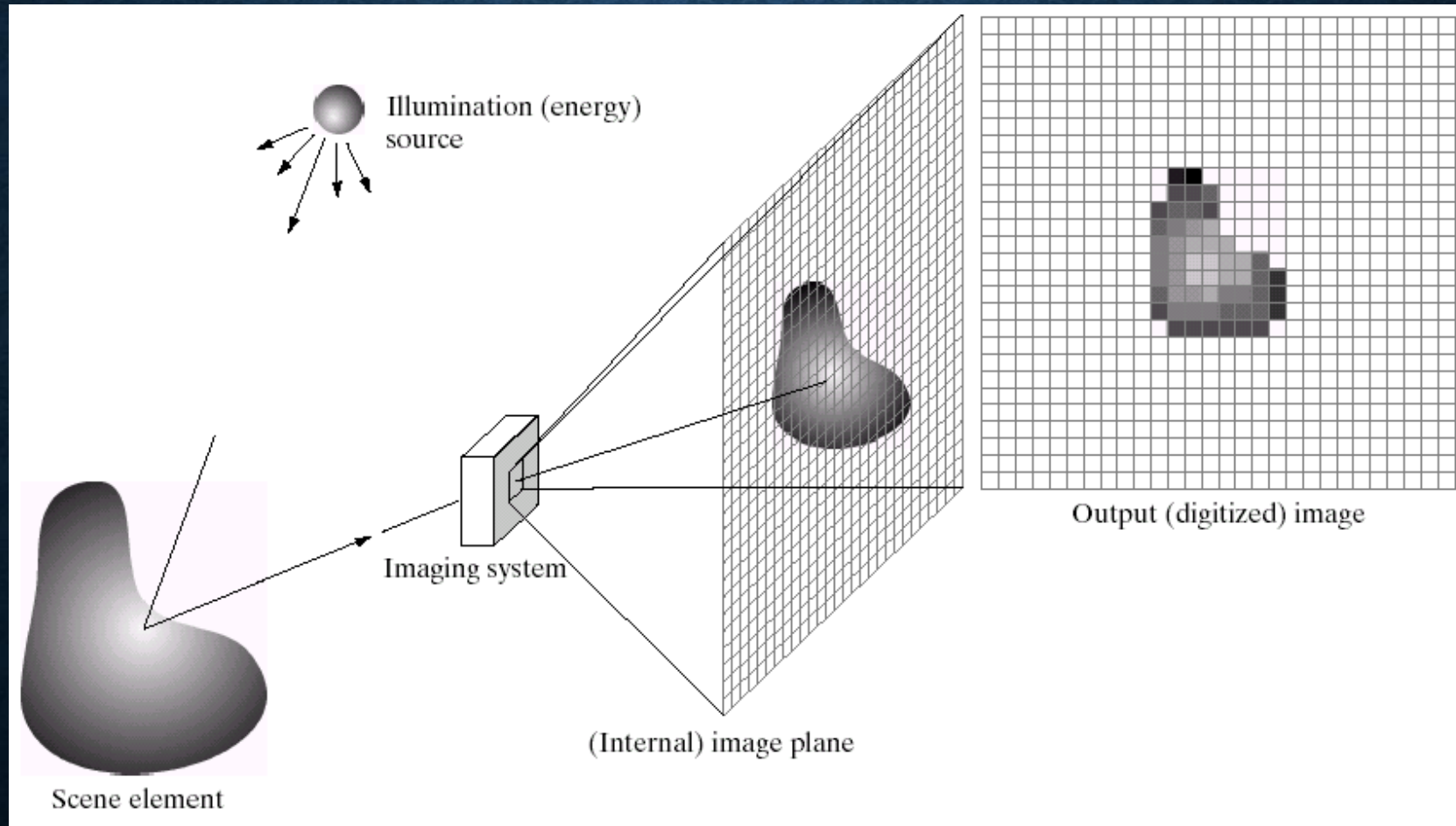


Paper Code: GIS 03
Principles of Remote Sensing
Digital Image Interpretation
PG Diploma in RS & GIS

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What is a Digital Image?

A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels.



Digital Image..

- A digital image is a two dimensional matrix (array). Its elements are called **pixels** (abbreviation of **picture elements**). They are sometimes further abbreviated to 'pels'.
- The process of displaying an image creates a pictorial representation of this matrix. The pixel values are assigned a particular grey-level (monochromatic image) or a particular colour in a multispectral image.

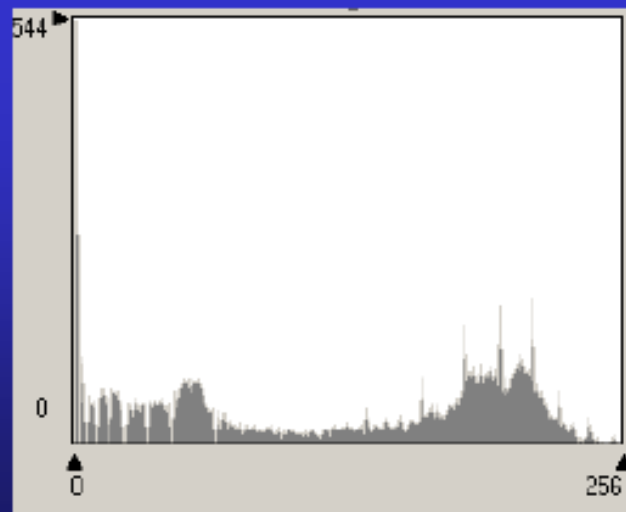
Binary and Grayscale Images



Binary Image



Grayscale Image (8-bit)



Grayscale Image Histogram

255	255	255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255	255	255
195	190	192	186	188	190	190	186	189	
88	76	78	62	70	73	73	62	73	
87	86	82	79	85	87	80	82	85	
82	84	91	80	85	91	84	82	82	
82	84	91	80	86	91	84	97	99	
82	84	91	80	87	82	86	88	89	
94	85	87	75	81	88	88	76	85	
90	85	126	120	119	121	120	136	144	
120	121	153	144	143	147	149	159	162	
188	197	198	184	185	190	195	197	195	
199	197	199	187	190	191	194	187	190	
199	189	193	210	208	197	190	199	202	
198	185	195	214	210	193	195	208	209	
197	194	200	213	210	197	205	213	209	
192	200	198	198	203	212	212	212	208	
197	204	204	204	207	212	211	205	207	

Grayscale dump of part of image



~ 0

~ 200

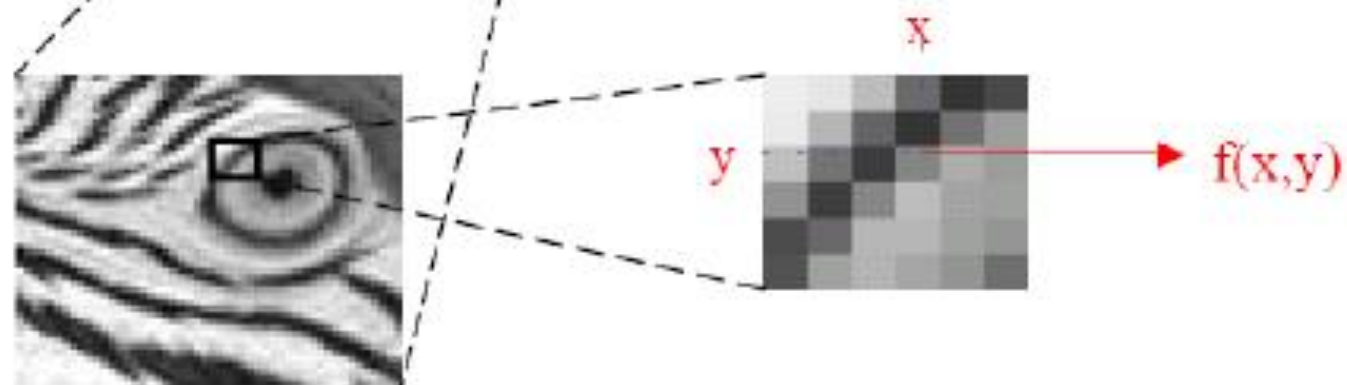
255

2D digital image is a 2D Intensity Function, $f(x,y)$

x and y are spatial coordinates and $f(x,y)$ encodes intensity

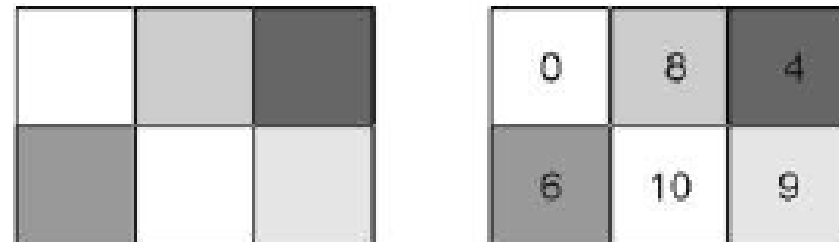
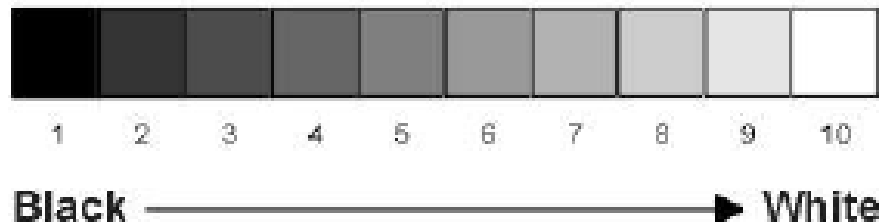


9	8	7	4	0	2
8	7	3	0	4	7
7	5	0	6	8	7
6	0	6	8	7	7
0	3	8	8	7	6
1	7	8	7	6	3



Shades of grey...

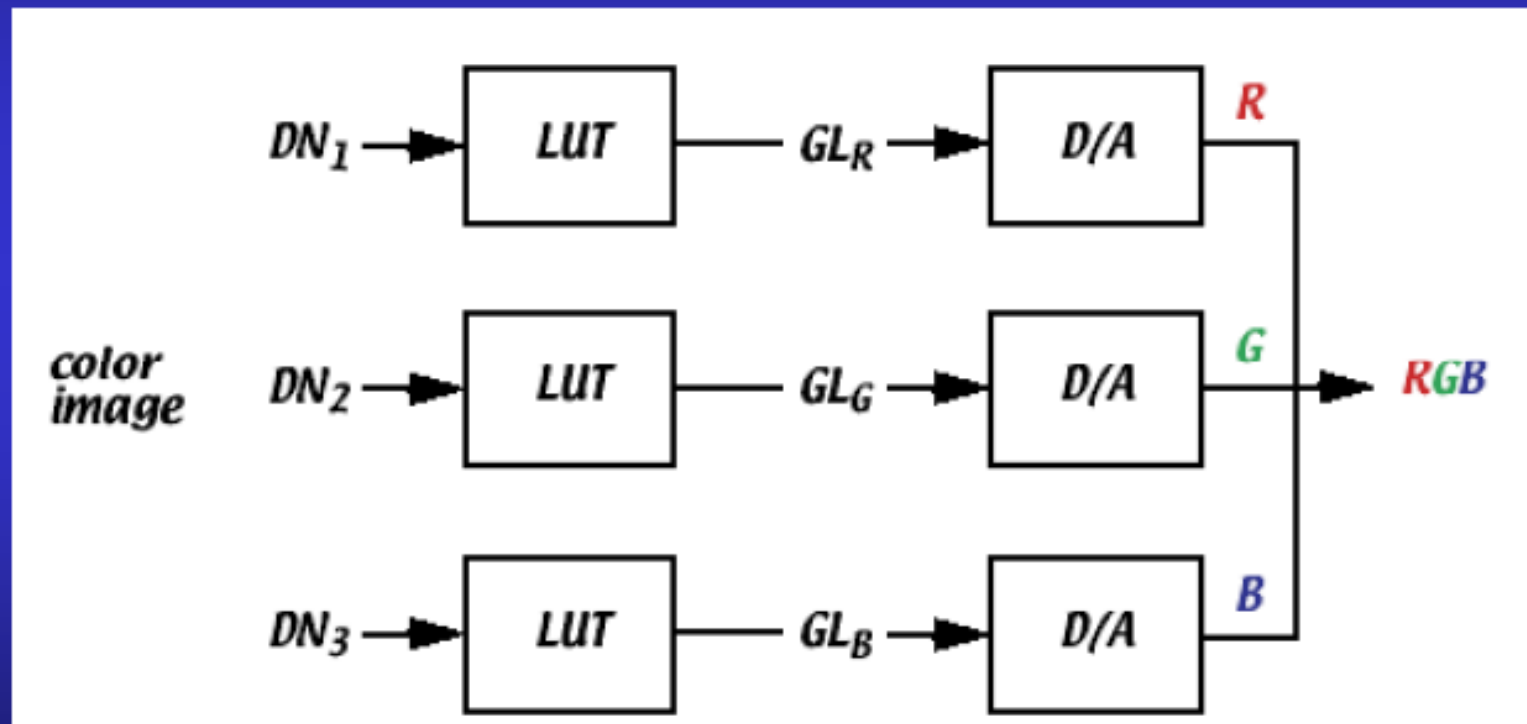
- To look at a satellite image on a computer screen, the variations in brightness (DN) are translated into a grey scale. The grey scale is made up of shades from black, through grey, to white.
- In a test image using this grey scale, the dark "black" pixels have a low intensity and a $DN = 0$. Bright "white" pixels are at the top end of the scale, with $DN = 10$. The pixels in between have different shades of grey with $DN = 1$ to $DN = 9$.





47	53	62	65	60	50	44	46	49	48	52	52
46	48	51	54	52	46	44	46	49	49	46	48
59	53	49	47	48	47	46	47	51	53	49	45
65	64	61	57	52	49	48	49	51	51	49	48
67	66	65	66	64	59	50	48	48	45	44	46
67	65	67	69	65	63	61	54	46	44	45	45
67	64	65	66	64	63	62	57	51	47	44	44
69	69	69	67	66	64	63	59	53	52	50	47
70	70	72	70	69	66	64	61	57	54	51	51
70	72	69	66	68	67	64	64	62	57	52	49
66	68	70	70	69	69	68	63	66	65	56	51
71	69	66	65	65	64	66	64	65	69	66	61
73	69	68	66	68	67	67	65	65	64	65	64
71	69	70	67	69	69	68	66	68	68	68	70
69	69	69	68	66	67	67	66	69	70	69	70
70	71	70	69	69	69	67	66	70	70	66	70
64	66	66	68	71	71	68	66	68	68	66	71
64	67	64	66	71	72	72	70	71	73	71	71

Colour Display



Principles of Image Interpretation

- ✓ Visual interpretation of satellite images is important in Remote Sensing and GIS for different applications.
- ✓ Visual interpretation is the skills that an image interpretation apply equally to an image.

IMAGE INTERPRETATION

- How is information extracted from images?
 - visual image interpretation (in this Unit)
 - semi-automatic processing by computer

IMAGE INTERPRETATION

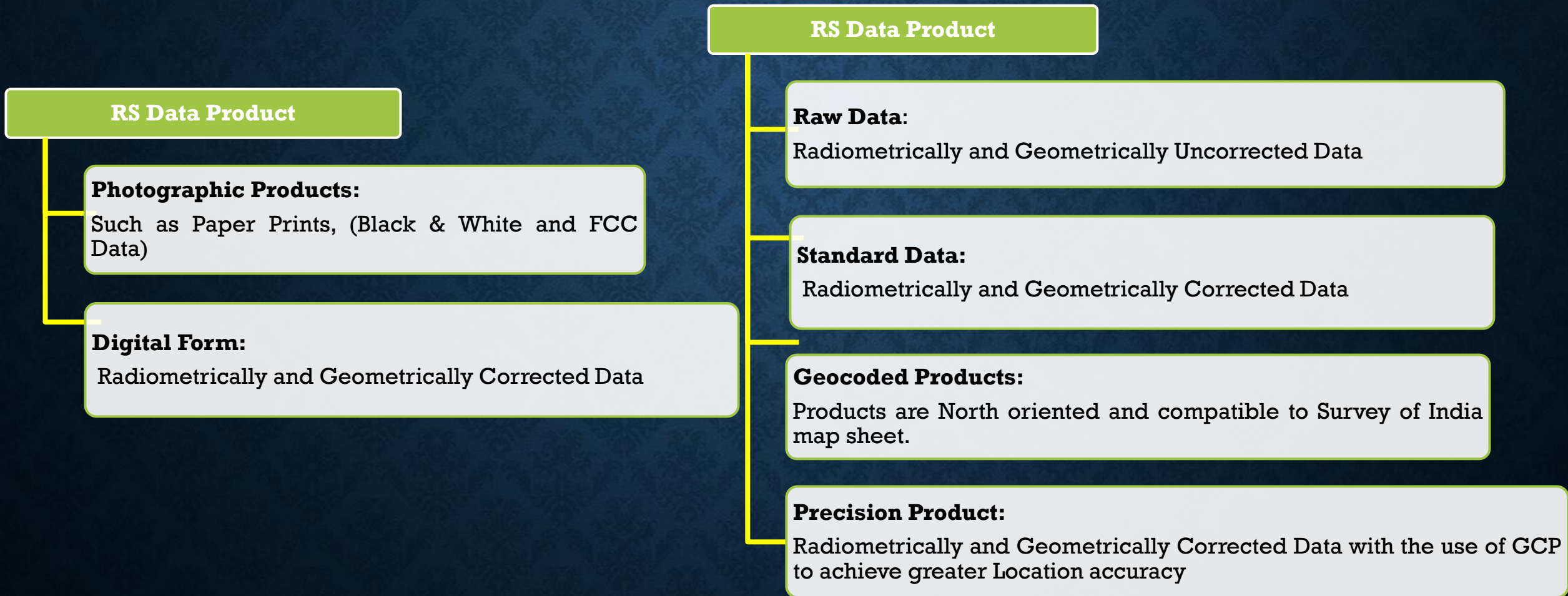
- ✓ Visual interpretation is based on relating colours and patterns to real-world features.
- ✓ Images can be displayed on a computer monitor or in hard copy form.
- ✓ Mapping conveys the findings.

FUNDAMENTALS

- Analysing an image is typically done through a combination of:
 - ❖ direct and “spontaneous recognition”;
 - ❖ using several clues to draw conclusions through a reasoning process (i.e. “logical inference”).

Type of Image Data Products

Depending on Correction applied & level of Processing



What do you see in this Image?

