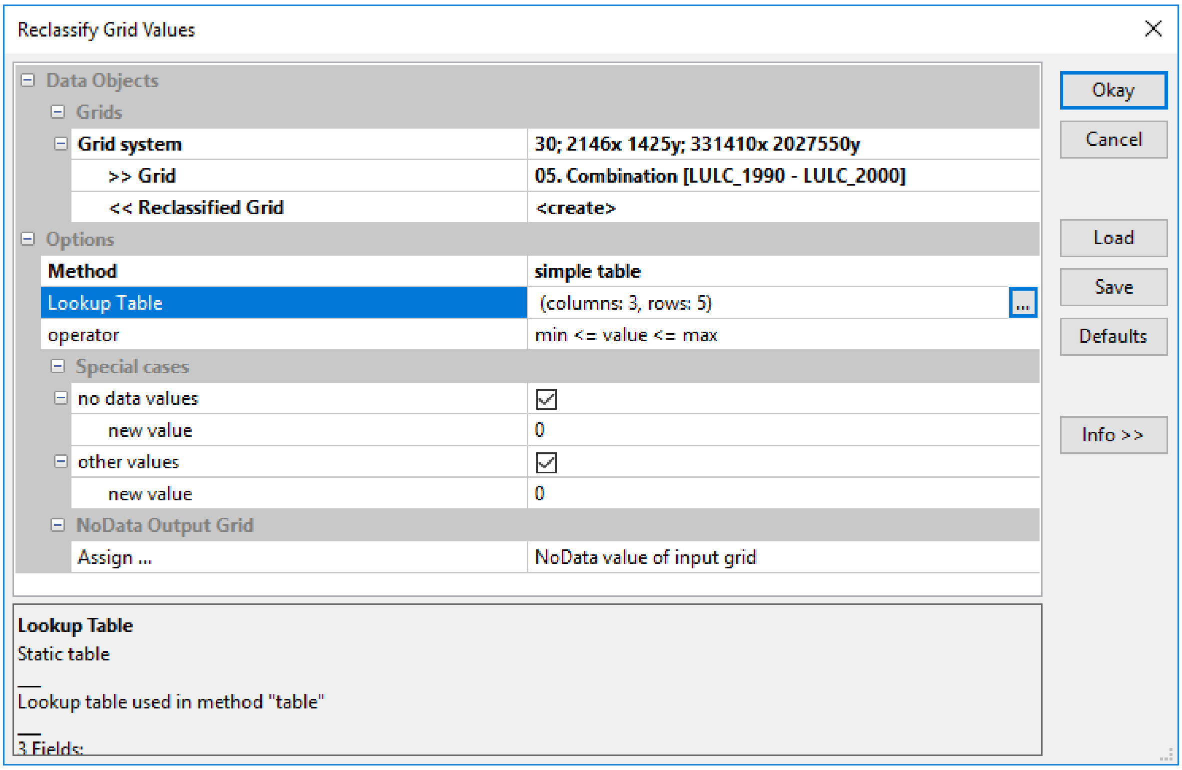
17. Histogram: Combination [LULC_1990 - LULC_2000]

	CLASS	AREA	COUNT	CUMUL	NAME	MIN	CENTER	MAX
1	1	14008500	15565	15565	Forest >> Shrubland	1	1	1
2	2	8542800	9492	25057	Forest >> Grassland	2	2	2
3	3	64800	72	25129	Forest >> Urban	3	3	3
4	4	877500	975	26104	Forest >> Mixed Cropland	4	4	4
5	5	779400	866	26970	Forest >> Water	5	5	5
6	6	24120900	26801	53771	Shrubland >> Forest	6	6	6
7	7	58780800	65312	119083	Shrubland >> Grassland	8	8	8
8	8	1401300	1557	120640	Shrubland >> Urban	9	9	9
9	9	8892900	9881	130521	Shrubland >> Mixed Cropland	10	10	10
10	10	736200	818	131339	Shrubland >> Water	11	11	11
11	11	3847500	4275	135614	Grassland >> Forest	12	12	12
12	12	29339100	32599	168213	Grassland >> Shrubland	13	13	13
13	13	34518600	38354	206567	Grassland >> Urban	15	15	15

