TRAINING IN APPLICATION OF REMOTE SENSING AND GIS IN COASTAL AND MARINE RESOURCE MAPPING - MANGROVES COVER MAPPING

(KENYA, TANZANIA, MOZAMBIQUE AND MADAGASCAR)

IMAGE PROCESSING TUTORIAL IN ENVI 4.7 & ENVI 5.1

TRAINING VENUE: RCMRD

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1.0 INTRODUCTION

1.1 Background

Land cover refers to the composition and characteristics of land surface elements, representing key environmental information. It is an important determinant of land use and hence of great importance to the society. Land cover varies at a range of spatial scales from local to global, and at temporal frequencies of days to millennia. As the need for environmental planning and management became important, an accompanying call for land cover information emerged in parallel. Land cover mapping is one of the common and applicable uses of remote sensing data. Specifically it is applied in natural resource management, urban planning, hydrological modeling and exploration of oil, gas, and minerals. The access to the previous data makes it possible to detect land cover back in time, and the subsequent continued supply of new images data allows for effective detection of changes in land cover in a certain time period. The process of performing a land cover classification based on a satellite image is basically a system of simplifying the wealth of information present in a satellite image into information that is easy to interpret for the end users (Chennai, et. al 2015; Cihlar, 2000; Malik & Husain, 2006).

The complexity of a specific classification procedure depends on many factors including the size and area of investigation, the required number of classes, the projected accuracy and in most cases the quality of the available satellite imagery data. The basic principle behind most land cover mapping is the ability to distinguish different surface covers based on their spectral signatures (i.e. a unique combination of reflected electro-magnetic radiation in different spectral bands). Occasionally this has been performed using pixel based image analysis, whereby each pixel's digital number is assessed individually. Besides, an object-based image analysis, whereby pixels are aggregated in a first step (segmentation) into objects that are homogeneous with regard to spatial or spectra characteristics. After which spectral, textural, shape or textual criteria can then be applied to interactively classify the objects into a predefined set of classes (Malik & Husain, 2006).

1.2 The Training Objectives

The objective of this training is to provide remote sensing image processing and Geographic Information Systems (GIS) skills to researchers and coastal resource managers, to enble them to identify coastal vegetation (mangroves and seagrass/sub-merged vegatation) cover types along Kenya, Tanzania, Mozambique and Madagascar coastlines. Because satellites beam back information every day, satellite imagery can be an excellent source of very current or historic information. Specifically, this training module uses Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) and Landasat 8 OLI (Operational Land Imager) imageries from 2010 to 2014. You will be guided through the necessary steps for acquiring, processing, classifying, interpreting and examining different classes in the study areas. Initially, you will analyze Landsat images to identify various natural and human-developed features present on the surface into land cover classes. These classifications will then be used to detect areas where mangrove forests occur within the project areas.

2.0 FILE MANAGEMENT

2.1 Data Files Directory and Data Formats

The satellite Images (raster data) used in this training manual are in **GeoTIFF** format, and the GIS data are in **Shapefile** format. File management is crucial for a successful project! Before you start compiling your data, ensure that you have become familiar with the file structure and the data used in this training project. If it has not been set up for you, you can create the folders on the drive on which you are allowed to save data. Open **Windows Explorer** and create the folder structure below on your working drive. In this case, they have been created on the "D" drive. The project is named "**TRAINING DATA_LANDSAT8"** with the following subfolders: **accuracy_test, Imagery, shapefiles and output.**

NB: Make sure the "**TRAINING DATA_LANDSAT8"** is copied to your computer preferably on the "D" compartment.

3.0 SATELLITE DATA ACQUISITION AND PRE-PROCESSING

3.1 Satellite Data Acquisition and Pre-processing: Landsat Imagery

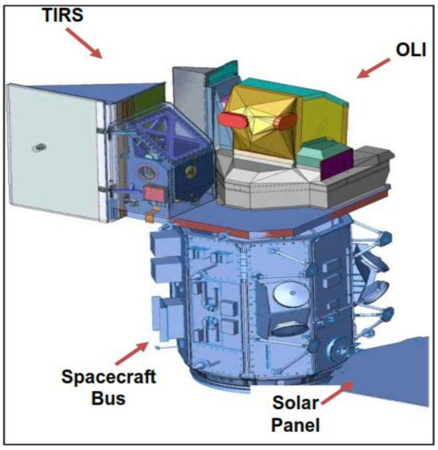
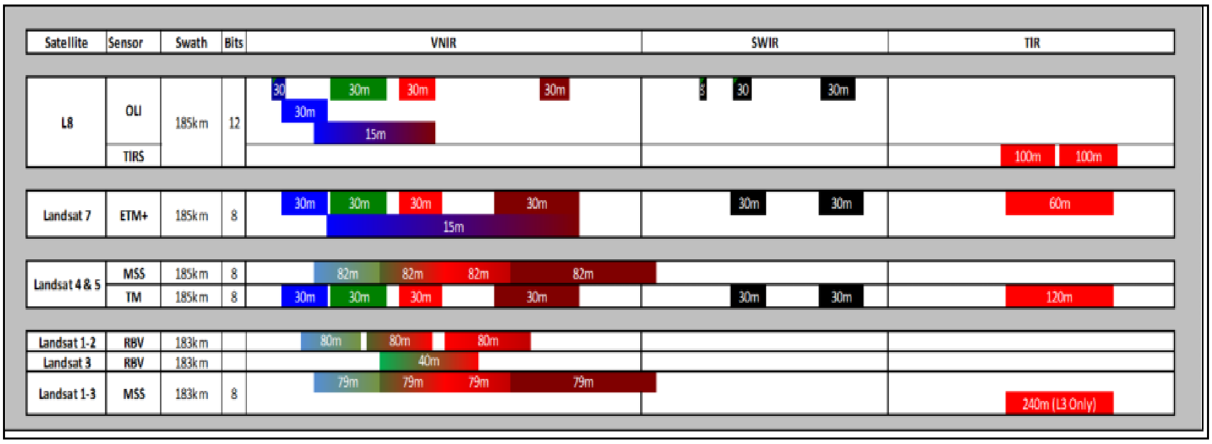


Figure 1: Illustration of of Lansat 8 Observatory. Source:("LANDSAT 8 (L8) DATA USERS HANDBOOK Version 1.0 June 2015," 2015).

Landsat program has provided over 42 years of calibrated high spatial resolution data of Earths's surface for various uses by the world community, cutting across differing fields: agribusiness, climate change science, decision makers just to mention a few. The main mission of the Landsat is to make available repetitive acquisition of moderate-resolution multispectral data of the Earth's surface ("LANDSAT 8 (L8) DATA USERS HANDBOOK Version 1.0 June 2015," 2015).

3.1.1 Landsat Missions



MSS(Multispectral Scanner),OLI(Operational Land Imager),TIRS(Thermal Infrared Sensor), TM(Thermatic Mapper), ETM+(Enhanced Thermatic Mapper Plus), RBV (A return Beam Vidicon)

Figure 2: Continuity of multispectral data coverage provided by Landsat missions beginning with Landsat 1 in 1972: Source ("LANDSAT 8 (L8) DATA USERS HANDBOOK Version 1.0 June 2015," 2015).

3.1.2 Lansat 8 & 7: What's different or new?

The Landsat 8 observatory offers many capabilities over its predecessor, Landsat 7.

	L7	L8
Scenes/Day	~450	~650
SSR Size	378 Gbits, block-based	3.14 Terabit, file-based
Sensor Type	ETM+, Whisk-Broom	Pushbroom (both OLI and TIRS)
Compression	No	~2:1 Variable Rice Compression
Image D/L	X-Band GXA×3	X-Band Earth Coverage
Data Rate	150 Mbits/sec × 3 Channels/Frequencies	384 Mbits/sec, CCSDS Virtual Channels
Encoding	not fully CCSDS compliant	CCSDS, LDPC FEC
Ranging	S-Band 2-Way Doppler	GPS
Orbit	705 Km Sun-Sync 98.2° inclination (WRS2)	705 Km Sun-Sync 98.2° inclination (WRS2)
Crossing Time	~ 10:00 AM	~ 10:11 AM

Figure 3: Comparison of Landsat 7 and Landsat 8 Observatory Capabilities

Landsat-7 ETM+ Bands (µm)			Landsat-8 OLI and *TIRS* Bands (µm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9

Figure 4: OLI and TIRS Spectral Bands Compared to EMT+Spectral Bands

OLI has two new bands besides the original Landsat bands (1-5, 7, and Pan). The Coastal/Aerosol band (band 1; 0.435-0.451micrometres) and the new Cirrus band (band 9; 1.36-1.38 micrometres) aids in detection of thin clouds comprised of ice crystals (cirrus clouds will appear bright while most land surfaces will appear dark through an otherwise cloud-free atmospheres containing water vapour)

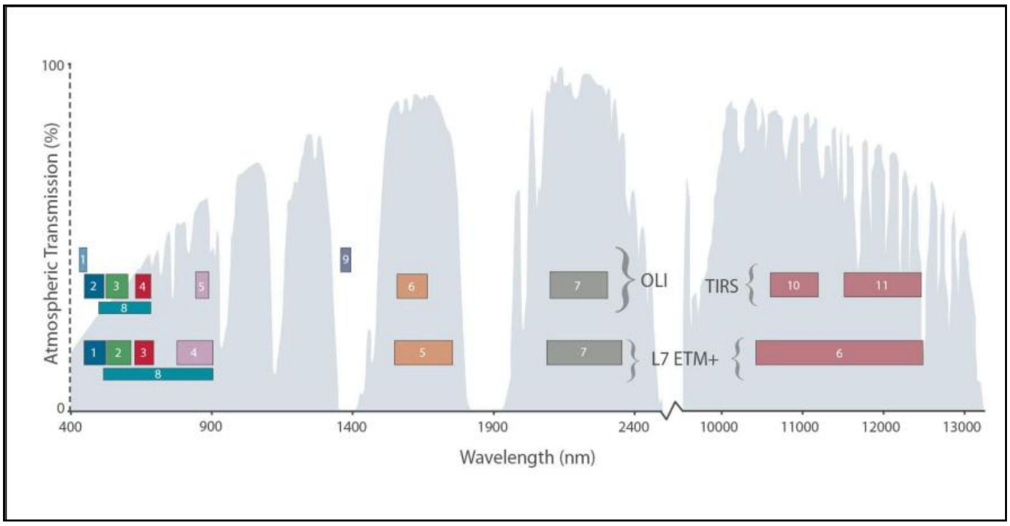


Figure 5: Landsat 8 Spectral Bands and Wavelengths compared to Landsat 7 EMT+

3.1.3 Landsat Data Availability and Download

All products are accessible via the internet for download via HTTP; there are no product media options. Landsat data are available at no cost to the user. Available data can be viewed through a number of interfaces:

- Earth Explorer:http://earthexplorere.usgs.gov

- Global Visualization Viewer:http://glovis.usgs.gov
- LandsatLook Viewer:http//landsatlook.usgs.gov

3.1.4 A look at Global Visualization Viewer (GloVis)

The Global Visualization (GloVis) Viewer is an easy to operate browse-based tool which displays all available Landsat scenes achieved in the USGS database. See the link above.