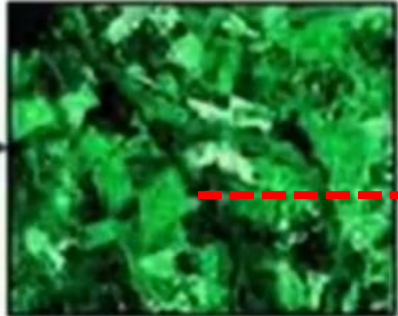
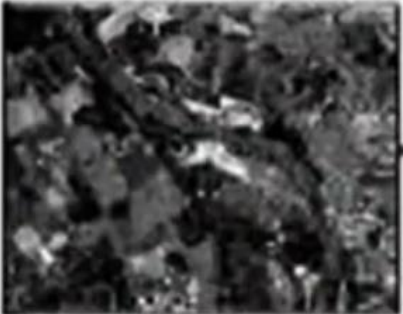


Making of Coloured / False Colour Composite (FCC)

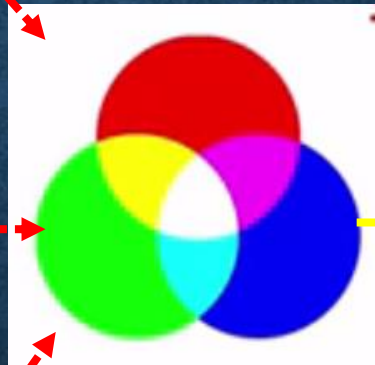
Green channel XS1



Red channel XS2



NIR channel XS3



Additive
colour
synthesis



Infrared false colour
composition

Color Composite

Color Composite:

RGB- Designed to display raster data in Red Green Blue (RGB) color space.

- True Color Composite (TCC)
- False Color Composite (FCC)

True color composite(TCC)- The True color composite is the image compositions with the band

R >>>> R

G >>>> G

B >>>> B

False composite(FCC)- The False color composite is an image with the different band combination than its natural color.

Sensor Monitor

NIR >>>> R

R >>>> G

G >>>> B

Concept of B&W and Colour Images

Blue



Green



Red



True colour



Concept of Colour Composite

True colour



Blue



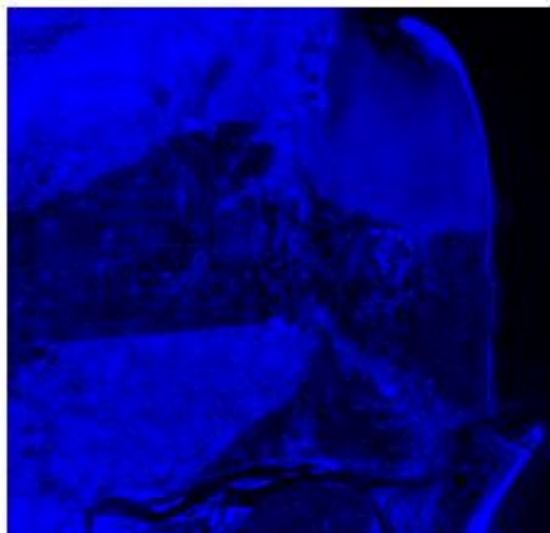
Green



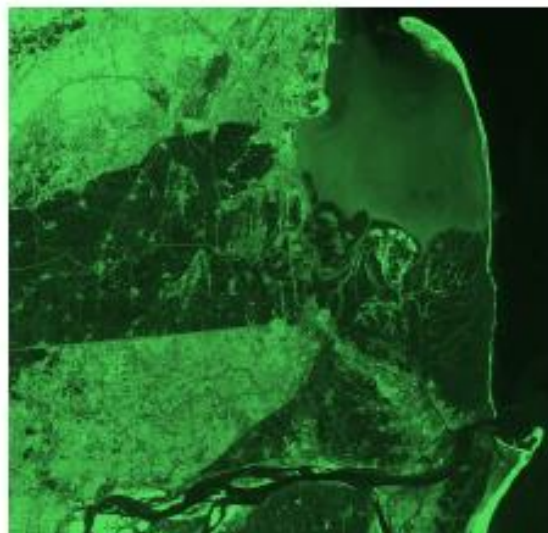
Red



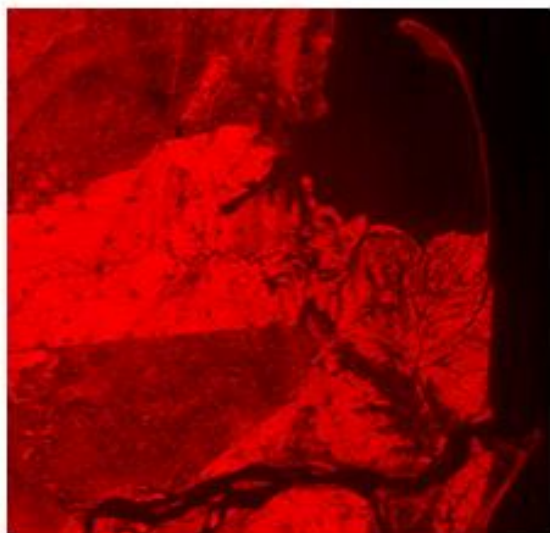
Concept of False Colour Composite - Kakinada, AP



Band - 2



Band - 3

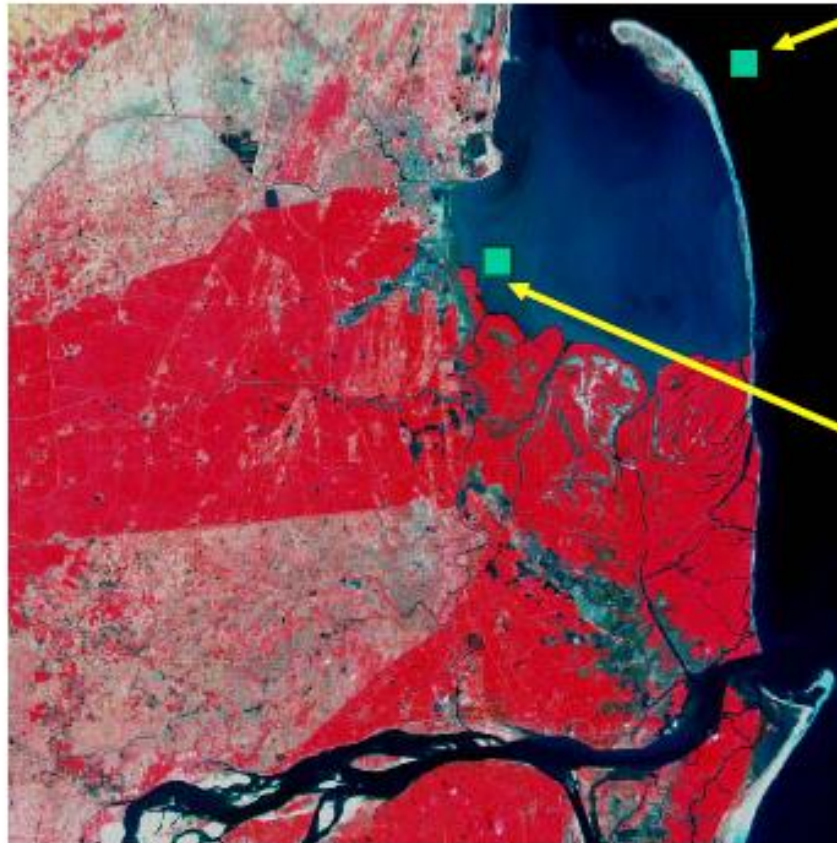


Band - 4



FCC

Pixel Values in Multispectral data (IRS/LISS-II)



Deep Water

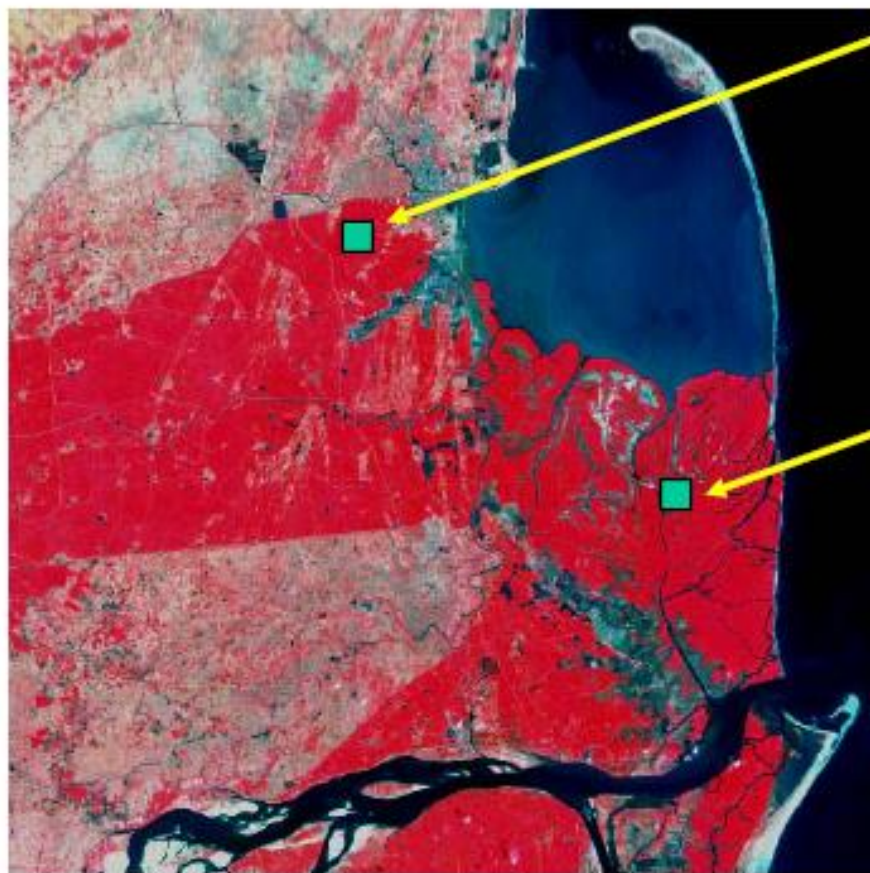
Band 1			Band 2			Band 3			Band 4		
42	43	42	18	18	18	16	16	16	11	11	11
42	42	44	18	18	18	16	16	16	11	11	11
42	43	43	18	18	18	16	16	16	11	11	11

Turbid Water

Band 1			Band 2			Band 3			Band 4		
50	50	50	31	32	31	30	29	30	17	17	17
50	50	50	31	31	31	29	29	29	18	17	17
50	50	50	32	32	31	29	29	29	18	17	17

Standard FCC

Pixel Values in Multispectral data



Standard FCC

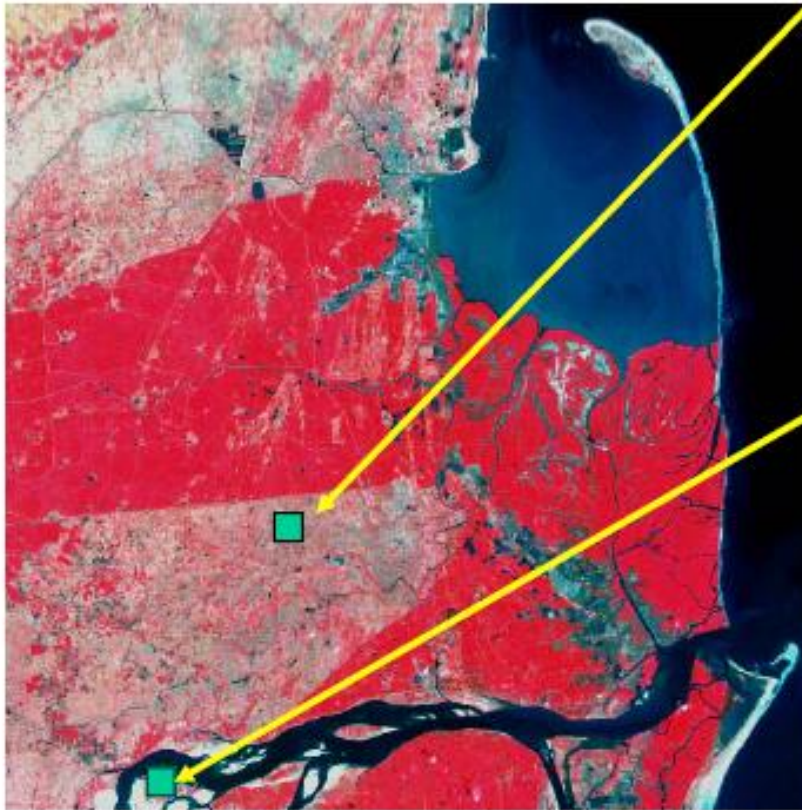
Agriculture

Band 1			Band 2			Band 3			Band 4		
44	44	44	23	22	23	21	20	21	80	79	77
44	44	44	23	22	23	21	20	21	84	83	81
44	44	44	23	22	23	21	21	21	80	78	78

Mangrove Forest

Band 1			Band 2			Band 3			Band 4		
43	43	43	23	22	23	21	21	20	59	55	59
43	43	43	23	22	23	21	20	21	57	56	56
42	43	43	23	22	23	20	20	20	56	56	56

Pixel Values in Multispectral data



Barren Area

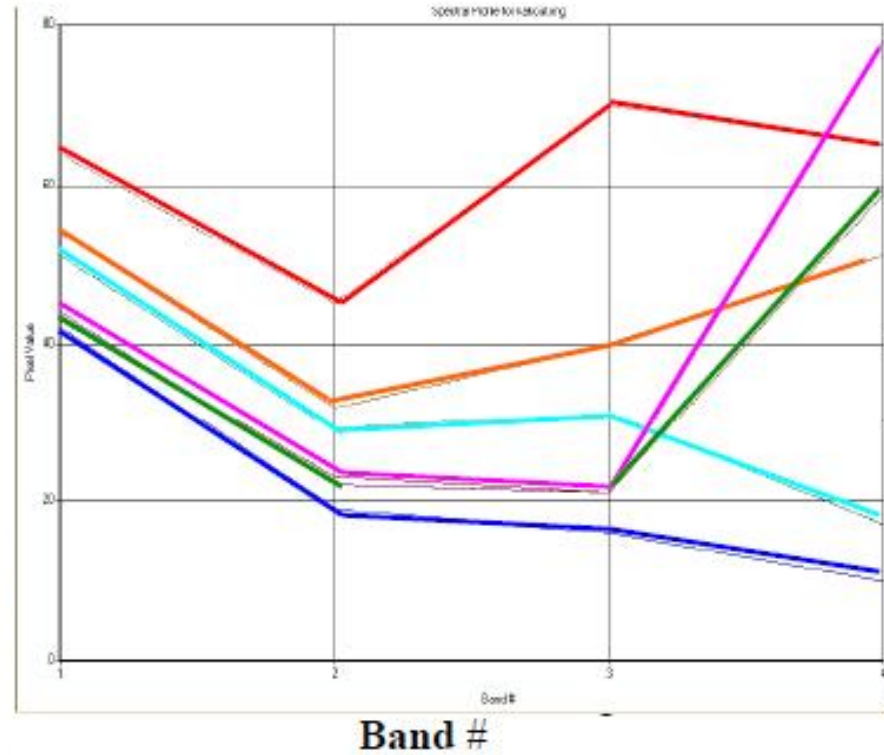
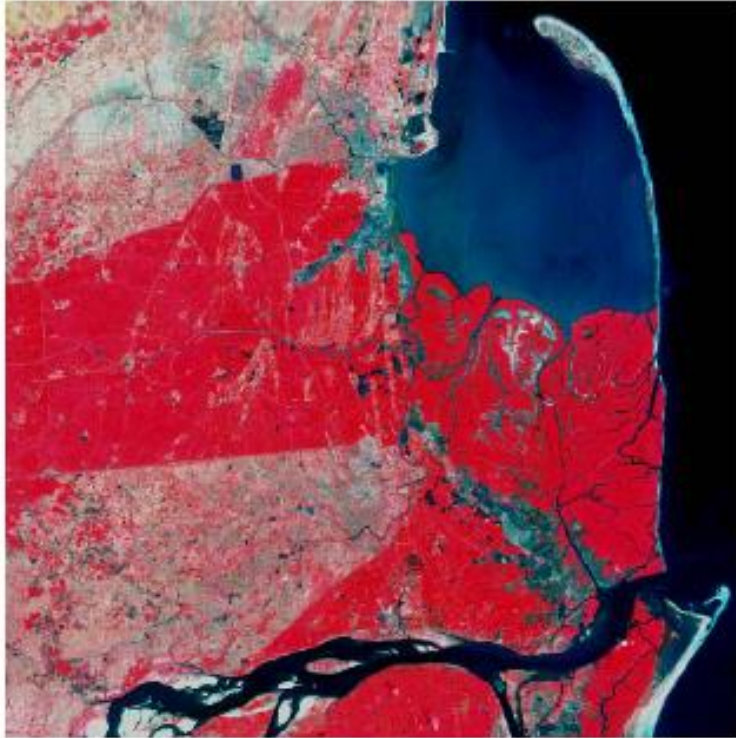
Band 1			Band 2			Band 3			Band 4		
55	54	54	32	32	32	41	41	41	53	51	50
55	54	54	32	32	32	40	40	41	53	51	52
54	54	54	31	31	32	42	40	40	52	51	53

Sandy Area

Band 1			Band 2			Band 3			Band 4		
63	65	64	43	44	44	67	69	69	62	64	65
63	65	65	44	45	44	68	68	69	64	65	65
63	65	64	44	45	44	69	69	69	63	65	65

Standard FCC 4,3,2 (R,G,B)

Spectral Profile of Land Features



— Deep Water

— Forest

— Turbid Water

— Barren Area

— Agriculture

— Sandy Area

Histogram

- For an image *band*, a graph of number of pixels with given grey values with corresponding grey values can be constructed, known as **image histogram**
- In other words a histogram is a graph showing **pixel values (X-axis)** with **corr. frequency of occurrence (Y-axis)**

