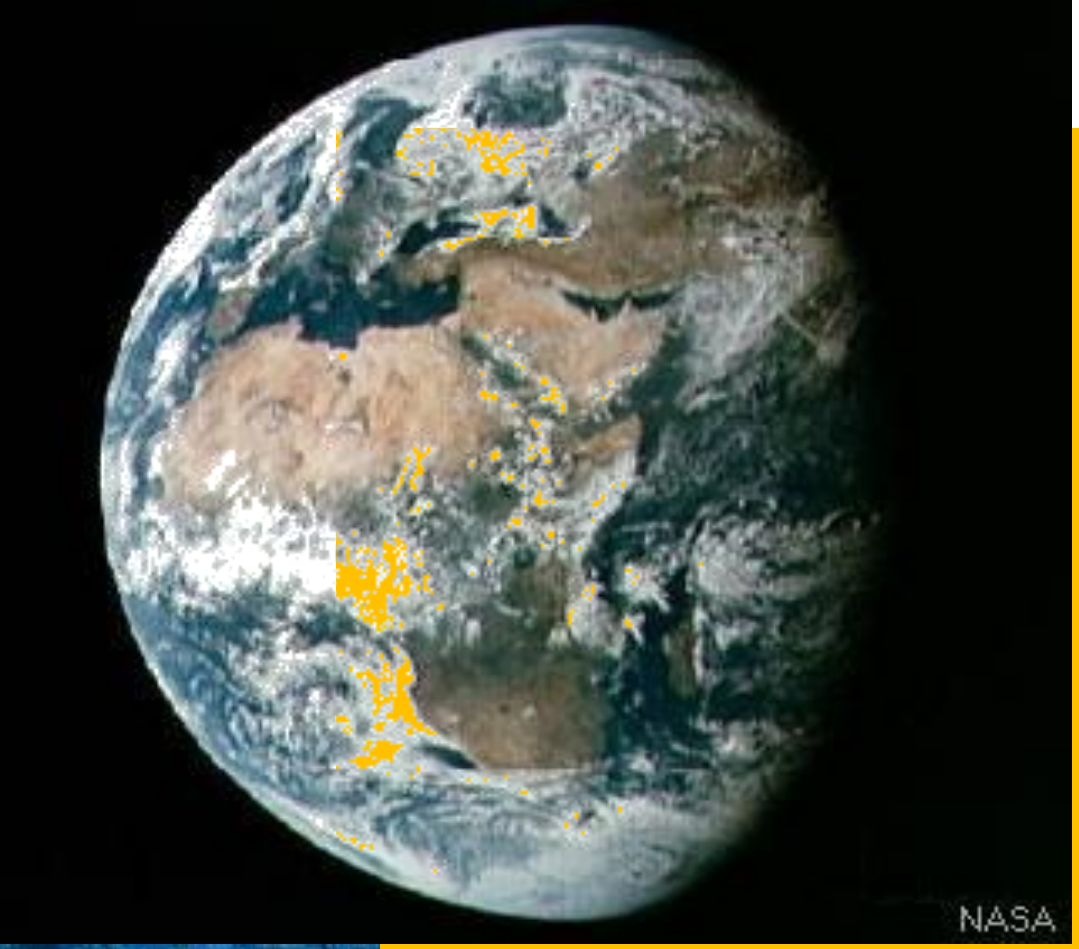
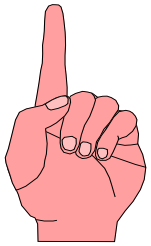


REMOTE SENSING

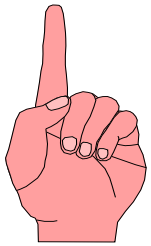
Prof MURALIKRISHNA IYYANKI

Ph D IISc Banga lore Mtech IIT Madras, MIEE, FIE FIS S

Dr Raja Ramanna DRDO Distinguished Fellow
Scientist SF ISRO
Professor and Director R&D JNTU Hyderabad



INSITU SENSING (PROXIMAL SENSING)



REMOTE SENSING

REMOTE SENSING

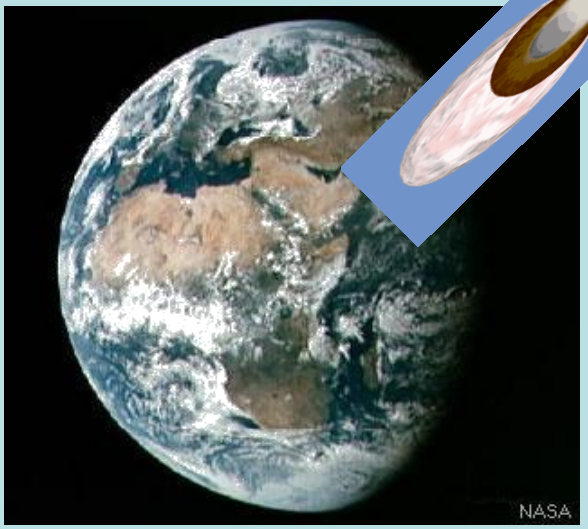
It is a valuable tool / technique for mapping and study of Earth resources, Terrain and Earth's Environment.

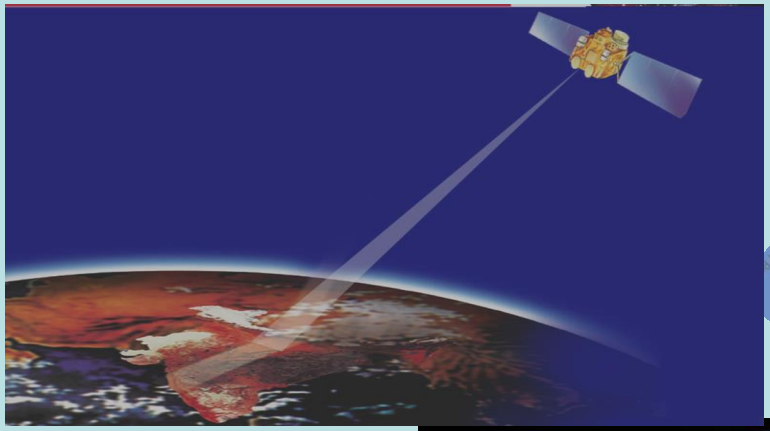
Remote sensing is a technique.
Remote sensing tool /technique to derive information about the object based on amount of ELECRO MAGNETIC ENERGY Reflected, Scattered or Emitted by the object on planet earth –

It is inverse of Astronomy

ASTRONOMY

Telescopes etc



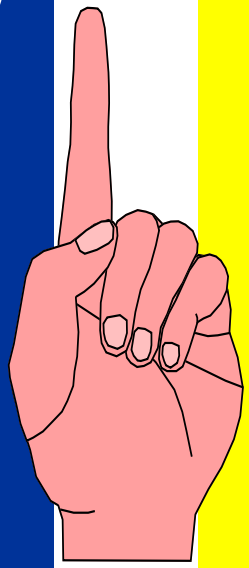


REMOTE SENSING
CCD based push broom or Opto-Mechanical Scanners

Remote Sensing is not study of Objects from a distance

-

It is some thing much more and more and more … … … than that-



We do several things – which are same as studying from a distance-

•Observe stars in space with telescope

(Astronomy- we do not call this as Remote sensing)

•Seeing through our Eye

(Our vision - we do not call this as Remote sensing)

Remote Sensing System.

A Multi-disciplinary science /Technology which includes a combination of various disciplines such as Optics, Geodesy, Spectroscopy, Photography, Computer Science, Telecommunication, Satellite launching etc Including Space Law, Natural Resource management , Environmental Management.

History of Development of Remote Sensing

Ability to observe in regions of electromagnetic spectrum,

Development of conventional photography, multi-spectral & infrared photography,

Non-photographic sensors & scanners,

Platforms for remote sensing such as aircraft & satellite, communication & data transmission, data processing and software and hard ware.

SPECIFICATIONS IN REMOTE SENSING

SPATIAL RESOLUTION- It is a measure of ability to see features

Pixel size etc 80 meters in 1972 to less than ONE meter (about 3 feet) today

SPECTRAL RESOLUTION- It is a measure of ability to distinguish features

No of bands, 4 bands in VIS and IR to 7 and to more than 33 channels

TEMPORAL RESOLUTION- It is a measure of ability to find changes in the features

Revisit time of satellite to the same observation area- 16 to 25 days.

