Intermediate Remote Sensing and GIS

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FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

CEGIS

Intermediate Remote Sensing and GIS

Training Manual Developed by CEGIS, USFS and BFD, 2014 -15

Preface

In January 2013, the United States Agency for International Development (USAID), the Bangladesh Forest Department and the United States Forest Service (USFS) began a collaborative project to address capacity needs in geospatial skills for natural resources management for staff of the Bangladesh Forest Department. Through this project, the USFS, together with local partner Center for Environmental and Geographic information Services (CEGIS), developed and carried out a series of workshops and trainings. These manuals consolidate the coursework and materials from three of these trainings:

1) Global Positioning Systems (GPS) 1
2) GPS 2
3) Training of Trainers for GPS

These courses were developed jointly by CEGIS and the USFS and taught by CEGIS. The initial course provided an introduction to maps and hands-on instruction in the use of GPS units. GPS 2 went more in-depth into the GPS technology, providing training in GPS unit operation, data collection, maps, navigation and data storage. The Final course, Training of Trainers, taught a selected group of Bangladesh Forest Department staff how to teach GPS use to their colleagues, with the plan to replicate this training nationwide.

This series of three manuals has been consolidated by CEGIS with input from the Remote Sensing Applications Center (RSAC) and the Flathead National Forest of the USFS. In addition to the course work, the manuals also include valuable reference materials. They can be used as a refresher for participants in these workshops or other workshops on GPS. Students who want to teach themselves about these subjects can also use these manuals as self-guided teaching materials. Finally, these manuals can be used by instructors to teach foresters or others about GPS tools and their applications.

We hope that these manuals are useful to you to refresh and further develop your GPS skills for management and monitoring of natural resources.

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Table of Contents

Introduction

The Manual on Intermediate Remote Sensing and GIS is for both the trainees and trainers through they have different objectives to achieve.

This Manual has been designed as a resource tool for those who would be using remote sensing and GIS in their area of work. It is expected that the Intermediate Remote Sensing and GIS Manual will on one hand, substantially enhance the capacity of those who will be imparting information and knowledge on the subject as Trainers, and on the other hand, develop the capacity of the Trainees to enable them to use these information and knowledge effectively, in their line of work.

It is underscored, that the Trainees or the participants of the training on RS & GIS will benefit more by constantly consulting the manual, during the post-training period, as it will reinforce their learning of the application of the remote sensing and GIS, and to apply the learnt skills, successfully.

The Trainers will go through this manual to make an assessment of their own knowledge and understanding of the subject, fill their own knowledge gaps on this subject matter, if found any, and decide on the approach to suitably present/facilitate knowledge and skills learning to the Trainees. They may use this manual as a support material for conducting the sessions.

The contents of the manual are organized under 6 (Six) Sections or Lessons. Each Lesson comprises a lecture [composed of several topics that cover the main subject of the Lecture] and an end of lesson knowledge and skills practice session. In addition, key objectives to be achieved after completion of each Lesson have been stated clearly so that the user is focused on the learning being transferred through each of the lessons. Topic-wise detailed notes have also been included as supplementary information. Moreover, notes also include additional reference links. Knowledge and skills practice sessions have been planned and developed with a view to help the users to assess what they learn from each lesson and explore the significance of ArcPad software with Trimble Juno, ERDAS Imagine software and ArcGIS software in Remote Sensing and GIS.

In all, this RS & GIS Manual is intended to assist in developing human resource capacity for Bangladesh Forest Department through an intermediate knowledge on Remote Sensing and GIS concepts and their different applications.

Lesson-1

Mapping Project Phases

Objective

By the end of this lesson, the participants will be able to :

1. Identify the different phases of Mapping Project
2. State the significance of different phases of Mapping Project

Mapping Project Phases

A mapping project comprises the following steps:

a) Planning
b) Geospatial Data Acquiring& Preprocessing
c) Producing Map Feature
d) Assembling Reference Data
e) Classifying Images
f) Drafting Map Review, Finalizing Map Development & Assessing Accuracy

Planning:

Project planning is the most important and crucial step to efficiently complete the project. Planning must be reviewed by the skilled person who has the required experience to handle such a type of project. You have to have a definite goal while preparing a map. At first, identify the major classes with definition and set the scale of this map. In the following step, you will identify the resources like skilled person, software and such according to the actual budget of this project.

Geospatial Data Acquiring& Preprocessing:

According to project planning, check the required data like raster data, vector data. If any recent raster data is required then order the respective organization for new acquisition. It needs some time to acquire and processing the data. This time should be included in project time sheet. The available satellite image will be processed using high configuration computer. It also requires skilled person to process this satellite images.

Producing Map Feature:

Identify the map units and delineate the map features according to available satellite images. A map feature is the individual unit of the map. This could be either a pixel (raster) or polygon. A map unit is a map category that you are interested in developing. Both of these must be defined prior to developing a map. For example, the map feature might be a single polygon and the specific map unit might be “dense forest”.

After identifying the map units and map features, segmentation of satellite images will be performed. Segmentation is a trial and error process. You will justify which segmentation is better to reach the goal of your mapping. There are different software that are used to segment the image object like eCognition, ERDAS Imagine etc. Sometimes you may not want to "segment" an image to create polygons but rather just use the image cells as the map feature. For instance, you could build a continuous pixel map of tree cover ranging from 0-100%. Following are the characteristics of map units and map features that should be considered while producing a map:

Map Units

- Dominance types, canopy cover, tree size class
- To be exhaustive
- To have mutually exclusive classes
- To be field applicable
- To be map-able

Map Features

- Determine the minimum map feature size
- Identify the source image data
- Determine feature delineation methodology

Assembling Reference Data :

Reference data may be a existing field data, photo interpreted data, high resolution satellite images, field visited sites etc. Time and cost is involved in selecting the reference data of your project. For example, if you plan to validate your map with field data then you need to include a field trip cost in your project workflow. Generally, integration of photo-interpreted data and field visited data are used as a reference data for any study.

Note: The details of reference data collection will be discussed in 'Advanced Remote Sensing and GIS Manual'.

Classifying Images :

Classification is performed according to project objectives. Reference data help to delineate the classes. Classification will be completed using different rules in the process tree of classification model. This classification gives an idea about the coverage of individual classes. Models built using the reference data are applied to assign the "un-labeled" map features. Image classification is an iterative process.

Drafting Map Review, Finalizing Map Development & Assessing Accuracy

Data Layers Reference sites Random Forest Model Development Model application

After classification, hardcopy and digital map are supplied to the local forest offices. The resource person will check the map. Accuracy assessment is performed using recent ground truth and photo interpreted data. If any error or problem is found in the map which does not represent his area, then it is reclassified again.

Recommendations

Project planning is necessary to complete any project successfully. Start the planning process at least 12months before any work begins. Identify the mapping objectives and map class with the help of the expertise. Different map may be required for different purposes. Develop a field data collection form before the start of field program.

Note: Actually 12 months is rule of thumb but the point is that it should start a while before the project begins so that all interested parties have time to discuss needs and define outputs.

Lesson Review

- ✓ Different phases of Mapping Project
- ✓ Significance of different phases of Mapping Project

Lesson-2
Overview of Geospatial Tools

Objective

By the end of this lesson, the participants will be able to:

1. Tell what Geospatial Tools are.
2. Tell the outline of Geospatial Tools, Remote Sensing, GIS, and GPS.

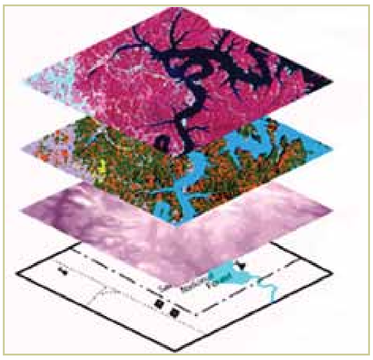
What are Geospatial Tools

Geospatial technology refers to equipment used in visualization, measurement, and analysis of Earth's features, typically involving such systems as GPS (Global Positioning Systems), GIS (Geographical Information Systems), and RS (Remote Sensing). Its use is well-known and widespread in the military and in homeland security, but its influence is pervasive everywhere, even in areas with a lower public profile, such as land use, flood plain mapping and environmental protection.

Source: http://www.usnews.com/science/articles/2011/05/11/geospatial-technology-as-a-core-tool

Remote Sensing

Provides view of the world



Geographic Information Systems

Stores and manages information about the world

Global Positioning Systems

Determines location in the world

Overview of Geospatial Tools

Integration of Remote Sensing, GIS and GPS plays a key role for forest inventory and identifying deforestation. Now a day's Remote Sensing, GIS and GPS are used in land use and land cover mapping of the forest area of Bangladesh. Bangladesh Forest Department personnel frequently use GPS to delineate the current status of forest area. Following are some examples of application geospatial tools:

- Map forest canopy changes using remotely sensed images
- Navigate and collect site specific information on the ground using a global positioning system (GPS)
- Store boundaries and attributes for a project area in a geographic information systems (GIS)

Overview of Remote Sensing

Satellite images with different resolution area used in different projects. Generally coarse resolution satellite image will be used for planning and preparing any proposal. Medium and high resolution satellite image will be used in project work. Arial photo is not frequently used in forest inventory.

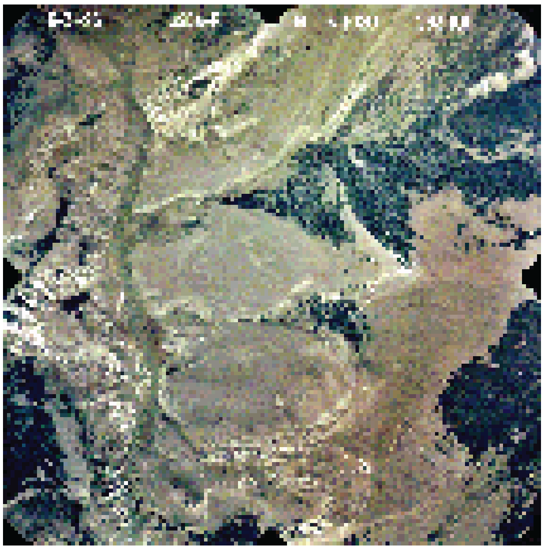
Higher-resolution satellite image

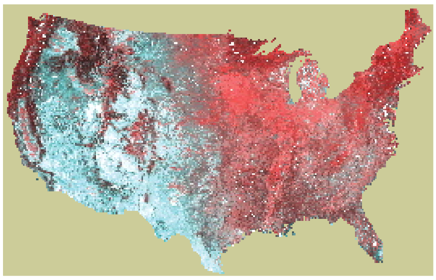
Higher resolution digital camera image collected from aircraft

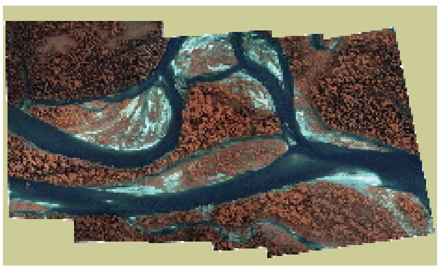
Moderate-resolution satellite image

Remote sensing imagery includes:

At present high resolution satellite image like IKONOS, GeoEye, QuickBird is used in different project of Bangladesh Forest Department. Google Earth software is also being used for to extract features. MODIS image is also being used to see the daily variation. Radar image can also be used to identify the deciduous forest. Aerial photography may be in the form of either Black & White, Natural Color or Color Infrared. Digital images may also be captured from aerial platform.