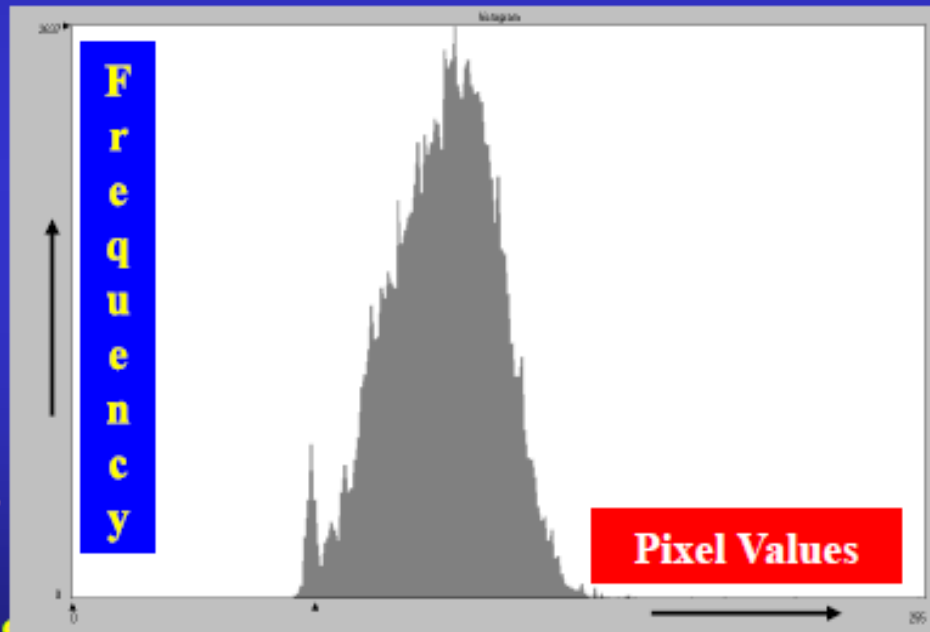




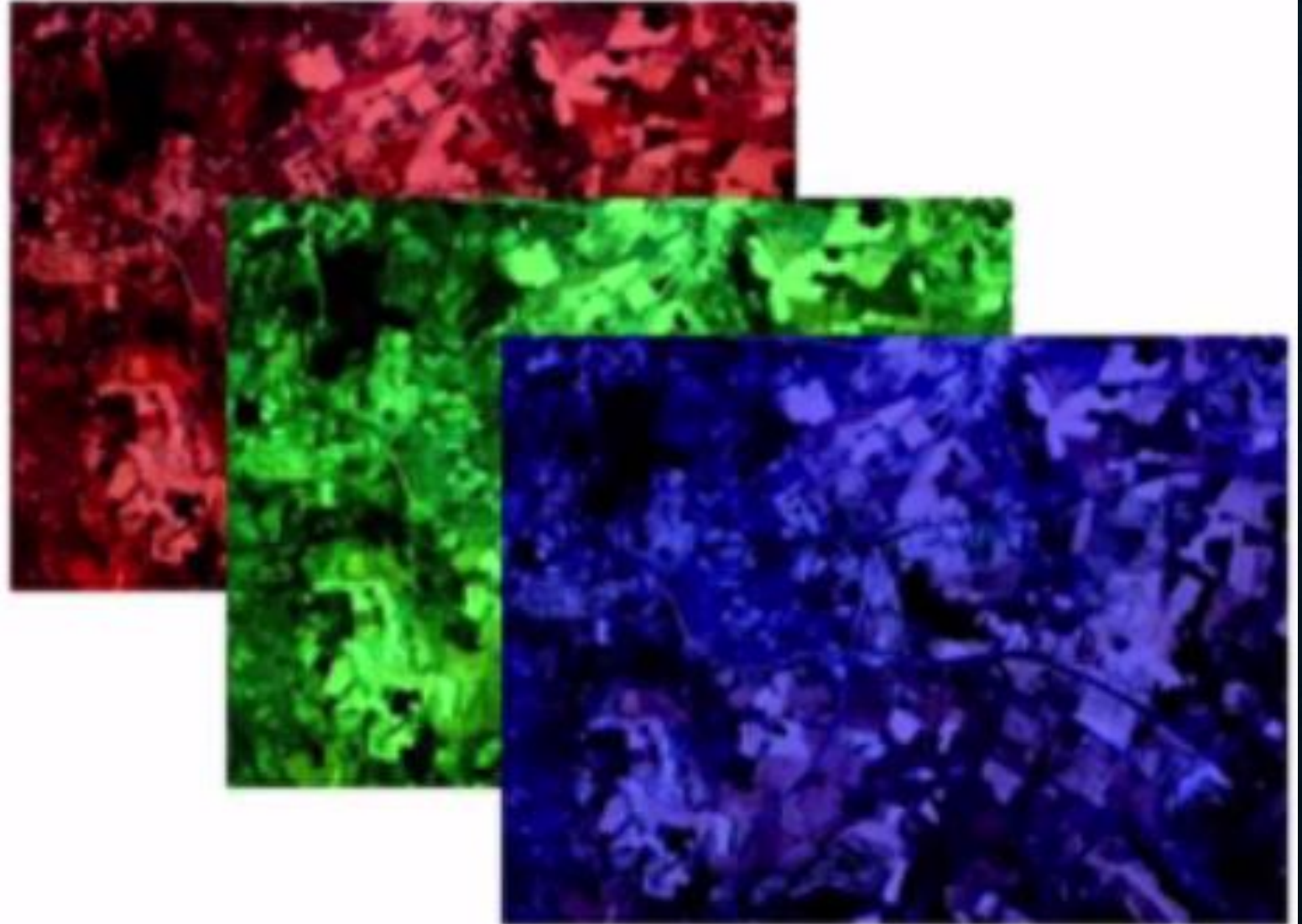
Figure 3. Showing IRS-IC-PAN image of 11 February 1997 of New Delhi, the national capital of India and surroundings. This image has been used as master image for image-to-image transformation and later as intensity image during the final stage of IHS-to-RGB transformation.



Figure 4. Shows the IRS-IC-LISS-III image (7 November 1996) standard FCC (RGB:321 band combination) of the same area as shown in figure 3. This FCC image has been used as secondary image during image-to-image transformation. Later, the two components (hue and saturation) of this image after RGB-to-IHS transformation have been used for IHS-to-RGB transformation.

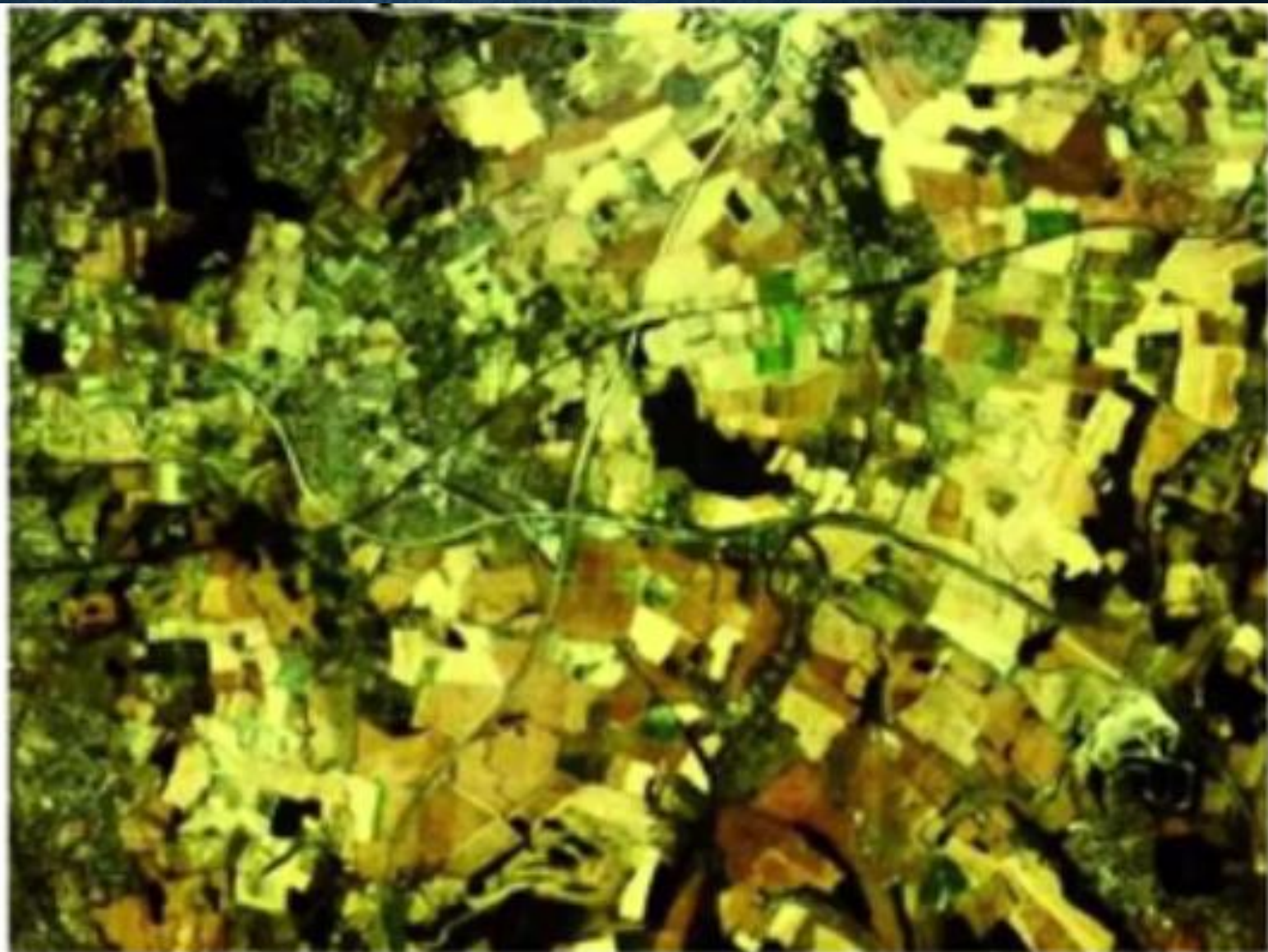
Color Composite(Real Colour Composite)

red band on red
green band on green
blue band on blue



Color Composite(Real Colour Composite)

red band on red
green band on green



Real/ True Color Composite



Image Merging / fusion techniques

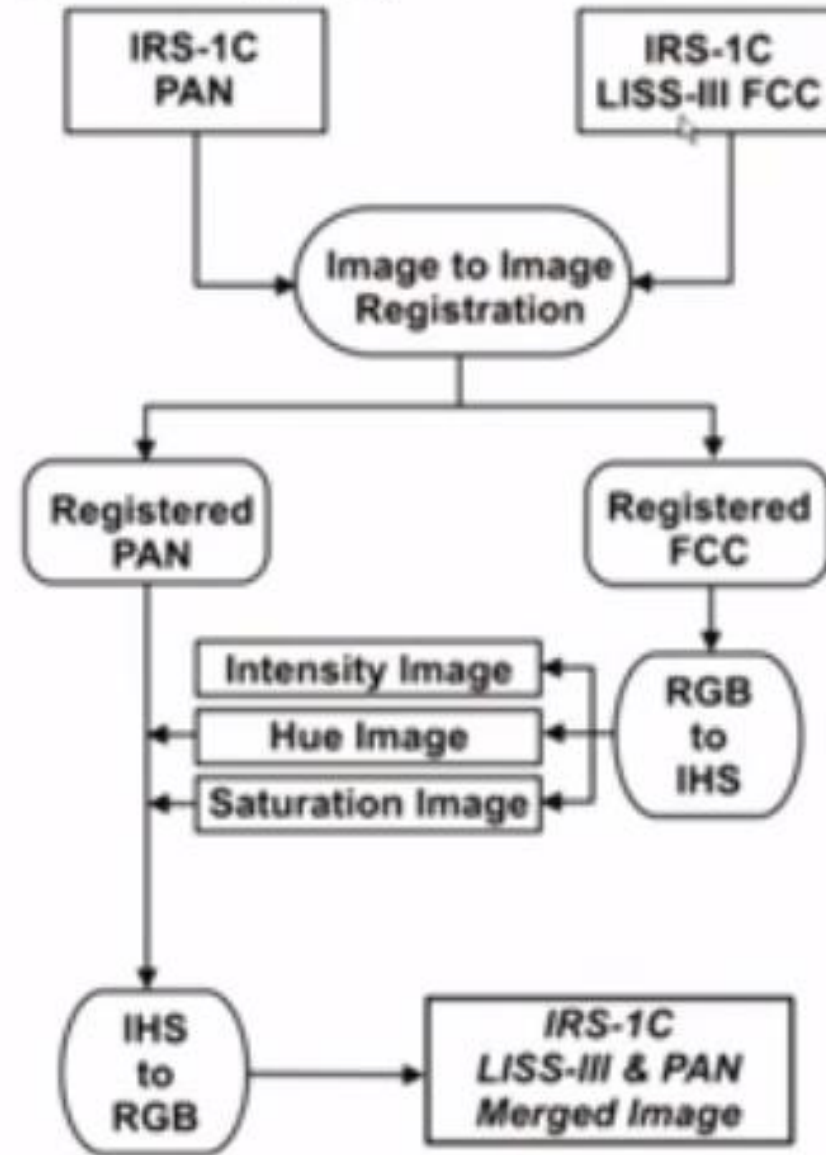


Image fusion / merged process



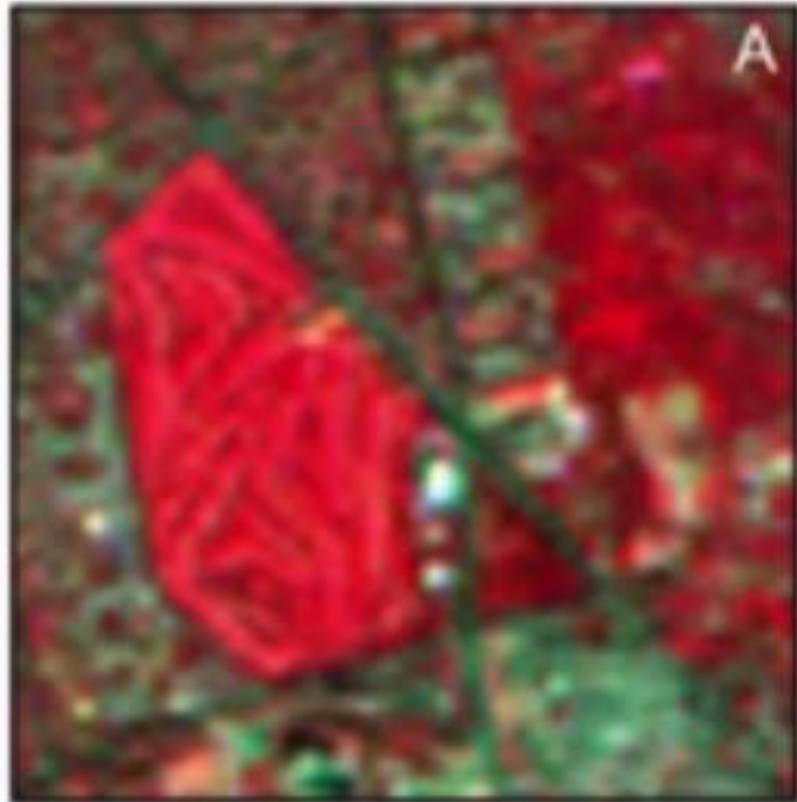
**IRS-1C-PAN
image 5.8m)
of 11 Feb
1997**



**IRS-1C-LISS-III image
23.5m) of 7
Nov 1996**



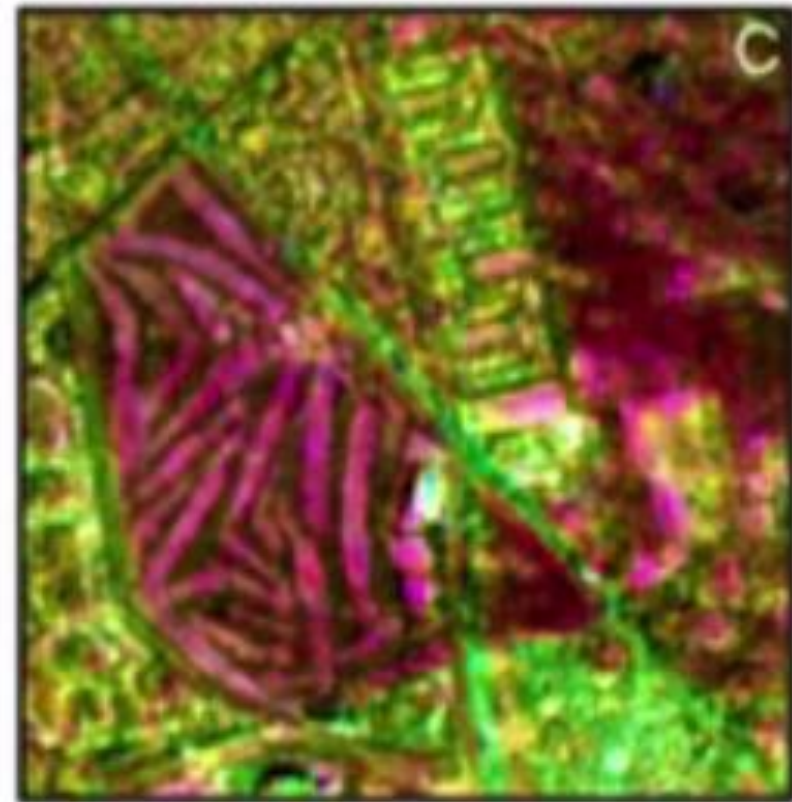
**IRS-1C-
PAN &
LISS-III
merged
image**



**IRS-1C-LISS-III
image 23.5m)
of 7 Nov 1996**



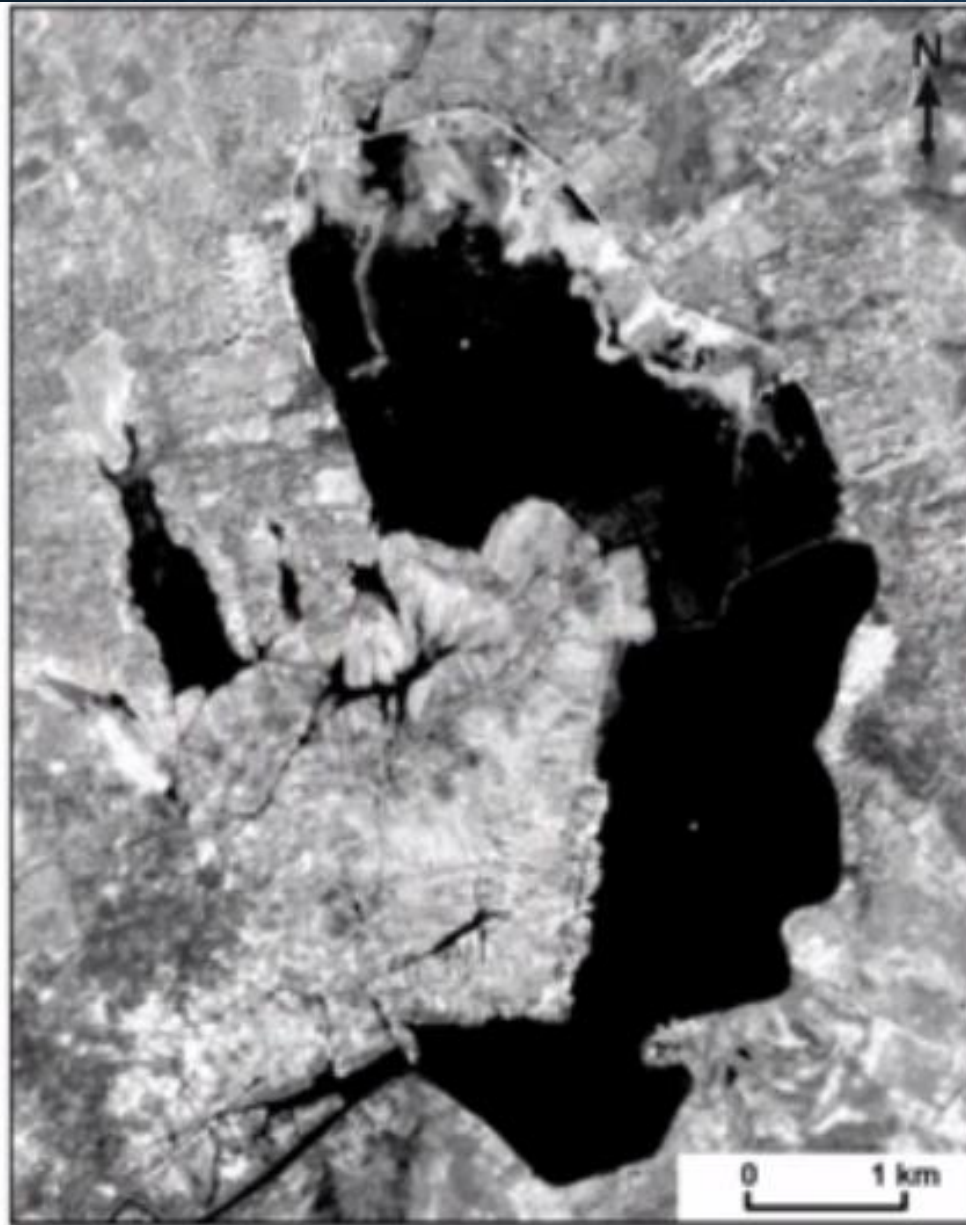
**IRS-1C-PAN
image 5.8m) of
11 Feb 1997**