Principal Divisions of the Electromagnetic Spectrum

Gamma rays

X-rays

Ultraviolet light

-9

Visible region - 400-700 nm[1 nm is 10 to the power of -9 ie 10

Infra-red - 700 nm to 21 microns

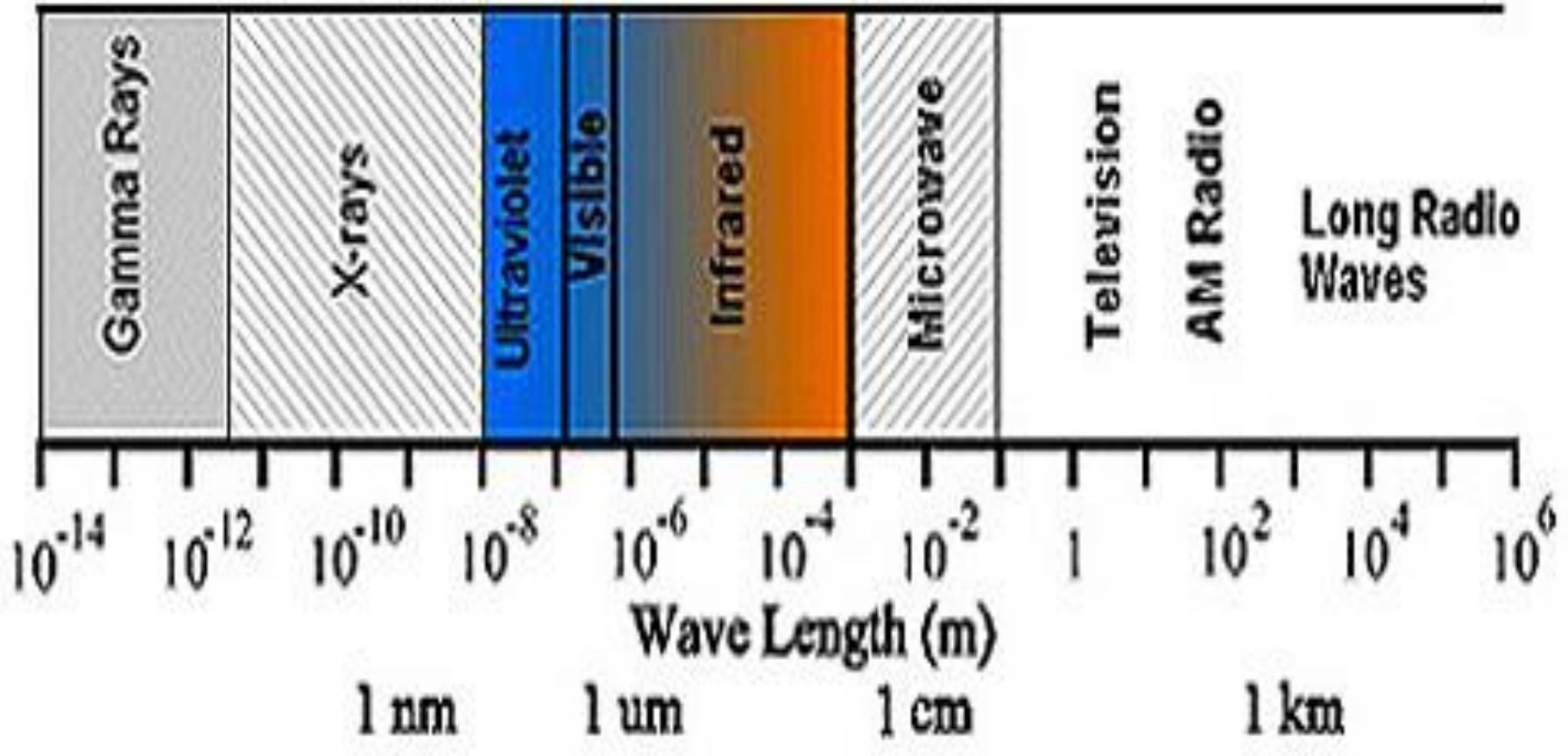
Microwaves Beyond VHF / HF

Radio waves

Principal Divisions of the Electromagnetic Spectrum

Visible region - 400-700 nm

Infra-red – Starts from 700 nm (0.7 micron) NIR- MWR -TIR



SPECTRAL SIGNATURE

TYPES OF TECHNIQUES OF REMOTE SENSING BASED ON SOURCE OF ELECTRO MAGNETIC ENERGY(EME)

-PASSIVE REMOTE SENSING

Based on Light and Thermal Energy from Sun.

-ACTIVE REMOTE SENSING-

They got their own source of EME-Example RADAR.

SOME IMPORTANT INITIAL MILESTONES

1972	Launch of LANDSAT 1
1973	Launch of SKYLAB, the first American space station
1970-80	Rapid advances in digital image processing due to powerful microprocessor based computers available
1975	Manual of Remote Sensing, (First Edition) published by American Society of Photogrammetry.
1978	Launch of SEASAT-1 as Oceanographic research satellite
1980	Launch of USSR METEOR Satellite
1980-90	Launch of LANDSAT 4, second generation of LANDSAT series with new sensor
1986	Launch of French Earth Observation Satellite (SPOT)
1988	ISRO –IRS series –Cartosat Chandrayan etc

TYPES OF ORBITS

- Polar Orbiting Satellites -sun-synchronous orbits at an altitude ranging from 700 to 800 kilometers, orbital periods of 98 to 102 minutes.

- Geostationary Satellites– At a distance of 36,000 km and located just above equator – Area of coverage steady and round the clock

REMOTE SENSING SATELLITES

Sun-synchronous orbit

i.e. the satellite always crosses the equator at precisely the same local

sun time

- **A normal orbit forms an ellipse**

- **Satellite weighs around 1000 Kg at an altitude of 800-900 Km yielding an orbital period of 103 min or about 14 orbits per day.**

REMOTE SENSING SATELLITES

- **The ground track speed - 7Km/sec**
- **Satellite rotates from N to S and cross equator at an angle & successive orbits typically at about 2500 Km apart.**
- **Narrow swath causes large gaps in image coverage between successive orbits on a given day.**
- **The satellite orbit progresses westward , just overshooting the orbit pattern of the previous day.**
- **Takes 15-25 days to come back at the same location for coverage repetition.**

Remote sensing satellites usually are placed in Polar orbit.

These satellites orbit the earth longitudinally passing directly over the poles at an altitude of about 850 km (530 miles) With each orbit, the satellite sees an area that is west of the previous pass.

These satellites are in a low orbit and look directly down.

The images recorded by these satellites show great details about Earth Surface features and cloud patterns..

Benefits of remote sensing data from Earth observation satellites.

- continuous acquisition of data
- regular revisit capabilities
- broad regional coverage
- good spectral resolution (including infra-red bands)
- good spatial resolution
- ability to manipulate/enhance digital data
- ability to combine satellite digital data with other digital data
- cost effective data
- map-accurate data
- large archive of historical data

PURPOSE FOR WHICH THE RS DATA IS USED

- **Meteorological applications of Weather satellites**
- **Assessment and monitoring of vegetation types and their status**
- **soil surveys**
- **mineral exploration**
- **water resources planning and monitoring**
- **urban planning**
- **agricultural property management planning- crop yield assessment**
- **natural disaster assessment**

Efforts started in the 1960's
culminated in Launching of LANDSAT 1 by NASA
and beginning of modern
Remote Sensing.

LANDSAT 1 ("LAND SATELLITE")
-ERTS 1 (Earth Resources Technology Satell
-ite) –
-first of several earth-orbiting
-satellites designed specifically
-for observation of theearth's land areas.

NOAA POES

NOAA Polar-orbiting Operational Environmental Satellites (POES) are three-axis-stabilized spacecrafts that are launched into an orbit 830-870 kilometers high,

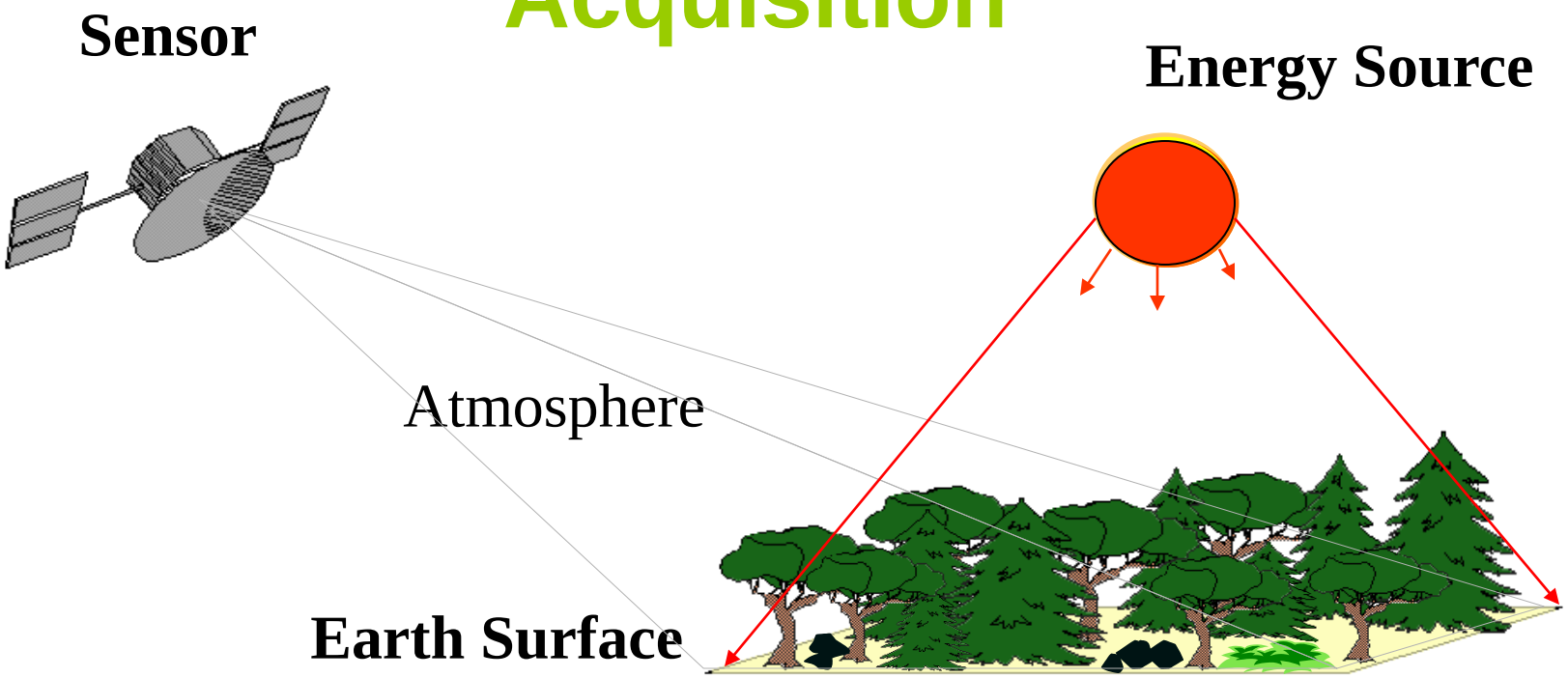
constantly circling the Earth in an almost north-south orbit, passing close to both poles.