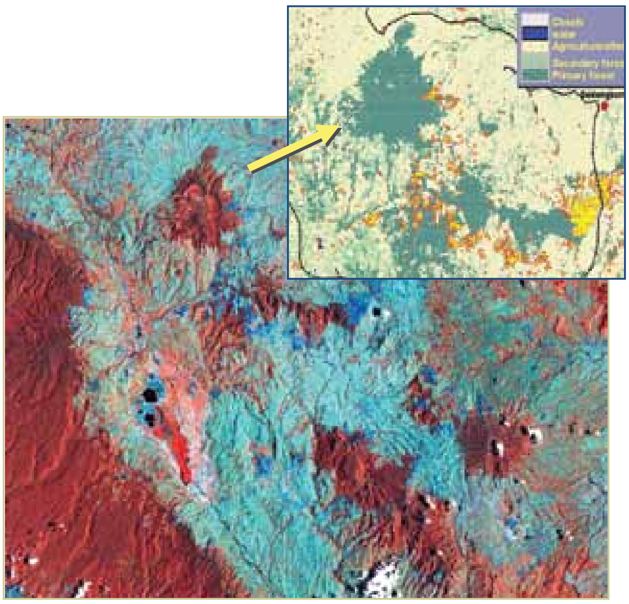




What does remote sensing imagery provide?

Different time series satellite image is used to assess the land cover change and vegetation change. When you select time series image, you should keep in mind to select the appropriate images to assess the change over time. For example, you want to assess the change in Teak plantation from the years 2000 to 2014. Teak is a deciduous tree and as such sheds all its leaves during dry season, specially,in the months of February and March. Thus, Satellite image of the month of Novembermay be appropriate to assess the changes of Teak Forest from the year 2000 to 2014.Daily MODIS image is helpful to assess the fires in the forest area. In Bangladesh, Radar image is used to assess the flood area. Remote sensing imageries may be used for the following purpose:

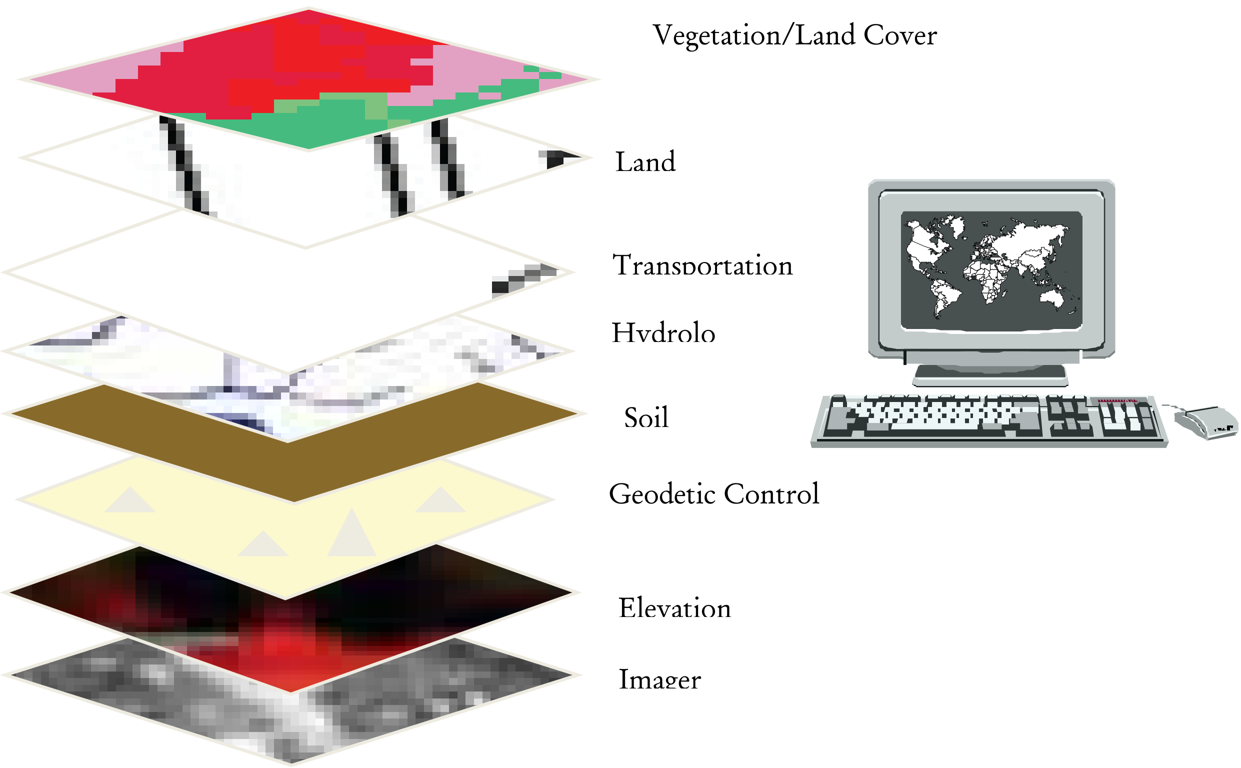
- Map making
  - o Land cover types
  - o Vegetation Map
  - o Tree Canopy Cover
- Temporal change detection
  - o Land cover changes
  - o Vegetation changes
- Monitor and map
  - o Information about fires, floods, and other disasters



Example of satellite image (A) andDerived land cover map (B)

Overview of GIS

GIS is a system for capturing, storing, manipulating, analyzing, and displaying data which are spatially referenced to the Earth.After extracting data from satellite image, GIS is used to analyze the spatial data. The attribute table of any shape file is useful to explore any information. GIS helps to prepare different maps with legend and scale that helps general people to visualize the real scenario. For example, you want to know the Arsenic distribution in your area. Field survey is performed to identify the arsenic in different points. Interpolation of this GIS data helps to prepare a surface which shows the spatial distribution of arsenic level.

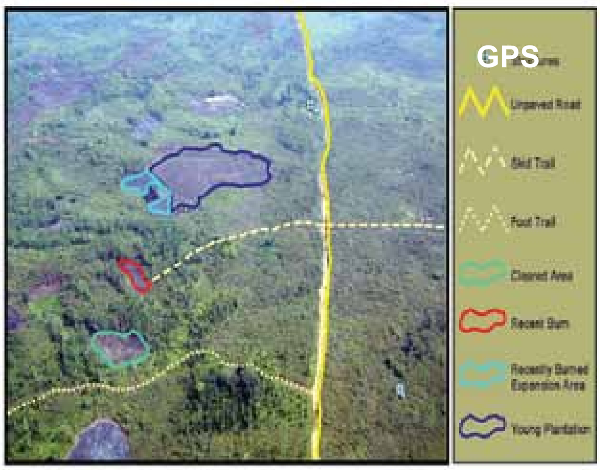


Overview of GPS

GPS is a navigation system that uses satellites to determine where you are on the ground. Information associated with ground locations may be collected when using GPS and may include:

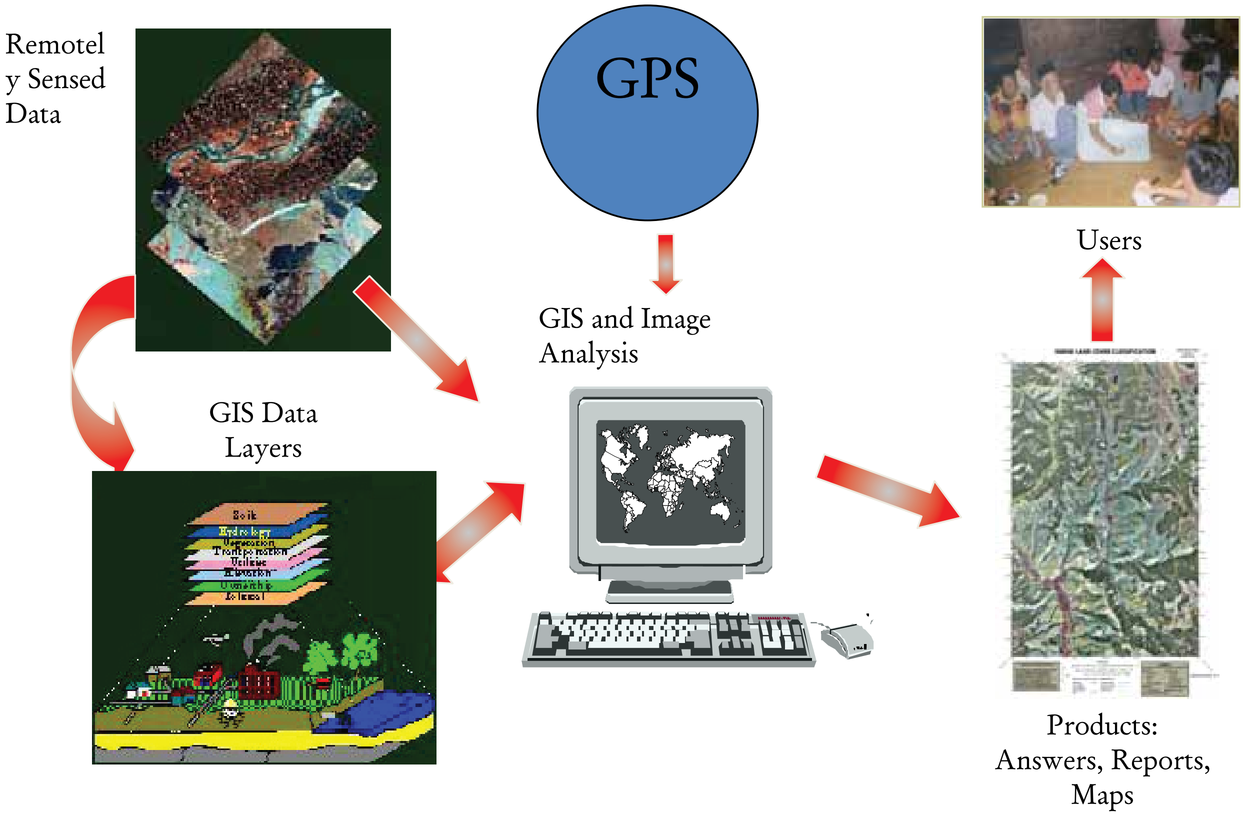
- Site characteristics: road condition, vegetation type, cause of illegal logging, soil type, etc.
- Photographs, either digital or film. Photos document field conditions and provide a reminder of the area once back in the office.

GPS is frequently used in different sectors in Bangladesh like, water resource management, forestry, ecology, agriculture and some more. Different GPS is used for different purposes. Recreation Grade GPS like Garmin 78s, Garmin eTrex are used for collecting latitude, longitude, and elevation. Survey GPS like Trimble Juno, Juno 3d, Juno 5D are used for more accurate data. Also, you can store more information using available function of this survey GPS. GPS data with attributes can be stored and displayed in a GIS.



Integration of Technologies

In general, Remote sensing provides a view of the world as well as information that can be stored in a GIS; GIS is the container that stores, manages, and provides tools for data analysis andGPS provides location information about where you are in the world. Integration of Remote Sensing, GIS and GPS helps to achieve the objective of your project.