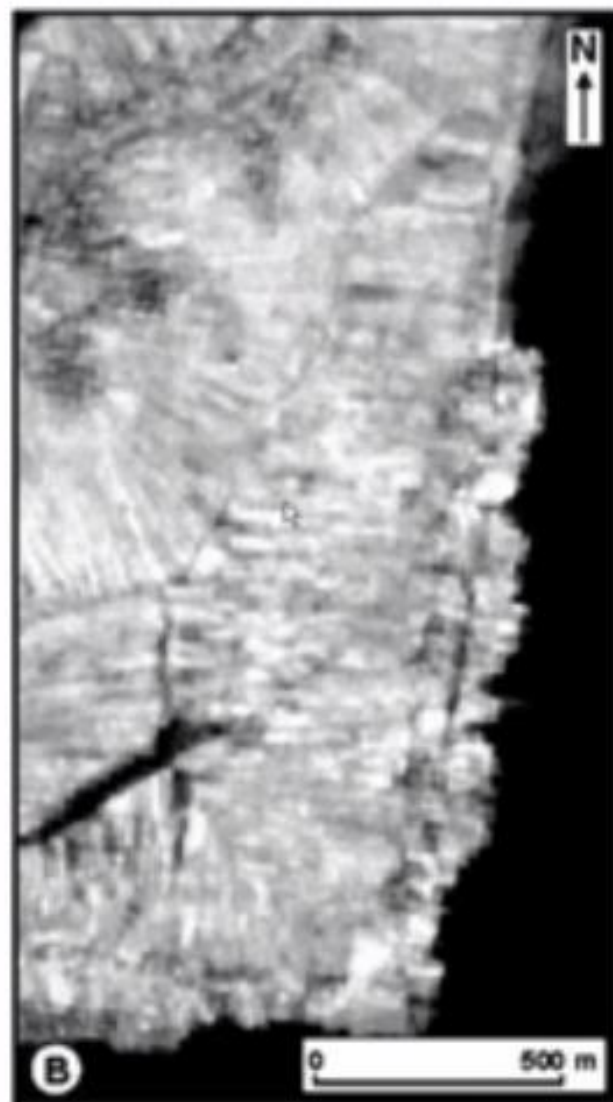
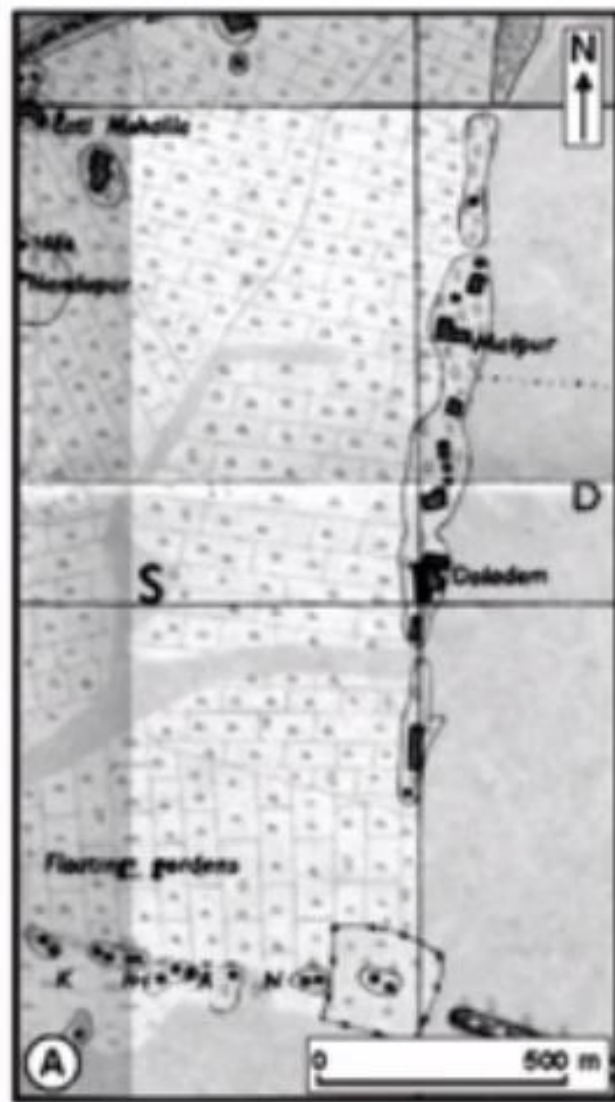
**IRS-1C-PAN &
LISS-III merged
image**



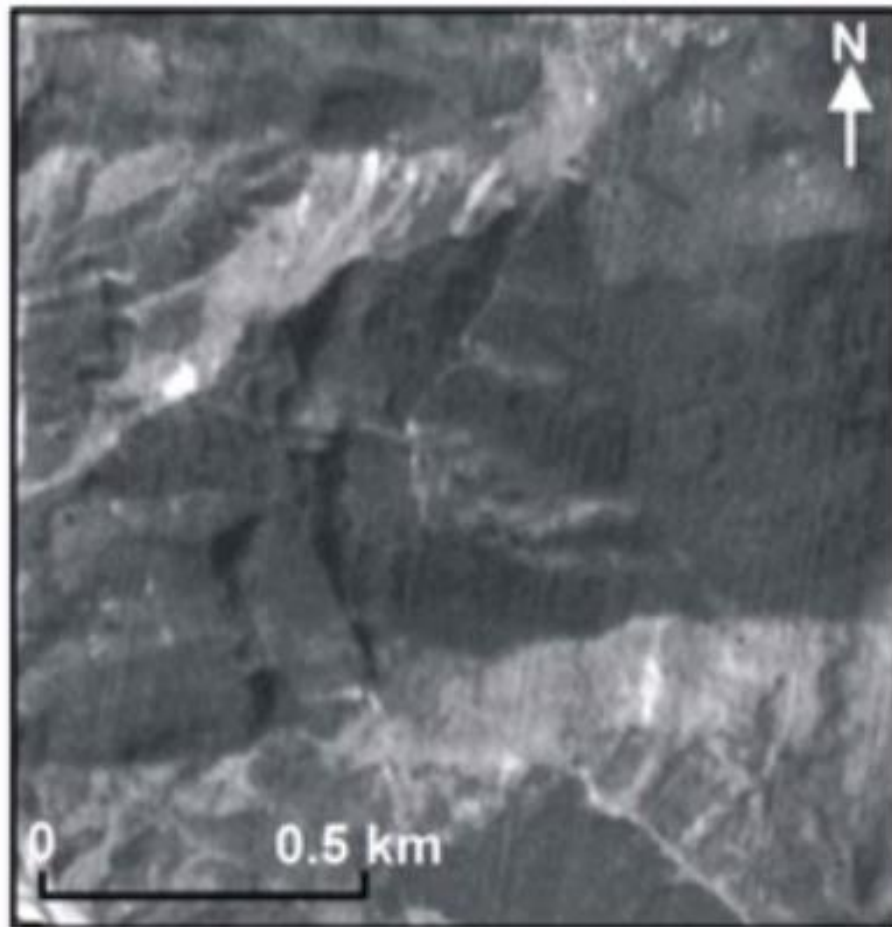
Dal Lake status: 1968



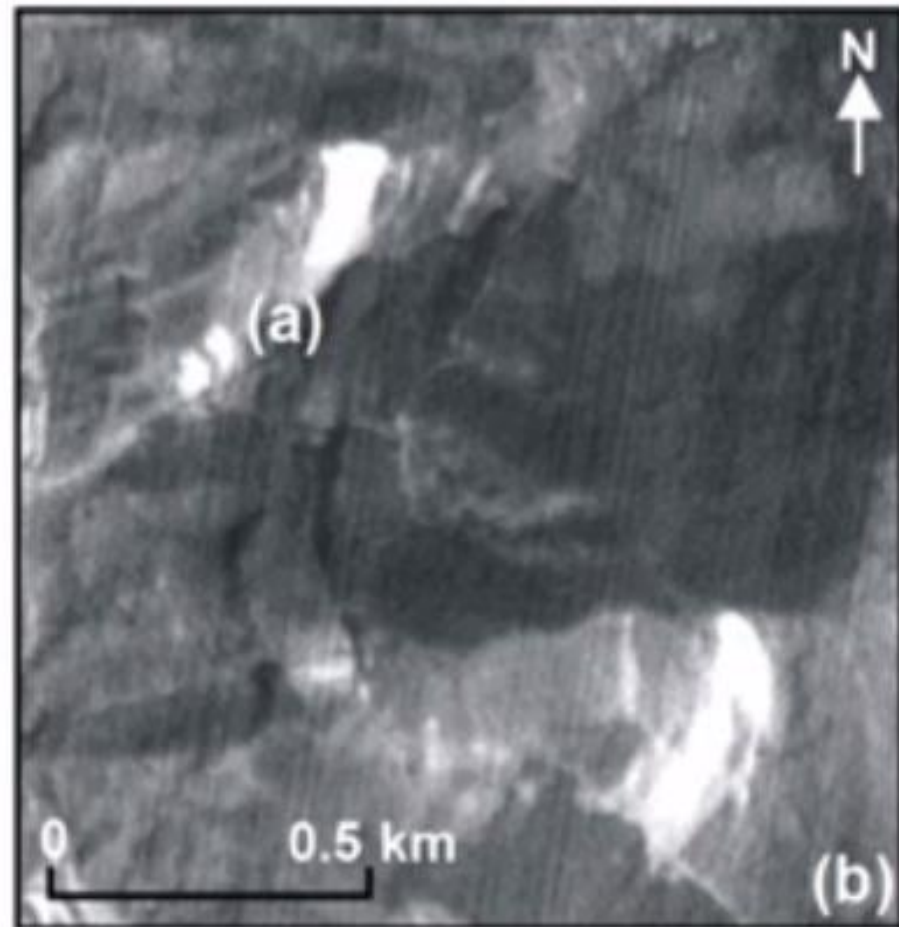
**1998 IRS-LISS-III
band 3 image**



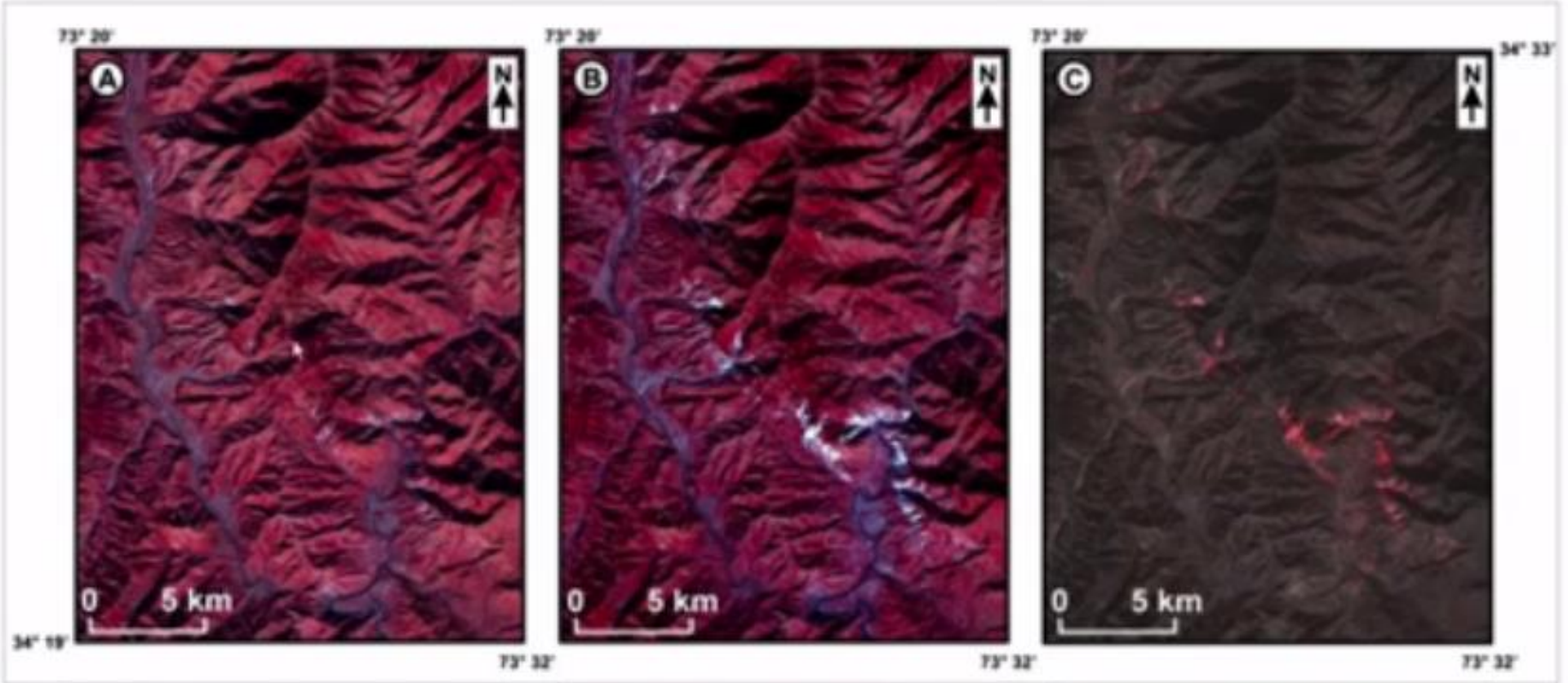
PCT image showing changes in Dal Lake area between 1968-1998



IRS-1C-PAN pre-earthquake image of 26 March 1999



IRS-1C-PAN post-earthquake image of 31 March 1999



Pre-earthquake ASTER image of 14 November 2000

Pre-earthquake ASTER image of 27 October 2005

Pseudo Colour Transform (PCT) image



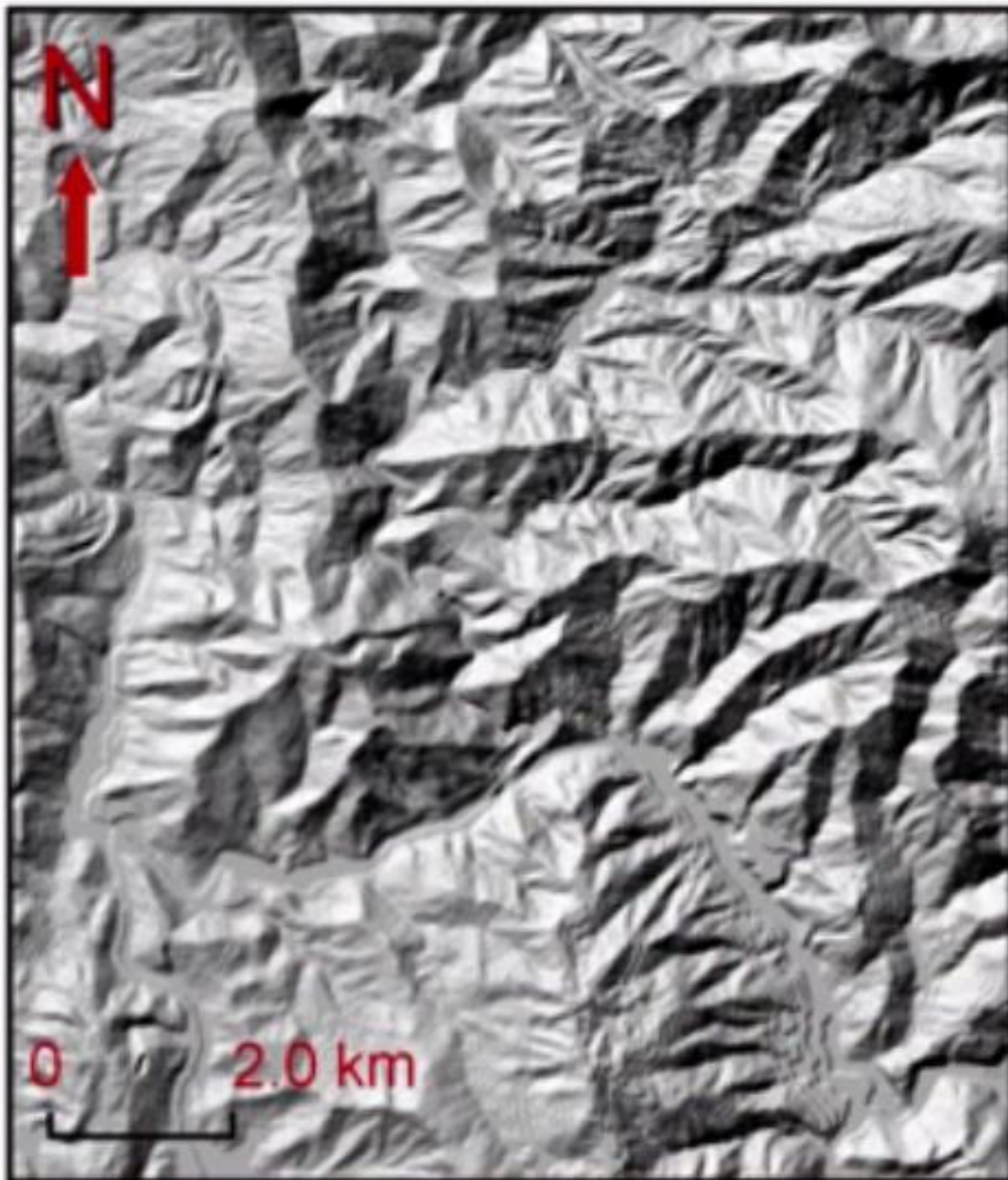
IRS-1D-LISS-III

12.10.1998

Sun Azimuth: 163.3°

Sun Elevation: 49.2°

4



Sun Azimuth: 343.3°

Sun Elevation: 49.2°

R

Image Interpretation Strategy

- ✓ Visual image interpretation: Process of identifying what we see on the images and communicate the information obtained from these images to others for evaluating its significance.
- ✓ Includes relative locations and extents.
- ✓ Use of data products like satellite single band image, FCC for performing image interpretations to extract thematic information for subsequent input to GIS

Level of Image Interpretation Keys

Interpretation Keys:

Criterion for identification of an Object with interpretation Elements or Keys.

interpretation elements provide guidelines to recognise certain objects:

1. X, Y Location
2. Size
3. Shape
4. Shadow
5. Tone/hue
6. Colour
7. Texture
8. Pattern
9. Height/elevation and Depth
10. Site, Situation and association

Basic Elements of Image Interpretation

Location

There are two primary method to obtain precise location in the from of Coordinates:

- i. Survey in the field using traditional survey techniques or global positioning system instrument.
- ii. Collect remotely sensed data of the object, rectify the image and ten extract the desired coordinate information.