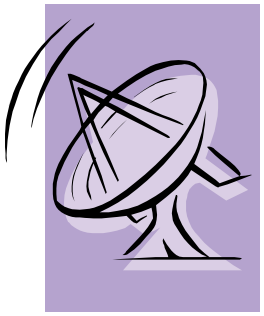
POES satellites from NOAA-offer 4 or 5 channel multispectral daily repetitive global coverage.Image provided by: National Climatic Data Center

Application dimensions

- In meteorology
- In earth resource management
  - Land use identification and mapping
  - Change detection
  - Water resources management
  - Agriculture
  - Forestry
  - Soil mapping
  - Coastal zone management
  - Marine applications

The Remote Sensing System – Data Acquisition





Receiving Station

User

EM Radiation – Object Interactions

- Reflectance gives an idea about the characteristics of the natural surfaces.
- Spectral response measured over objects permits an assessment of the type and condition of them.
- These responses are called ‘ Spectral Signatures”
- These responses are not absolute and unique. Therefore, they are response patterns
- Spectral response patterns can be changed due to spatial and temporal effects – Change detection

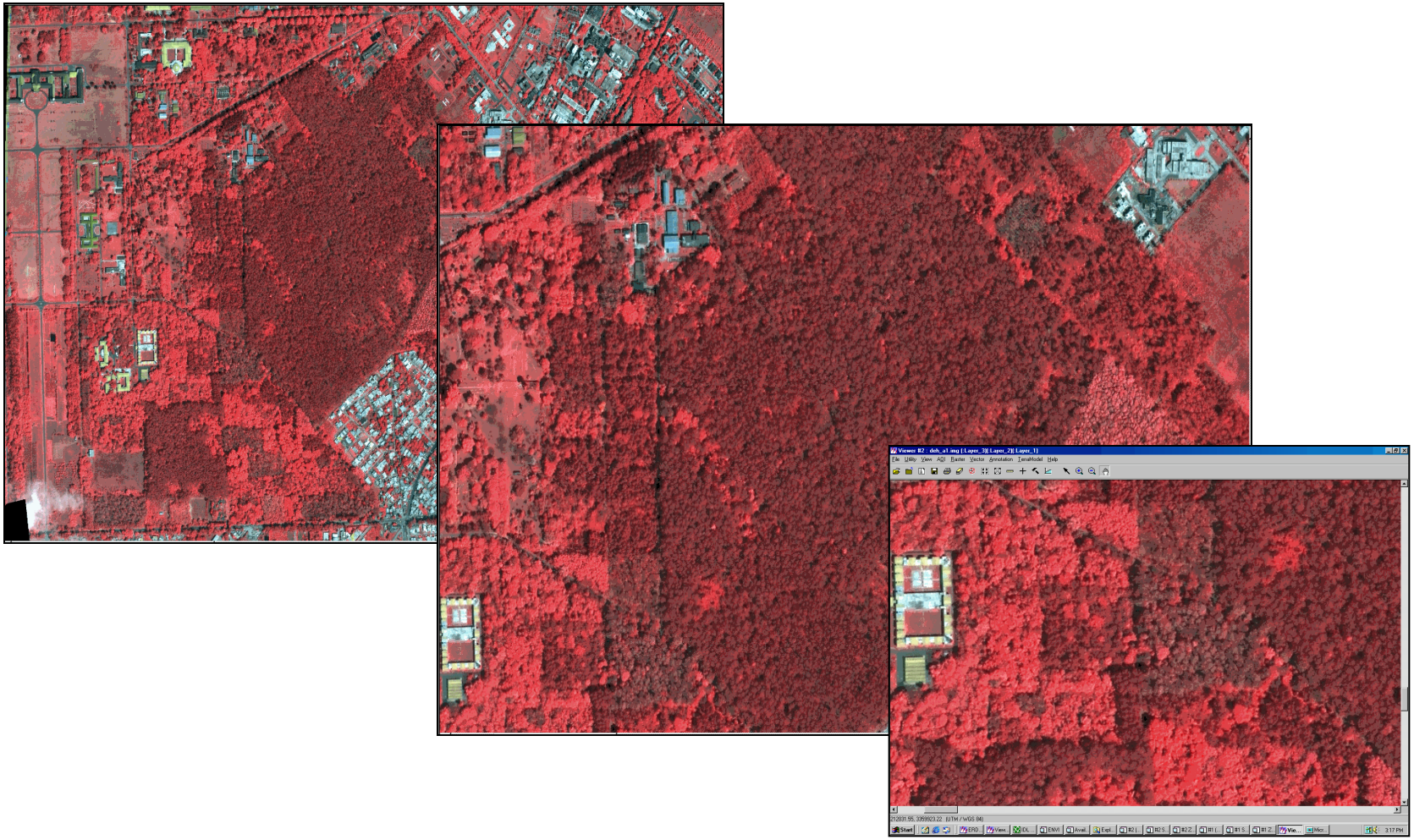
EM Radiation – Object Interactions

- Vegetation
  - In visible spectrum
    - **Radiation is absorbed by leaf pigments for photosynthesis (chlorophyll)**
    - **Main pigments are Chlorophyll a & b with two absorption bands in blue and red**
  - In NIR
    - **Leaf pigments and the cellulose containing walls are transparent, received radiation is reflected or transmitted**
    - **High levels of reflectance from vegetation**

Reflectance from vegetation

- In MIR
  - **Reflectance of vegetation is affected by the water content**
  - **Healthy vegetation show two absorption bands - 1.3 to 1.45 μm and 1.8 to 2.00 μm correspond to water absorption bands**
  - **Two reflectance peaks – 1.65μm & 2.2μm**

EM Radiation – Object Interactions



EM Radiation – Object Interactions

- Soil
  - **Reflectance increases regularly from visible to NIR**
  - **Absorption bands due to water (1.4μm & 1.9μm)**
- **W**ater
  - **Reflectance regularly decreases from visible to NIR**
  - **Complete absorption in NIR**
  - **When the water is loaded with particles, the curve shows a similar form but the reflectance is higher**

EM Radiation – Object Interactions

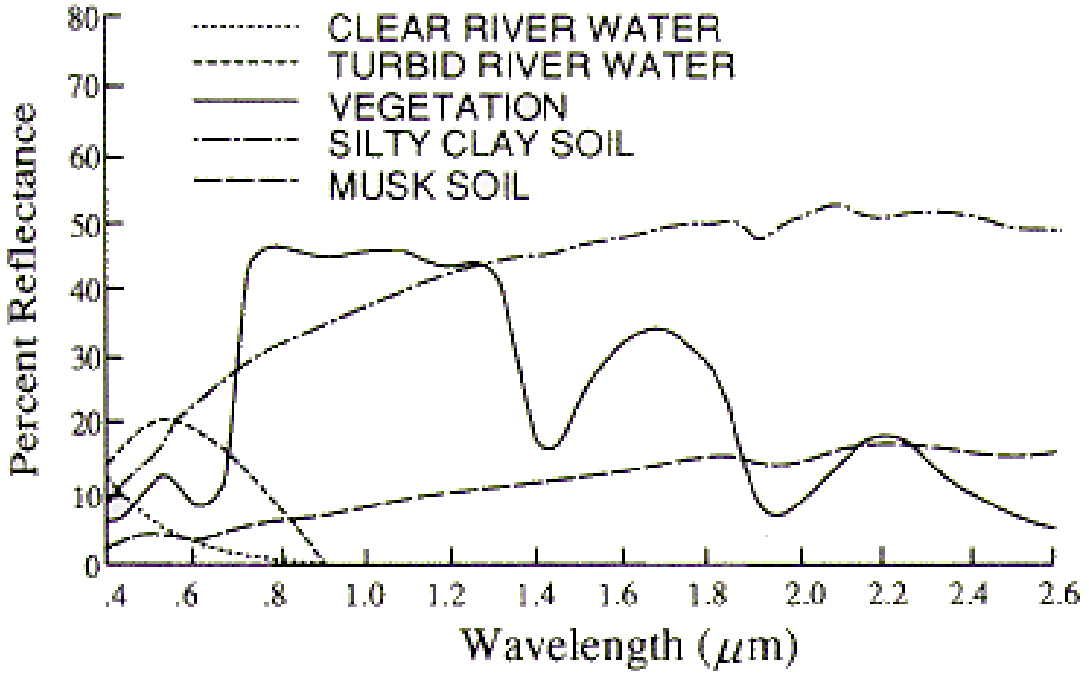


Figure 1.9.1 Spectral reflectance of vegetation, soil and water

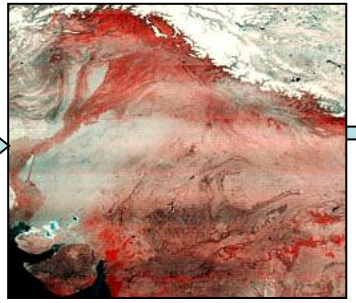
Satellites and their Sensor Properties

- **Spatial Resolution**
  - **The area covered by a single pixel on the ground (Pixel is the smallest homogenous area of a recorded image)**
  - **Small pixels – High spatial Resolution**
  - **Large pixels – Low spatial resolution**
- **Spectral Resolution**
  - **Spectral resolution describes the ability of a sensor to define fine wavelength intervals.**
- **Temporal Resolution**
  - **Frequency of obtaining data over a given area**
- **Radiometric Resolution**
  - **The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy.**

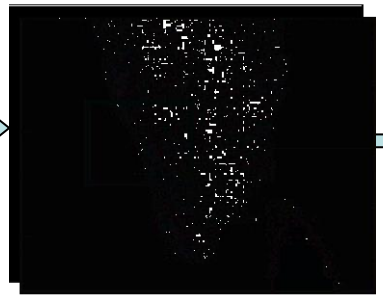
Scale Diversity of Remote Sensing Data

Global to Local

NOAA
AVHRR

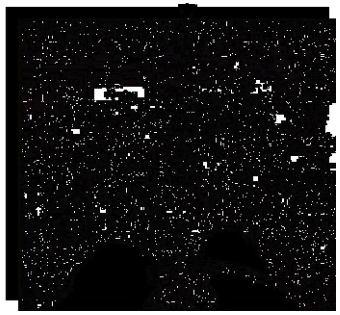


OCM

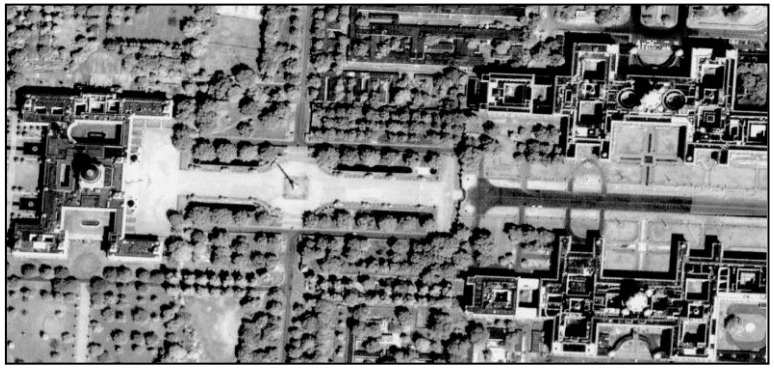


WiFS

LISS-III



PAN



IKONOS

Scale Diversity of Remote Sensing Data

Image Interpretation

- **Image data should be interpreted to extract required information**
  - **Visual Interpretation**
  - **Computer assisted interpretation – Digital Image Interpretation**
- **Information Extraction**
  - **Classification**
  - **Change detection**
  - **Extraction of physical quantities**
  - **Extraction of indices**