Lesson Review

- ✓ What are Geospatial Tools
- ✓ Overview of Geospatial Tools, Remote Sensing, GIS, and GPS

Lesson-3
ArcPad and the Trimble Juno

Objective

By the end of this lesson, and through the knowledge and skills practice 3 and 4, the participants will be able to:

1. State the difference between Garmin and Trimble Juno
2. Tell what is ArcPad and its application
3. Edit the Shapefile using ArcPad software by Trimble Juno

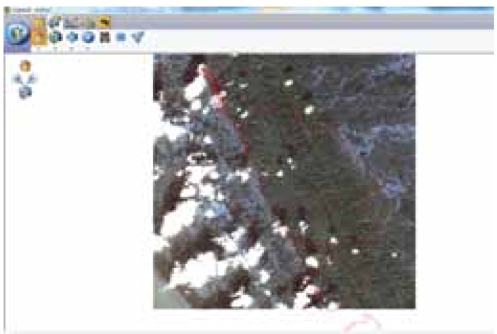
GPS Comparison

GPS ranges from recreational-quality to survey-quality, with intermediate levels in between. As you move from recreational-quality to survey-quality, both accuracy and cost increase. Garmin is a recreational GPS unit and Trimble Juno is an intermediate survey grade GPS unit. Characteristics of Garmin and Trimble Juno are stated below:

- Garmin
  - o Simple
  - o Collects XY coordinate data
  - • DNR Garmin software is used to download data from Garmin GPS.
- Trimble Juno
  - • Uses ArcPad
  - • Can display imagery while you are in the field
  - • Edit Shapefiles directly while conducting field data collection
  - • The Trimble software package for GPS data collection includes Terrasync, which is installed on the GPS device, and Pathfinder Office, which is installed on a desktop/laptop and used for data management and post-processing.

ArcPad

ArcPad is mobile field mapping and data collection software designed for GIS professionals. It includes advanced GIS and GPS capabilities for capturing, editing, and displaying geographic information quickly and efficiently. The user interface is similar to the ArcMap, where raster data as well as vector data can be handled. ArcPad with Trimble Juno empowers your mobile workforce with a fully integrated, handheld GIS/GPS data collection system for everyday fieldwork.



Delivered in a compact package resistant to dust, water and shock, the Trimble Juno handheld provides a complete, integrated package of positioning, imaging, and communications for total flexibility day after day.

Source: http://webhelp.esri.com/arcpad/8.0/userguide/index.htm#getting_started/arcpad_basics/concept_arcpadtoolbars.htm

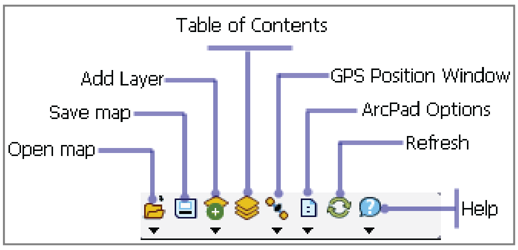
ArcPad Toolbars

The ArcPad toolbar consists of the following four tools:

- Main tools
- Browse tools
- Drawing tools
- Quick Browse tools

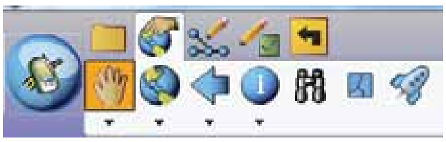
Main Tools :

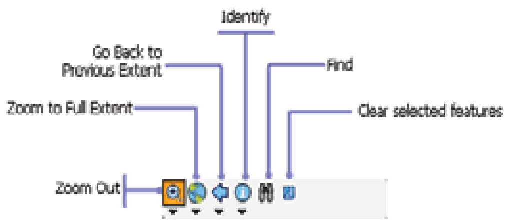
The Main toolbar provides the tools to manage your map, its layers, and their associated properties. You will also find the options to connect to a GPS, rangefinder, or camera; set your display preferences, such as color or pen size; and establish your default map and system file paths. The Main Toolbar cannot be toggled off.



Browse tools :

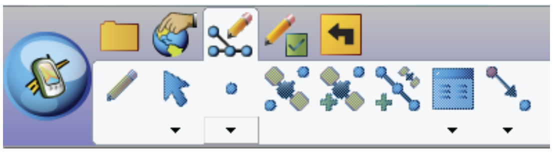
The Browse toolbar includes tools for resizing, reframing, information retrieval, spatial bookmarks, and panning and zooming of your display.

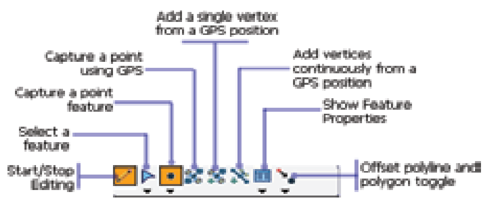




Drawing or Editing tools :

All editing takes place after a data layer is selected from either the Start/ Stop Editing tool on the Edit toolbar or from the Table of Contents. When a layer is set as editable within the Table of Contents, the Edit toolbar is automatically added. A GPS needs to be activated in order for the GPS buttons to be enabled.





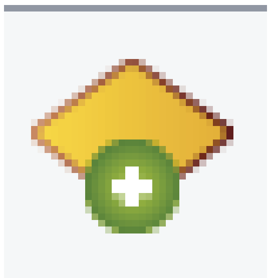
Quick Browse tools :

Source:
http://webhelp.esri.com/arcpad/8.0/userguide/index.htm#getting_started/arcpad_basics/concept_arcpadtoolbars.htm

ArcPad Practice

All Raster Layers must have either a World file or AUX file, with the exception of GeoTIFF and MrSID images. When adding a Raster layer to an ArcPad map, ArcPad first looks in the image header for the georeferencing information, then in the associated .aux (if present), and then within an associated World file (if present). Shapefiles can be displayed and edited in ArcPad, but depending on the nature of your project editing capabilities for any one Shapefile may vary.

1. Open ArcPad
   - Open Data Layers in your ArcPad session
   - Use Add Layers button to open image
   - Add: qb_2008_mosaic_degrade.tif, Bariyadhala_Range_Boundary.shp



2. Use your Browse tools to explore the image
   - Zoom
   - Pan
   - Full extent display

Source:
http://webhelp.esri.com/arcpad/8.0/userguide/index.htm#getting_started/arcpad_basics/concept_arcpadtoolbars.htm

Lesson Review

✓ Comparison of GPS

✓ Demonstration of ArcPad software and its different tools

✓ Edit Shapefile using ArcPad software by Trimble Juno.

Lesson-4
Introduction to Landsat

Objective

By the end of this lesson, the participants will be able to:

1. State the specification of Landsat Satellites
2. State the application of different bands of Landsat 8 Satellite.

Landsat Mission

Landsat 1: Launched on July 23, 1972, Operations terminated January 6, 1978

Landsat 2: Launched on January 22, 1975, Terminated January 22, 1981

Landsat 3: Launched on March 5, 1978, Terminated March 31, 1983

Landsat 4: Launched on July 16, 1982, Terminated 1993

Landsat 5: Launched on March 1, 1984, Decommissioned June 5, 2013.

Landsat 6: Launched on October 5, 1993, Failed to reach orbit.

Landsat 7: Launched on April 15, 1999, Functioning with faulty scan line corrector (May 2003).

Landsat 8: Landsat Data Continuity Mission was launched on February 11, 2013.May 30, 2013 Landsat Data Continuity Mission was turned over to USGS and renamed Landsat 8.

Source: http://landsat.usgs.gov/about_mission_history.php

Specification of Landsat Satellite

Landsat 1

- o Altitude: 917 km (570 mi)
- o Repeat cycle: 18 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 6 bit
- o Sensors:
  - — RBV (Return Beam Vidicon) Sensors
  - — MSS (Multispectral Scanner) Sensors

Landsat 1

RBV: Return Beam Vidicon Sensor, a camera system which is operated by shuttering three independent cameras, simultaneously, each sensing a different spectral band in the range of 0.48 to 0.83 μm.

Operated from July 23, 1972 to August 5, 1972, recorded only 1692 images with 80 meter-ground resolution

Three cameras operating in the following spectral bands:

- Band 1 Visible blue-green (475-575 nm)
- Band 2 Visible orange-red (580-680 nm)
- Band 3 Visible red to Near-Infrared (690-830 nm)

MSS: 80-meter ground resolution in four spectral bands:

- Band 4 Visible green (0.5 to 0.6 μm)
- Band 5 Visible red (0.6 to 0.7 μm)
- Band 6 Near-Infrared (0.7 to 0.8 μm)
- Band 7 Near-Infrared (0.8 to 1.1 μm)

Source: http://landsat.usgs.gov/about_landsat1.php

Landsat 2

- o Altitude: 917 km (570 mi)
- o Repeat cycle: 18 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 6 bit
- o Sensors:

— RBV (Return Beam Vidicon) Sensors

— MSS (Multispectral Scanner) Sensors

Landsat 2

RBV: The RBV system on Landsat 2 was operated primarily for engineering evaluation purposes and only occasional RBV imagery was obtained, primarily for cartographic uses in remote areas.

- Spatial Resolution: 80m resolution in the multispectral band
- Three cameras that operate in the following spectral bands:
  - o Visible blue-green (475-575 nm)
  - o Visible orange-red (580-680 nm)
  - o Visible red to Near-Infrared (690-830 nm)

MSS: 80-meter ground resolution in four spectral bands:

- Band 4 Visible green (0.5 to 0.6 μm)
- Band 5 Visible red (0.6 to 0.7 μm)
- Band 6 Near-Infrared (0.7 to 0.8 μm)
- Band 7 Near-Infrared (0.8 to 1.1 μm)

Source: http://landsat.usgs.gov/about_landsat2.php

Landsat 3

- o Altitude: 917 km (570 mi)
- o Repeat cycle: 18 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 6 bit
- o Sensors:
  - — RBV (Return Beam Vidicon) Sensors
  - — MSS (Multispectral Scanner) Sensors

Landsat 3

RBV: The RBV system on Landsat 3 used two cameras, mounted side-by-side, with panchromatic spectral response and higher spatial resolution (40 m) to complement the multispectral coverage provided by the Multispectral Scanner (MSS). Each of the cameras produced a swath of about 90 km (for a total swath of 180 km).