Most scientists use relatively inexpensive GPS instruments in the filed to obtain the desired location.

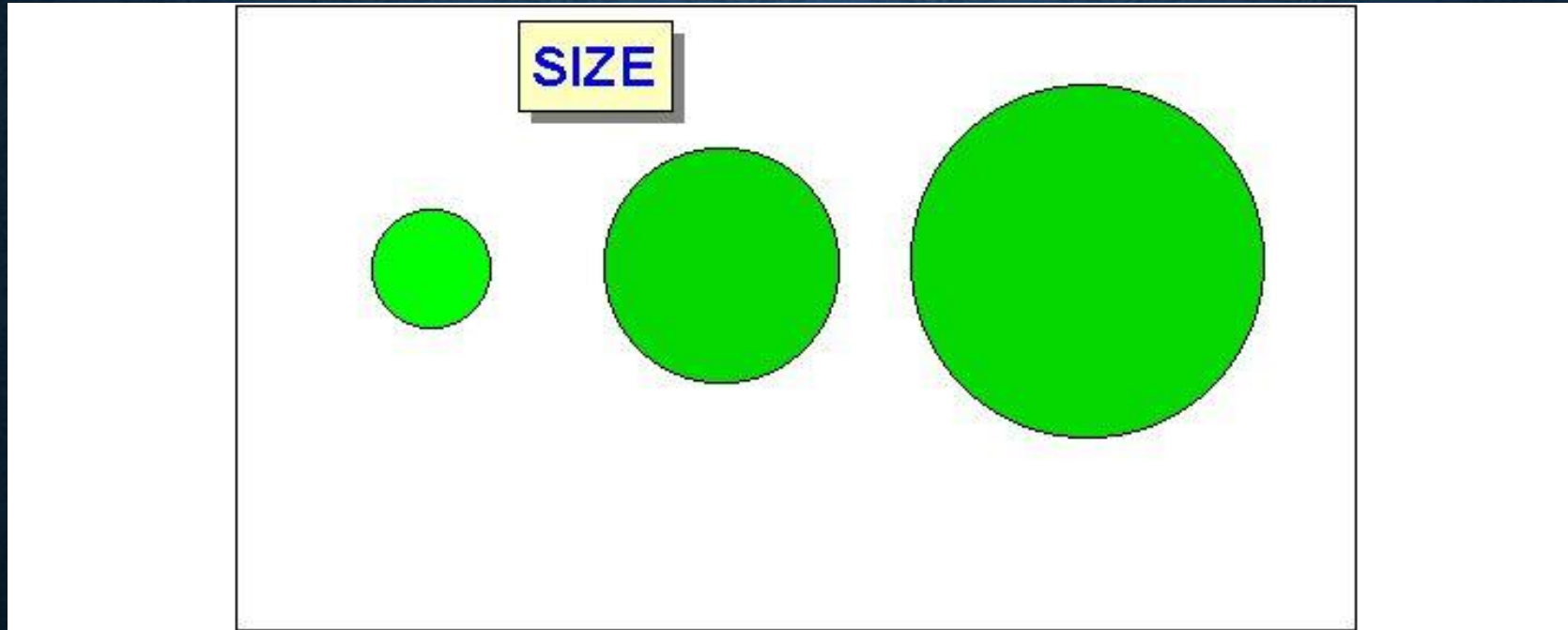
Size

- ✓ The size of an object is one of the most distinguishing characteristics and one of the more important elements of interpretation.
- ✓ Most commonly, length, width and perimeter are measured. To be able to do this successfully, it is necessary to know the scale of the photo. Measuring the size of the unknown object allows the interpreter to rule out possible alternative.
- ✓ **Most commonly measured parameters:**
length., width, perimeter, area occasionally volume

Shape

- ✓ Shape of an object described as the geometric form represented on an image.
- ✓ Regular shapes are signs of man-made objects.
- ✓ Irregular shapes with no distinct geometrical pattern are signs of a natural environment.

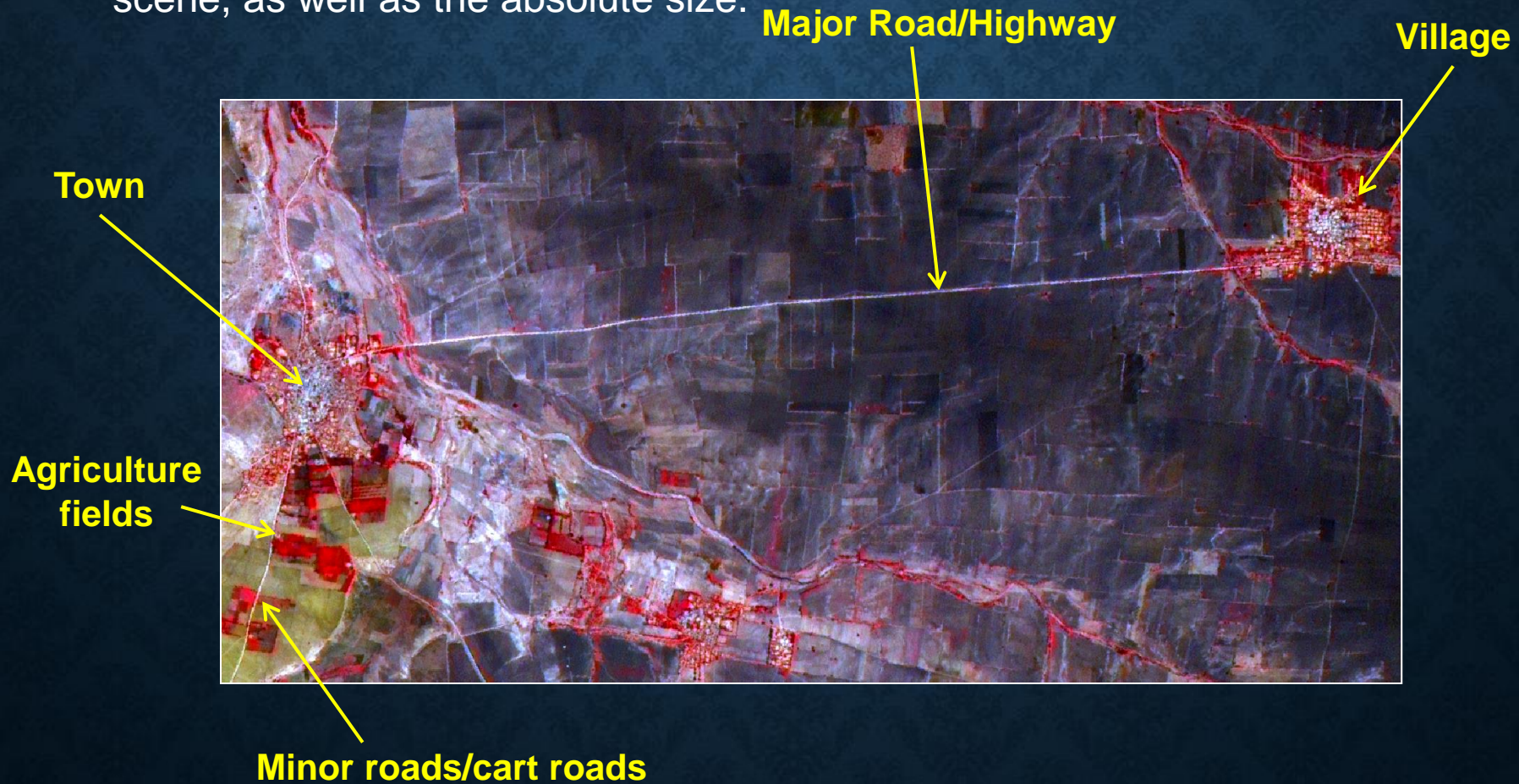
Size: Length, breadth and height



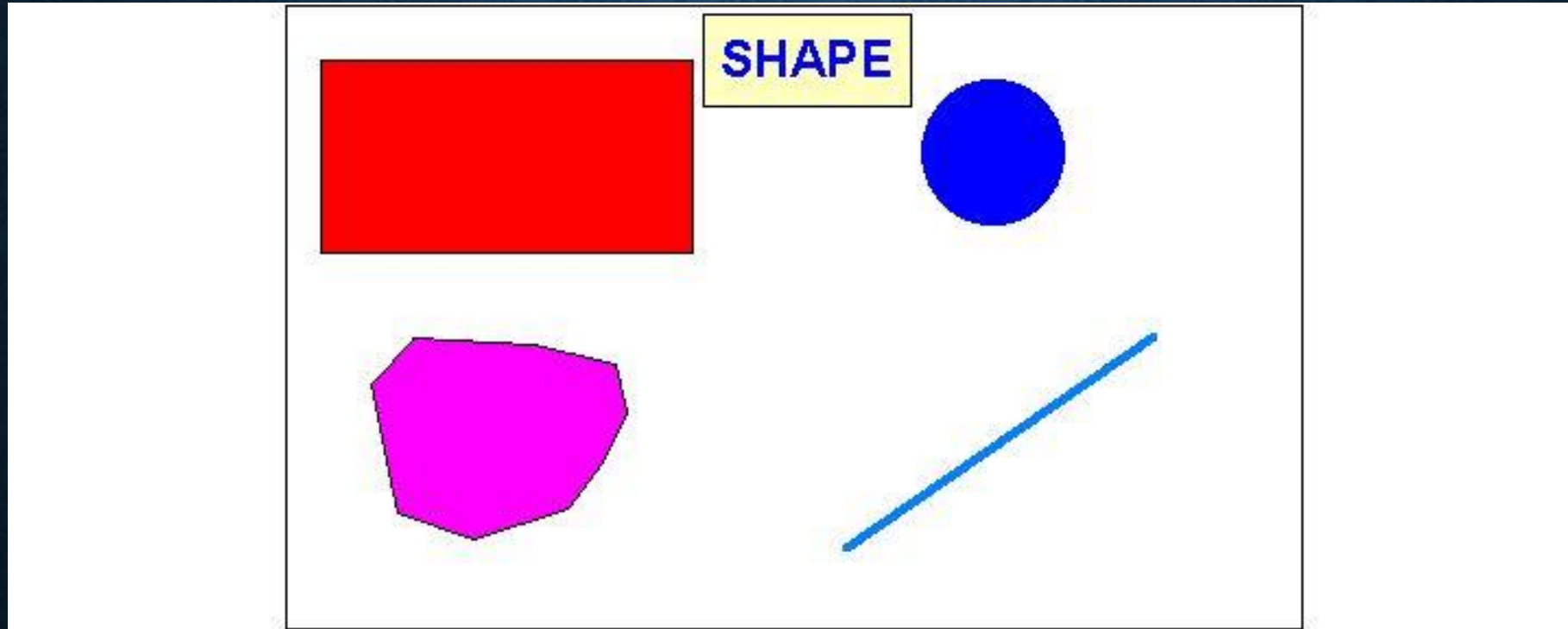
Elements of Image Interpretation

Size of objects in an image is a function of scale.

- It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size.



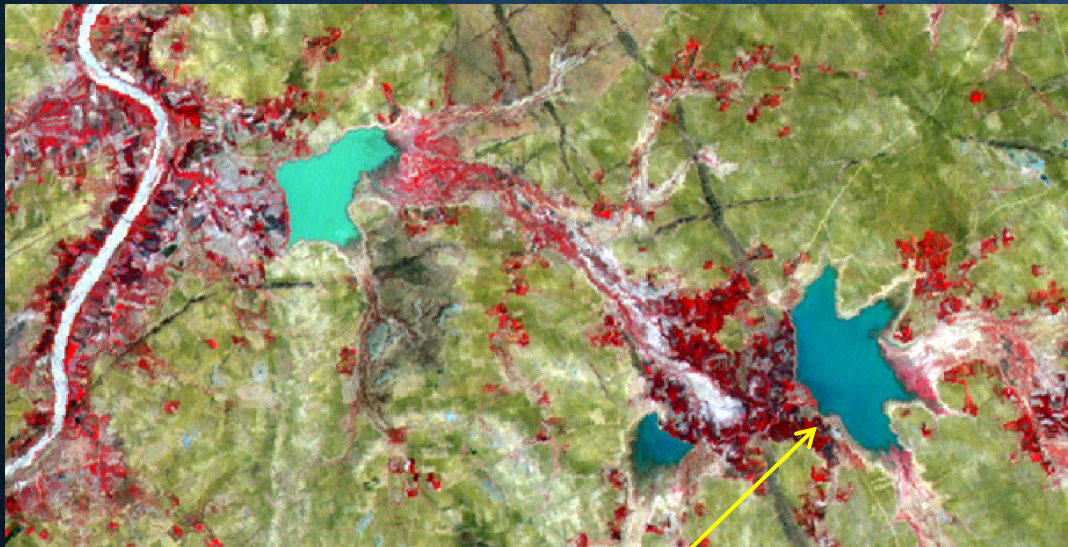
Shape: Regular, Irregular, Even, Uneven



Elements of Image Interpretation

Shape refers to the general form, structure, or outline of individual objects.

- Straight edge shapes typically represent urban or agricultural fields, while natural features, such as forest edges, are generally more irregular in shape.



**Regular shaped:
Dam**



**Regular shaped:
Agriculture fields**

Shadow

- ✓ Generally remotely sensed data from polar orbiting satellites are collected between 9:30 to 10:30 am to avoid extended shadow in the image.
- ✓ This is because shadows can obscure other objects that could otherwise be identified.
- ✓ On the other hand, the shadow cast by an object may be key to the identify of another object.

Shadow

- ✓ Take for example the Washington monument in Washington D.C while viewing this from above it can be difficult to discern the shape of the monuments, but with a shadow cast, this process becomes much easier.
- ✓ It is good practice to orient the photos so that the shadows are falling towards the interpreter.
- ✓ A pseudoscopic illusion can be produced if the shadow is oriented away from the observer. This happens when low points appear high and high points appear low.