NB: The latest version of Java needs to be installed on your computer.

3.1.5 Exercise 1: Getting Started with Global Visualization Viewer (GloVis) Interface

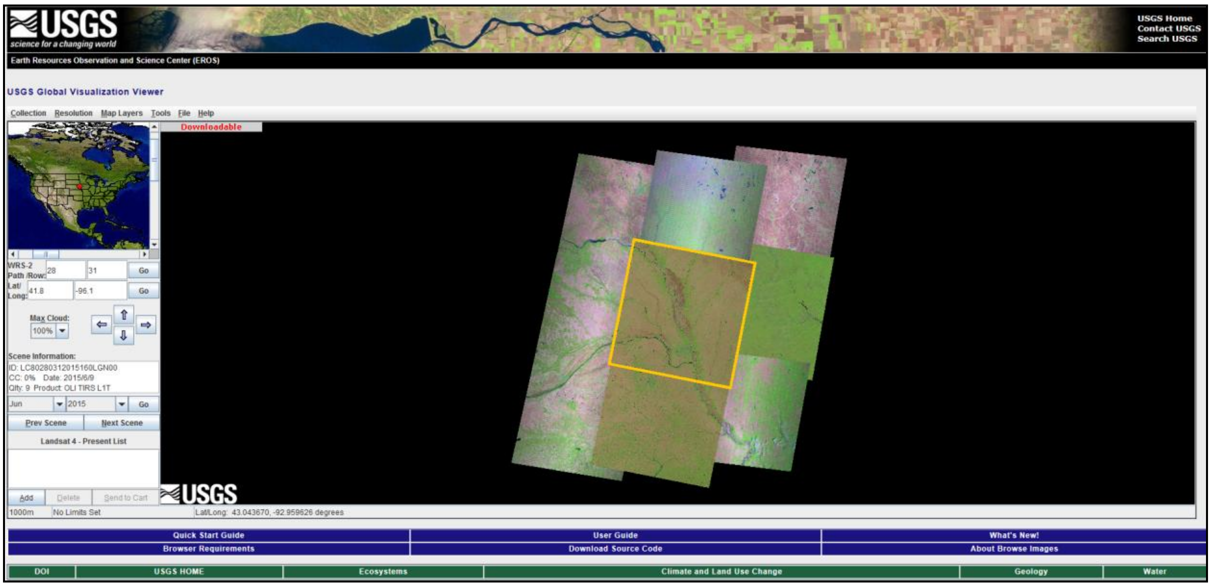


Figure 6: Global Visualization Viewer (GloVis) Interface

When first opened, the viewer displays the most recent, least cloudy image of Path 28 Row 31 (Southeast South Dakota) **Figure** 6. One can navigate to an area of interest by feeding a Path/Raw, Latitude/Longitude decimal coordinates, or moving the map using the mouse. Though, regardless of where the map is moved, the most recent, least cloud free image will be displayed. Users can then "page" through all of the scenes covering the same Path/Row area, using the arrows or Previous Sceneand Next Scene buttons on the left side. Cloud limits can also be changed on the left side of the viewing window.

The collection menu lists the searchable data sets, including Landsat 8. The Resolution Menu allows the display to be changed from 1000 meters (9 scenes in the view) to 250 meters only (only the selected scene will be displayed). Map layers (cities, country/administration boundaries, roads) can be added to aide in the search. The Tools Menu allows users to set search limits or look for specific scene ID's. Users can also compile and save scene lists from the tool, or upload already created scene lists. Scenes added to the Scene List are sent to the Cart, which forwards the request to EarthExplorer and prompts users to login. The data can then be downloaded individually, or added to bulk download order.

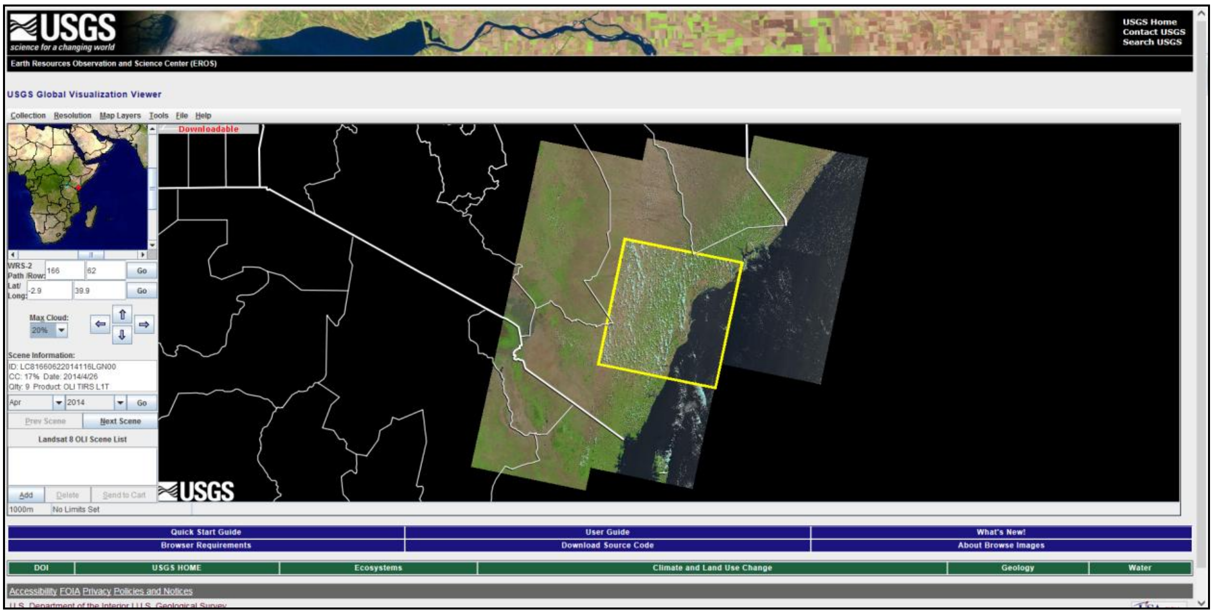


Figure 7: Path/Row 166/62 within the entire Kenyan Coastline

3.2 Landsat Data Pre-processing: Quick Atmospheric Correction (QUAC) in ENVI 5.1

The following example describes how to use QUAC with Landsat imagery. Because Landsat scenes typically have large areas of background pixels, the example shows how to apply a mask that excludes these areas from QUAC processing.

3.2.1 Exercise 2: Starting the software ENVI 5.1

Envi can be started using desktop shortcut icons or through program files and Envi 5.1 folder where Envi+IDL or Envi stand alone can be started by a single mouse click as shown below

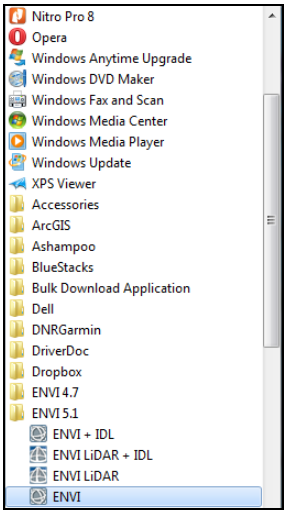


Figure 8:Lauching Envi 4.7 through program files Menu

Exercise 3: Opening and loading the Image: Click the **Open** button in the toolbar.

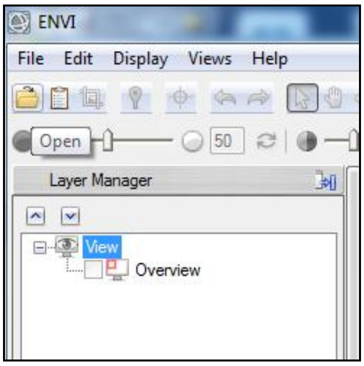


Figure 9: Loading the Image

Go to G:\TRAINING DATA_LANDSAT8\Imagery and load **LC81660632014036LGN00**

1. For Landsat 8, select a *_MTL.txt metadata file.
2. For Landsat 4, 5, or 7 images with metadata, select a*_MTL.txt, *_wo.txt, or *.met file. By opening the metadata file, ENVI reads the entire dataset plus the available metadata.
3. Right-click on the Landsat filename in the Data manager and load True Color.
4. Then right click Layer Manager and select Zoom to Layer Extent. Now you can see the black background pixels, for example:

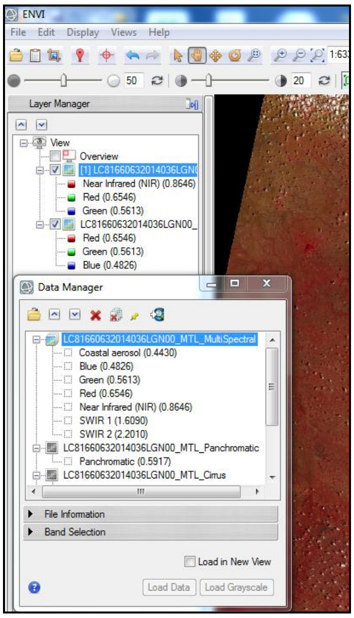


Figure 10: Loaded Image showing black background pixels

5. Click the Cursor Value button in the toolbar, and then move the cursor over the background pixels to verify their values. The pixel values are 0, 0, and 0 for the R, G, and B bands/channels.

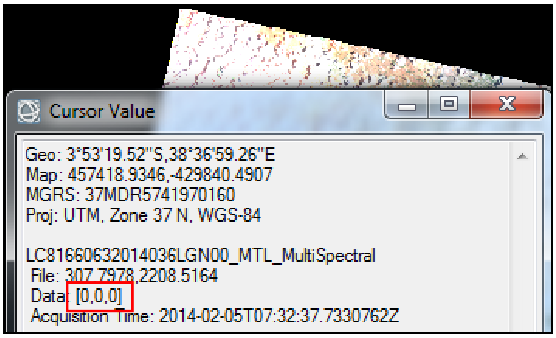


Figure 11: Cursor values

Exercise 4: Creating a mask: This procedure outlines steps to build and apply a mask which eliminates pixel values of 0 from QUAC processing:

- In the Search field of the Toolbox, type QUAC. Double-click the QUAC tool which appears in the search results
- In the QUAC Input File dialog, select the first filename in the list i.e. the OLI multispectral dataset, locate the number 7 in the Dims field, which denotes the OLI dataset with 7 channels.