Digital Image Processing

- **Steps**
  - **Data input/ output**
  - **Image rectification and restoration**
  - **Image enhancement**
  - **Classification**
  - **Output**

Digital Image Processing

- **Data Input**
  - Input data to the image processing system
    - **Digital Data – CCT, HDDT, CD**
    - **Analog data – Digitizing, Scanning**
- **Image rectification and restoration**
  - **Radiometric Correction**
  - **Geometric Correction**

Geometric Correction

- **Geometric errors in the image due to**
  - **Earth's curvature**
  - **Sensor's viewing geometry**
  - **Terrain variations**
- **Geometric errors can be removed by rectifying the image to a map.**
- **Rectification is necessary in cases where the pixel grid of the images must be changed to fit a map projection system or a reference image.**

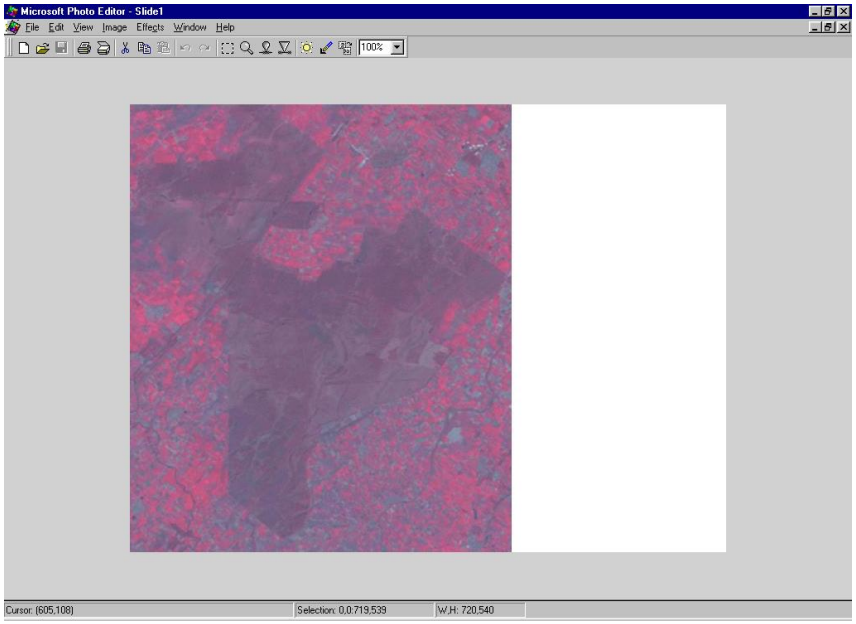
Geometric Correction

– Entering GCPs into the software
– Selection of GCPs – Nature of GCPs…
– Error calculations and correction (in GCPs)
– Resampling into a new grid
– Geometrically corrected image

Image Enhancement

- **to convert the image quality to a better and more understandable level for feature extraction or image interpretation**
- **helps to increase the contrast between the features in the image**
- **techniques involve image transformations, generation of colour composites and development of indices**

Image Enhancement



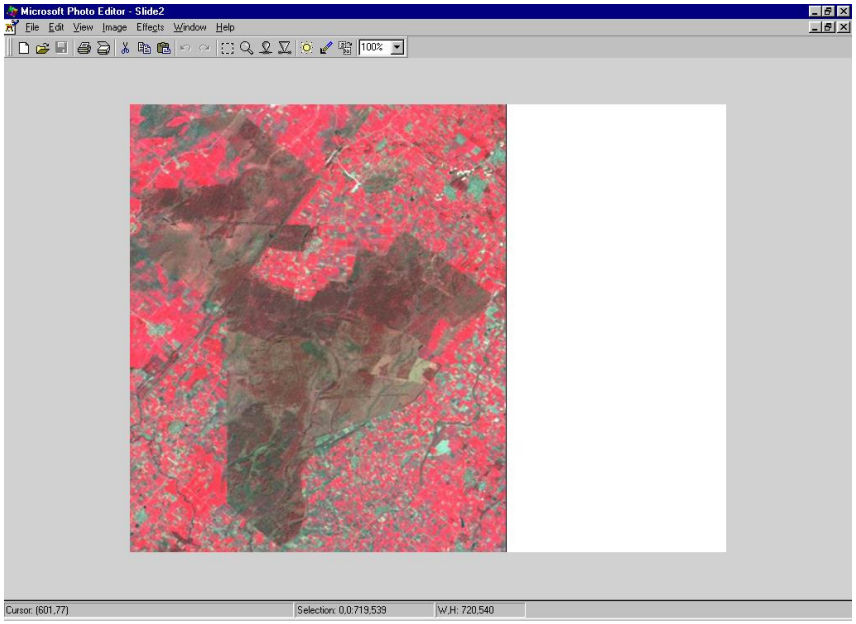
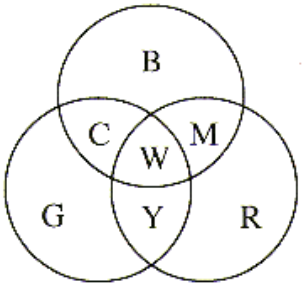


Image Enhancement

- **Colour Display of Image Data**
  - **Colour display of remotely sensed data is important for effective visual interpretation**
    - **colour composite - to generate colour with multi-band data**
    - **pseudo colour display - to assign colour to the gray scale of a single image**



(a) additive color composite

Figure 10.4.1 Metho

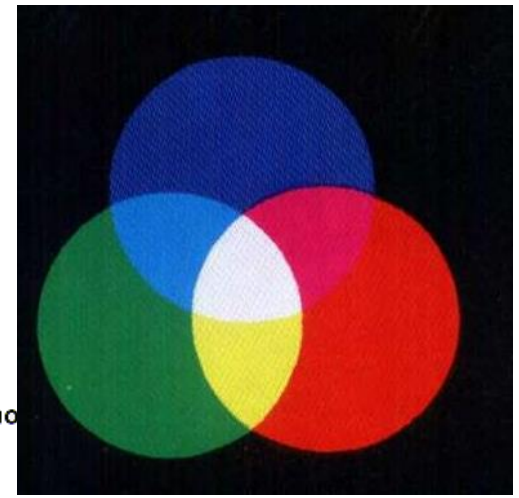


Image Classification

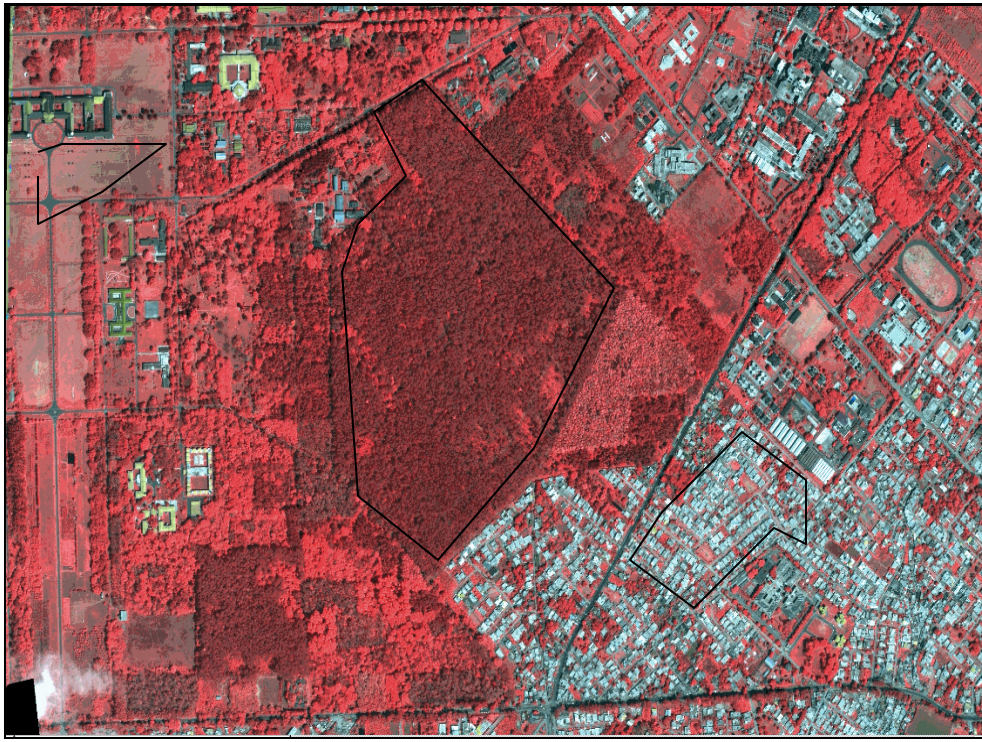
- **objective of image classification is to automatically categorize pixels in an image into land cover classes or themes**

- **spectral pattern present within the data for each pixel is used as the numerical basis for categorization**

- **Classification can be performed in two ways**
  - **Supervised Classification**
  - **Unsupervised Classification**

Supervised Classification

- **An interpretation key that describe the spectral attributes of each feature type of interest has to be prepared using Training Samples or Area of Interest**
- **Training areas are the representative areas for different land cover types**
- **Entire image pixels are classified based on the training samples**



Unsupervised Classification

- Unsupervised classifiers do not utilize training data as the basis for the classification
- examine the unknown pixels in an image and aggregate them into a number of classes based on the natural groupings present in the image
- The identity of the spectral classes is initially unknown
- The analyst must compare the classified data with some reference data (maps, ground survey data or imagery) to determine the identity of the classes

Applications of RS

- **Selection of remotely sensed data should be done based on the nature of the application**
- **Need to consider spatial, spectral, temporal and radiometric resolutions of the data**
- **Temporal resolution is important in multi temporal analysis or monitoring**
- **Radiometric resolution is important in identifying subtle variations in the object of investigation**

MODIS – the useful sensors for climate change

MODIS (Moderate-Resolution Imaging Spectroradiometer

Earth's climate will modify in response to radiative forcing induced by changes in atmospheric trace gases, cloud cover, cloud type, solar radiation, and tropospheric aerosols- For this purpose

.