- — 40 m resolution from 2, 80 m resolution cameras
- — Two cameras with a panchromatic spectral response

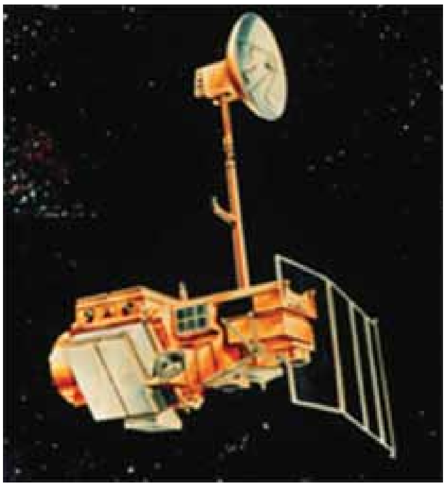
MSS: Five spectral bands, including a thermal band:

- Band 4 Visible (0.5 to 0.6 μm)
- Band 5 Visible (0.6 to 0.7 μm)
- Band 6 Near-Infrared (0.7 to 0.8 μm)
- Band 7 Near-Infrared (0.8 to 1.1 μm)
- Band 8 Thermal (10.4 to 12.6 μm)

You will find some Landsat 1-3 MSS data of Bangladesh in http://glovis.usgs.gov/

Source: http://landsat.usgs.gov/about_landsat3.php

Landsat 4



Landsat 4

- o Altitude: 705 km (438 mi)
- o Repeat cycle: 16 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 8 bit
- o Sensors:
  - — MSS (Multispectral Scanner) Sensors
  - — TM (Thematic Mapper)

MSS: Four spectral bands (identical to Landsat 1 and 2):

- Band 4 Visible (0.5 to 0.6 µm)
- Band 5 Visible (0.6 to 0.7 µm)
- Band 6 Near-Infrared (0.7 to 0.8 µm)
- Band 7 Near-Infrared (0.8 to 1.1 µm)

Ground Sampling Interval (pixel size): 57 x 79 m

TM: Seven spectral bands, including a Thermal Band:

- Band 1 Visible (0.45 - 0.52 µm) 30 m
- Band 2 Visible (0.52 - 0.60 µm) 30 m
- Band 3 Visible (0.63 - 0.69 µm) 30 m
- Band 4 Near-Infrared (0.76 - 0.90 µm) 30 m
- Band 5 Near-Infrared (1.55 - 1.75 µm) 30 m
- Band 6 Thermal (10.40 - 12.50 µm) 120 m
- Band 7 Mid-Infrared (IR) (2.08 - 2.35 µm) 30 m

Ground Sampling Interval (pixel size): 30 m reflective, 120 m thermal

Source: http://landsat.usgs.gov/about_landsat4.phpSource: http://landsat.usgs.gov/about_landsat4.php

Landsat 5

- o Altitude: 705 km (438 mi)
- o Repeat cycle: 16 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 8 bit
- o Sensors:
  - — MSS (Multispectral Scanner) Sensors
  - — TM (Thematic Mapper)

Landsat 5

MSS: Acquisitions of Landsat 5 MSS data over the United States ceased in 1992; global acquisitions ended in 1999. Limited acquisitions were made from June 2012 through January 2013, after the loss of the TM sensor on the satellite. Four spectral bands (identical to Landsat 1 and 2):

- Band 4 Visible green (0.5 to 0.6 µm)
- Band 5 Visible red (0.6 to 0.7 µm)
- Band 6 Near-Infrared (0.7 to 0.8 µm)
- Band 7 Near-Infrared (0.8 to 1.1 µm)

Ground Sampling Interval (pixel size): 57 x 79 m

TM: Seven spectral bands, including a Thermal Band:

- Band 1 Visible (0.45 - 0.52 µm) 30 m
- Band 2 Visible (0.52 - 0.60 µm) 30 m
- Band 3 Visible (0.63 - 0.69 µm) 30 m
- Band 4 Near-Infrared (0.76 - 0.90 µm) 30 m
- Band 5 Near-Infrared (1.55 - 1.75 µm) 30 m
- Band 6 Thermal (10.40 - 12.50 µm) 120 m
- Band 7 Mid-Infrared (2.08 - 2.35 µm) 30 m

You will find Landsat 4-5 TM data of Bangladesh from 1987-2011 in http://glovis.usgs.gov/

Source: http://landsat.usgs.gov/about_landsat5.php

Landsat 6

- o Altitude: 705 km (438 mi)
- o Repeat cycle: 16 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 8 bit
- o Sensors:
  - — Enhanced Thematic Mapper (ETM)

Landsat 6 was lost just after its launch on 3 October 1993.

ETM: Eight spectral bands, including a Pan and Thermal Band:

- Band 1 Visible (0.45 - 0.52 µm) 30 m
- Band 2 Visible (0.52 - 0.60 µm) 30 m
- Band 3 Visible (0.63 - 0.69 µm) 30 m
- Band 4 Near-Infrared (0.76 - 0.90 µm) 30 m
- Band 5 Near-Infrared (1.55 - 1.75 µm) 30 m
- Band 6 Thermal (10.40 - 12.50 µm) 120 m
- Band 7 Mid-Infrared (2.08 - 2.35 µm) 30 m
- Band 8 Panchromatic (PAN) (0.52 - 0.90 µm) 15 m

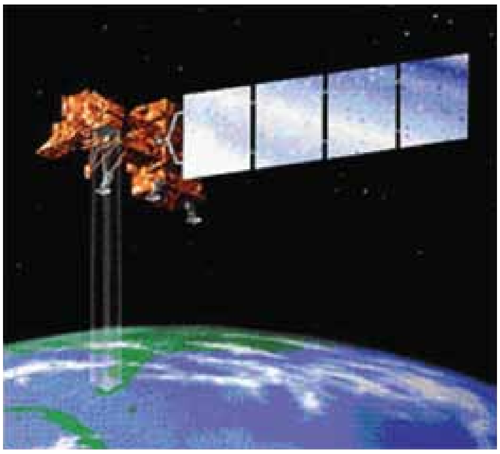
Ground Sampling Interval (pixel size): 30 m reflective, 120 m thermal

Source: http://landsat.usgs.gov/about_landsat6.php

Landsat 7

- o Altitude: 705 km (438 mi)
- o Repeat cycle: 16 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 8 bit
- o Sensors:
  - — Enhanced Thematic Mapper Plus (ETM+)

TM+: Eight spectral bands, including a Pan and Thermal Band:



Landsat 7

- Band 1 Visible (0.45 - 0.52 µm) 30 m
- Band 2 Visible (0.52 - 0.60 µm) 30 m
- Band 3 Visible (0.63 - 0.69 µm) 30 m
- Band 4 Near-Infrared (0.77 - 0.90 µm) 30 m
- Band 5 Near-Infrared (1.55 - 1.75 µm) 30 m
- Band 6 Thermal (10.40 - 12.50 µm) 60 m Low Gain / High Gain
- Band 7 Mid-Infrared (2.08 - 2.35 µm) 30 m
- Band 8 Panchromatic (PAN) (0.52 - 0.90 µm) 15 m

Ground Sampling Interval (pixel size): 30 m reflective, 60 m thermal

You will find some Landsat 7ETM+ data of Bangladesh from 1999-2003 in http://glovis.usgs.gov/

Source: http://landsat.usgs.gov/about_landsat7.php

Landsat 8

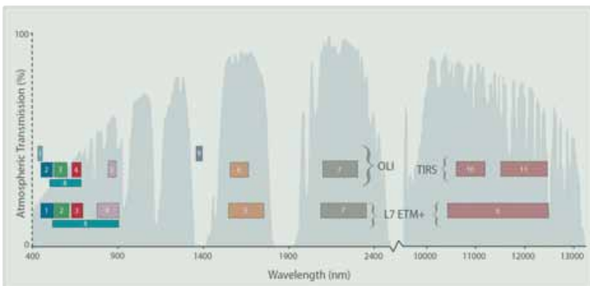
- o Altitude: 705 km (438 mi)
- o Repeat cycle: 16 days
- o Swath width: 185 km (115 mi)
- o Radiometric Resolution: 12 bit
- o Sensors:
- — Operational Land Imager (OLI)
- — Thermal Infrared Sensor (TIRS)

Landsat 8

Radiometric Resolution: Landsat 8 collect 12 bit data products but delivered to the users as 16 bit data products.

OLI: Nine spectral bands, including a pan band:

- Band 1 Visible (0.43 - 0.45 µm) 30 m
- Band 2 Visible (0.450 - 0.51 µm) 30 m
- Band 3 Visible (0.53 - 0.59 µm) 30 m
- Band 4 Red (0.64 - 0.67 µm) 30 m
- Band 5 Near-Infrared (0.85 - 0.88 µm) 30 m
- Band 6 SWIR 1(1.57 - 1.65 µm) 30 m



Comparison of Landsat 7 & Landsat 8

TIRS: Two spectral bands:

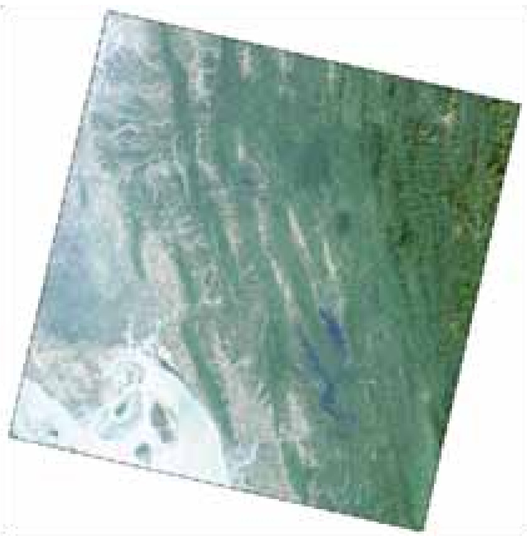
- Band 10 TIRS 1 (10.6 - 11.19 µm) 100 m
- Band 11 TIRS 2 (11.5 - 12.51 µm) 100 m

User will find Landsat 8 data of Bangladesh from April, 2013 to present.

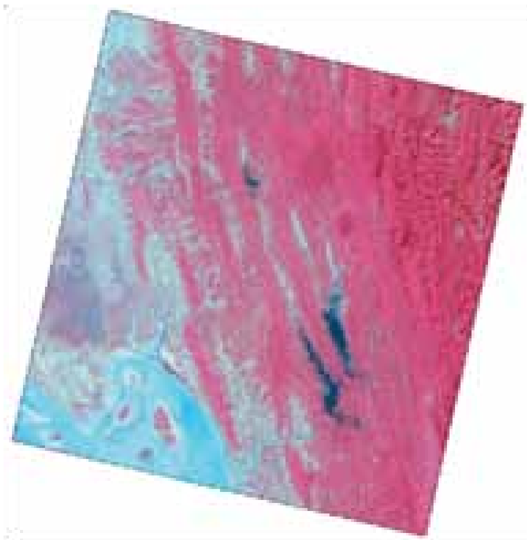
Source: http://landsat.usgs.gov/about_ldcm.php

Application of Landsat 8

Different band combination of Landsat 8 data help to identify features from satellite images. For example a true color (4,3,2 band combination) shows the vegetation area in green color, dense vegetation in dark green because, shallow water in light blue and deeper water in blue to dark blue color. However, false color (5,4,3 band combination) shows the vegetation area in red color, dense vegetation in dark red color , water in blue color and fallow or bare area in bright color.



True Color Landsat8



False Color Landsat8

Band	Wavelength	Useful for mapping
Band 1 – Coastal aerosol	0.43-0.45	Coastal and aerosol studies
Band 2 – Blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - Green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - Red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	085.-0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	.50-.68	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.36 -1.38	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.5-12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture

Source: http://landsat.usgs.gov/best_spectral_bands_to_use.php

Lesson Review

- ✓ Landsat Mission
- ✓ Specification of Landsat Satellites
- ✓ Application of Landsat 8 Satellites

Lesson-5

Unsupervised Classification

Objective

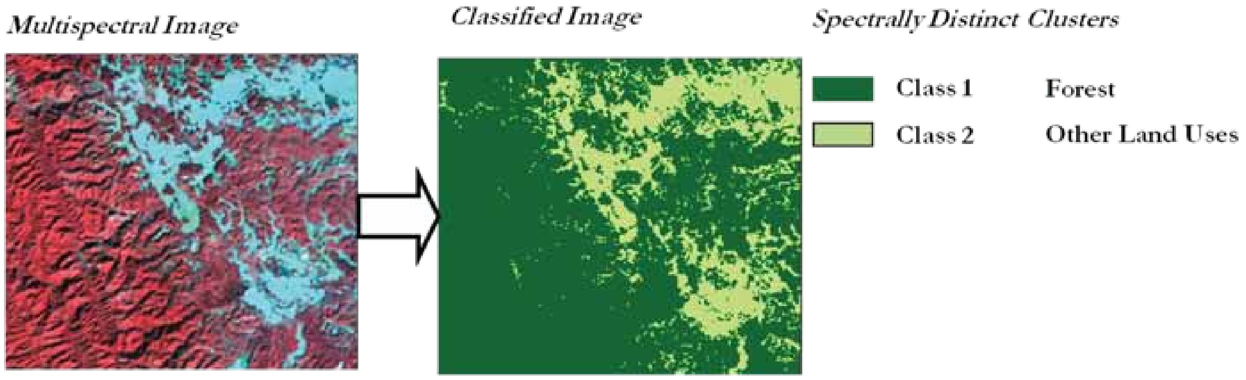
By the end of this lesson, and through the knowledge and skills practice 8, the participants will be able to:

1. State what is Unsupervised Classification
2. State the advantages and disadvantages of Unsupervised Classification.
3. Classify a multispectral image using the recommended steps of Unsupervised Classification

What is Unsupervised Classification ?