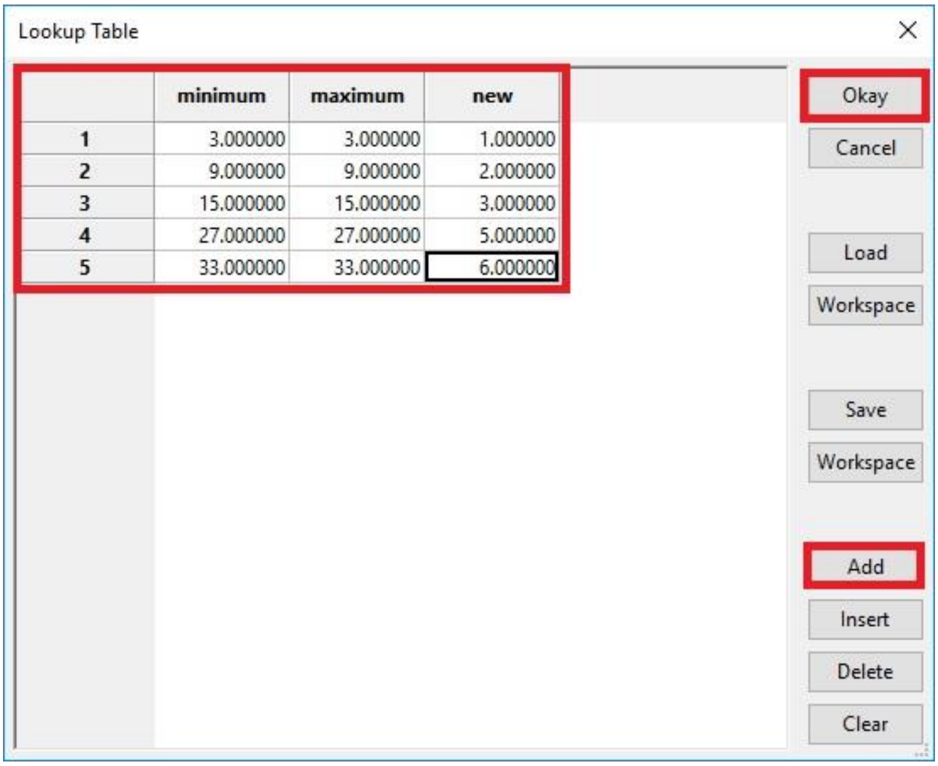
33. To further analyze the class transitions, we can view them on the map. This way we can visually understand the distribution of a land cover transition. We must extract them from this table. Let us try to extract urban growth.

34. Note down the '*MIN/MAX*' values of all the transitions contributing to *Urban* class. (Eg. Shrubland>>Urban). These should be 3, 9, 15, 27 and 33.

35. Open the ***'Reclassify Grid Values'*** module *(Geoprocessing → Grid → Values → Reclassify Grid Values)*. Select the current Grid System and select ***'Combination [LULC_1990>>LULC_2000)*** under ***'Grid'***. From the 'Method' field, select ***'simple table'***. Select the 'Lookup Table' row and click on the ... button to open it.

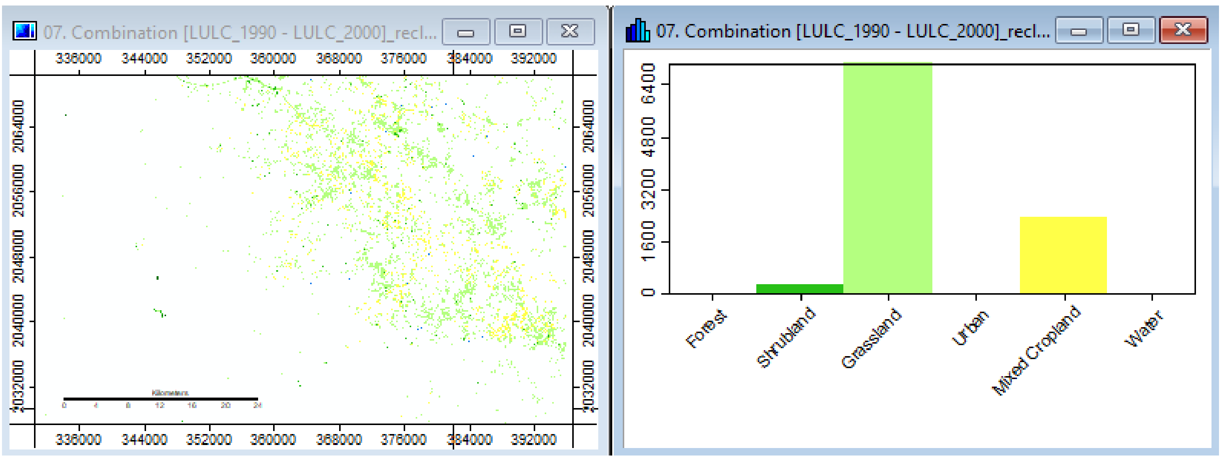


36. Press ***'Add'*** till you get five classes in *'Lookup Table'* window. Replace the ***MINIMUM / MAXIMUM*** values with the ones you noted down earlier, see below figure. The *'new'* values will be the class from which the transition has taken place. Click ***'Okay'***. Set the *Operator* as ***'min <= value <= max'***. Check *'Other Values'* and keep the *'new value'* entry as ***'0'***. Press *'Okay'* in *'Reclassify Grid Values'* window.



37. Open the *'Reclassified Grid'* layer in new map window by double clicking over it under *Data* list. It may not have the colors differentiated since the new classes are numerically adjacent to each other.

38. We can use the original palette to describe the land transitions. Load the *'Lookup_Table.txt'* file via the Settings tab (*refer Step 4 -5*).



Question 6: List the possible applications of change detection?