Two MODIS (Moderate Resolution Imaging Spectroradiometer) instruments, the first launched on 18 December 1999 onboard the Terra Platform second on 4 May 2002 onboard the Aqua platform,

These are uniquely designed

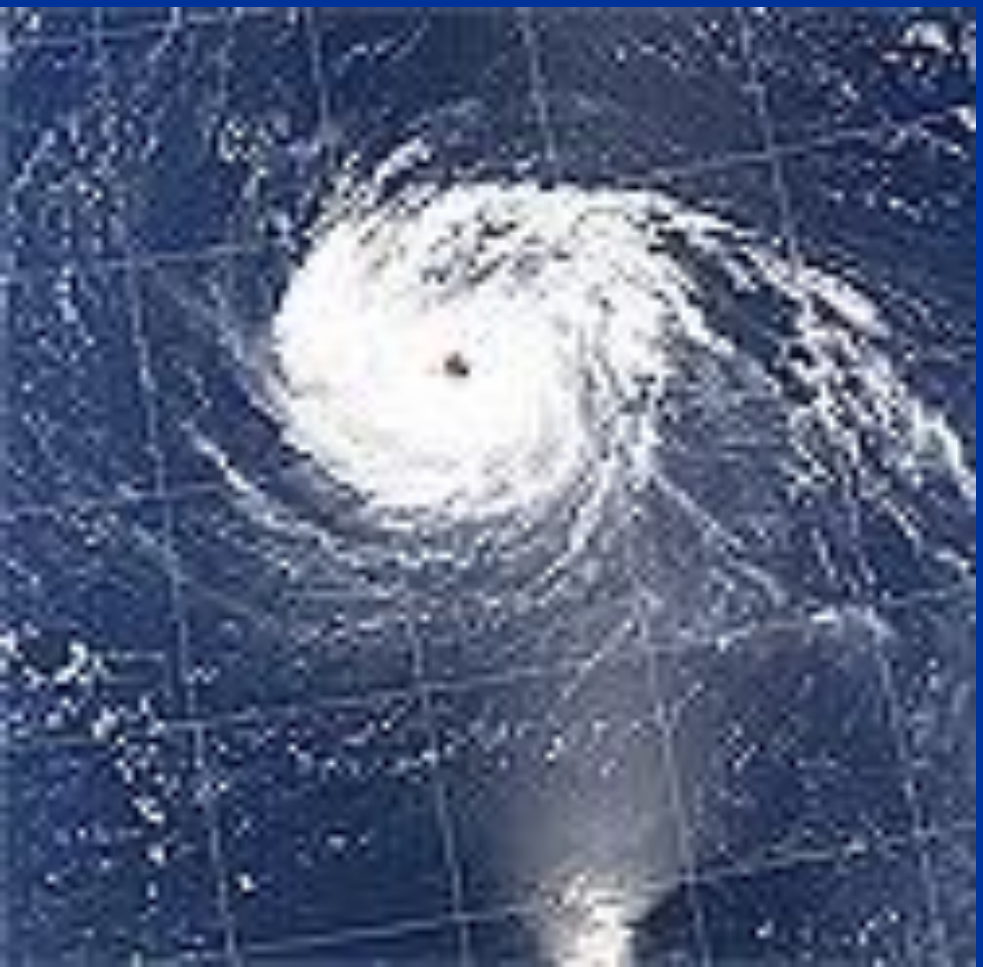
wide spectral range,

high spatial resolution,

and near daily global coverage . (MORE)

ISABEL- ***Powerful Catagory 5 Hurricane***

September 11th 2003, the Terra-MODIS instrument captured this image of extremely dangerous Hurricane Isabel in the western Atlantic moving slowly but steadily towards the U.S. In this image, the center of Isabel was located about 300 miles east-northeast of the northern Leeward Islands.



With maximum sustained winds of 160 mph and gusts to 195 mph, Isabel is a Category 5 hurricane on the Saffir-Simpson hurricane scale. Isabel is the f first Category 5 hurricane in the Atlantic Basin since Hurricane Mitch in 1998.. More RGB images of MODIS

L1B Granules

SPOT

Designed in France, and developed with the participation of Sweden and Belgium.

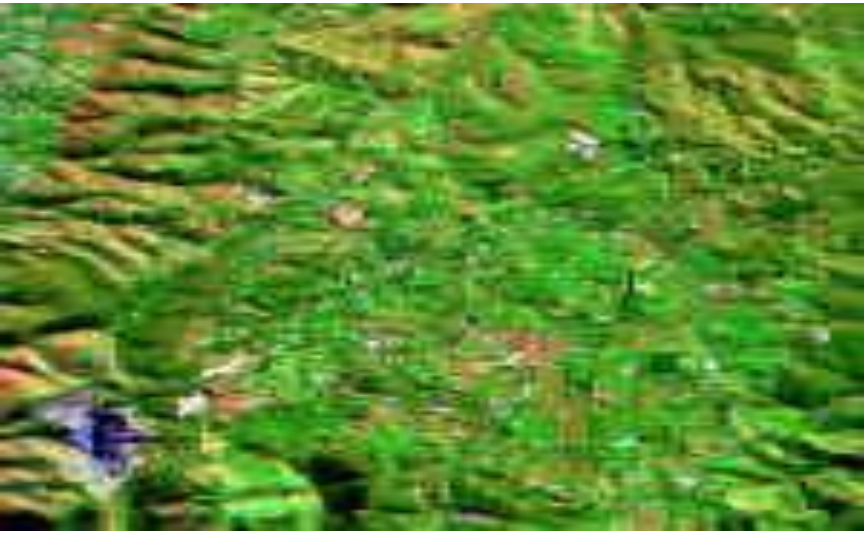
The system comprises a series of spacecrafts plus ground facilities for

satellite control and programming,

image production and distribution

The SPOT satellites capture panchromatic and Multispectral imagery in resolutions ranging from 2.5m to 20m.

10m Multi & 5m Pan



5m Multi & 2.5m Pan

High Resolution data Uses

Telecommunications
Land use and planning
Environmental assessment- Marine studies
Mapping / surveying- Civil engineering
Natural resources -Mining and exploration
Tourism- Urban planning
Agriculture

IKONOS –New Era in satellite Remote sensing

Launched on 24 September 1999,.

IKONOS is the world's first

High-resolution commercial satellite to offer 1-metre Earth imagery.

Onboard sensors point -Along and Across the satellite track, providing a revisit capability of 1-3 days.

IKONOS IMAGERY

1meter Pan

SPATIAL RESOLUTION VALUES

THE SPATIAL RESOLUTION VALUES NECESSARY TO *DETECT, RECOGONIZE, IDENTIFY*

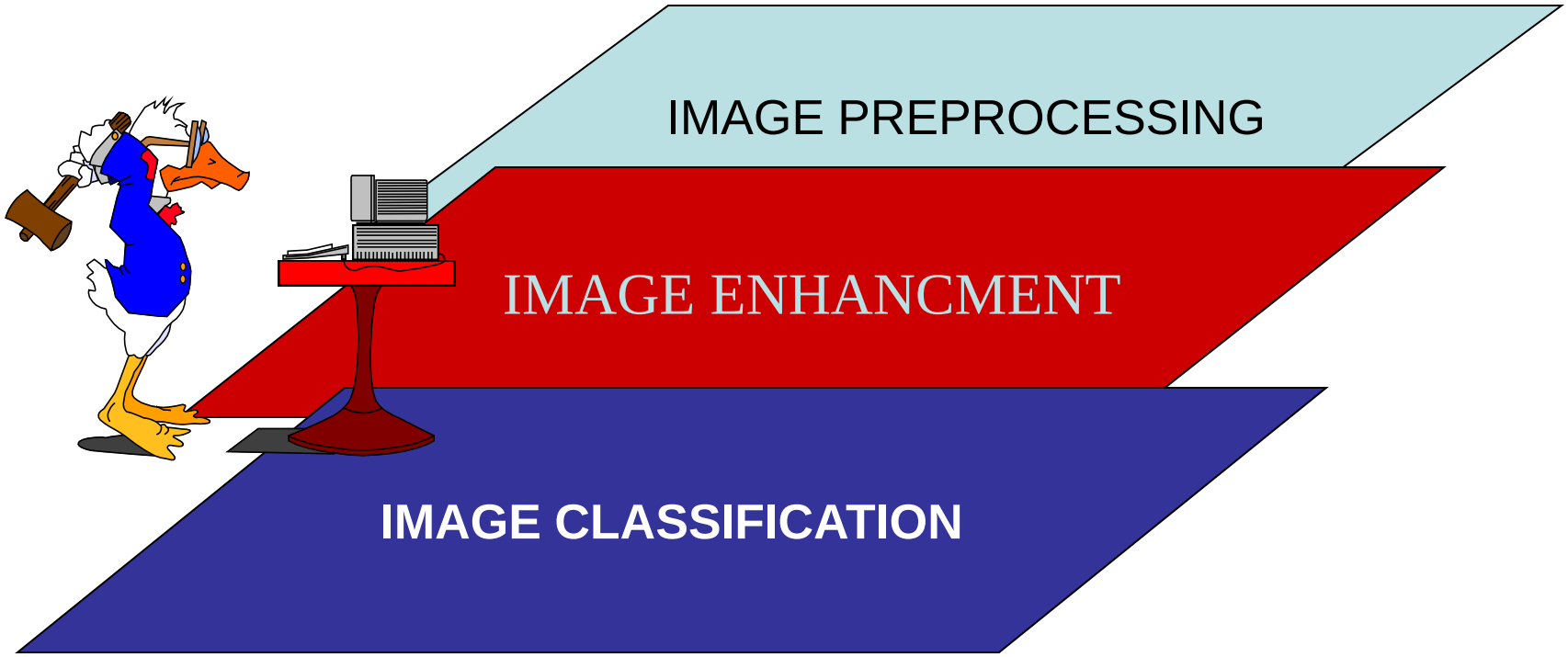
AND *DESCRIBE* VARIOUS INSTALLATIONS.