**Shadow:
Shadow of building, tree, hills**

SHADOW

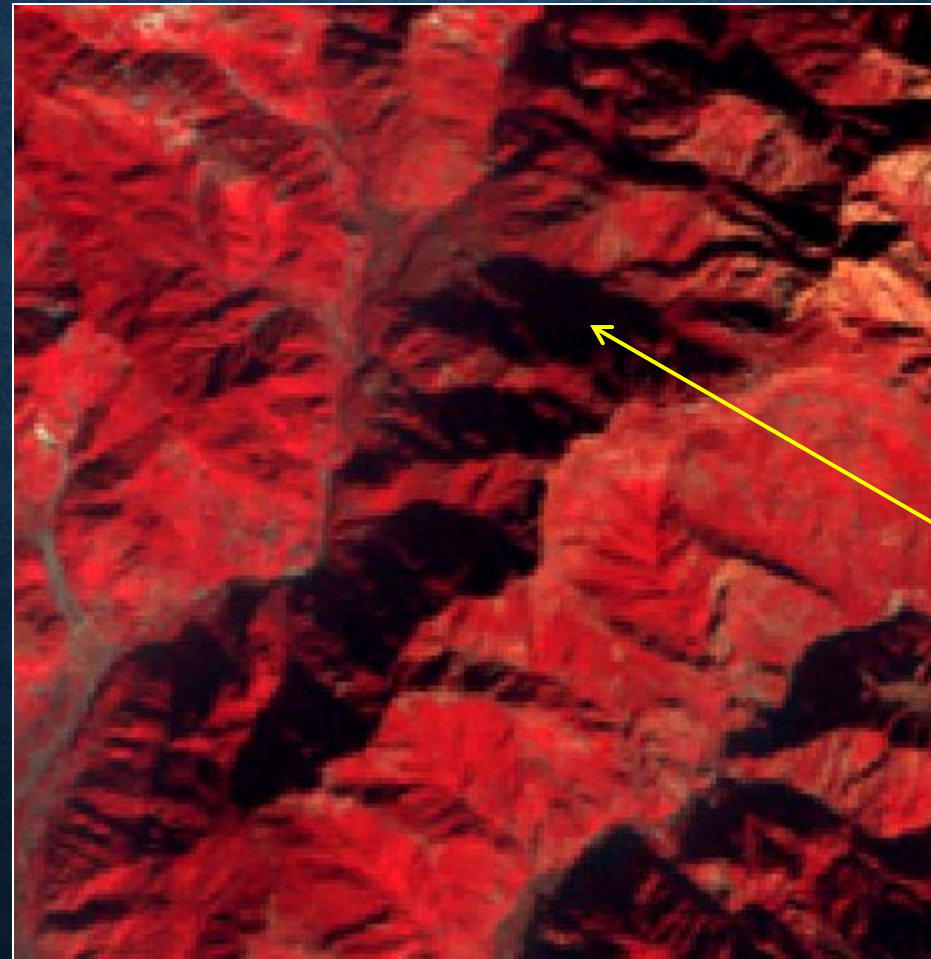
**Ronald Regan
Airport,
Washington**

**61 Centimeter
Quick Bird
Satellite data**

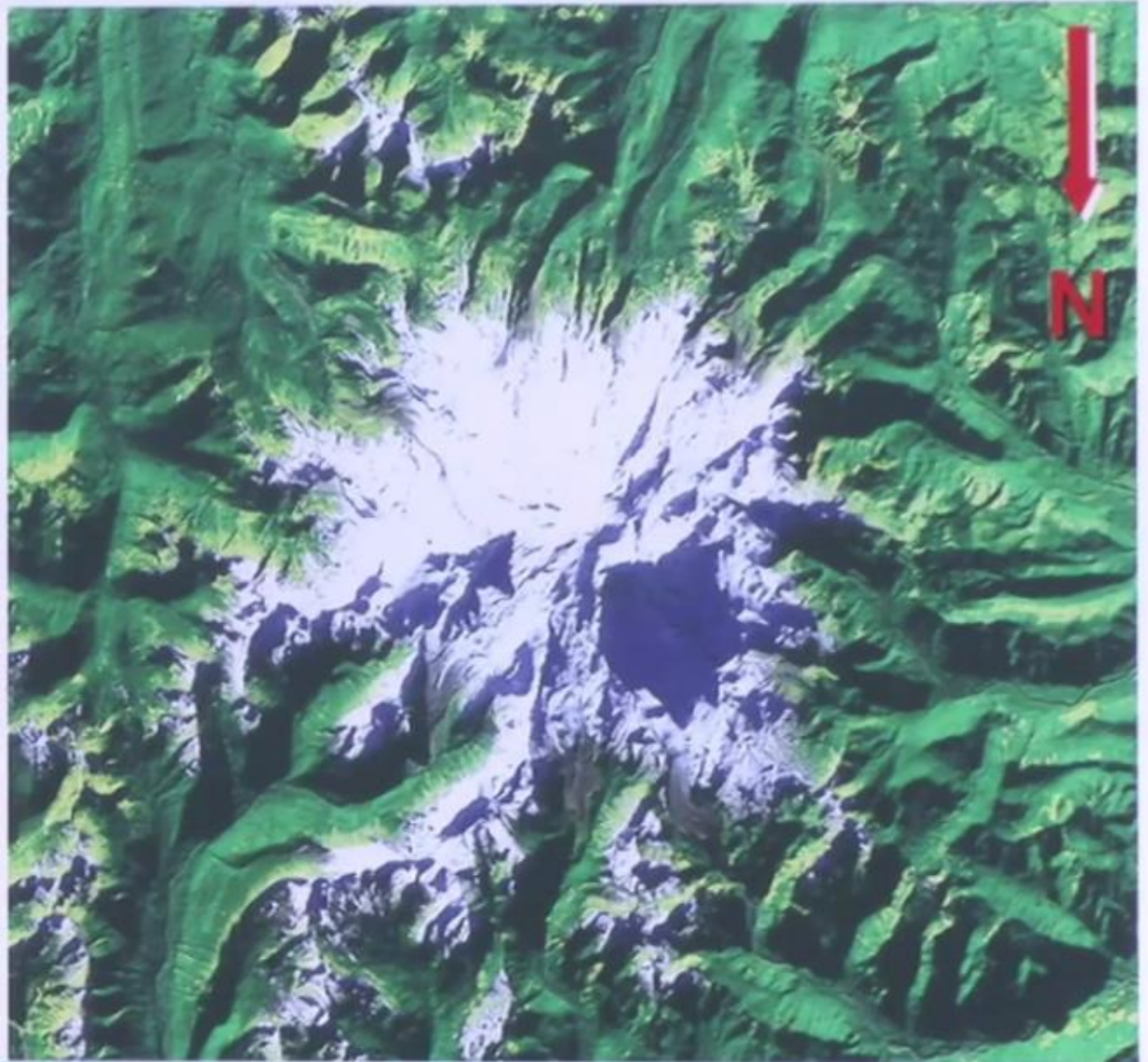
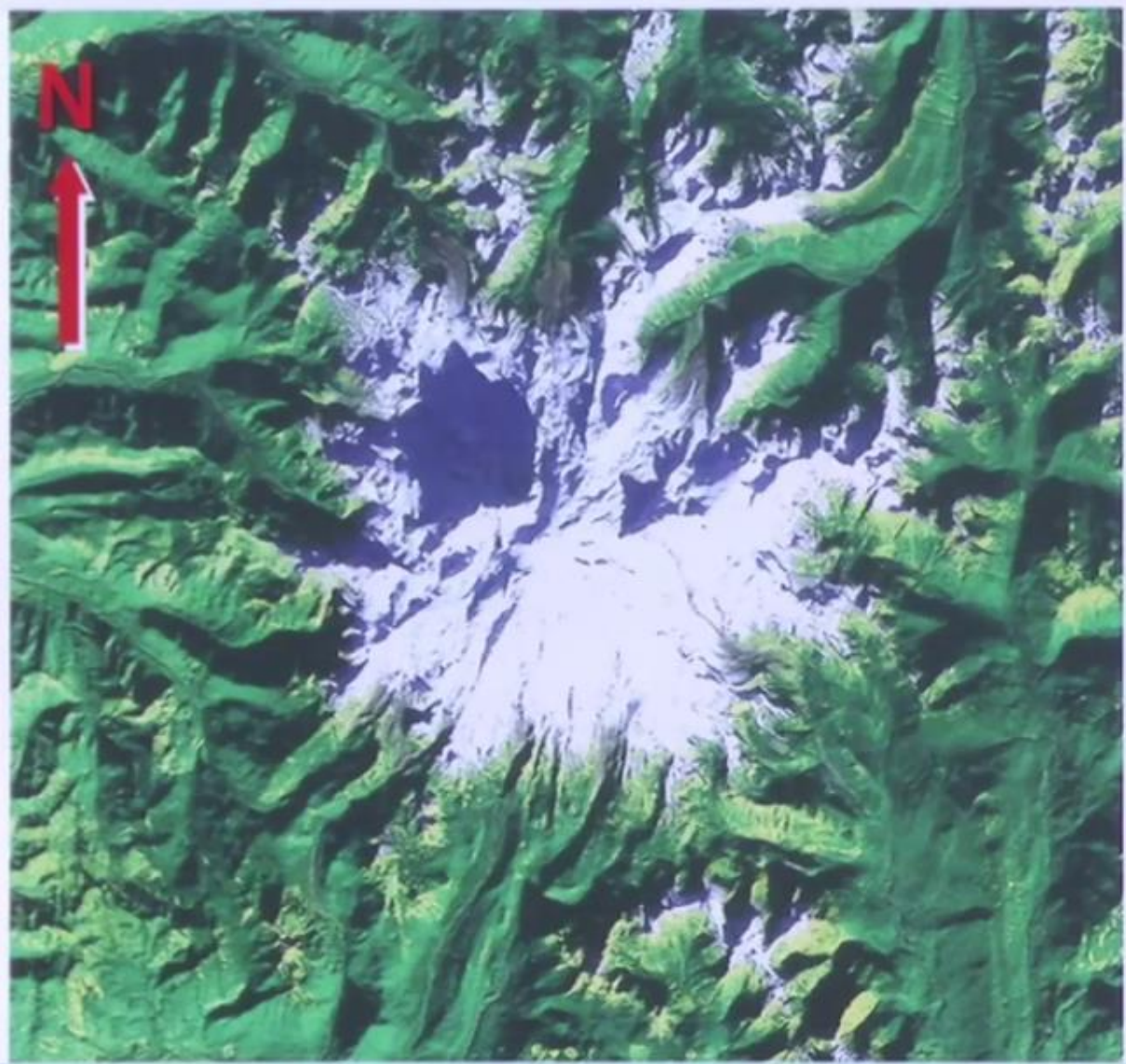


Elements of Image Interpretation

Shadow is also helpful in interpretation as it may provide an idea of the profile and relative height of a target.



Shadow regions



Tone and Colour

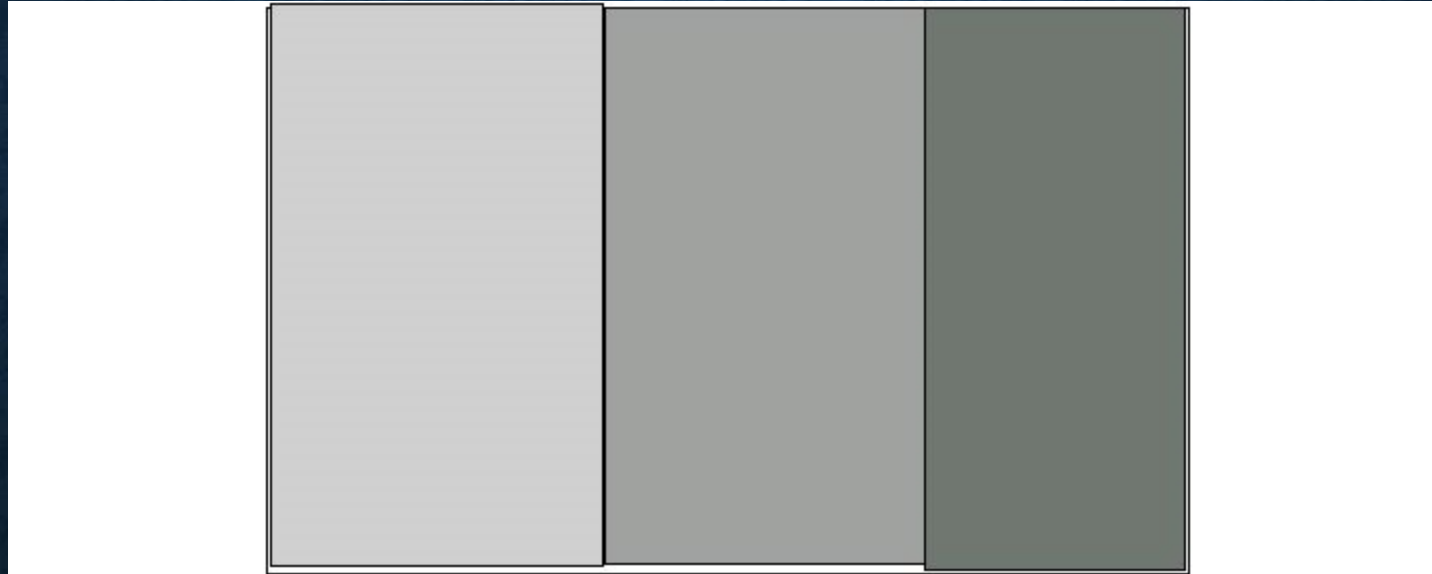
Band of EM spectrum recorded by RS system may be displayed in **shades of grey** ranging from **black and white**.

Tone :

- ✓ Continuous grey scale varying from white to black.
- ✓ It refers to relative brightness or colour of objects in an image.
- ✓ Vegetation, water and bare soil reflect different proportions of energy in blue , green , red and infrared portions of the electro-magnetic spectrum.
- ✓ An interpreter can document the amount of energy reflected from each at specific wave lengths to create a spectral signature.

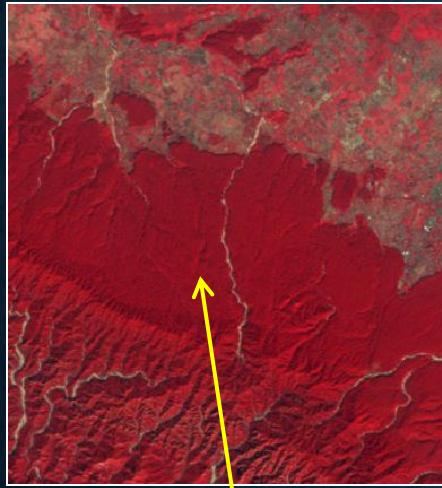
Tone/colour: Light, Medium and dark

TONE/COLOUR

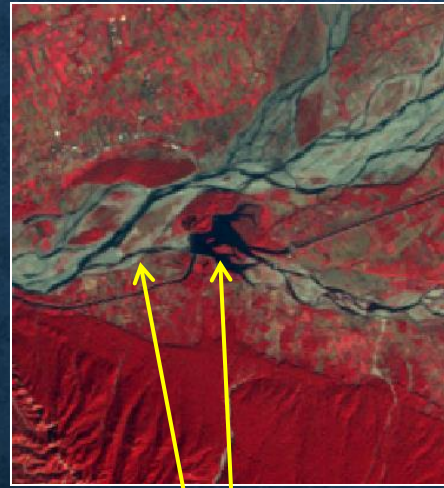


Elements of Image Interpretation

Tone refers to the relative brightness or colour of objects in an image.



**Dark/Bright
Red : Forest**



**Black/Dark Blue:
: River/water**



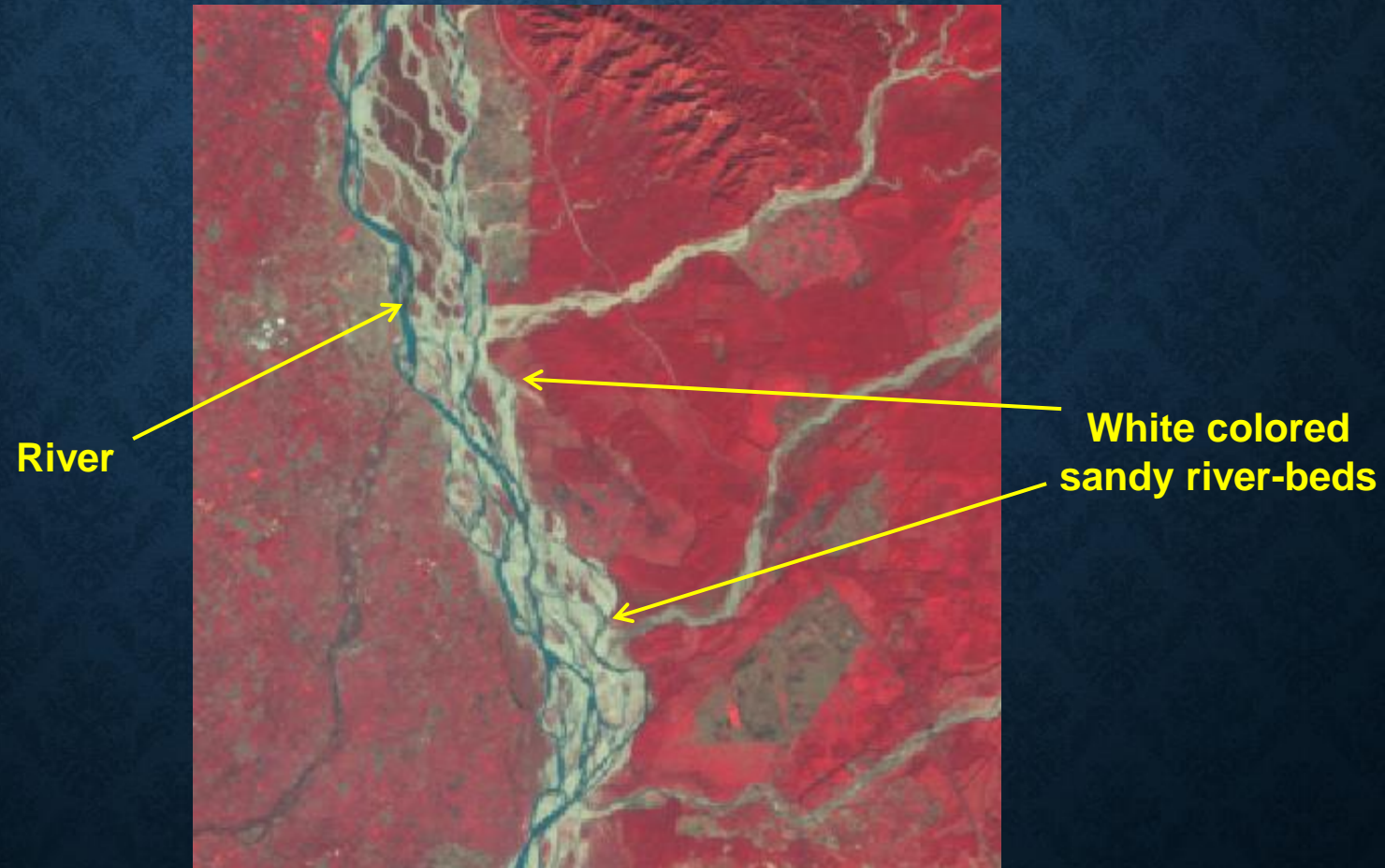
**Light
Red/Pink :
Agriculture**



**Light
Blue/Cyan :
Settlement**

Elements of Image Interpretation

7. Association takes into account the relationship between other recognizable objects or features in proximity to the target of interest.