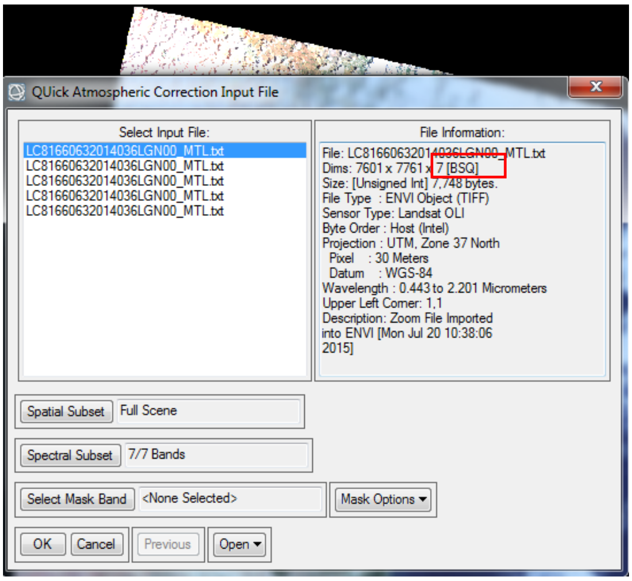


Figure 12: OLI dataset with 7 channels

- In the QUAC Input File dialog, click the **Mask Options** drop-down list and select **Build Mask.**
- In the Mask Definition dialog, click the **Options** drop-down list and select **Import Data Range.**
- Select the same OLI multispectral dataset as in bullet 2, then click **OK.**
- In the Input for Data Range Mask dialog, enter a value of 0 in both the **Data MaxValue** fields.
- Select the option to **Mask pixel if ANY band matches range**

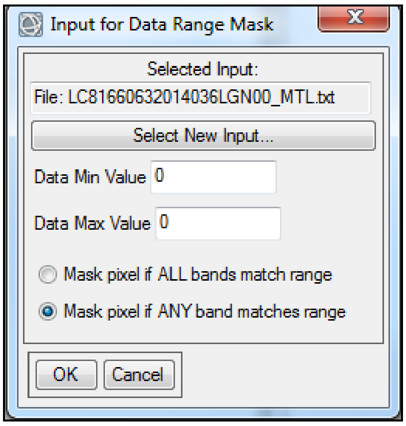


Figure 13: Mask Parameters

- Click **OK** in the Input for Data Range Mask dialog
- In the Mask definition dialog, click the **Options** drop-down list and choose **selected areas off.** This will assign a value of 0 to the masked pixels, meaning that those areas of the Landsat image will be ignored after applying the mask.

- In the Mask Definition dialog, enter an output filename if you want to save the mask to disk. Otherwise select the **Memory** option.
- Click **OK** in the Mask Definition dialog. When processing is complete, the mask appears in the image window and the Layer Manager.
- Mask should be listed next to the Select Mask Band button in the QUAC Input File dialog. If not, then **Select Mask Band** and choose the mask that you created.
- Click **OK** in the QUAC Input File dialog.

Setting QUAC Parameters:

- In the QUAC parameters dialog, you can leave the **Sensor Type** option as **Unknown**. ENVI already has the wavelength information needed to perform the atmospheric correction.
- Enter a filename for the QUAC output file, then click OK. When processing is complete, the resulting image appears in the image window and Layer Manager. QUAC creates a surface reflectance image, scaled into 2-byte integers using a reflectance scale factor of 10,000. So if you divide the current pixel values by 10,000, you will have the surface reflectance values, scaled from 0 to 1. In the example below, the surface reflectance values over a bright region are:

  - **Red:0.0893 (8.93%)**
  - **Green: 0.0653 (6.53%)**
  - **Blue:0.0818 (8.18%)**

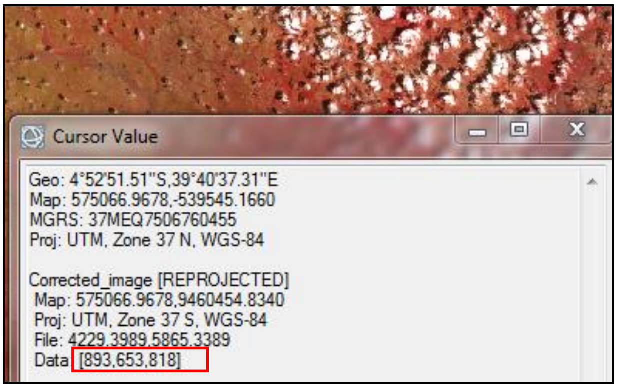


Figure 14: Surface Reflectance Values

4.0 ACCESSING, LOADING, DISPLAYING, STACKING AND RESIZING DATA IN ENVI 4.7

4.1 Exercise 5: Starting the software

Envi can be started using desktop shortcut icons or through program files and Envi 4.7 folder where Envi+IDL or Envi stand alone can be started by a single mouse click as shown below:

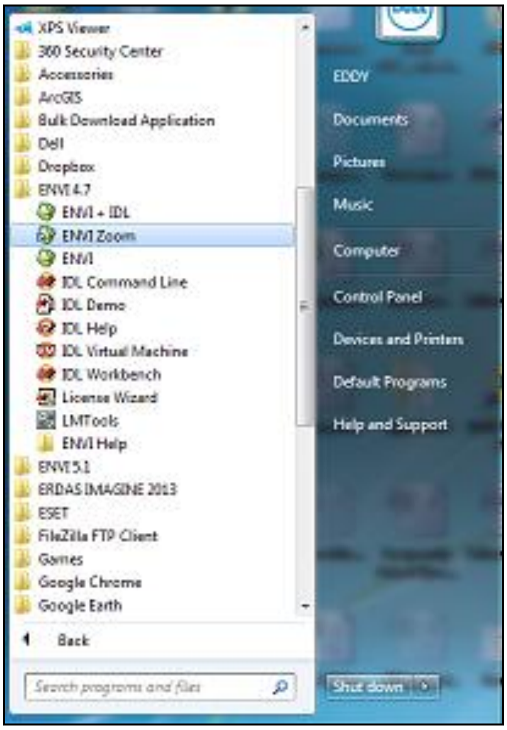


Figure 15: Launching Envi 4.7 through program files Menu

4.2 Exercise 6: Setting Default Data Directory

After starting Envi 4.7 default data directories can be configured using the preferences option in file menu. System preferences dialogue box appears and default directories can be defined. (Set your input default directory to **D:\ TRAINING DATA-LANDSAT 8** and output directory to **D:\ TRAINING DATA-LANDSAT 8\Outputs**)

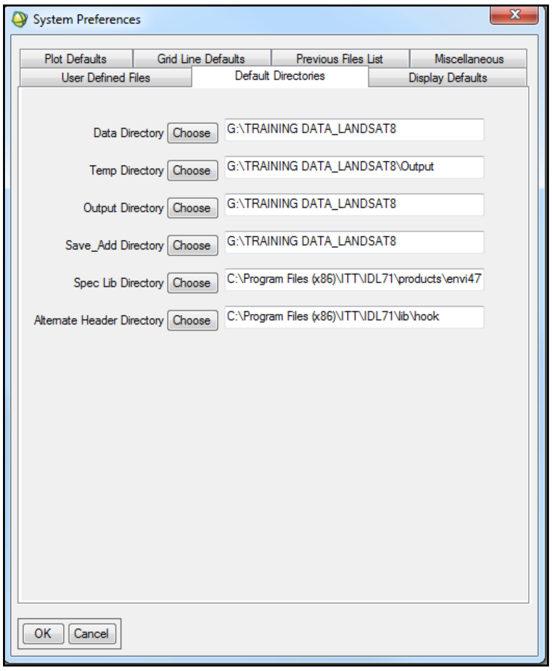


Figure 16: Defined default data directory

4.3 Exercise 7: Adding and Displaying Image

Add Landsat image single bands to the program as shown in Figure 3. The available band list window displays the loaded images Figure 4.

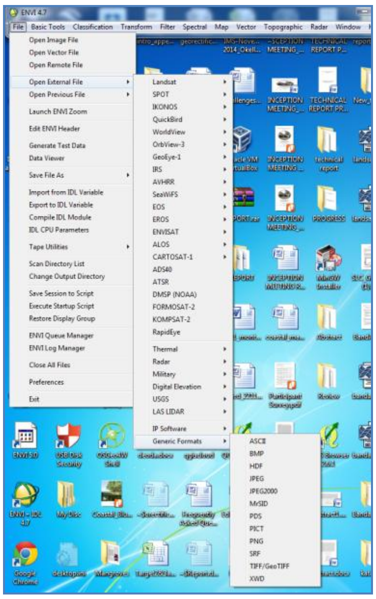


Figure 17: Adding Landsat image (GeoTiFF format) to Envi

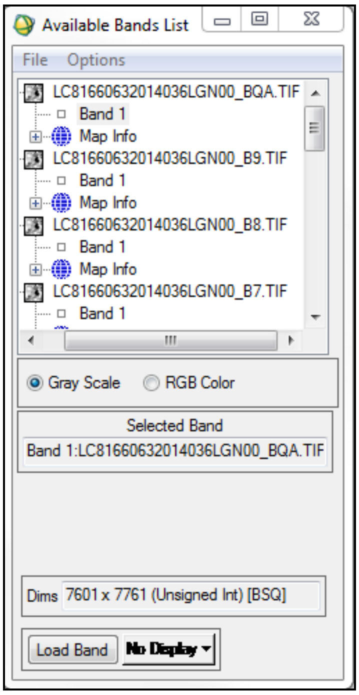


Figure 18: Available list of bands loaded

4.4 Exercise 8: The Display Group

Three windows appear concurrently: zoom, scroll and image window displays.This facilitates interactive visualization. The zoom display window magnifies a selected area with a certain magnifying factor. Scroll window allows interactive movement/panning within the image scene to select an area of interest. Finally, the image window displays a certain portion of the entire scene but not in great detail.