OBJECTIVES	DETECTION	RECOGNI-TION	IDENTIFICA TION	DESCRIP-TION
ROADS	9	6	1.8	0.6
URBAN AREAS	60	30	3	3
MILITARY AIRFIELDS	-	90	4.5	1.5
SUBMARINE ON THE SURFACE	30	6	1.5	0.9

RESOLUTION in meters

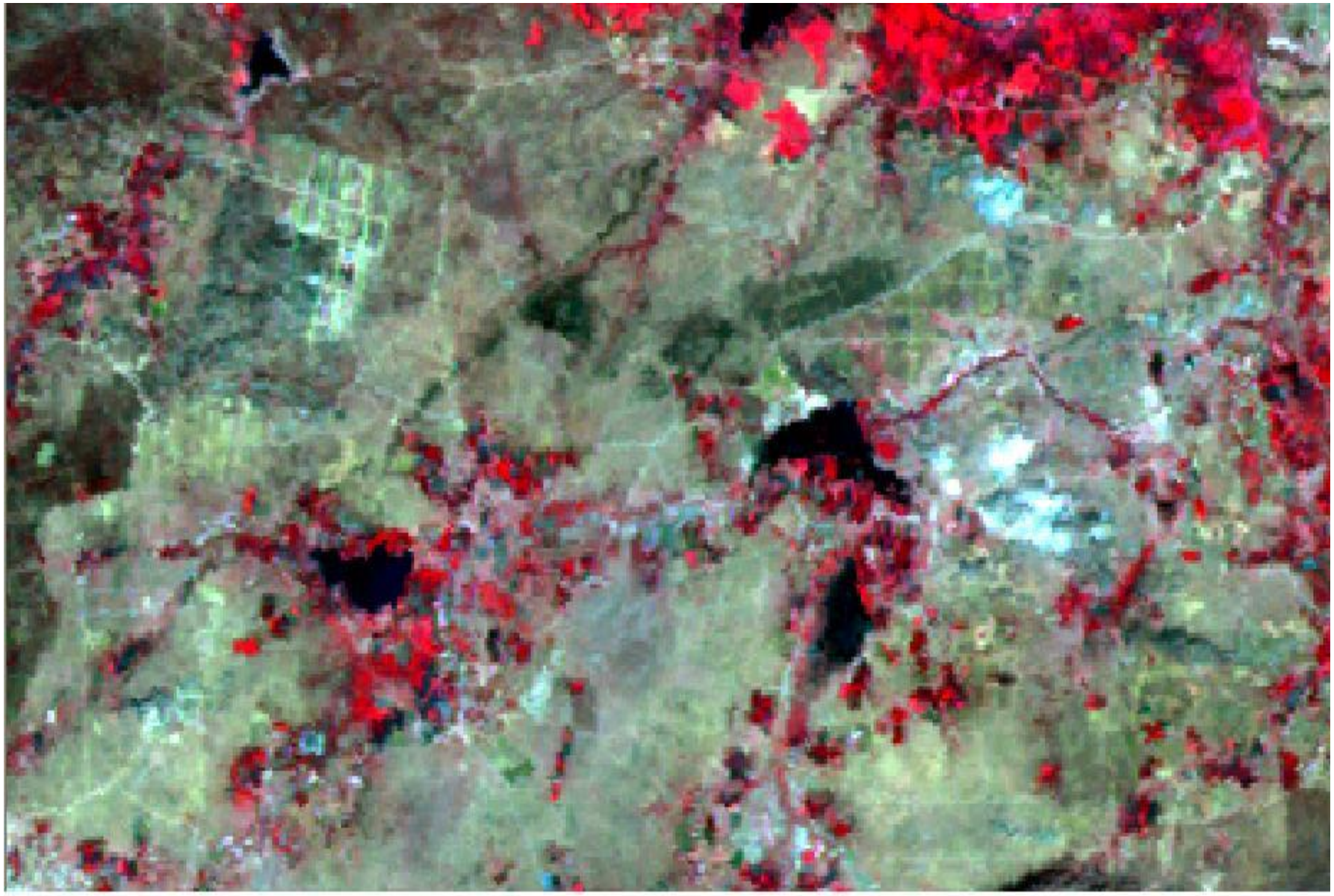
OBJECTIVE	DETECTION	RECOGNI - TION	IDENTIFICA- TION	DESCRIP- TION
BRIDGES	5	4.5	1.5	0 .90
RADAR	3	0.9	0.3	0.15
RADIO COMMUNICA- TIONS	3	1.5	0.3	0.15
MATERIAL DEPOTS	1.5	0.6	0.3	0.025

Basic Steps of Digital Image Processing

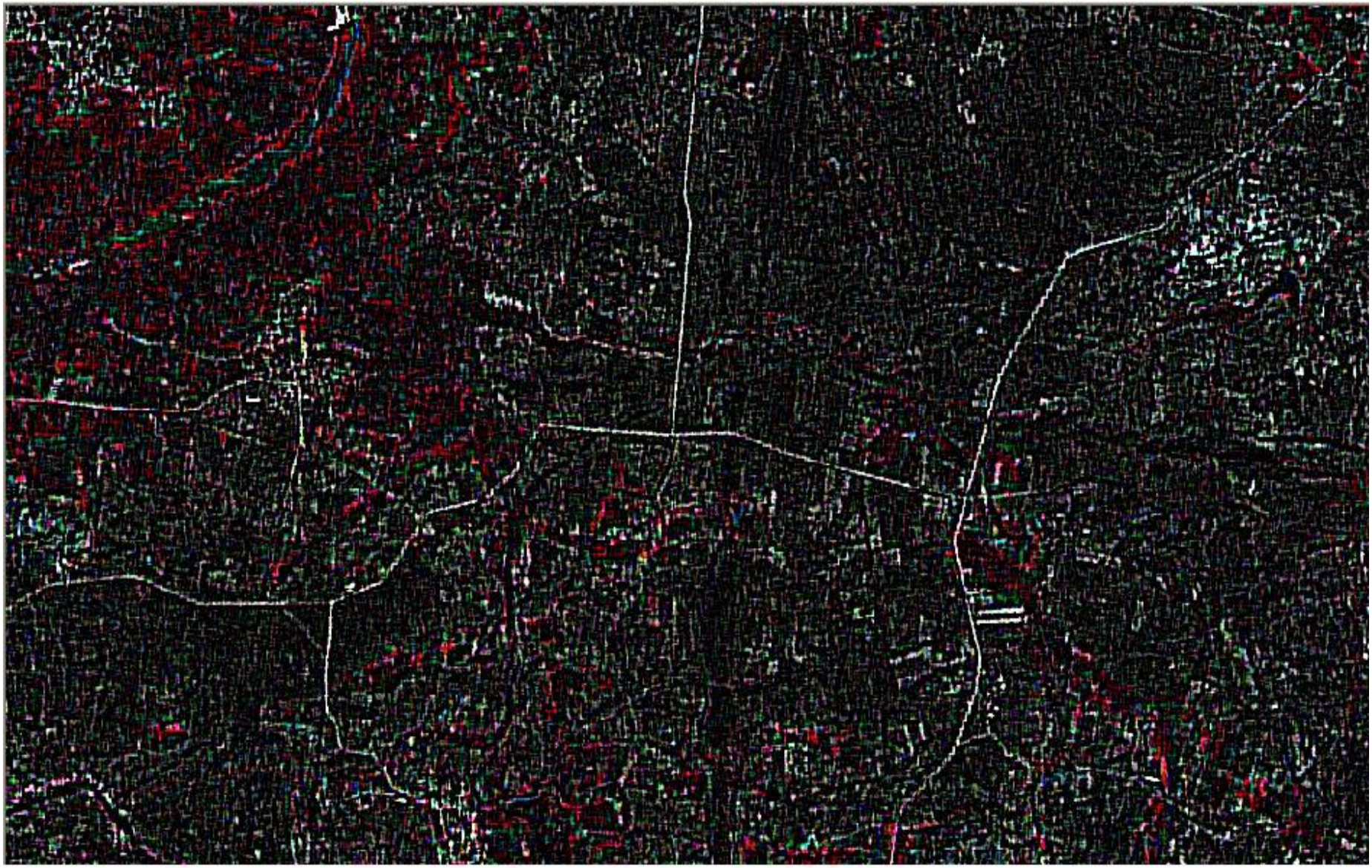


EXTRACTION OF ROADS FROM IRS LISS III IMAGE

INPUT LISS III Image



Out put image



Output Image

Available Data

- Landsat TM, IRS 1D LISS III and Survey of India (SOI) topographical maps on 1:50,000 Scale have been used for base map preparation.
- . The study area falls with in the SOI top sheet Nos. 56E, I, J, M & N. on 1:50,000 Scale were used while conducting field operations. Besides, reports of previous studies related to land use land cover have been consulted in the finalization of maps and report writing.

Land Use & Land Cover Classification:

- Land Use and Land Cover maps have to be prepared adopting visual or digital interpretation techniques in conjunction with collateral data such as topo maps and census data.
- If the digital method is followed then digital output is converted into line maps which corresponds to other theme maps. The total number of classes vary from area to area. The imagery has to be interpreted and ground checked for corrections.