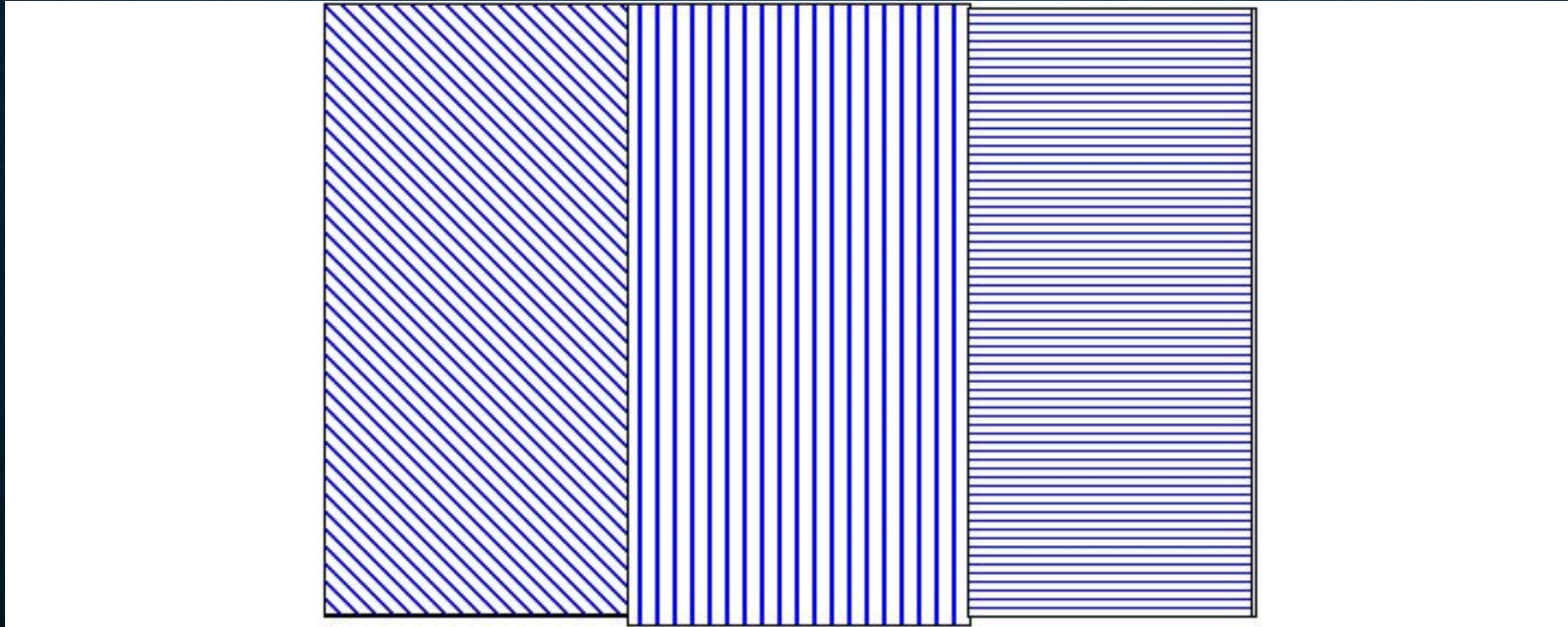


Tone and Colour

- ✓ These signature can help to understand why certain objects appear as they do on black and white or colour imagery.
- ✓ These shades of grey are referred to as tone
- ✓ The darker an object appears, the less light it reflects.
- ✓ Colour image is often preferred because, as opposed to shades of grey (humans differentiate 40-50 individual shades of grey) where's humans can detect thousands of different colour.
- ✓ Colour aids in the process of photo interpretation.

Pattern: Special arrangement of object

PATTERN



- ✓ Texture : characteristics placement and arrangement of repetitions of tone of color in an image.
- ✓ Visual impression of roughness or smoothness of an image region.

Pattern

Pattern is the spatial arrangement of objects in the landscape. The objects may be arranged randomly or systematically. They can be natural, as with a drainage pattern of river or man made.

Elements of Image Interpretation

Pattern refers to the spatial arrangement of visibly noticeable objects.

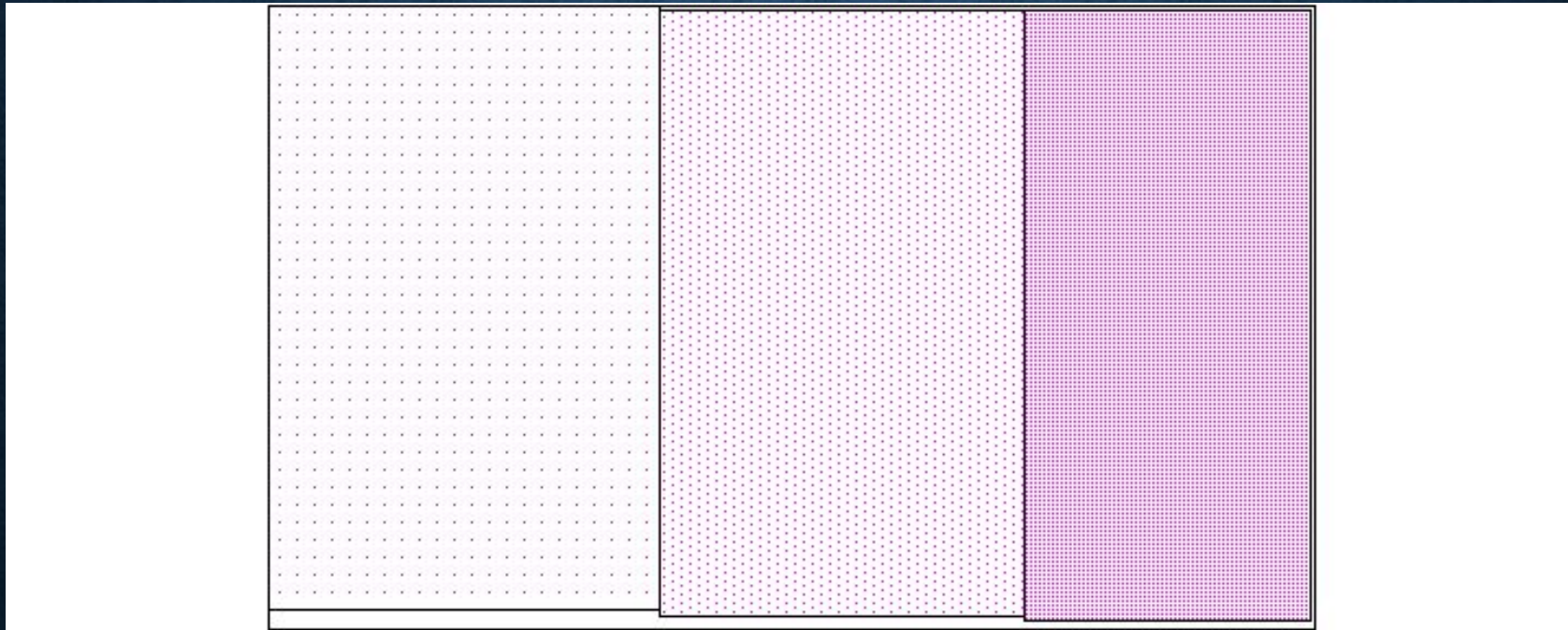
- An orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern.
- For example, plantations with evenly spaced trees and urban streets with regularly spaced houses are good examples of pattern.



Pattern of trees
and grassland in
FRI campus

Texture: Smooth, linear, irregular, fine ,medium and coarse

TEXTURE

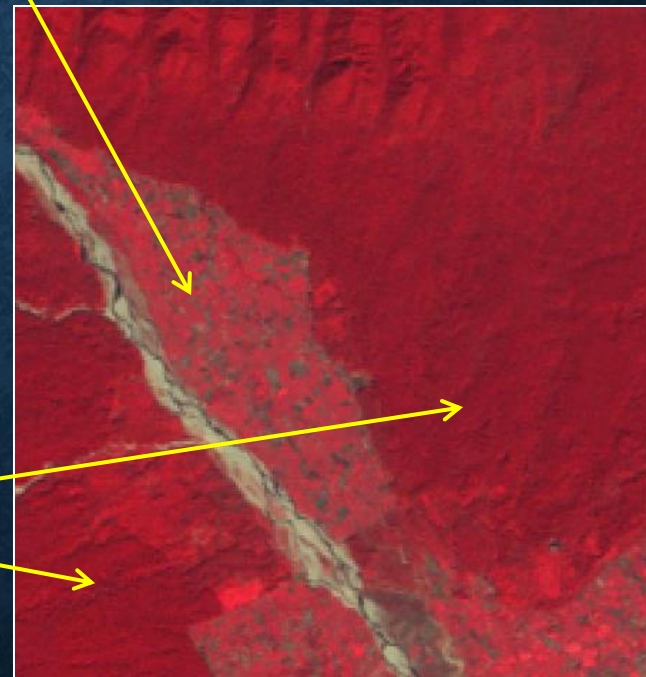


- ✓ Texture: characteristics placement and arrangement of repetitions of tone of color in an image.
- ✓ visual impression of roughness or smoothness of an image region.

Elements of Image Interpretation

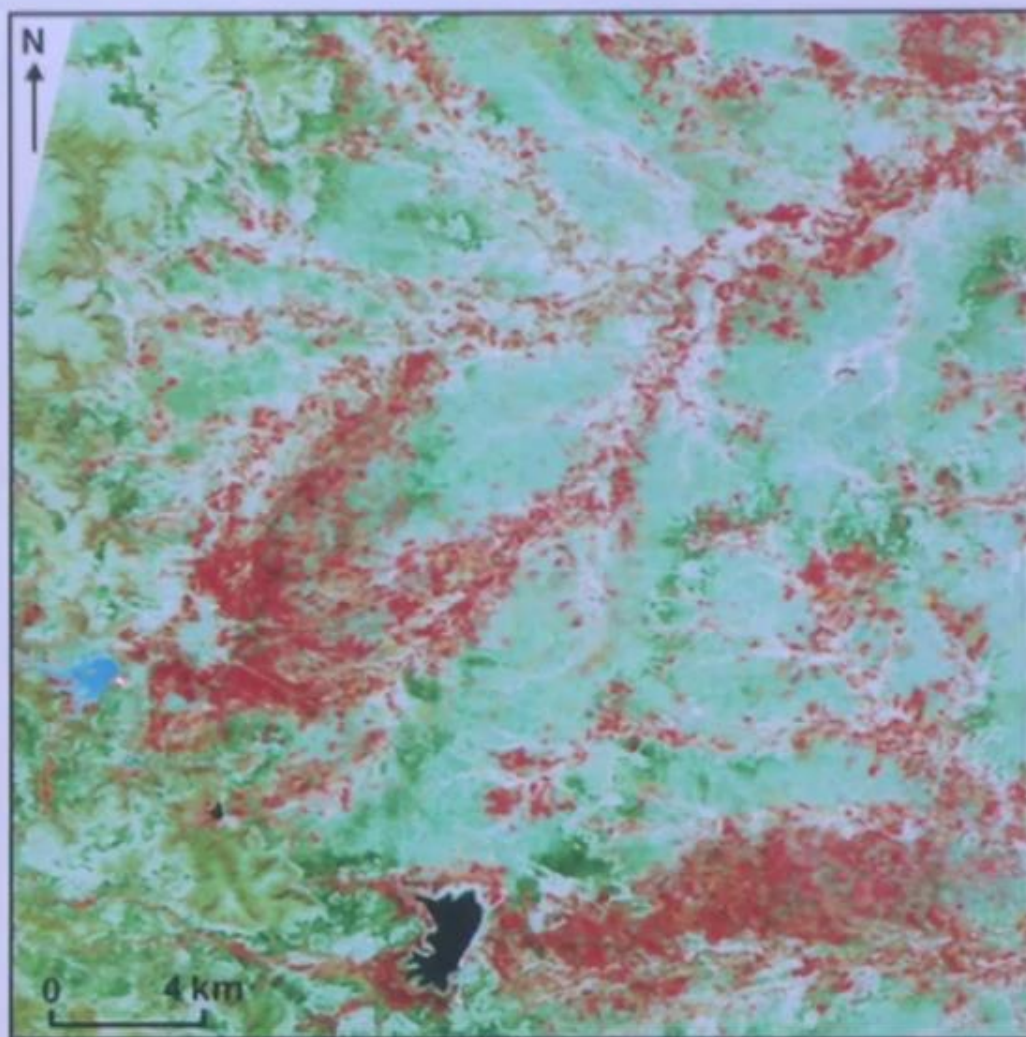
Texture refers to the arrangement and frequency of tonal variation in particular areas of an image.

- Rough textures would consist of a mottled tone where the color levels change abruptly in a small area, whereas **smooth textures** would have very little tonal variation.
- Smooth textures are most often the result of uniform, even surfaces, such as fields or grasslands.
- A target with a rough surface and irregular structure, such as a forest canopy, results in a **rough textured** appearance.

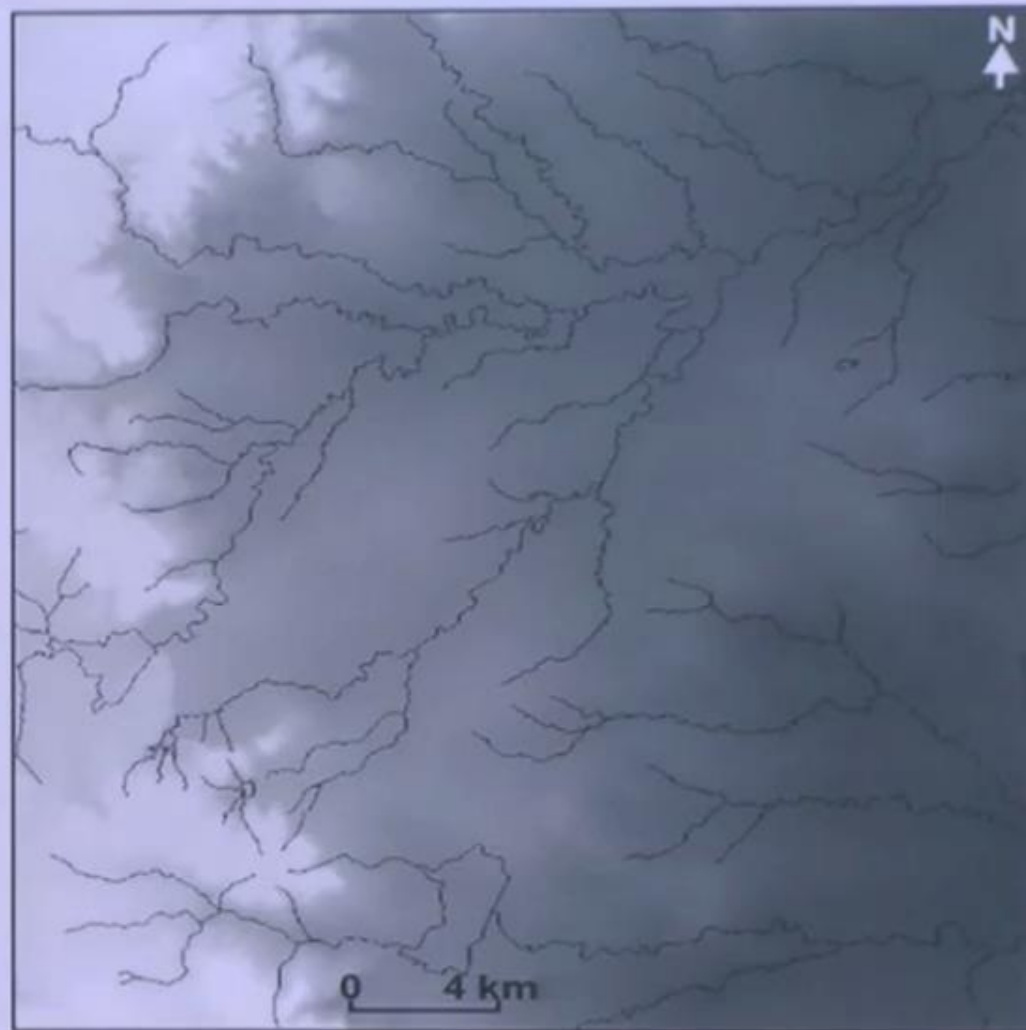


Site, Situation and Association

- ✓ Site has unique physical characteristics which might include elevation, slope and surface cover (e.g. grass, forest, water, bare soil)
- ✓ Site can also have socio economic characteristics such as the value of land or the closeness such as the value of land or the closeness to water
- ✓ Situation refers to how the objects in the an image are organized and situated in respect to each other
- ✓ Most power plants have materials and building associated in a fairly predictable manner.
- ✓ Association refers to the fact that when you find a certain activity within a photo or image you usually encounter related or associated feature or activities.
- ✓ Site, situation and association are rarely used independent of each other when analyzing an image.