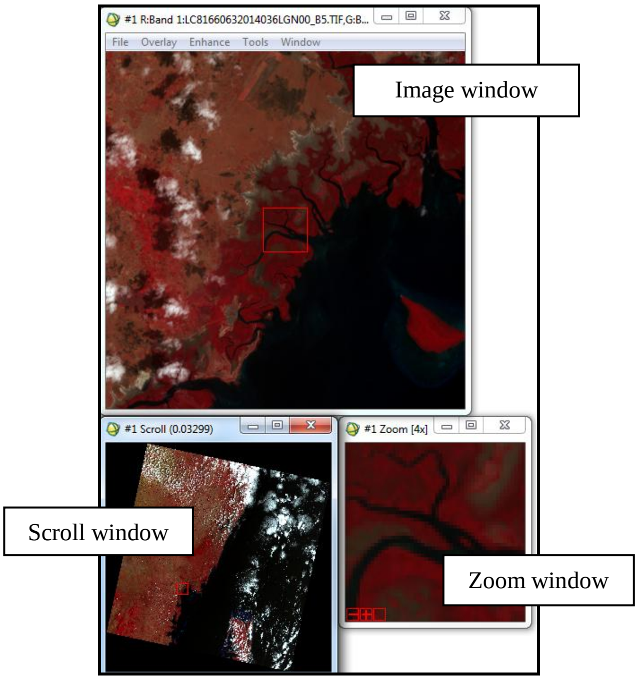


Figure 19: Interactive display window in Envi Classic showing false color composite

4.5 Exercise 9: Developing Image Composites

For maximum feature/object/class selection, composite images are utilized. These images are bands of the same scene acquired using different portions of the Electromagnetic Spectrum. Such images bear different information of that feature extraction. Therefore, Landsat bands should be stacked together to enable display in either natural colour combination (Blue, Green, Red) or false colour composites.

4.6 Exercise 10: Image Layer/Band Stacking

Layer stacking combines several bands and makes it possible to display images in different colour composite depending on aim of the project undertaken. In this practical guide we will use false colour combination: 5, 4, 3 (Near infrared, Red and Green bands) for Landsat 8 OLI (Operational Land Imager) and 4, 3, 2 combination for Landsat 7 EMT+ (Enhanced Thematic Mapper Plus).

	Landsat 7 Landsat 5	Landsat 8
Color Infrared:	4, 3, 2	5,4,3
Natural Color:	3, 2, 1	4,3,2
False Color:	5,4,3	6,5,4
False Color:	7,5,3	7,6,4
False Color:	7,4,2	7,5,3

Figure 20: Displayed below are some common band combinations in various Landsat Imageries ("LANDSAT 8 (L8) DATA USERS HANDBOOK Version 1.0 June 2015," 2015).

False color combination (5, 4, 3): This is the standard "false colour" composite. Vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan. Coniferous trees will appear darker red than hardwoods. This is a very popular band combination and is useful for vegetation studies, monitoring drainage and soil patterns and various stages of crop growth. Generally, deep red hues indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue. Mangroves would appear in deep red hues just along the coastal strip hence is easy to discern and discriminate.

Layer stacking in Envi 4.7: From Envi 4.7 Menu bar go to:Basic Tools > Layer Stacking

Dialogue box in **Figure 21** appears. Click the tab *Import File* in order to choose bands to stack. A layer Stacking input menu **Figure 22** appears where files from the directory can be added via (Open > New File).

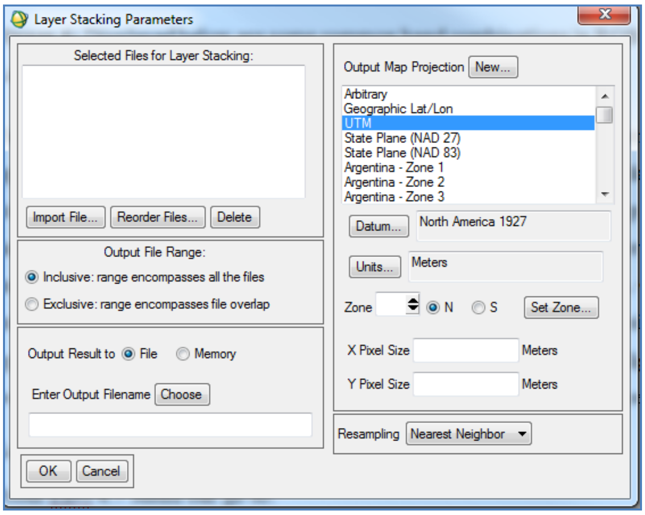


Figure 21: Layer stacking

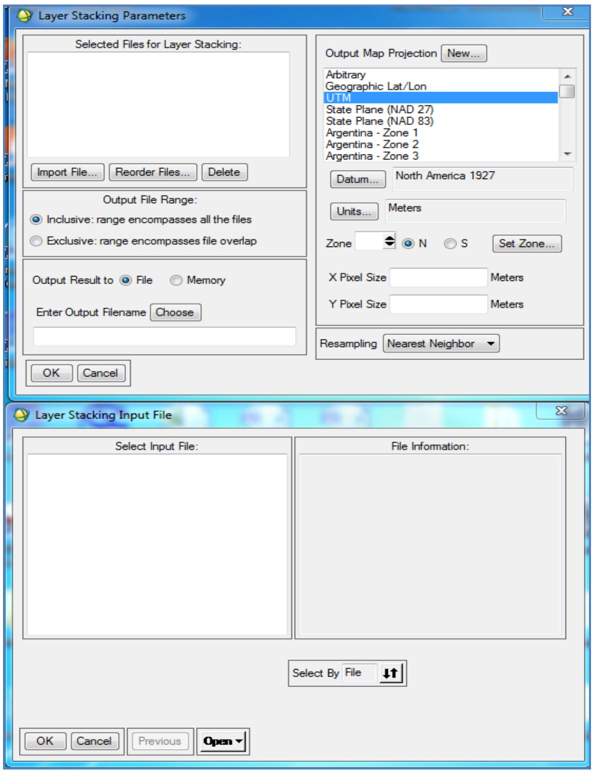


Figure 22: Adding an image from the directory

After adding files for stacking, you can re-order them and when satisfied define an output directory to obtain the output image. See **Figure 23**. After everything is defined, click *ok* to execute the process.

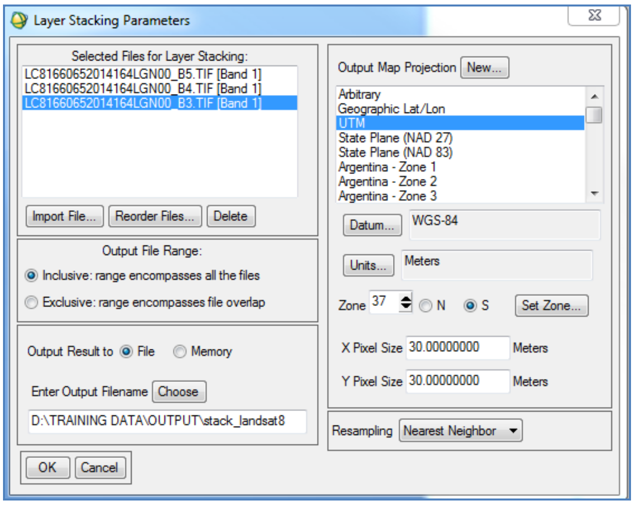


Figure 23: Selected bands for final layers stacking

The stacked images can be displayed in 5,4,3 false colour composite by selecting the RGB color display and passing band 5 through red filter display, band 4 through green filter and band 3 through blue display as shown in **Figure 24** below. The resultant image appears as shown in **Figure 25**.

NOTE: This process can be duplicated for developing other composites.

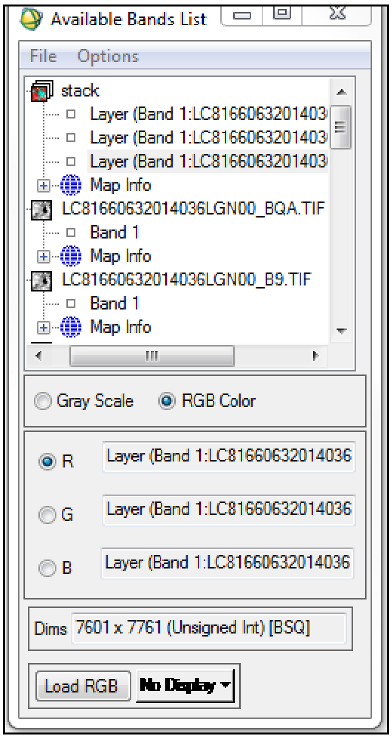


Figure 24: 5, 4 , 3 color composite

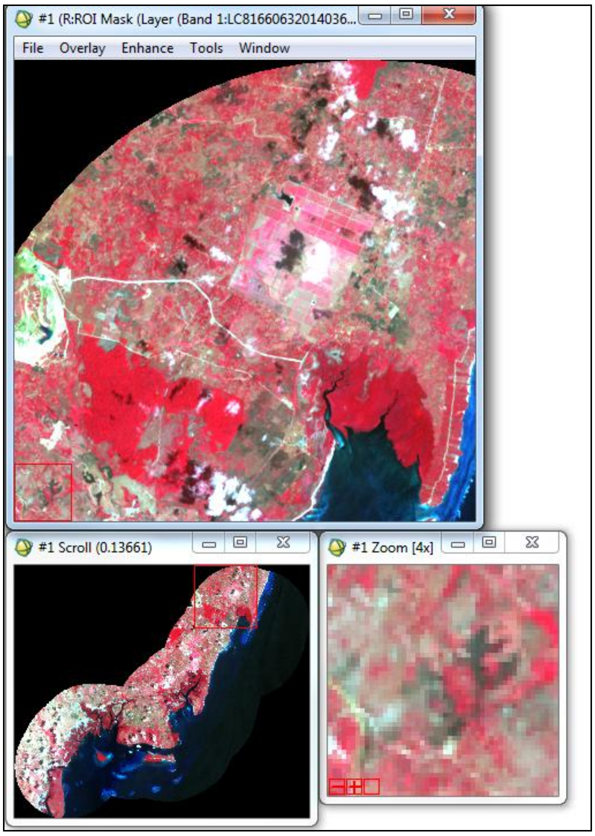


Figure 25: False color composite (5, 4, 3)

4.7 Exercise 11: Image Resizing

NOTE: For this exercise use data in **shapefile** data folder.

According to some previous studies mangroves occur on the coastline and hence is highly unlikely to occur further away from the coast (Kirui et al., 2013). Hence this procedure is important in reducing the size of the image to about 15 km from both sides of the coastline. This ensures that during classification only the features within the boundary (15km buffer) are classified. This is done using a predefined vector file of the region of interest (ROI). In Envi this process is known as subset: From the Menu bar:

Basic Tools > Subset Data via ROIs: First the vector file (**shapefile**) should be loaded into Envi and converted to ROIs as follows. From the Menu bar select: Note: Ensure you select *.shp* extension as you browse to the folder location. After opening the vector file the following dialogue box appears

Vector > Open Vector File

Confirm the parameters in the first dialogue box and click ok then the second dialogue box appears **Figure 26** below.