Classification

Land use /land cover are classified into six classes.
They are

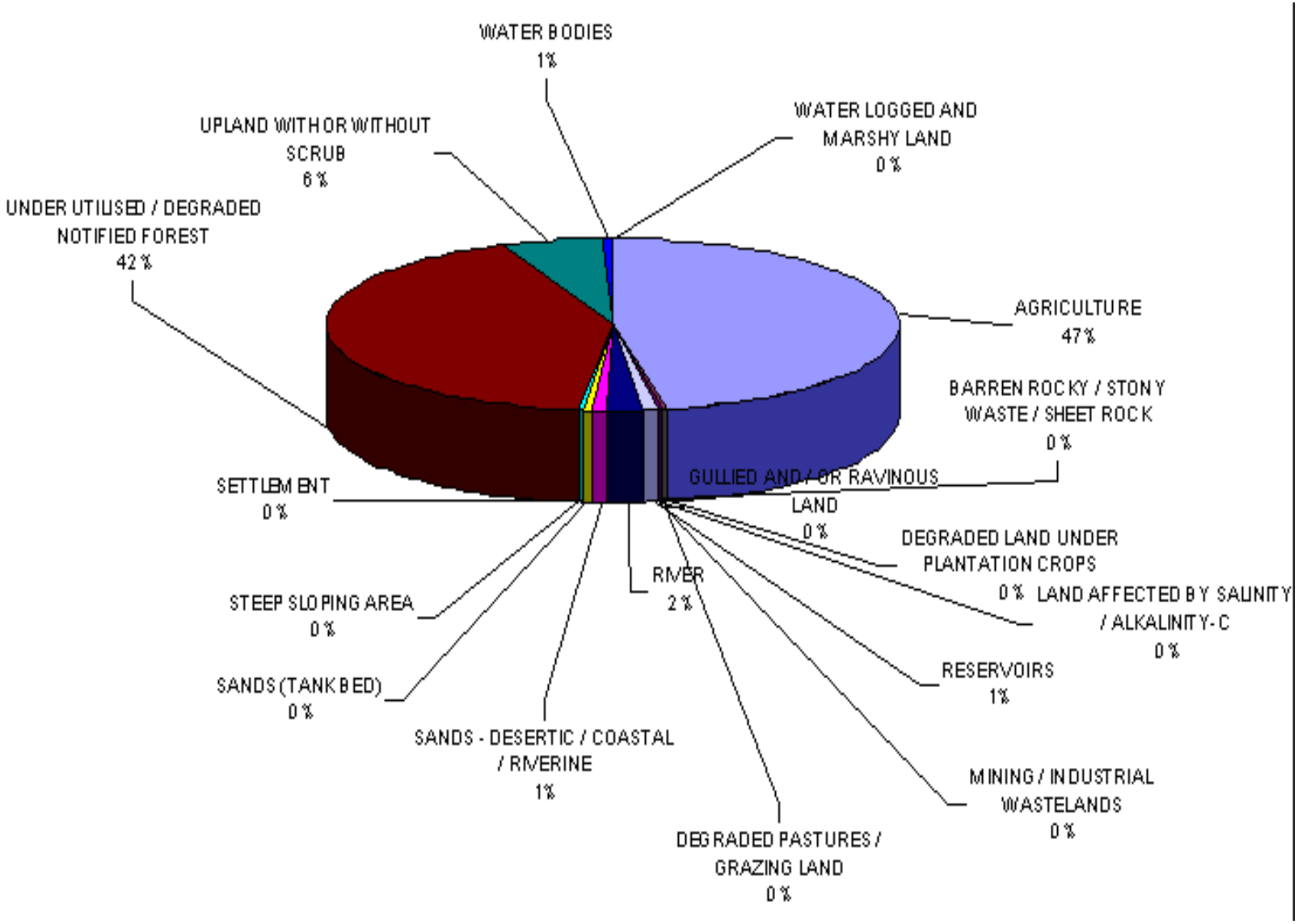
- Built-up land
- Agriculture land
- Forest
- Water bodies
- Waste land
  - Gullied / ravenous land
  - Land with or without scrub
  - Barren rocky/stony waste /sheetrock area
  - salt affected land
  - waterlogged land
  - marshy/ swampy land
  - sandy area

Results & Analysis

Category wise Distribution Of LULC Adilabad District, 1986

DESCRIPTION	AREA SQ.KM
AGRICULTURE	7577.81
BARREN ROCKY / STONY WASTE / SHEET ROCK	48.64
DEGRADED LAND UNDER PLANTATION CROPS	0.92
DEGRADED PASTURES / GRAZING LAND	0.17
GULLIED AND / OR RAVINOUS LAND	44.12
LAND AFFECTED BY SALINITY / ALKALINITY-C	0.25
MINING / INDUSTRIAL WASTELANDS	4.53
RESERVOIRS	129.30
RIVER	288.29
SANDS - DESERTIC / COASTAL / RIVERINE	159.77
SANDS (TANK BED)	54.57
SETTLEMENT	67.02
STEEP SLOPING AREA	1.13
UNDER UTILISED / DEGRADED NOTIFIED FOREST	6737.83
LAND WITH OR WITHOUT SCRUB	914.68
WATER BODIES	92.94
WATER LOGGED AND MARSHY LAND	0.59
Grand Total	16122.55

Statistics of LULC Adilabad District in 1986



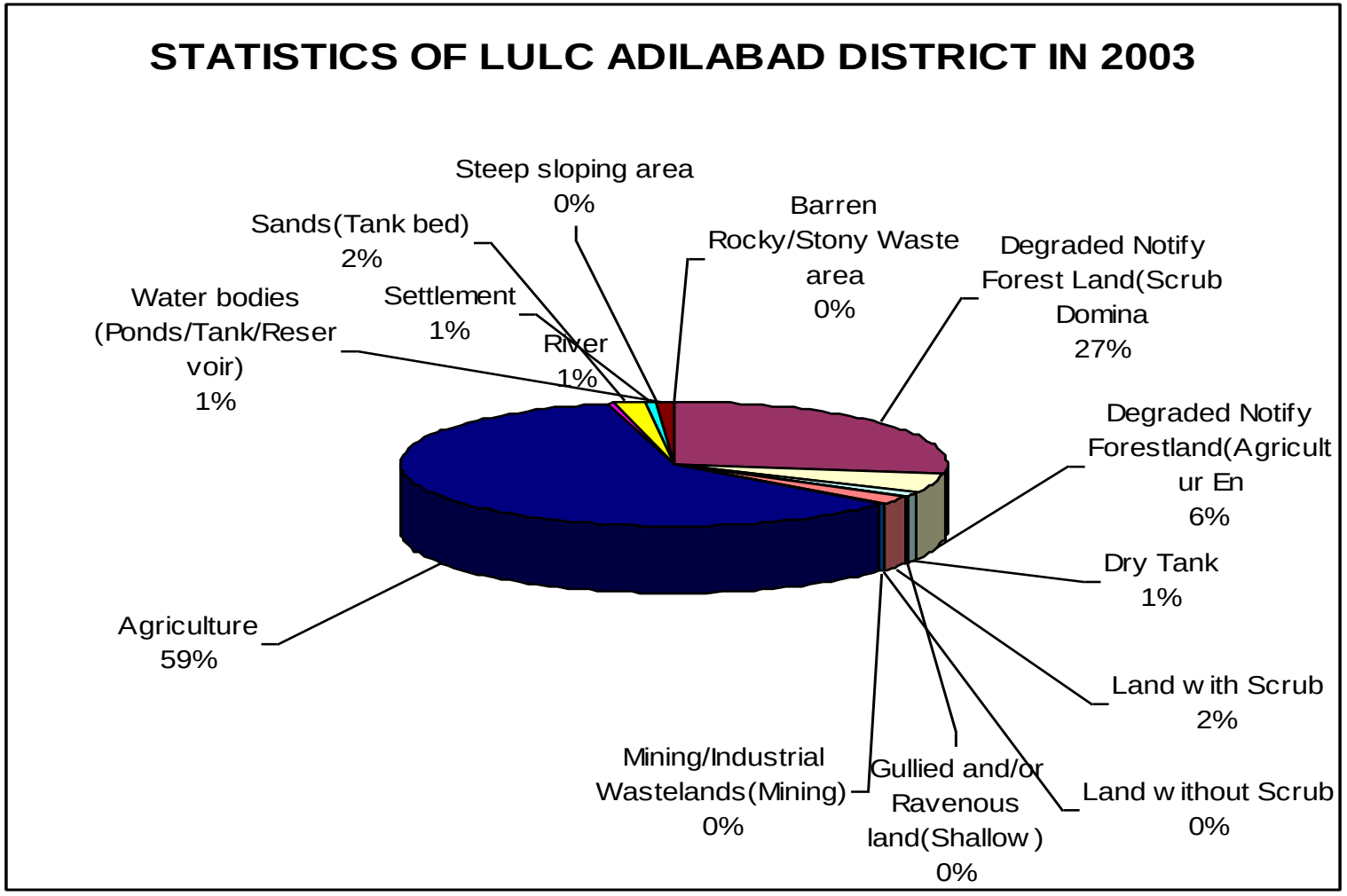
Conclusion from the above statistics for year 1986

- Out of 16122.55sq km area of district, 47% of the area is covered Land with Agriculture.
- The major part of the wasteland is Scrub dominated degraded forestland covering 42% and Land with or without scrub covered 6% of area in 1986.

Category wise Distribution Of LULC, Adilabad District, 2003

DESCRIPTION	AREA SQ.KM
Barren Rocky/Stony Waste area	19.70
Degraded Notify Forest Land(Scrub Domina	4375.27
Degraded Notify Forestland(Agricultur En	889.23
Dry Tank	134.96
Gullied and/or Ravenous land(Shallow)	34.73
Land with Scrub	367.40
Land without Scrub	30.67
Mining/Industrial Wastelands(Mining)	12.17
Agriculture	9611.81
River	85.65
Sands(Tank bed)	286.52
Settlement	114.51
Steep sloping area	0.49
Water bodies (Ponds/Tank/Reservoir)	159.44
Grand Total	**16122.55**

Statistics of LULC Adilabad District in 2003



Conclusion from the above statistics for year 2003

- Out of 16122.55sq km area of district, 59% of the area is covered Land with Agriculture.
- The major part of the wasteland is Scrub dominated degraded forestland covering 27%, Land with or without scrub covered 2% of area and Agriculture Encroachment covers 6% of area in 2003.