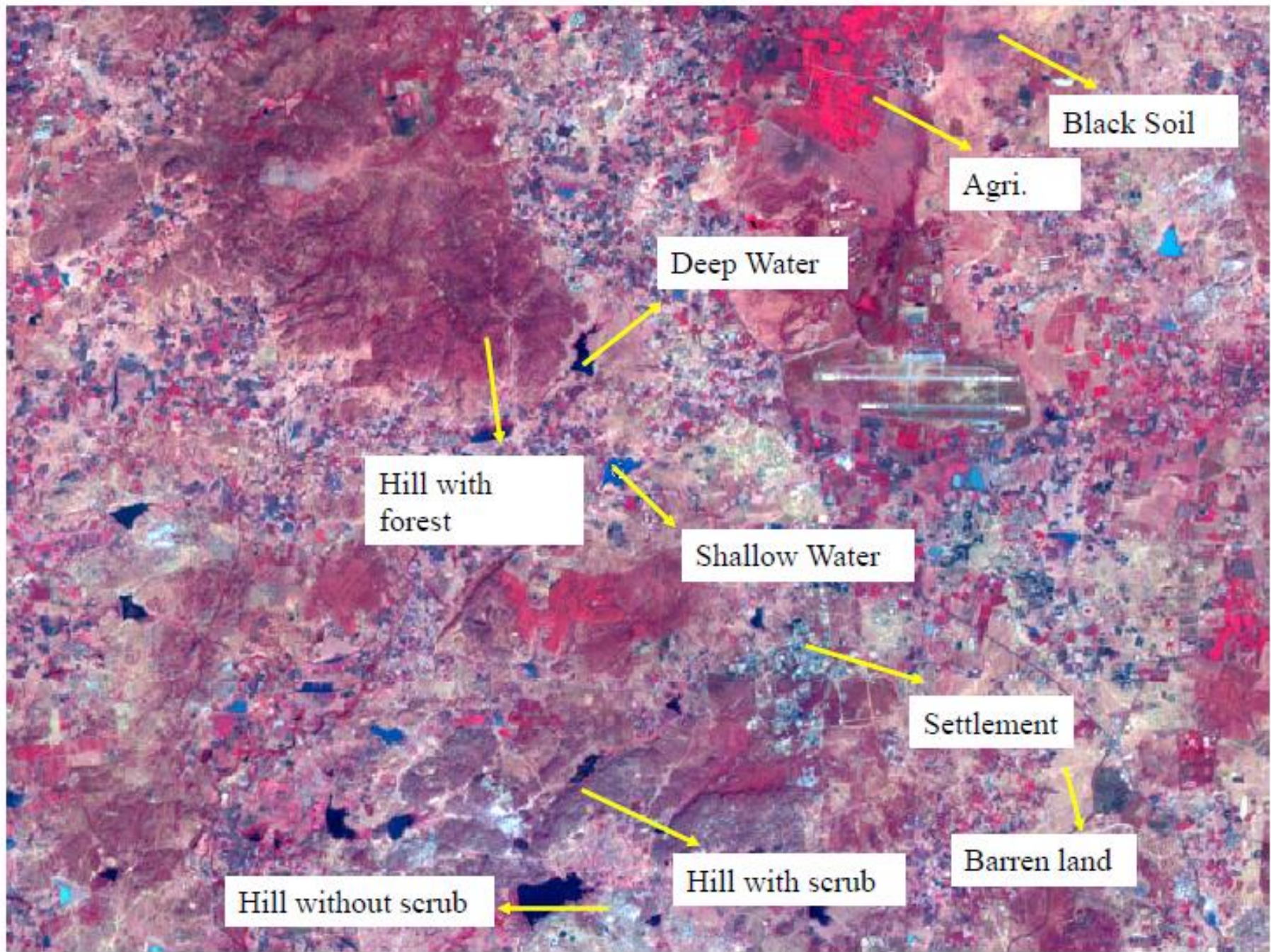
IRS-LISS-II (27 February 1995) FCC (bands 432 in RGB scheme)



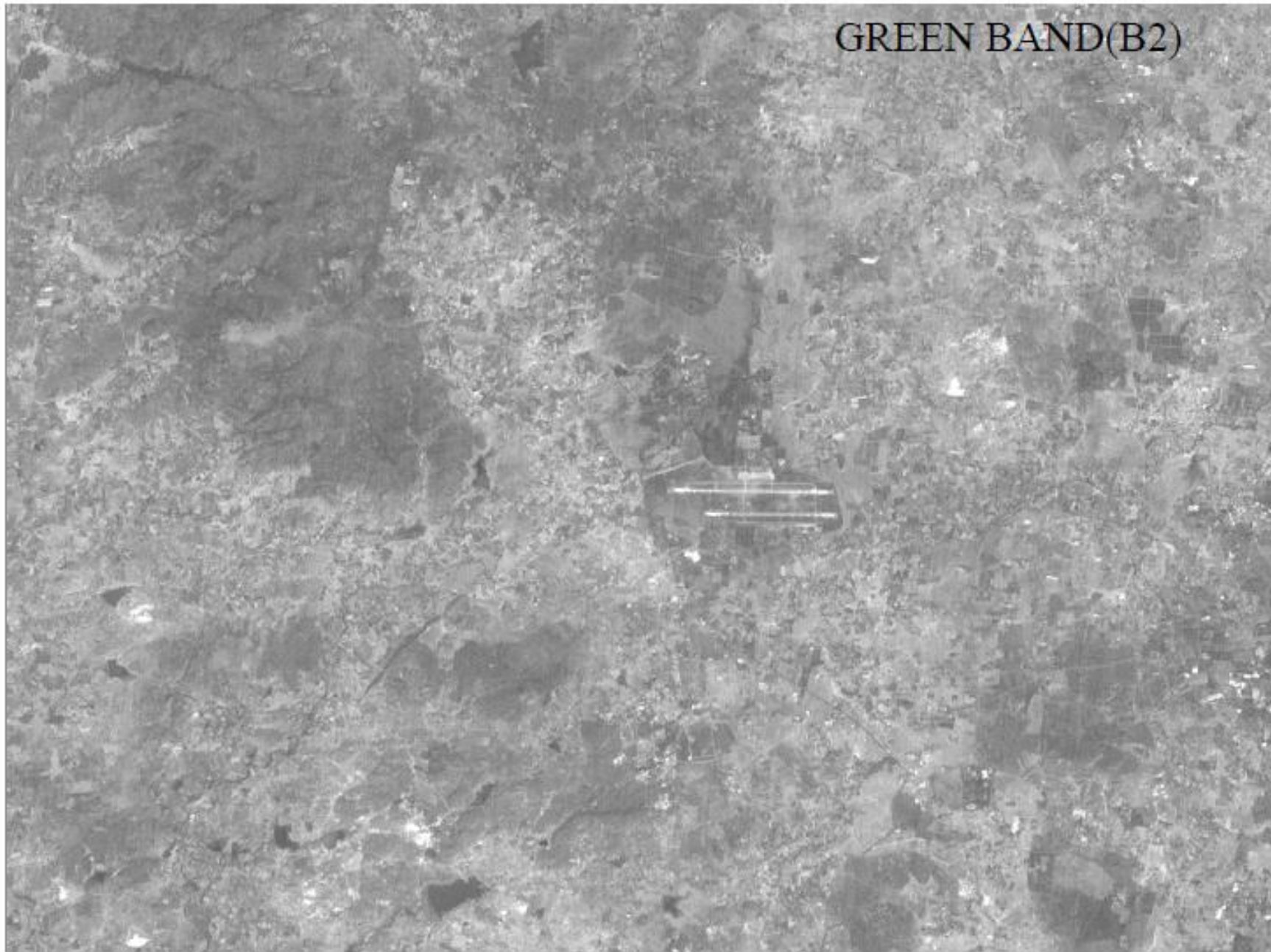
Digital Elevation Model (DEM) of the same area shown in the left image

What do you see in this Image?

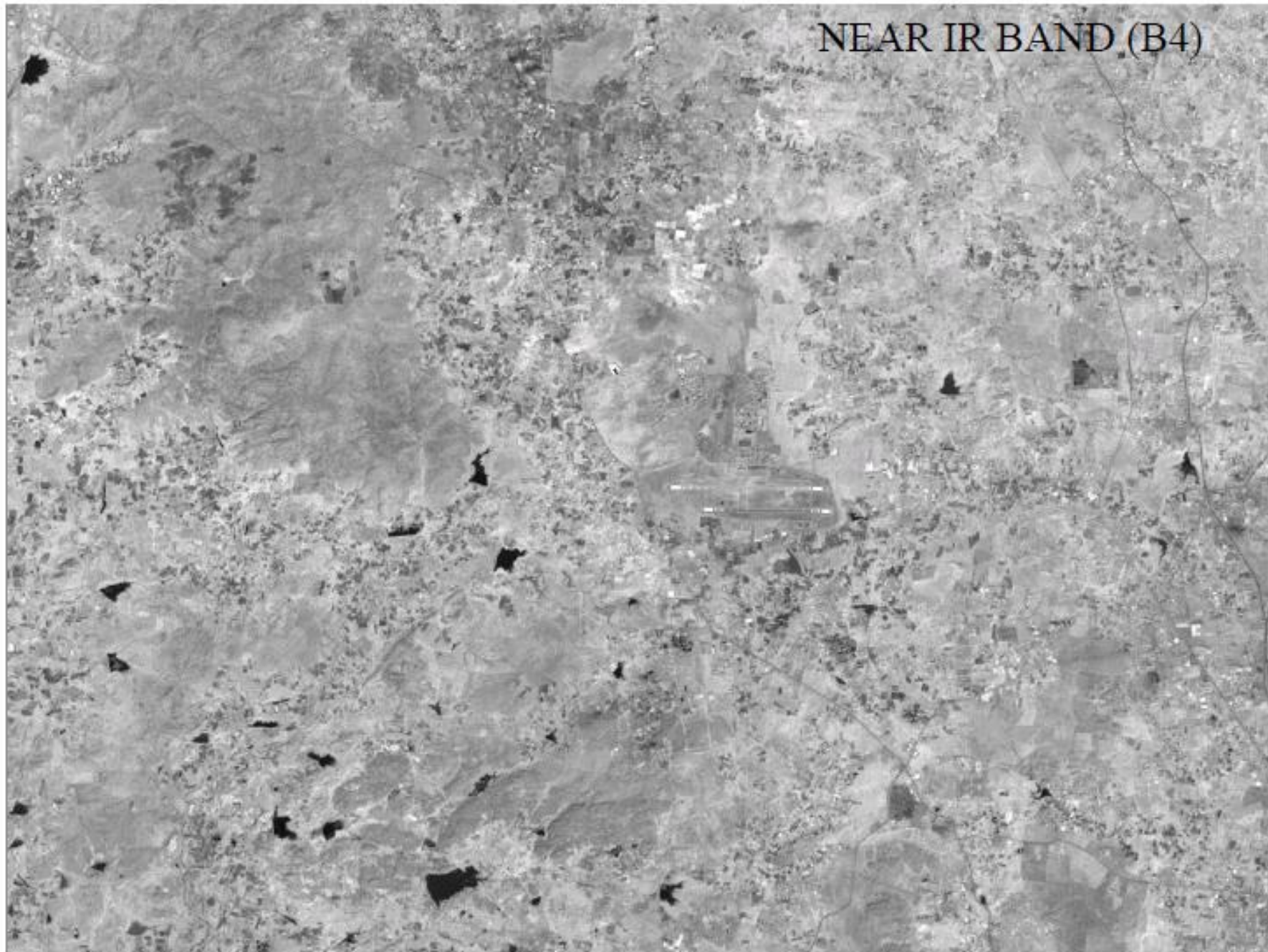




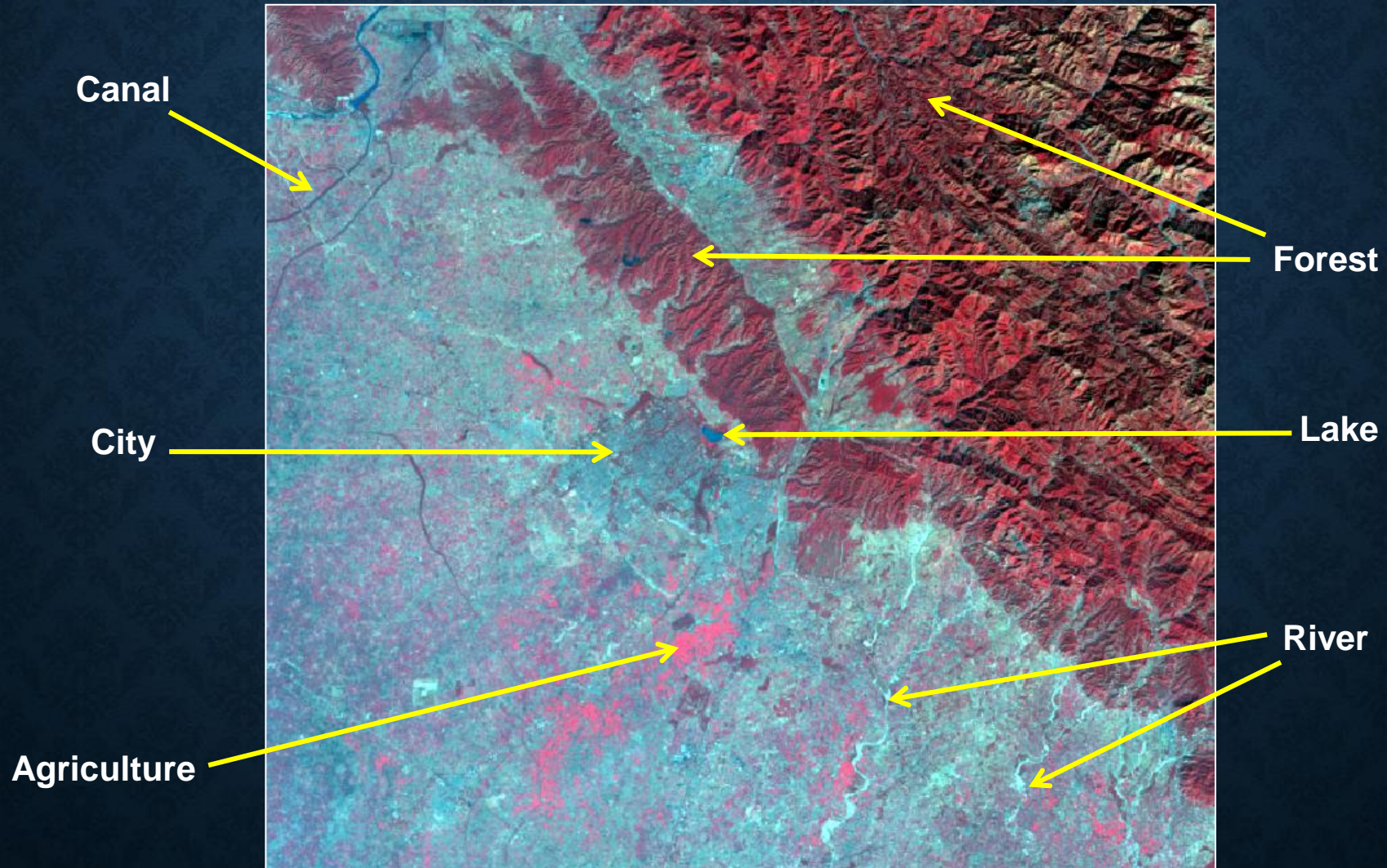
GREEN BAND(B2)



NEAR IR BAND (B4)



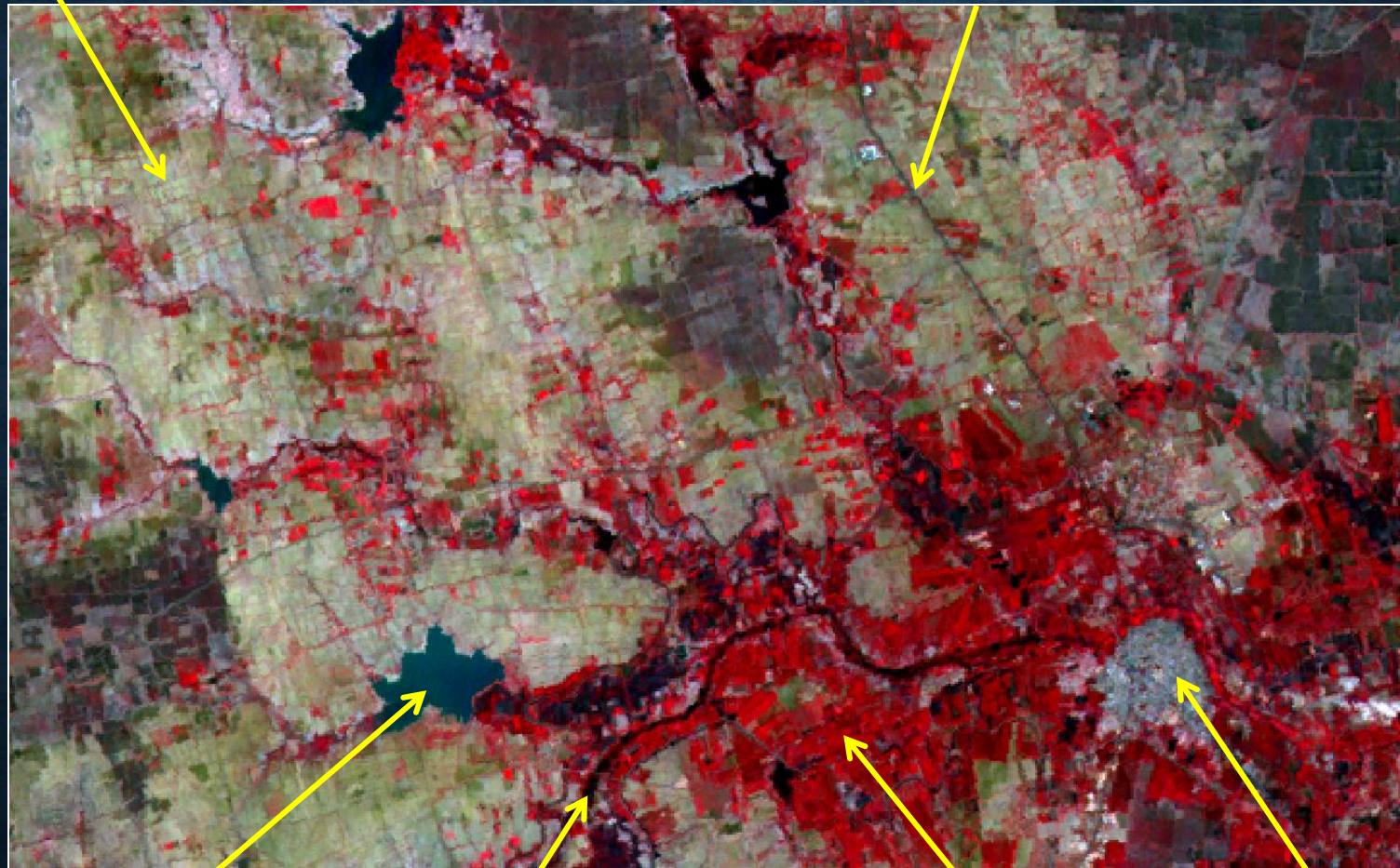
Feature Identification on Landsat-5 TM



Feature Identification on LISS-III

Agriculture Fallow lands

Road



Lake

River

Agriculture crops

Village

Comparison of Features

Elements of Image Interpretation	Forest		Tree Outside Forest (TOF)	Scrub/ Grassland	River/Stream/Canal (Perennial)	Water Body (Perennial)	Dry River Channel	Agriculture	Settlement
	Dense Forest	Less Dense Forest							
Tone/Colour	Dark red/Bright red	Lighter shades of red	Scattered pixels of red color	Light pink and bright tones	Black to blue	Black to blue	White to off-white tones with bright reflectance	Light red/Pinkish tones	Cyan
Size	Varies	Varies	Small	Varies	Varies	Varies	Varies	Small rectangular patches combine to form varied sizes	Varies
Shape	Irregular	Irregular	Spherical to irregular	Irregular	River-Irregular Canal-Straight/linear	Natural-Irregular Artificial-Regular	Natural-Irregular Artificial-Regular	Rectangular patches	Angular, definite shape
Texture	Coarse	Smoother than dense forest	Coarse	Smooth	Smooth	Smooth	Smooth	Smooth	Coarse
Pattern	Irregular	Irregular	Linear pattern	Irregular	Continuous feature	Varies	Contiuous	Regular rectangular pattern	Definite
Shadow	In hilly regions	In hilly regions	In hilly regions	In hilly regions	NA	NA	NA	NA	High-rise bulidings in cities
Association	In a cluster, away from settlements	In small clusters	On roadsides, near settlements	On steep hill slopes and foothills	Sandy river-beds with bright reflectance, presence of vegetation, linear row of trees near canal	Dams-in hilly regions, Ponds & Pools-in city regions	Join the main river channel, passing through hilly and forest areas	Present in sub-urban areas, near village settlements. Not present in core city areas.	In clusters, found near agriculture

Reference images: Landsat-5 TM and Liss-3