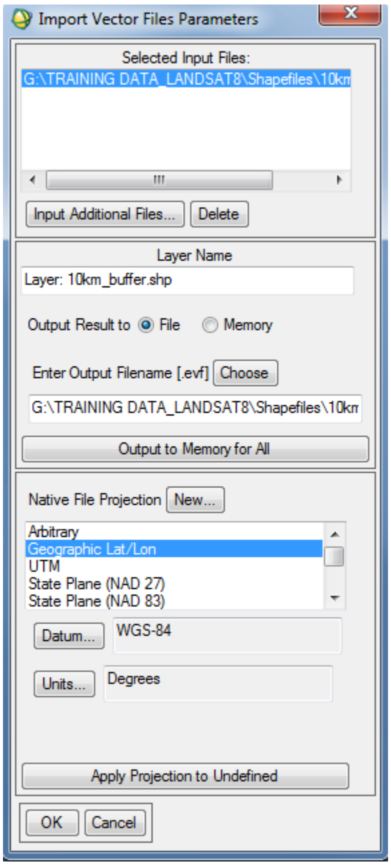


Figure 26:First dialog box

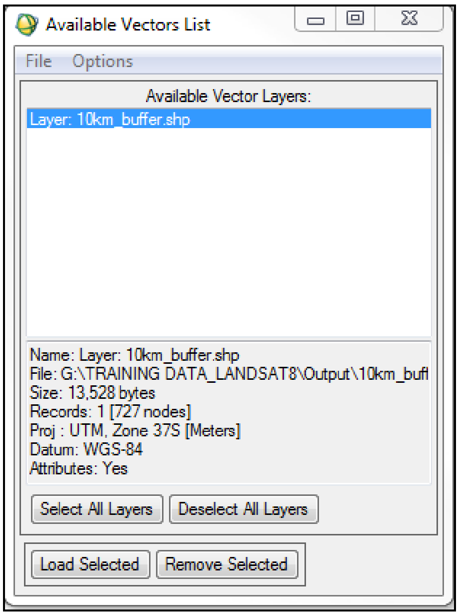


Figure 27: Second context box

From second context **Figure 27** export the shapefile to Envi ROI file as follows: *File* > *Export Layers to ROI*

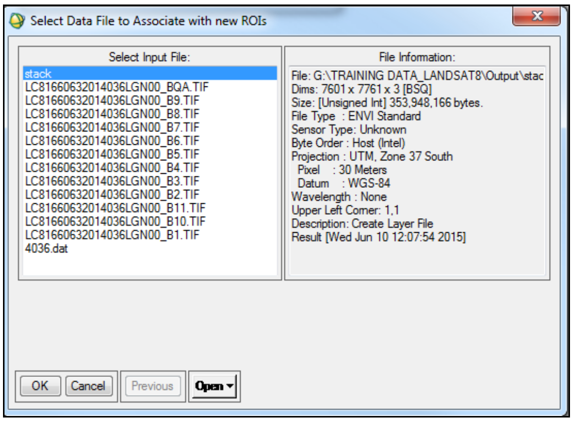


Figure 28: Selecting an image to use as a base for exporting shapefile to ROI

Once the image is selected another dialogue box appears with an option to convert all records to one ROI or convert each record to new ROI files see **Figure 29**. Select the first option and click ok.

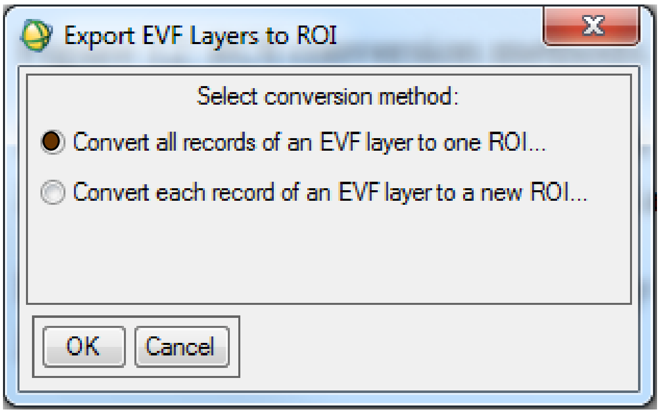


Figure 29: ROI conversion methods

In order to view the converted ROIs go to the image viewer and: *Tools* > *Region of Interest* > *ROI Tool*. A window will appear showing the ROI.

From this point we are ready to clip the image using: *Basic Tools* > *Subset Data Via ROIs*

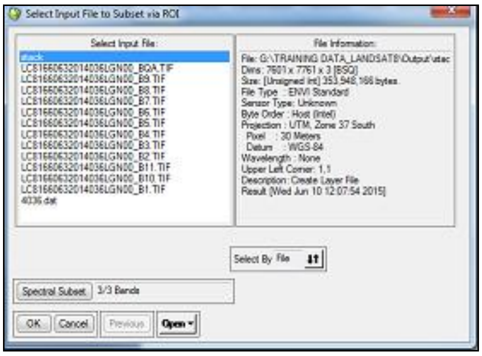


Figure 30: Selecting the image to subset

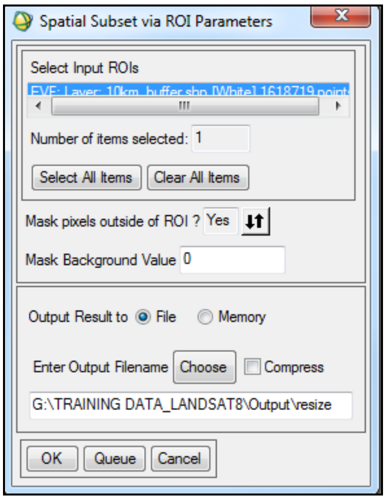


Figure 31: Accepting masking of pixels

Select the image to subset **Figure 30** and select the ROI to use, accept masking of pixels outside of the ROI and select a background value **Figure 31. NB**: Once the process is executed load the clipped/resized image from the available band list.

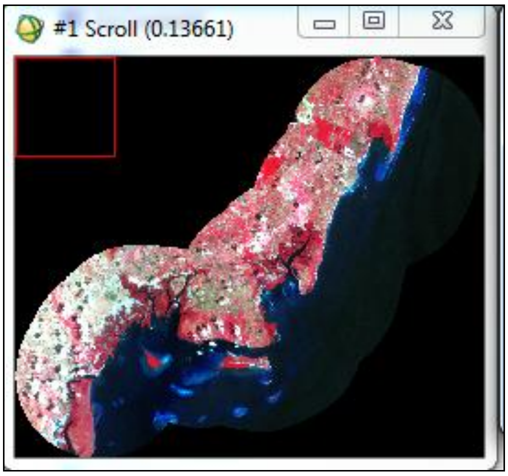


Figure 32: Resized image

5.0 VISUAL IMAGE INTERPRETATION

Image interpretation is the act of examining images with a goal of identifying objects and judging their significance.This is process is very important in training site selection which is a critical step in image classification. Training sites are areas in the image that are known to be representative of a particular land cover type – for each land cover type of interest.

Elements of image interpretation aid in identifying the sites during the process of training site selection, they include: Tone/colour, texture, size, height, shadow, shape, pattern and site and association. Such classes in image interpretation act as training sites (spectral examples of classes). Landsat band combinations can be used to enhance the extraction of classes or features from the images. The following combinations are among several used for different applications.

NOTE: Band combination vary from intended application and sensor types. Combinations presented below applies to Landsat 8 OLI.

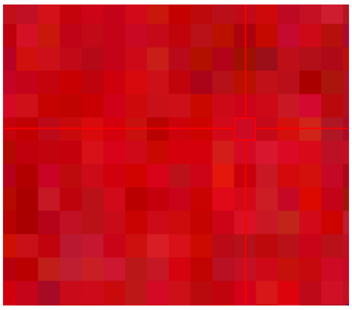
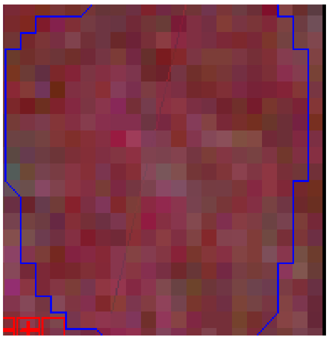
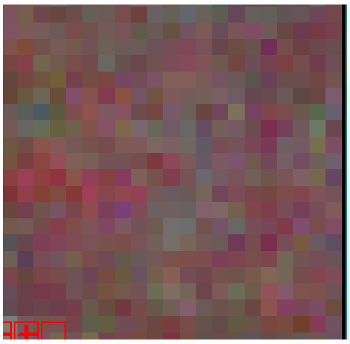
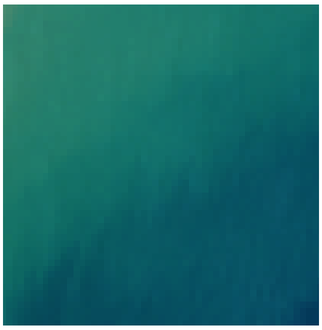
5.1 Exercise 12: Landsat True-Color Composite (RGB: 4, 3, 2)

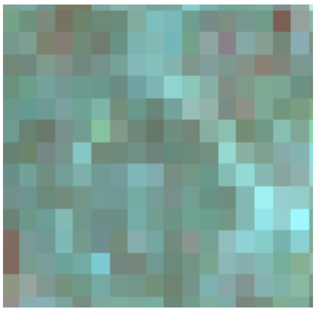
True-color composite images approximate the range of vision for the human eye, and hence these images appear to be close to what we would expect to see in a normal image or photo. For instance, healthy vegetation appears as green, recently cleared fields are very light, unhealthy vegetation is brown and yellow, roads are gray and shorelines are white. This band combination provides the most water penetration and superior sediment and bathymetric information. True-color images tend to be low in contrast and somewhat hazy in appearance. This is because blue light is more susceptible than other bandwidths to scattering by the atmosphere. Broad-based analysis of underwater features and land-cover are representative applications for true-color composites.

5.2 Exercise 13: Near Infrared Composite (RGB: 5, 4, 3)

Adding a near infrared (NIR) band and dropping the visible blue band creates a near infrared composite image. This is standard "false colour" composite. Vegetation appears in shades of red, urban areas are cyan blue and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan.Vegetation in the NIR band is highly reflective due to chlorophyll, and a NIR composite vividly shows vegetation in various shades of red. Water appears dark, almost black, due to the absorption of energy in the visible red and NIR bands.