Unsupervised classification is more computer-automated. It enables you to specify some parameters that the computer uses to uncover statistical patterns that are inherent in the data. These patterns do not necessarily correspond to directly meaningful characteristics of the scene, such as contiguous, easily recognized areas of a particulars oil type or land use. They are simply clusters of pixels with similar spectral characteristics. Spectral classes are grouped first, based solely on the numerical information in the data, and then matched by the analyst to information classes.

This method is usually used when less is known about the data before classification. It is then the analyst's responsibility, after classification, to attach meaning to the resulting classes (Jensen, 1996). Unsupervised classification is useful only if the classes can be appropriately interpreted.



Spectral Classes

Spectral classes are groups of pixels that are uniform with respect to the brightness in their several spectral channels.

The analyst can observe spectral classes within remotely sensed data; if it is possible to define links between the spectral classes on the image and the informational classes that are of primary interest, then the image forms a valuable source of information.

Thus remote sensing classification proceeds by matching spectral categories to informational categories. If the match can be made with confidence, then the information is likely to be reliable. If spectral and informational categories do not correspond, then the image is unlikely to be a useful source for that particular form of information.

Seldom can we expect to find exact one-to-one matches between informational and spectral classes. Any informational class includes spectral variations arising from natural variations within the class. For example, a region of the informational class "forest" is still "forest," even though it may display variations in age, species composition, density, and vigor, which all lead to differences in the spectral appearance of a single informational class.

Furthermore, other factors, such as variations in illumination and shadowing, may produce additional variations even within otherwise spectrally uniform classes. *(Campbell et.al, 2011)*

Information Classes

Informational classes are the categories of interest to the users of the data. Informational classes are, for example, the different kinds of geological units, different kinds of forest, or the different kinds of land use that convey information to planners, managers, administrators, and scientists who use information derived from remotely sensed data. These classes are the information that we wish to derive from the data—they are the object of our analysis.

However, these classes are not directly recorded on remotely sensed images; we can derive them only indirectly, using the evidence contained in brightnesses recorded by each image.

For example, the image cannot directly show geological units, but rather only the differences in topography, vegetation, soil color, shadow, and other factors that lead the analyst to conclude that certain geological conditions exist in specific areas. *(Campbell et.al, 2011)*

Advantage of Unsupervised Classification

To conduct unsupervised classification, no detailed prior knowledge is required, but knowledge of the region is required to interpret the meaning of the results produced by the classification process.

Opportunity for human error is minimized. Many of the detailed decisions required for supervised classification are not required for unsupervised classification, so the analyst is presented with less opportunity for error. If the analyst has inaccurate preconceptions regarding the region, those preconceptions will have little opportunity to influence the classification.

The classes defined by unsupervised classification are often much more uniform with respect to spectral composition than are those generated by supervised classification. Unique classes are recognized as distinct units. Such classes, perhaps of very small areal extent, may remain unrecognized in the process of supervised classification and could inadvertently be incorporated into other classes, generating error and imprecision throughout the entire classification.

Disadvantages and Limitations

The disadvantages and limitations of unsupervised classification arise primarily from reliance on "natural" groupings and difficulties in matching these groups to the informational categories that are of interest to the analyst.

Unsupervised classification identifies spectrally homogeneous classes within the data that do not necessarily correspond to the informational categories that are of interest to the analyst. As a result, the analyst is faced with the problem of matching spectral classes generated by the classification to the informational classes that are required by the ultimate user of the information.

The analyst has limited control over the menu of classes and their specific identities. If it is necessary to generate a specific menu of informational classes (e.g., to match to other classifications for other dates or adjacent regions), the use of unsupervised classification may be unsatisfactory.

Spectral properties of specific informational classes will change over time (on a seasonal basis, as well as over the years). As a result, relationships between informational classes and spectral classes are not constant, and relationships defined for one image cannot be extended to others.

Steps of Unsupervised Classification

Generate a thematic raster layer using the ISODATA algorithm.

After a classification is performed, you can use the Raster Attribute Editor to compare the original image data with the individual classes of the thematic raster layer that was created from the unsupervised classification. This process helps identify the classes in the thematic raster layer. Spectral classes generated using ISODATA algorithm are than associated with information classes using the available reference data.

After assigning information classes, Recode function is used for combining several spectral classes that represents similar information classes on the ground.

Suitable conditions for choosing the unsupervised classification method:

- o The following list includes suitable conditions for choosing the unsupervised classification method
- o Little is known about the data before classification
- o Many classes are needed
- o Training fields are hard to find
- o Homogeneous areas are numerous, small, and have great spectral diversity among them
- o Maximum separate-ability is desired in area of little spectral variation

ISODATA Clustering

The Iterative Self-Organizing Data Analysis Technique (ISODATA) (Tou and Gonzalez, 1974) clustering method uses spectral distance as in the sequential method, but iteratively classifies the pixels, redefines the criteria for each class, and classifies again, so that the spectral distance patterns in the data gradually, emerge.

ERDAS IMAGINE uses the ISODATA algorithm to perform an unsupervised classification. The ISODATA clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set. Each time the clustering repeats, the means of these clusters are shifted. The new cluster means are used for the next iteration.

The ISODATA utility repeats the clustering of the image until either a maximum number of iterations have been performed, or a maximum percentage of unchanged pixel assignments has been reached between two iterations.

Performing an unsupervised classification is simpler than a supervised classification

Source: ERDAS Field Guide™. (2005). Norcross, Georgia: Leica Geosystems Geospatial Imaging, LLC.

ISODATA Clustering Parameters

To perform ISODATA clustering, you specify:

- o N: The maximum number of clusters to be considered. Since each cluster is the basis for a class, this number becomes the maximum number of classes to be formed. The ISODATA process begins by determining N arbitrary cluster means. Some clusters with too few pixels can be eliminated, leaving less than N clusters.
- o T: A convergence threshold, which is the maximum percentage of pixels whose class values are allowed to be unchanged between iterations. This threshold prevents the ISODATA utility from running indefinitely. By specifying a convergence threshold of .95, you are specifying that as soon as 95% or more of the pixels stay in the same cluster between one iteration and the next, the utility should stop processing. In other words, as soon as 5% or fewer of the pixels change clusters between iterations, the utility stops processing.
- o M: The maximum number of iterations to be performed.

Initial Cluster Means

- o On the first iteration of the ISODATA algorithm, the means of N clusters can be arbitrarily determined.
- o After each iteration, a new mean for each cluster is calculated, based on the actual spectral locations of the pixels in the cluster, instead of the initial arbitrary calculation.
- o Then, these new means are used for defining clusters in the next iteration.

The process continues until there is little change between iterations.

Output of ISODATA Function

The spectral distance between the candidate pixel and each cluster mean is calculated. The pixel is assigned to the cluster whose mean is the closest. The ISODATA function creates an output image file with a thematic raster layer and/or a signature file (.sig) as a result of the clustering. At the end of each iteration, an image file exists that shows the assignment of the pixels to the clusters.

Source: https://wiki.hexagongeospatial.com/index.php?title=Unsupervised_Training

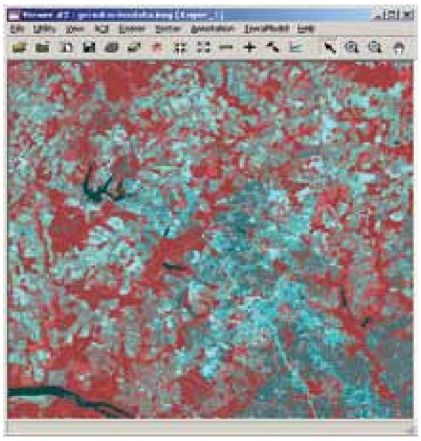
Generate Thematic Raster Layer

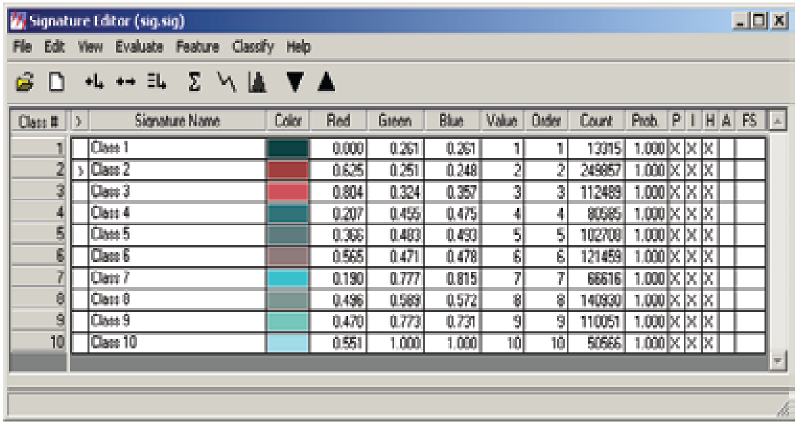
Open Unsupervised Classification dialog from the Classification>Unsupervised Classification..menu to perform an unsupervised classification using the ISODATA algorithm.

In the Unsupervised Classification dialog:

— Under Input Raster File, enter the image file that is classified.

Thematic layer ***Signature file***





Class #	Signature Name	Red	Green	Blue	Value	Order	Count	Prob.
1	Class 1	0.000	0.261	0.261	1	1	13315	1.000
2	Class 2	0.625	0.251	0.248	2	2	249857	1.000
3	Class 3	0.804	0.324	0.357	3	3	112489	1.000
4	Class 4	0.207	0.455	0.475	4	4	80585	1.000
5	Class 5	0.366	0.483	0.493	5	5	102708	1.000
6	Class 6	0.565	0.471	0.478	6	6	121459	1.000
7	Class 7	0.190	0.777	0.815	7	7	66616	1.000
8	Class 8	0.496	0.589	0.572	8	8	140930	1.000
9	Class 9	0.470	0.773	0.731	9	9	110051	1.000
10	Class 10	0.551	1.000	1.000	10	10	50566	1.000

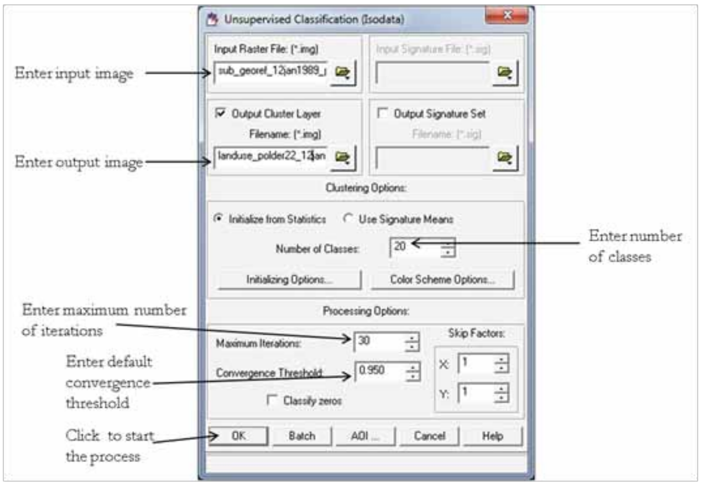
— Under Output File, enter the name for the output thematic raster layer.

— Under Clustering Options, enter the desired number of classes in the Number of Classes field.

— Enter a suitable number in the Maximum Iterations number field under Processing Options.

This is the maximum number of times that the ISODATA utility reclusters the data. It prevents this utility from running too long, or from potentially getting stuck in a cycle without reaching the convergence threshold.

— Confirm that the Convergence Threshold number field is set to .950.



— Click OK in the Unsupervised Classification dialog to start the classification process. The Unsupervised Classification dialog closes automatically.

A Job Status dialog displays, indicating the progress of the function.

— In the Job Status dialog, click OK when the process is 100% complete.

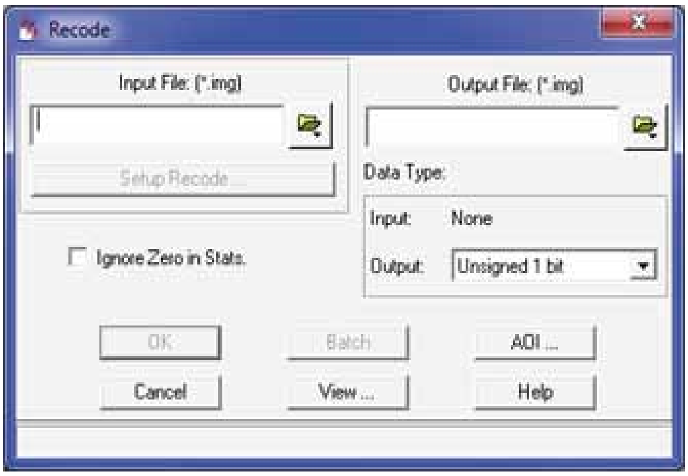
Source: ERDAS IMAGINE® Tour Guides™. (2006). Norcross, Georgia: Leica Geosystems Geospatial Imaging, LLC.

Assign Information Classes to Spectral Classes

The classes that result from unsupervised classification are referred to as spectral classes. Because they are based on natural groupings of the image values, the identity of the spectral classes will not be initially known. You must compare classified data to some form of reference data (such as large-scale imagery, maps, or site visits) to determine the identity or information classes of the spectral classes. Each information class will probably include several spectral classes. Your reference data will come from the site visits done in previous years and new data that you have collected.

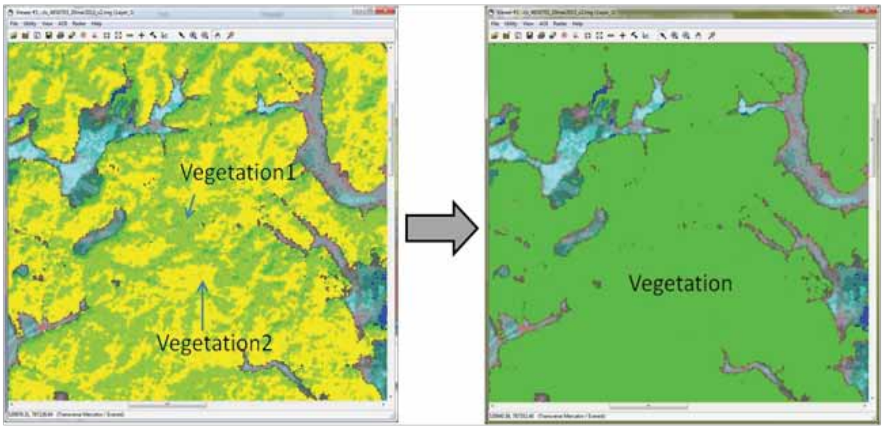
Source: International Conference on Information and Communication Technologies (ICICT- 2014), A Study on Hyperspectral Remote Sensing Classifications, International Journal of Computer Applications (0975 – 8887)

Recode and Merging



Most information classes will include several spectral classes. In ERDAS Imagine Recoding is used to combine several spectral classes into one Information Class. To open Recode dialog in ERDAS Imagine select Image Interpreter > GIS Analysis... > Recode

This dialog allows you to assign a new class value number to any or all classes of an existing .img file, creating an output file using the new class numbers. This function can also be used to combine classes by recoding more than one class to the same new class number.



Source: ERDAS IMAGINE® Tour Guides™. (2006). Norcross, Georgia: Leica Geosystems Geospatial Imaging, LLC.

Lesson Review

- ✓ What is Unsupervised Classification
- ✓ Advantages and Disadvantages of Unsupervised Classification
- ✓ Steps of Unsupervised Classification

Lesson-6

Application of Remote Sensing to Monitor Forest Resources in Different Countries

Objective

By the end of this lesson, the participants will be able to :

1. State the application of Remote Sensing in Forestry issues of Indonesia, Bangladesh and US Forest Service.
2. State the Google Earth Application to Forest Mapping and Classification

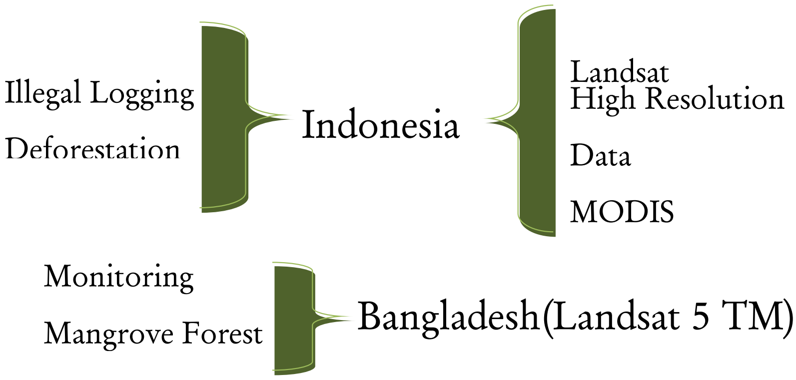
Application of RS in Indonesia and Bangladesh

Illegal logging means processing of logs without the necessary licenses.Illegal logging is the primary/one of the prime causes of deforestation.Illegal logging and deforestation in Indonesia are monitored using Landsat, High resolution data, MODIS (Moderate Resolution Imaging Spectroradiometer), and SAR (Synthetic Aperture Radar).

Sundarbans is one of the largest mangrove forests in the World. To assess the temporal changes in the mangrove forest within Sundarbans, Landsat 5 TM was used in Bangladesh.

The Applications section highlights how remote sensing may be used to address forestry issues.

Three topics are presented:



Illegal Logging - Indonesia

There are some indicators that help to assess the illegal logging in any area. High resolution satellite data is used to detect the forest openings, new road, trails, landing sites. These are the direct indicators of illegal opening / Logging. If density of any forest area is decreased or canopy is thinning, it also indirectly indicates an illegal logging area.

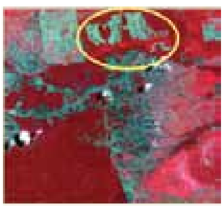
Following are some indicators of logging that can be detected by remote sensing

Direct Indicators:

- Forest openings
- Roads, trails, landing sites

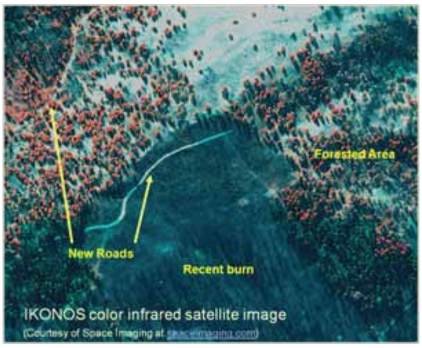
Indirect Indicators:

- Thinning canopy and canopy changes over time



Direct Indicators

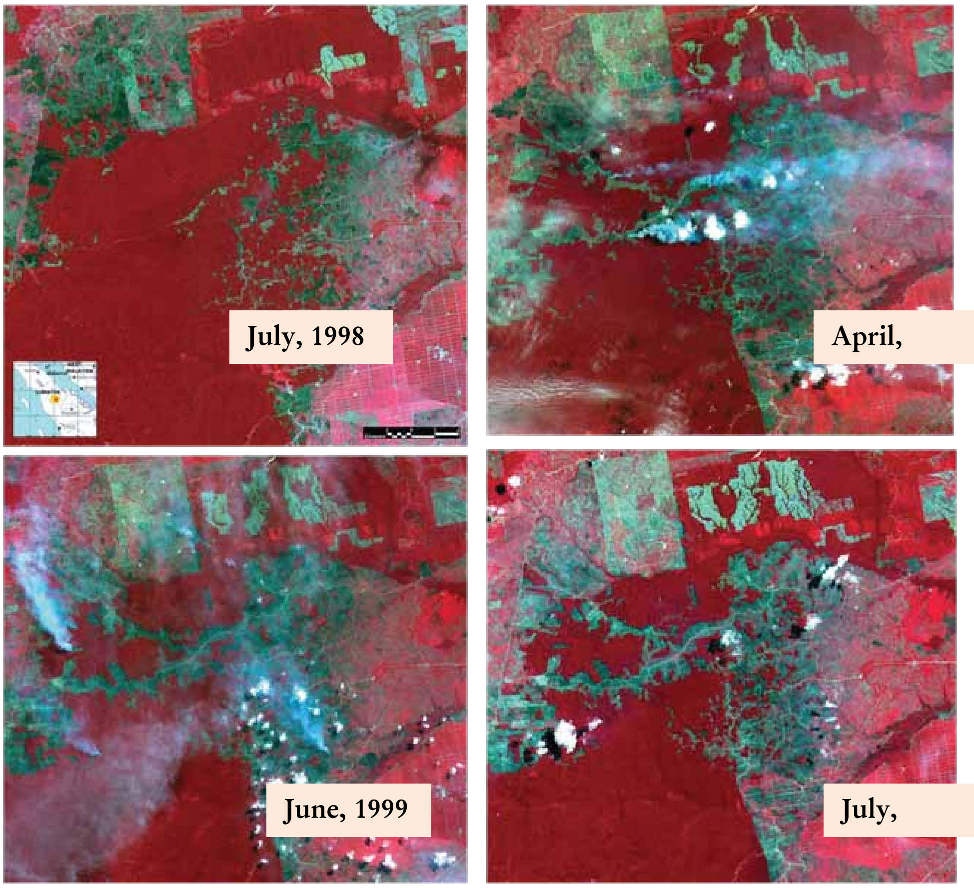
High resolution satellite imagery like IKONOS and QuickBirdimages are multispectral image.There are options to change the band combination and identify the illegal sites using natural color, false color, black and white color of these IKONOS and QuickBird images.



The following color infrared IKONOS images show the new roads, recent burn area and forested area. Recent burn area within the high resolution IKONOS image may be the direct indication of illegal logging.

Logging Monitored using SPOT

Spot is a multispectral satellite image. The following four figures show different time series 20 meter SPOT images. The acquisition month and year of these four images are July 1998; April 1999, June 1999 and July 1999. These time series images show land clearing increased at a rapid pace over one year. It is to be noted that the logging activity shown here may not be illegal.