Table 1: Samples of Training Areas using Landsat 8 false colour composites

1) Very dense  5 4 3 RGB	2) Dense  5 4 3 RGB
3) Moderately Dense  5 4 3 RGB	4) Sparse forest/Grassland  5 4 3 RGB
5) Water/Suspended  5 4 3 RGB	6) Water at deep sea  5 4 3 RGB

7) Urban/Bare	8) Clouds and shadows
	
5 4 3 RGB	5 4 3 RGB

6.0 IMAGE ENHANCEMENT

During the image interpretation some images may have poor contrast. Such images may limit or slow the process of visual image interpretation. In such cases image enhancement can be used.

6.1 Exercise 14: Enhancing the Image

Enhance Menu tools in image window > Enhance. **Figure 34** can be used to perform quick contrast stretches, to perform interactive contrast stretching using histograms and to apply quick filter enhancements to displayed data. These enhancements are not applied to the data files. Any of the enhancement options can be used and the changes are reflected in the image immediately.

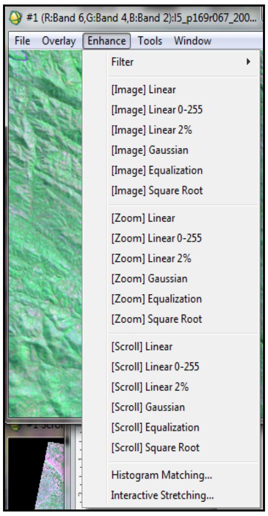


Figure 33: Image enhancement methods

7.0 CREATING TRAINING SITES

NOTE: For this exercice, six (6) class types will used i.e Mangroves, Non-mangroves, Water, Bare/Urban, Clouds and Shadows.

Areas in the image that are known to be representative of a particular land cover type should be digitized. Sample training areas are then used as spectral signatures during classification. After loading the image to be classified, training areas are created as follows:

From the image window go to:

7.1 Exercise 15: Accessing the ROI Tool

Tools > Region of Interest > ROI Tool The *ROI Tool* when opened allows sites of representative classes to be added and later used for classification as follows;

- To add new ROI use *the New Region* button
- In order to rename the created *ROI* double click it and a cursor appears giving you the chance to rename the file.

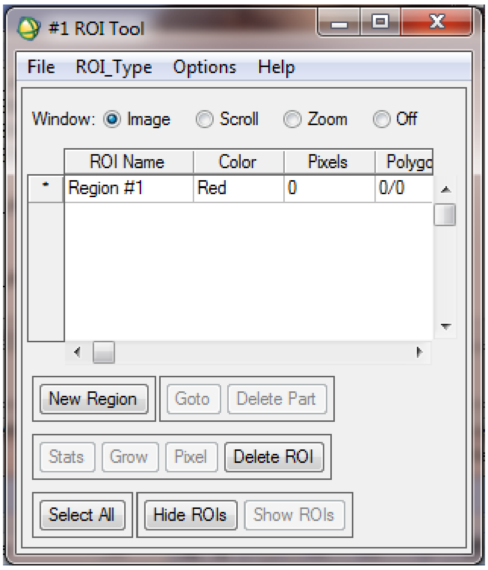


Figure 34: ROI tool used for collecting training sites.

Training areas can be digitized from the image, scroll or zoom display windows; currently the image display window is selected.

ROI Types: *Points, polyline, polygon, rectangle or ellipse* can be used to extract the sites i.e. go to *ROI Type* to select these options **Figure 35**.

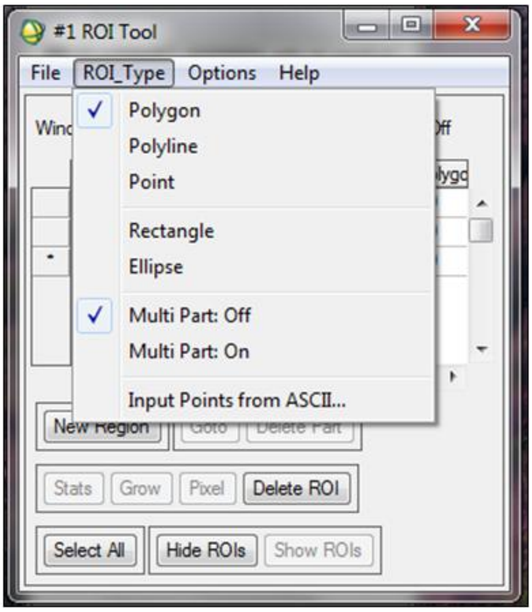


Figure 35: ROI types used for extracting training sites

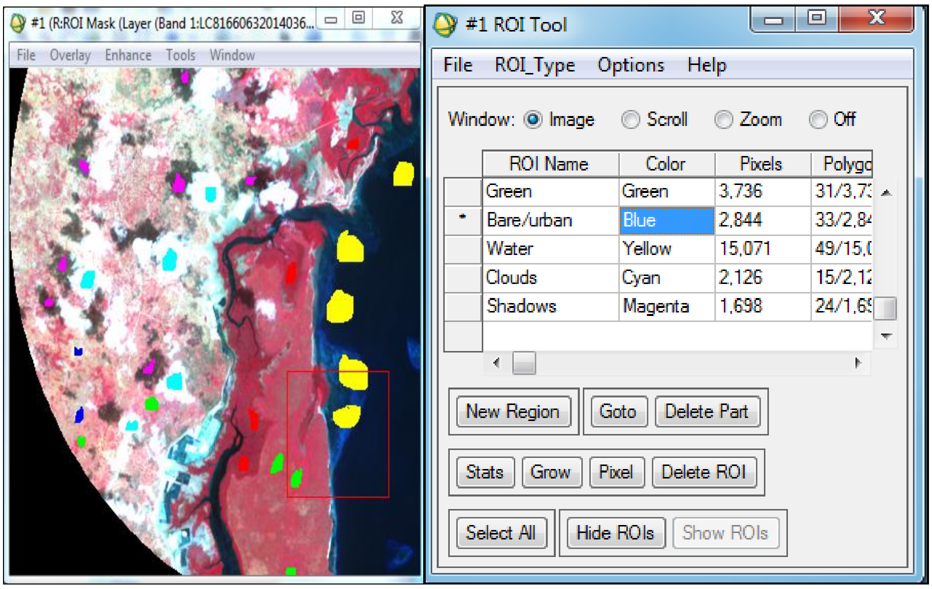


Figure 36: Selected training sites

Deleting ROIs: In the process of creating the ROIs in the ROI tool, wrongly added polygons can be deleted by going to the area (using *Go to button* in the ROI tool) then using the active display in the ROI Tool (in this case zoom) position the cursor on top of the site and press down the scroll button of the Mouse.

8.0 IMAGE CLASSIFICATION

Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information. There two approaches in classification (supervised and unsupervised). For the purpose of this short training, we shall use a supervised classification technique known as the Maximum likelihood probabilistic method.

Exercise 16: Maximum likelihood classification (MLC)

- Maximum likelihood classification (MLC) can be executed from the standard menu:

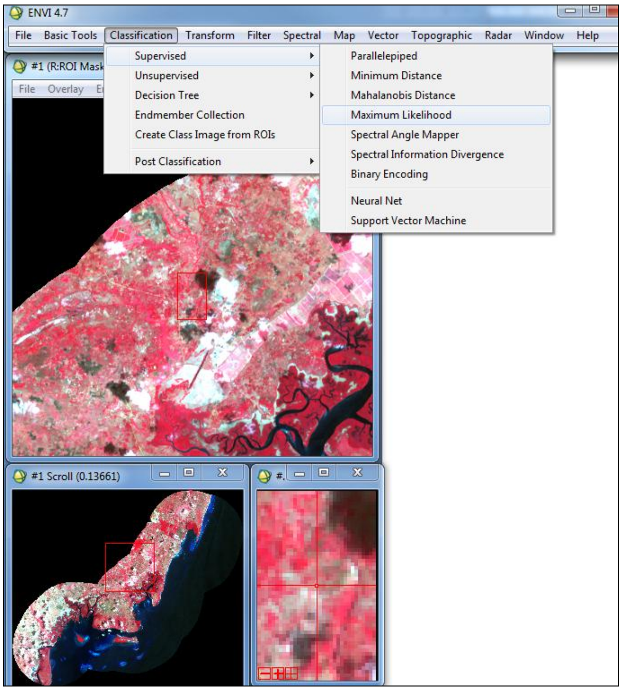


Figure 37: MLC (Maximum Classification Classifier)

- On accessing the maximum likelihood tab a dialogue box appears giving an option to select the input image. After selecting the input image and number of bands to be used (*using Spectral Subset*) a window appears which enables the Training areas created using the ROI Tool to be selected see **Figure 40** below.