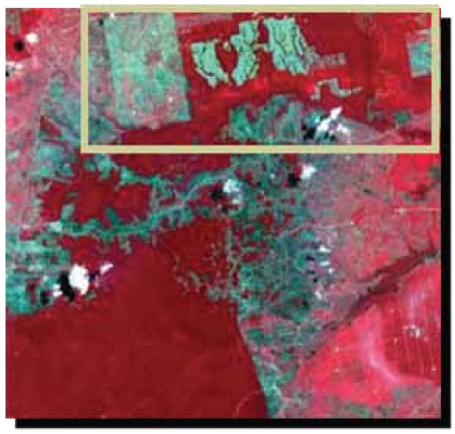


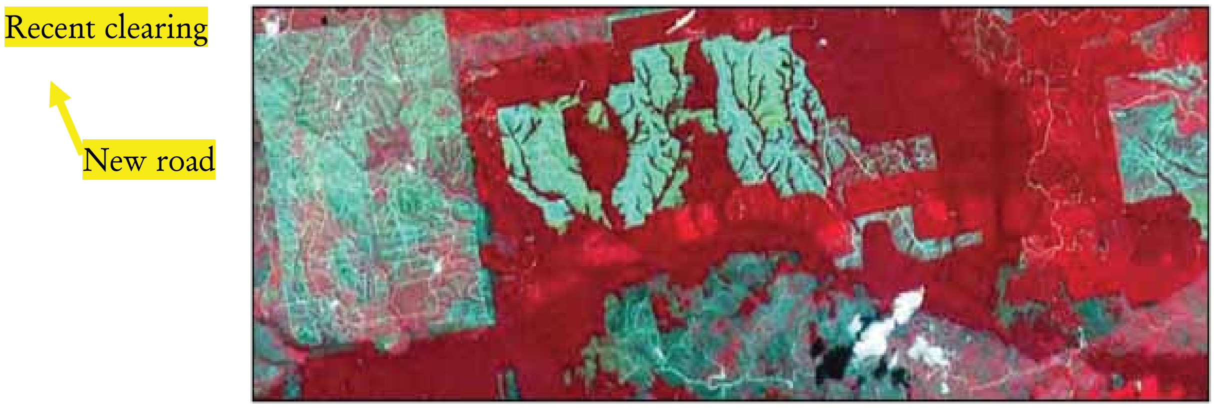
Deforestation and Logging: SPOT - Indirect Indicators

The zooming area of July, 1999 shows lots of openings in the forest area compared to July, 1998. Also, new roads and new plantation forest were identified in the July, 1999 image. This may be indirect indication of deforestation and illegal logging.

Indirect evidence of logging activity includes:

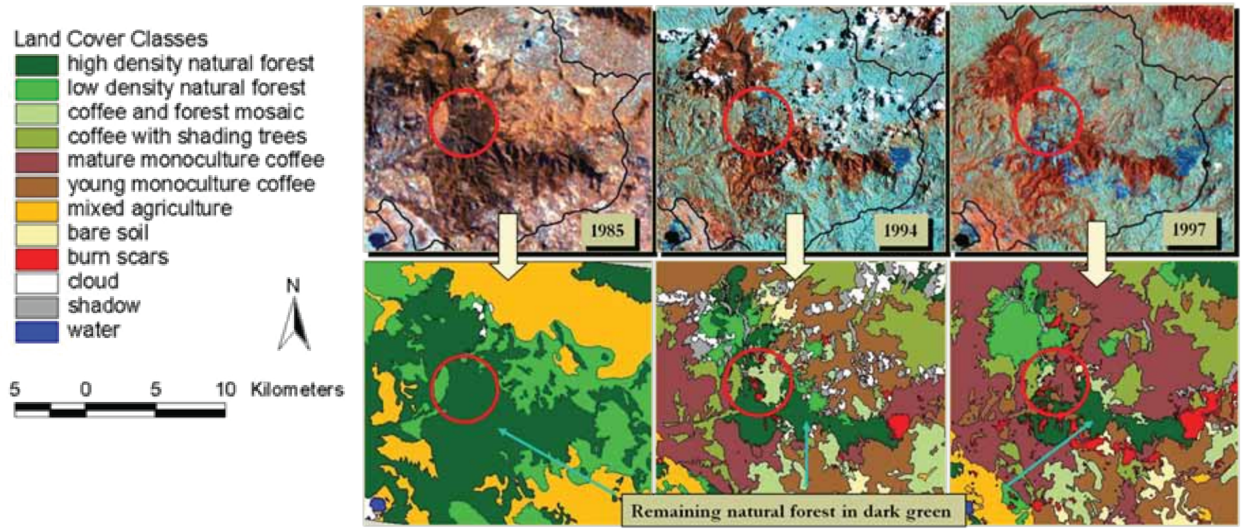
- Burn scars
- Road building
- New openings





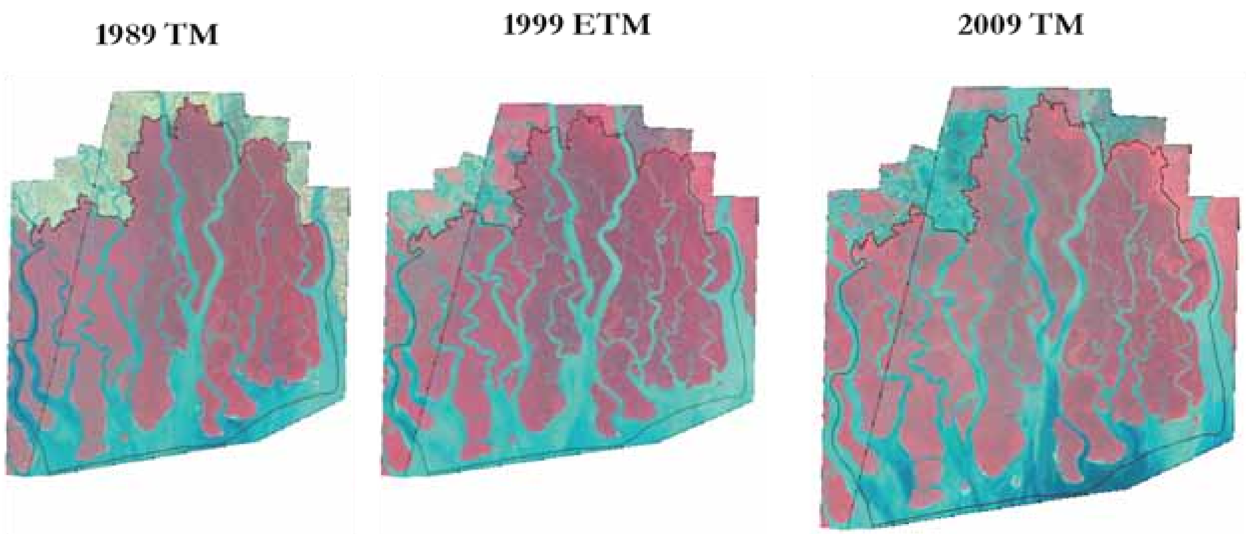
Monitoring and Mapping Deforestation-Indirect Indicators

Computer-aided mapping techniques can capture deforestation by comparing recent and historical images. The following land cover maps derived from Landsat images show indirect indicators of illegal logging. The land cover map shows different classes. A number of new land cover classes were found in 1994 and 1997. These new land cover classes indicated the decrease in natural forest within the national park. Some burn scars were found in land cover map of 1994 and 1997. These burn scars may relate to the indicator of illegal logging.



Mangrove Change within the Sundarbans, Bangladesh

In this example, three Landsat 5 TM images with 10 year interval were used to understand the change of mangrove within the Sundarbans, Bangladesh. The acquisition year of these Landsat images are 1989, 1999 and 2009. The spatial resolution of these Landsat images are 30 meter. The sensor of the two satellite images are TM (Thematic Mapper) and one is Enhanced Thematic Mapper (TM).

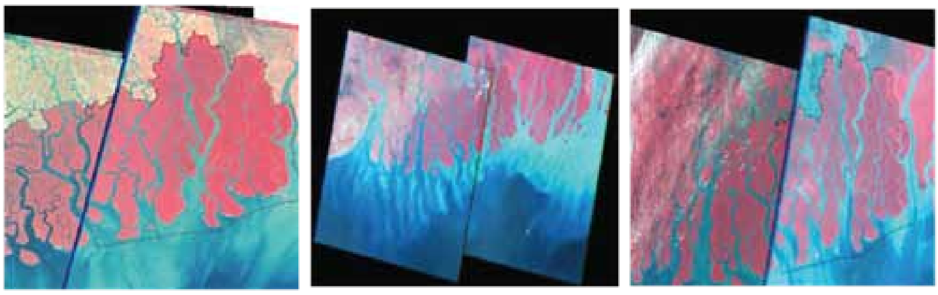


Steps of Image Processing

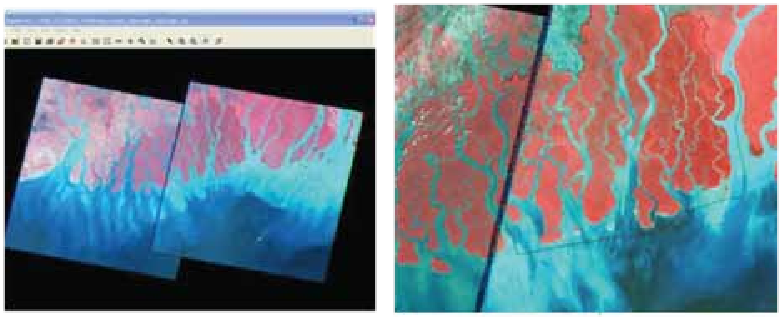
- Calibration - The Digital Number (DN) in raw Landsat images was transformed to reflectance using the calibration that comes with the files and the equations and constants of Price (1987), and Markham and Barker (1985).

- Atmospheric Correction - Two forms of path radiance are introduced into the signal due to atmosphere. One is radiance from Rayleigh and the other is radiance from aerosols or haze. These path radiances can be removed simultaneously using dark object subtractions
- Normalized Difference Vegetation Index – After calibration and atmospheric correction the normalized difference vegetation index (NDVI) was calculated. It is a quantification of green biomass.

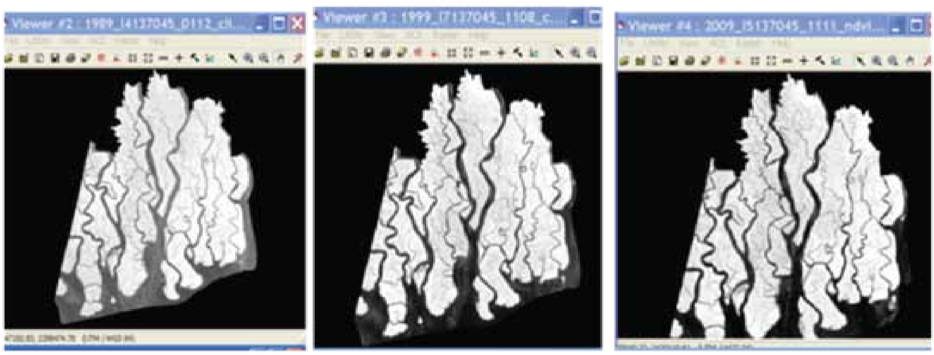
1. Image Calibration



2. Cloud Corrected



3. Normalization



Method: Unsupervised Change Detection

Difference Image

"Difference image" is the most widely used types of unsupervised change-detection techniques. It is very basic and simple. It is known to work well for monitoring extensive land use change. One of the main problems of unsupervised change detection methods based on the "difference image" is the lack of efficient automatic techniques for discriminating between changed and unchanged pixels in the difference image.