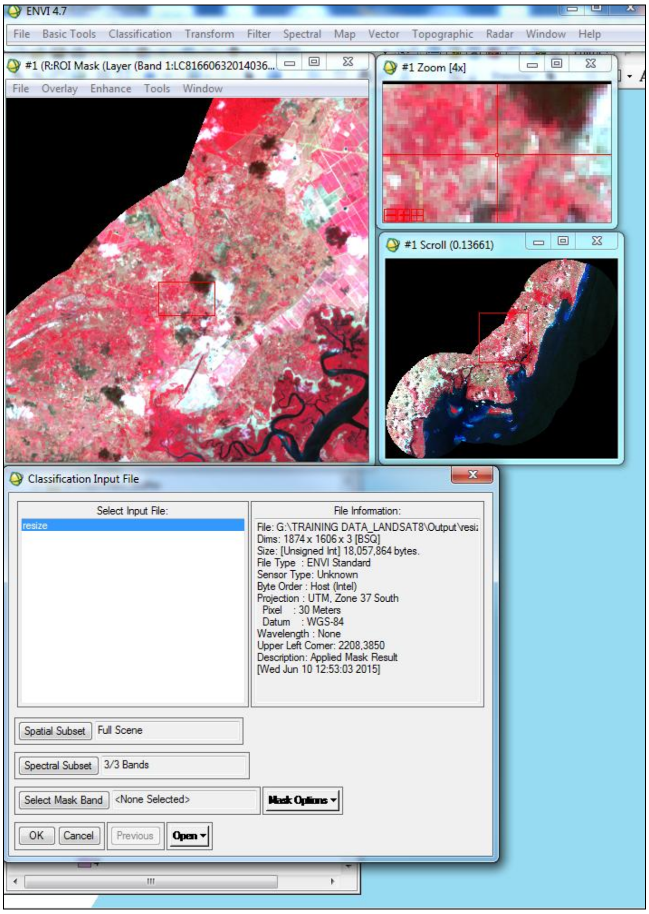


Figure 38: Selecting an input for MLC

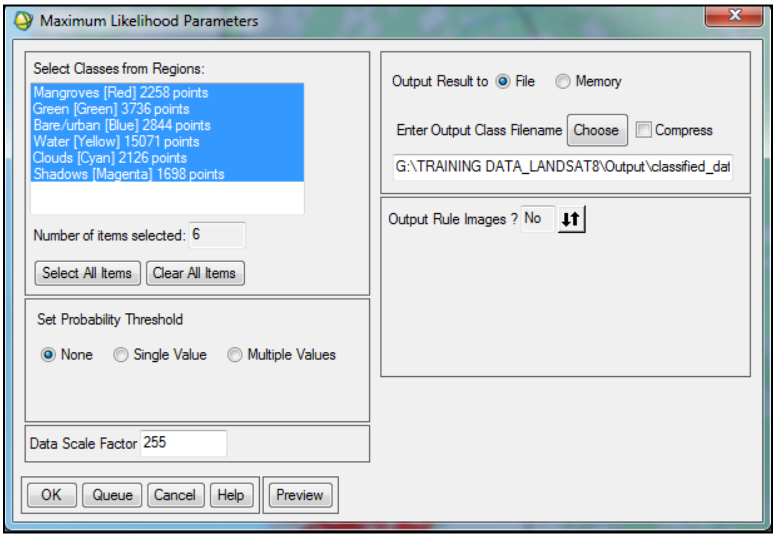


Figure 39: Selecting training areas to be used as spectral signatures

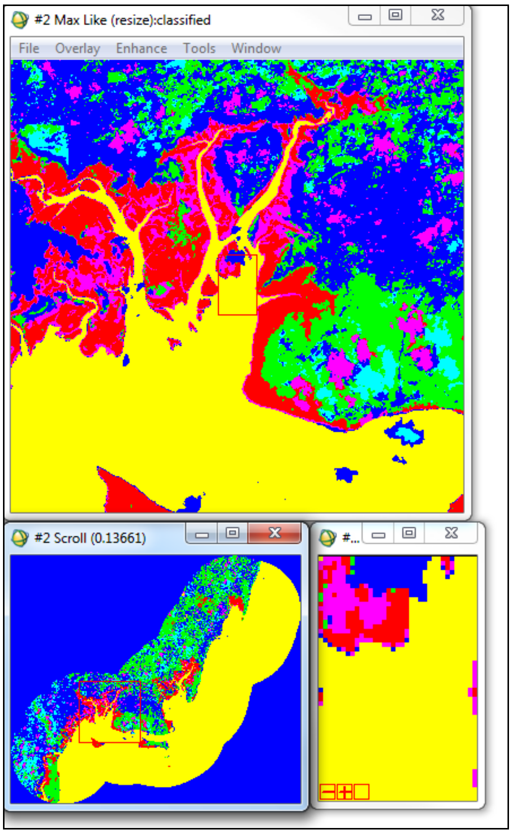


Figure 40: Sample of a classified image

9.0 POST- CLASSIFICATION SMOOTHING

Exercise 17: Postclassification through majority/minority analysis

After applying MLC, smoothing should be done on the classified images in order to eliminate the effect of salt and pepper that is common with pixel based methods. In Envi 4.7 this is done through minority/majority analysis to remove such effects (salt and paper). The following procedure is applied: *Classification* > *Postclassification* > *Majority/Minority Analysis.*

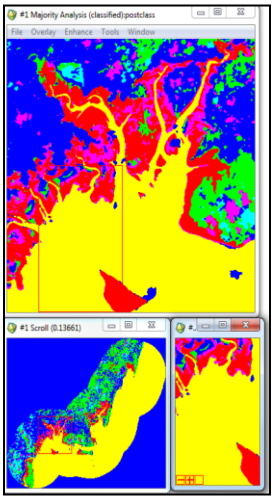


Figure 41: Filtered Image

10.0 GROUND - TRUTH DATA COLLECTION

Verification is a key phase in terms of the generation of data and information products from remotely sensed data. Accuracy assessment allows one to both determine whether the data achieves a predetermined minimum acceptable level of accuracy and to determine the uncertainty in the data produced. At each location, based on the Landsat 7 & 8 mangrove cover derived maps, randomly selected mangrove sites were surveyed. Randomly generated non-mangrove sites were also surveyed. Due to the scale of the imagery used in creating the cover map (30m x 30m pixels), the surveys had to incorporate sufficient distance between data points at each site.This was in accordance with the methodology proposed by ICFI (2009). There were no local maps with known accuracy or sufficient field data available to assess relative accuracy. Hence, we based our estimation of classification accuracy on independent and systematic method for selecting validation points. We used random points separated by 200 metres within random sampling blocks. Due to time and logistical limitations, we assessed the areas we did not collect validation points from by visual interpretation of high-resolution images (Digital Globe) in Google Earth software. We only used the areas identified as mangroves on the landcover map or in Google Earth. In total, some 258 survey points were collected across the sampling blocks visited. Surveys were conducted at the randomly selected mangrove sites, using the GPS coordinates.

11.0 ACCURACY ASSESSMENT PROCEDURES

The random sample validation points from field will be used for accuracy assessment using the error matrix/confusion matrix. The confusion matrix shows the proportion of correctly classified and misclassified pixels in a matrix and therefore several accuracy measures can be derived from it.

11.1 Exercise 18: Performing accuracy test

- Open ***Classified*** classified image, i.e. go to *File* > *Open Image File* then browse to ***output*** Folder inside ***TRAINING DATA_LANDSAT8*** folder **Figure 43**.

- Open vector in ***Accuracy Test*** Folder (contains all shapefile of categories sampled and observed in the field) **Figures 44**. Locate by: Vector > Open Vector File. Then export the layers to ROI (*Convert each record of an EVF to a new ROI*) using the loaded classified as base **Figures 43.**

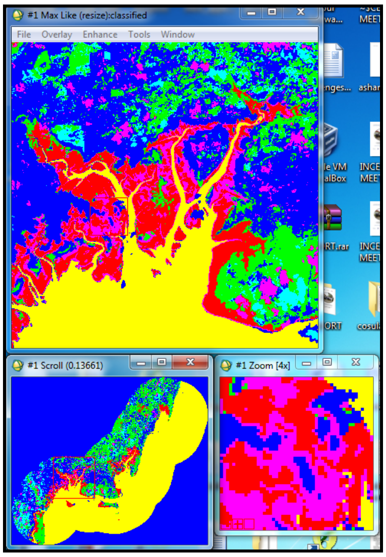


Figure 42: Base Image

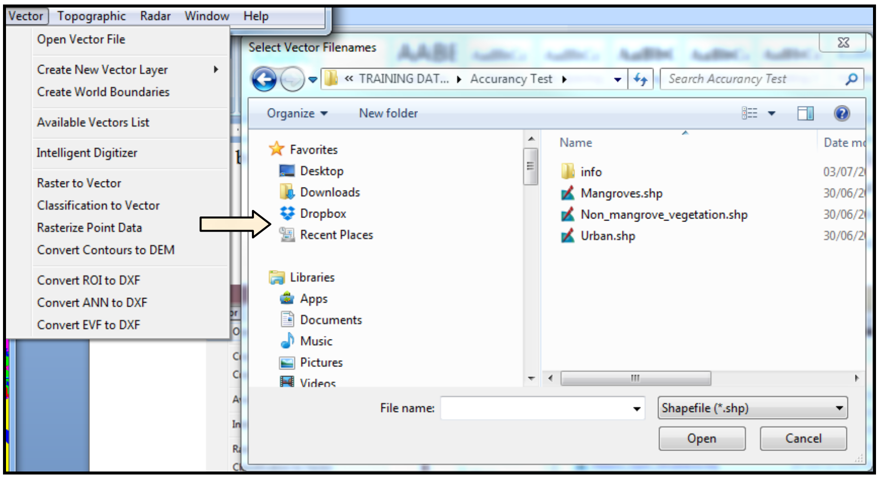


Figure 43: Accessing the class category layers

➢ Export the layers you opened into ROI and convert them into one record using the option *(Convert all records of an evf to one ROI)* see **Figure 45.**

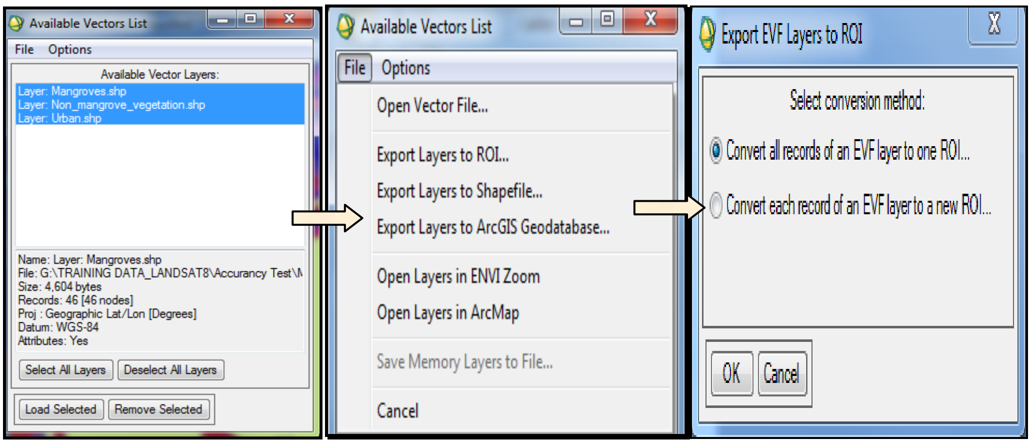


Figure 44: Using a base image to Convert all records of an evf to one ROI for use in accuracy assessment

➢ Confirming the converted layers > Open the ROI tool to view the converted layer **Figure 46.**

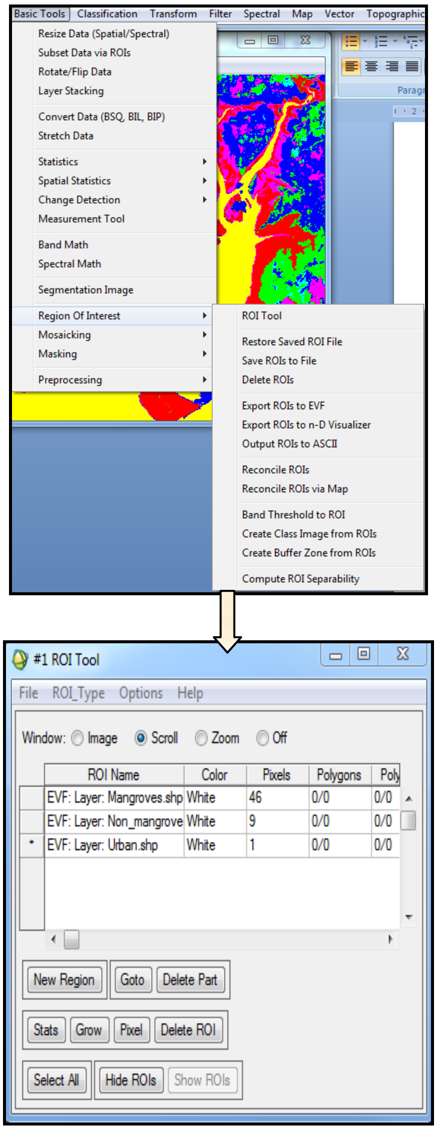


Figure 45: The converted shapefiles to ROIs

- Click > *Classification* > *Postclassification* > *Confusion Matrix* > *Using Ground Truth ROIs.* To start the accuracy assessment tool using ground truth ROIs see **Figure 47** and select the land-cover as a base image.

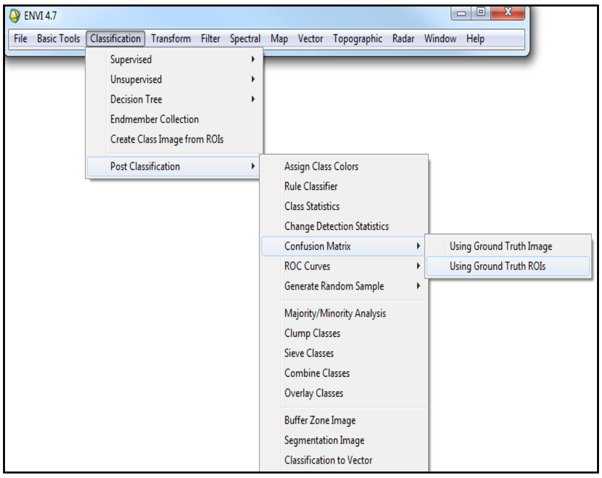


Figure 46: Performing accuracy assessment tool using ground truth ROIs

- ➢ A dialogue box will appear allowing you to match the classes in the image with ground truth points. Select corresponding combinations then click on *Add Combination.* In this case the there are only three layers to match with i.e. Mangroves corresponds with mangroves, Non-mangroves corresponds to Non-mangroves and Urban corresponds with Bare/Urban **Figure 48.**

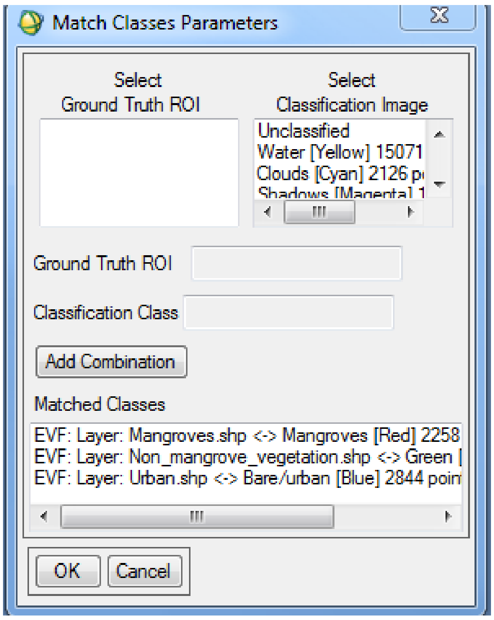


Figure 47: Equating ground truth data with classified image

- ➢ Finish the process of matching the classes and ground truth data by accepting the parameters in the dialogue box that pops up below to generate the report **Figure 49.**

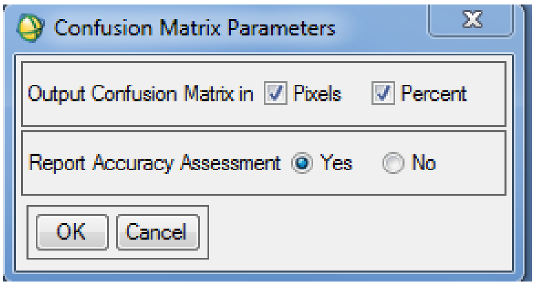
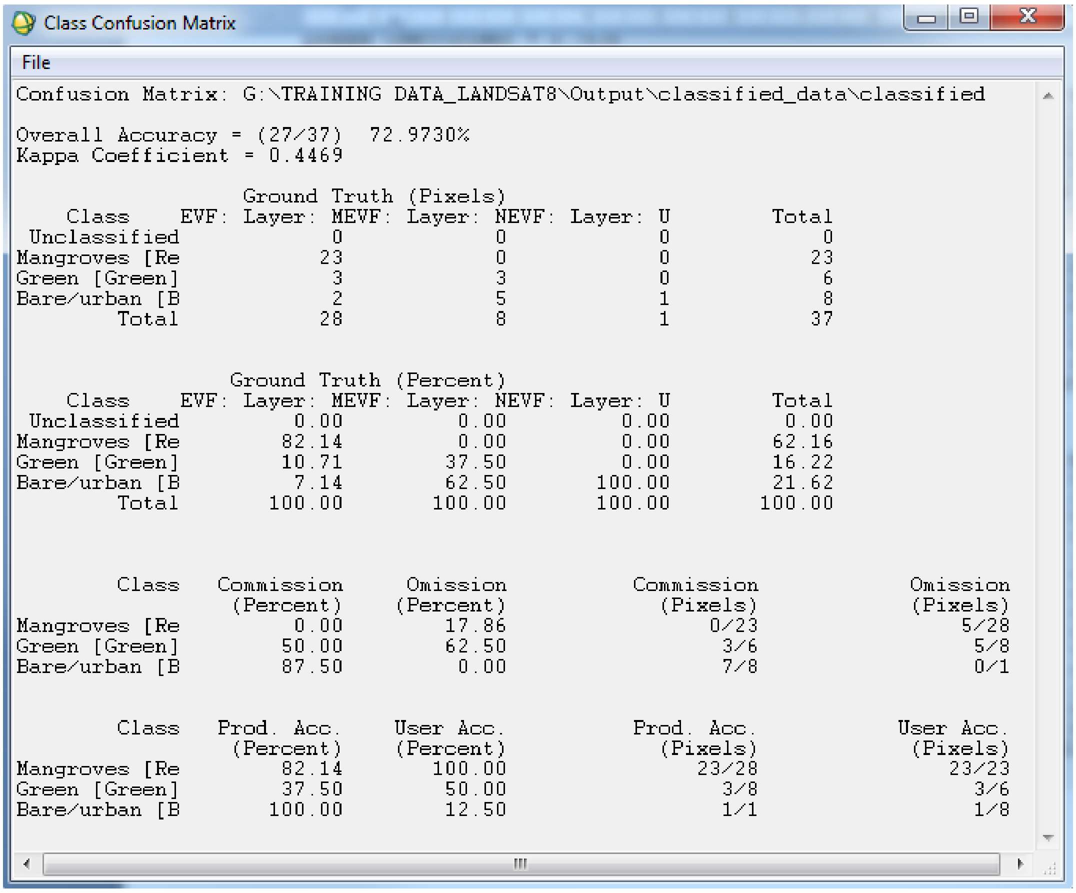


Figure 48: The parameters sets for generating accuracy report

- Confusion matrix is generated automatically by the software, containing class accuracy and overall accuracy Figure


Class Confusion Matrix

File

Confusion Matrix: G:\TRAINING DATA_LANDSAT8\Output\classified_data\classified

Overall Accuracy = (27/37) 72.9730%
Kappa Coefficient = 0.4469

Ground Truth (Pixels)

Class	EVF: Layer: MEVF:	Layer: NEVF:	Layer: U	Total
Unclassified	0	0	0	0
Mangroves [Re	23	0	0	23
Green [Green]	3	3	0	6
Bare/urban [B	2	5	1	8
Total	28	8	1	37

Ground Truth (Percent)

Class	EVF: Layer: MEVF:	Layer: NEVF:	Layer: U	Total
Unclassified	0.00	0.00	0.00	0.00
Mangroves [Re	82.14	0.00	0.00	62.16
Green [Green]	10.71	37.50	0.00	16.22
Bare/urban [B	7.14	62.50	100.00	21.62
Total	100.00	100.00	100.00	100.00

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Mangroves [Re	0.00	17.86	0/23	5/28
Green [Green]	50.00	62.50	3/6	5/8
Bare/urban [B	87.50	0.00	7/8	0/1

Class	Prod. Acc. (Percent)	User Acc. (Percent)	Prod. Acc. (Pixels)	User Acc. (Pixels)
Mangroves [Re	82.14	100.00	23/28	23/23
Green [Green]	37.50	50.00	3/8	3/6
Bare/urban [B	100.00	12.50	1/1	1/8

Figure 49: Confusion/Error Matrix

11.2 Interpretating the Error/Confusion Matrix

Accuracy of each class was expressed as a matrix showing errors of commission and omission. This was derived from the field data points and extracted points from the classification map. Overall classification accuracy and Kappa coefficient was computed i.e 72.97 and 0.45 respectively. Overall map accuracy was computed by dividing the total number of correctly classified pixels by the total number of reference pixels in the error matrix. Overall accuracy uses only the main diagonal elements of the error matrix. The accuracy of individual categories is computed by dividing the corresponding row or the corresponding column. When the number of correct pixels in a category is divided by the total number pixels in the corresponding row (i.e. the total number pixels that were classified in that category), the result is an accuracy measure called "user's accuracy" and is a measure of commission error. "User's accuracy", or reliability, is indicative of the probability that a pixel classified on the map actually represent that category on the ground. On the other hand, when the correct number of pixels in a category is divided by the total number of pixels in the corresponding column (i.e. the total number of pixels for that category in the reference data) the result is called "producer's accuracy". Producer's accuracy indicates the probability of reference pixels being correctly classified and is really a measure of omission error. For this particular training both the overall accuracy is lower than the limits of U.S. Geological Survey's suggested threshold of 85%. Though, the overall accuracy wholly depends on how the accuracy assessment regions of intrest are selected for a particular region.

12.0 SUMMARY

This training manual and products were developed using LandSat 8 OLI data, a supervised classification method was used. It involves the creation of training sites and then the use maximum likelihood classification method to develop the land cover products.Post classification procedures such as filtering, pixel/cell editing are used to refine the classification of the final products. Accuracy assessment was conducted using randomly generated actual field data and point interpretation from LandSat imagery. Used indices for assessing the map accuracy were the Overall accuracy and the Kappa coefficient. At the end of the training, the participants are expected to have acquired skills in image acquisition, exploration, analysis, visualization, enhancenment, classification and interpretation. Besides, the students will have gained skills in GIS, the generation of indices for assessing map accuracy, and interpretation of such indices.

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