Z-score analysis (outlier change detection method)

This is a more recent method, which is best known to capture subtle changes in wetlands (Neilson et al., 2008). The U.S. Forest Service (USFS) provided technical support to the Resource Information Management System (RIMS) unit of the Forest Department (FD) of Bangladesh in developing a method to monitor changes within the Sundarbans Reserve Forest using remote sensing and GIS technology. It included comparing the simple image differencing method with the Z-score outlier change detection method to examine changes within the mangroves of Bangladesh.

Remote Sensing Application in the US Forest Service

National Level Mapping: Integration of different remote sensed data like Landsat, MODIS, SPOT; SRTM data and Forest Inventory and Analysis (FIA) data were used in National Level Forest Mapping program in USA.

Post-Fire Mapping: Integration of different remote sensed data with field data help to delineate the monitoring of post-fire effects and forest recovery patterns. Medium to coarse resolution data like AVHRR, MODIS and SPOT sensors are used to mark/identify burn area.

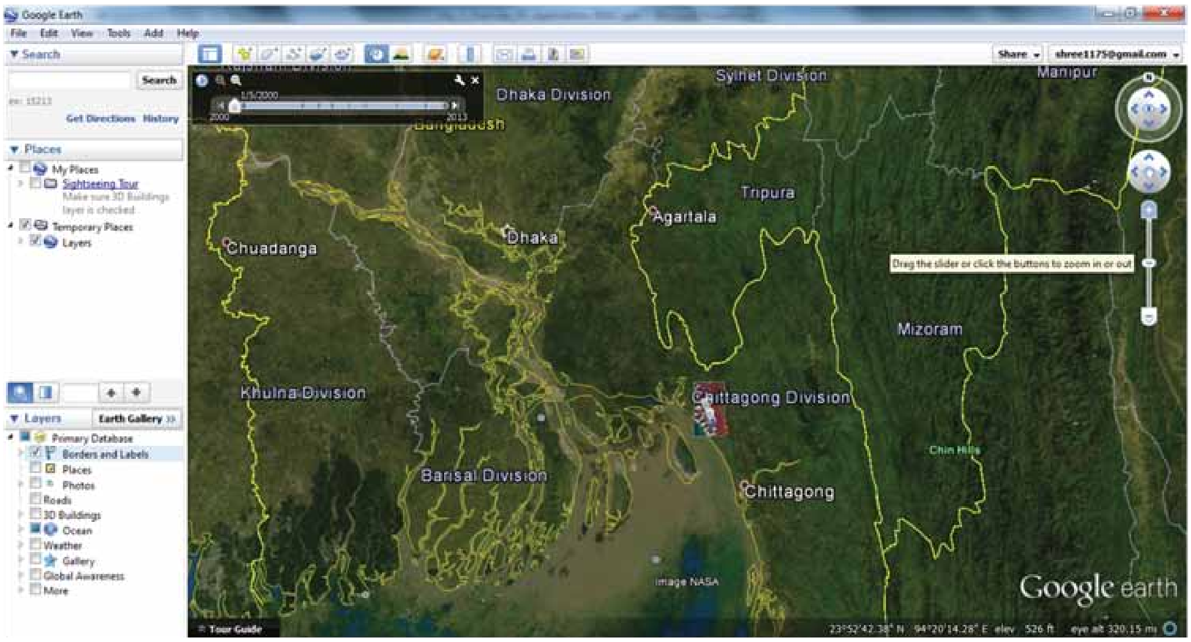
Mid-level Existing Vegetation Mapping: Most Regions in the USDA FS use Landsat imagery to produce mid-level vegetation maps. Mapping efforts are coordinated regionally and comply with national technical guide standards.

Forest Monitoring: The USDA Forest Service, Forest Health Monitoring (FHM) is a national program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis. The FHM program uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources and develops analytical approaches to address forest health issues that affect the sustainability of forest ecosystems.

Source: http://www.fs.fed.us/eng/rsac/

Google Earth Application to Forest Mapping

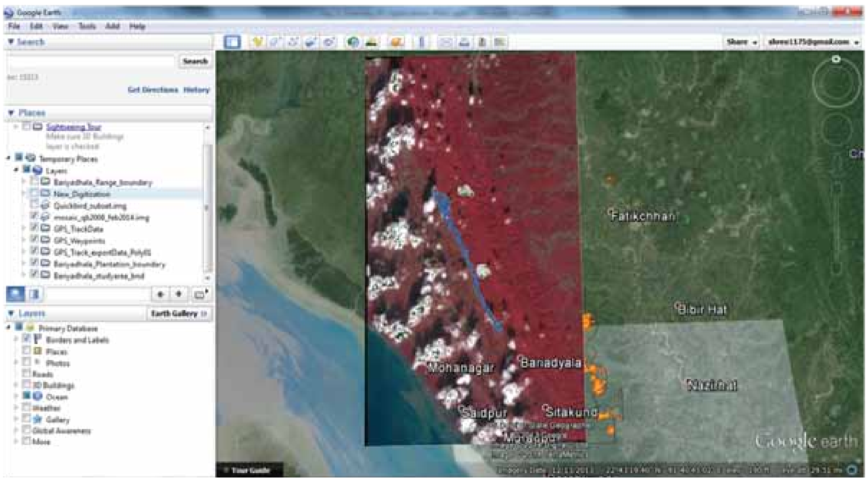
Google Earth is freely available software. There is an option to see different satellite images (only true color satellite images) with different acquisition dates. You can download the images, extract a forest in its different years and quantify the changes of that forest area. In addition, you can also find administrative boundary, roads and names of important locations name that would help to explore any area.



There is an option to show the time series images in Goggle Earth Software. In this way you can easily identify the deforestation area within the study area. If you want to see different time series images of any area, zoom the area and click the icon  from the Google Earth Toolbar. Now, you will see a Time bar that shows the available image acquisition data of this area.

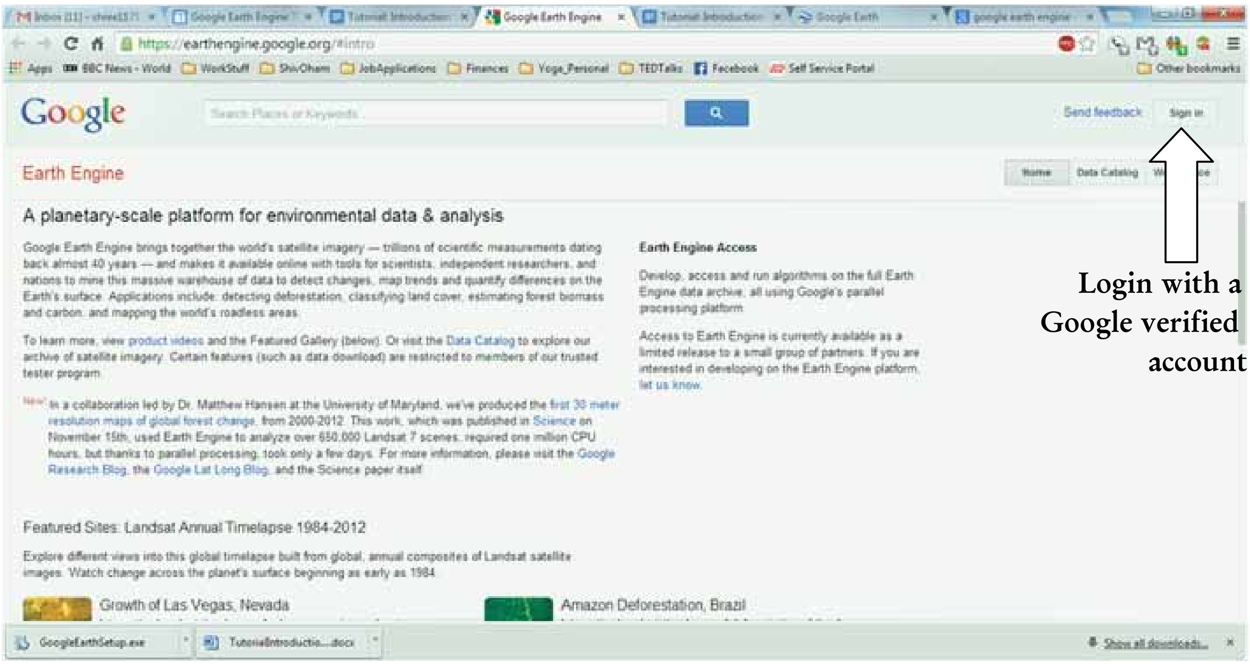
Load data on Google Earth using .kmz

Google Earth Software supports .kml or .kmz files. If you want to show any data in Google Earth software, you must convert theses data into .kml or .kmz file. There are different software, where you can find a tool to convert shape file into .kml or .kmz file like ArcGIS, Global Mapper etc. You can also add .img file in Google Earth software.



Google Earth Engine

Users will find different time series satellite images in Google Earth Engines. There are lots of data dating back almost 40 years available to the user to identify and quantify the changes.



Lesson Review

- ✓ Application of Remote Sensing in Forestry issuses of Indonesia, Bangladesh and US Forest Service.
- ✓ Application of Google Earth in Forest Mapping and Classification

Lesson-7

Knowledge and Skills Practice

There are 8 (Eight) Knowledge and Skills Practice sessions in **Intermediate Remote Sensing and GIS Manual** that are included with data in the attached CD (with this Manual). Some Knowledge and Skills Practice sessions are continuity of **Basic Remote Sensing and GIS Manual** and rest of the Knowledge and Skills Practice sessions are designed according to the selected Lessons of this manual. The Knowledge and Skills Practice sessions of this manual are given below-

1. Knowledge and Skills Practice 1 : **Create a Project Directory**
2. Knowledge and Skills Practice 2 : **Import and Edit Data from GPS-I to ARCMAP**
3. Knowledge and Skills Practice 3 : **Create an ArcPad Project within ArcMap**
4. Knowledge and Skills Practice 4 : **Collect Data Using ArcPad**
5. Knowledge and Skills Practice 5 : **Downloading and Viewing Landsat Data**
6. Knowledge and Skills Practice 6 : **Geo-rectification of Landsat Image**
7. Knowledge and Skills Practice 7 : **Subset Landsat Image**
8. Knowledge and Skills Practice 8 : **Unsupervised Classification**

The Knowledge and Skills Practice 3 and 4 are linked to the Lesson 3: **ArcPad and the Trimble Juno.**

The Knowledge and Skills Practice 5 linked with Lesson 4: **Introduction to Landsat.**

The Knowledge and Skills Practice 8 linked with Lesson 5: **Unsupervised Classification.**

Summary

The Intermediate Remote Sensing and GIS manual is a resource for understanding the various applications of remote sensing and GIS. It covers topics, which are presented both in theoretical and practice formats, enabling the user to gain intermediate level of knowledge in remote sensing and GIS and apply those to his/her relevant field. Where required, reference links to relevant websites have also been given with the Lectures.

One may not always need to apply all the concepts discussed in this manual. However, getting introduced to some new applications of remote sensing and GIS like ArcPad software, source of time series Landsat images(http://glovis.usgs.gov/), elaborate discussions on Unsupervised Classification, application of Remote sensing and GIS in Indonesia, Bangladesh and US Forest Service, gives the user to know what can be done with remote sensing and GIS. And that is important.

We hope all of you the participants have enjoyed this lesson, knowledge and skills practice session.

Best of luck!

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