Statistics Of LULC - Change In Adilabad District

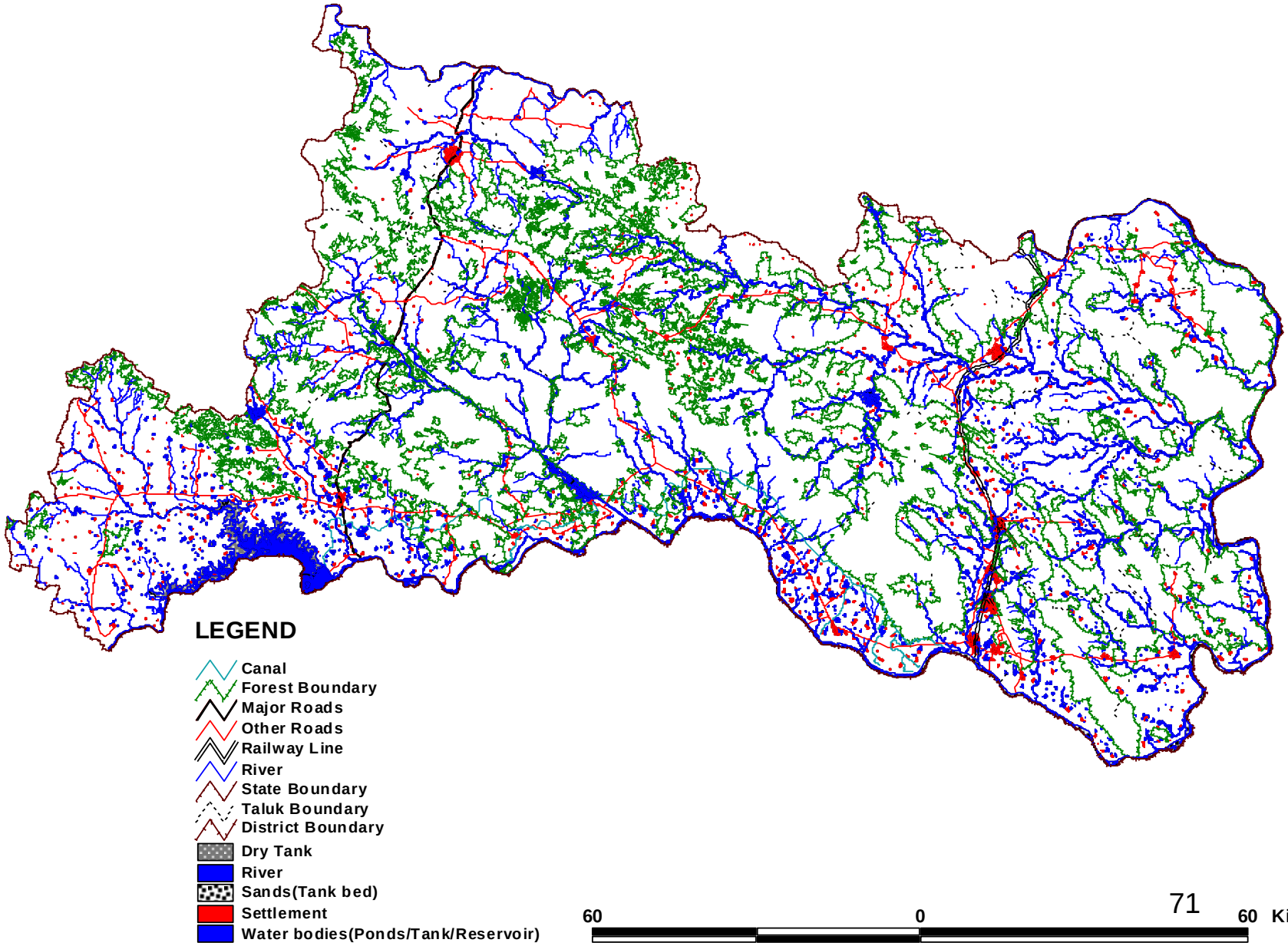
(1986 - 2003)

	2003	1986	CHANGE
DESCRIPTION	**AREA SQ.KM**	**AREA SQ.KM**	**AREA SQ.KM**
Barren Rocky/Stony Waste area	19.70	48.64	-28.94
Degraded Notify Forest Land(Scrub Domina	4375.27	6739.76	-2364.49
Degraded Notify Forestland(Agricultur En	889.23	0.00	889.23
Gullied and/or Ravenous land(Shallow)	34.73	44.12	-9.39
Land with Scrub	367.40	914.68	-547.27
Land without Scrub	30.67	0.00	30.67
Mining/Industrial Wastelands(Mining)	12.17	4.53	7.64
Agriculture	9611.81	7577.81	2033.99
Sands(Tank bed)	421.48	214.33	207.15
Settlement	114.51	67.02	47.49
Steep sloping area	0.49	1.13	-0.64
Water bodies (Ponds/Tank/Reservoir)	245.10	510.53	-265.43
Grand Total	**16122.55**	**16122.55**	0.00

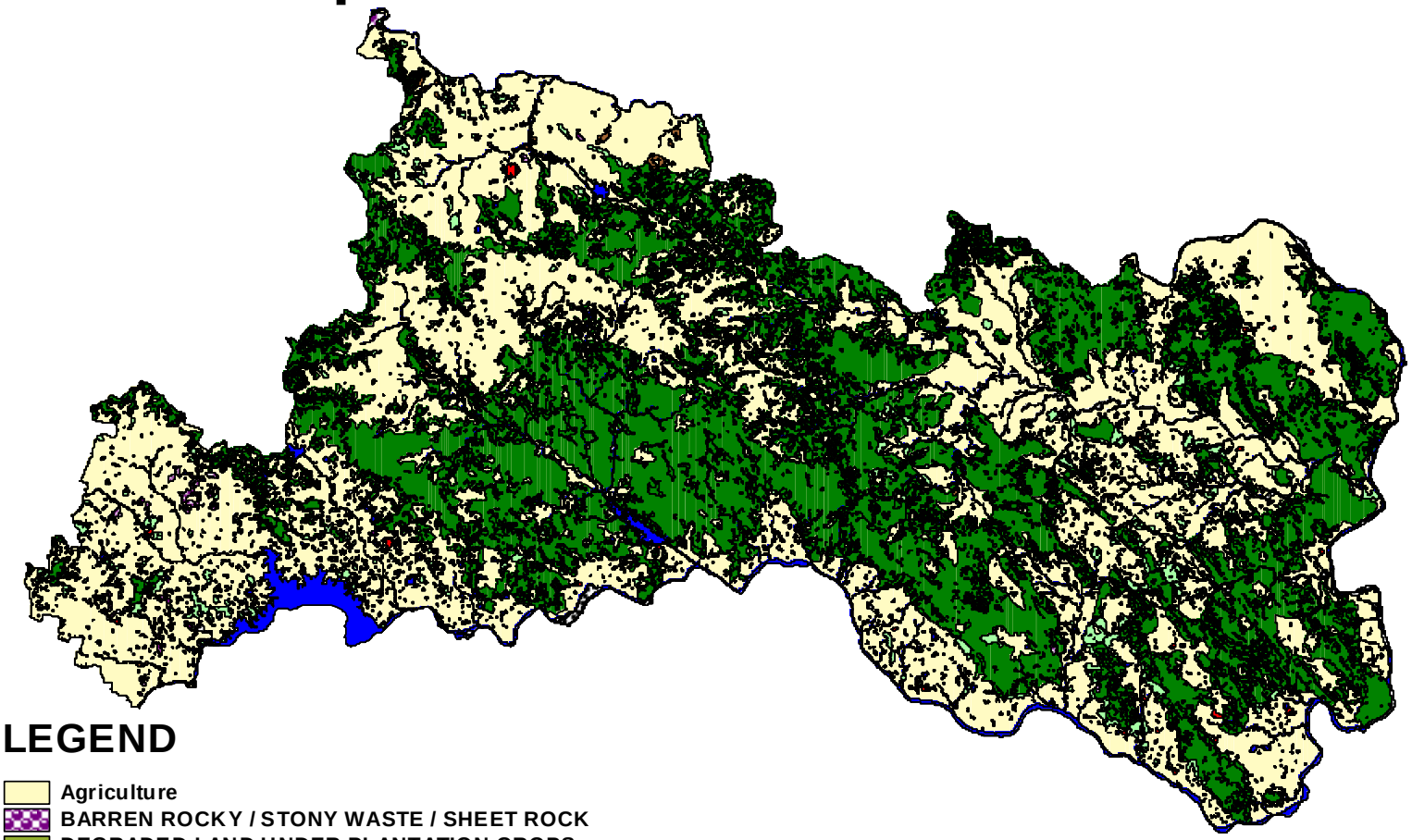
Conclusion from Above Statistics

- Land Use/Land Cover statistics generated by using remote sensing techniques compiled and tabulated.
- It is seen from the area under land use land cover, the Agriculture area is 7577.81 sq.kms in 1986 and 9611.81 sq.kms in 2003. 2034 sq.kms area increased during last 18 years.
- Most of the land wasteland categories have been cultivated and so this area changed into agricultural land.
- The Forest area is 6739.76 sq.kms in 1986 and 4375.27 sq.kms in 2003. 2365 sq.kms area decreased during last 18 years.
- Most of the land wasteland categories have been cultivated and so this area changed into agricultural land called encroachment.
- The land under scrub earlier 915 sq.kms and present 367 sq.kms. almost 547 sq.kms of area changed into cultivated land.

Base Map of Adilabad District



LULC Map of Adilabad District -1986

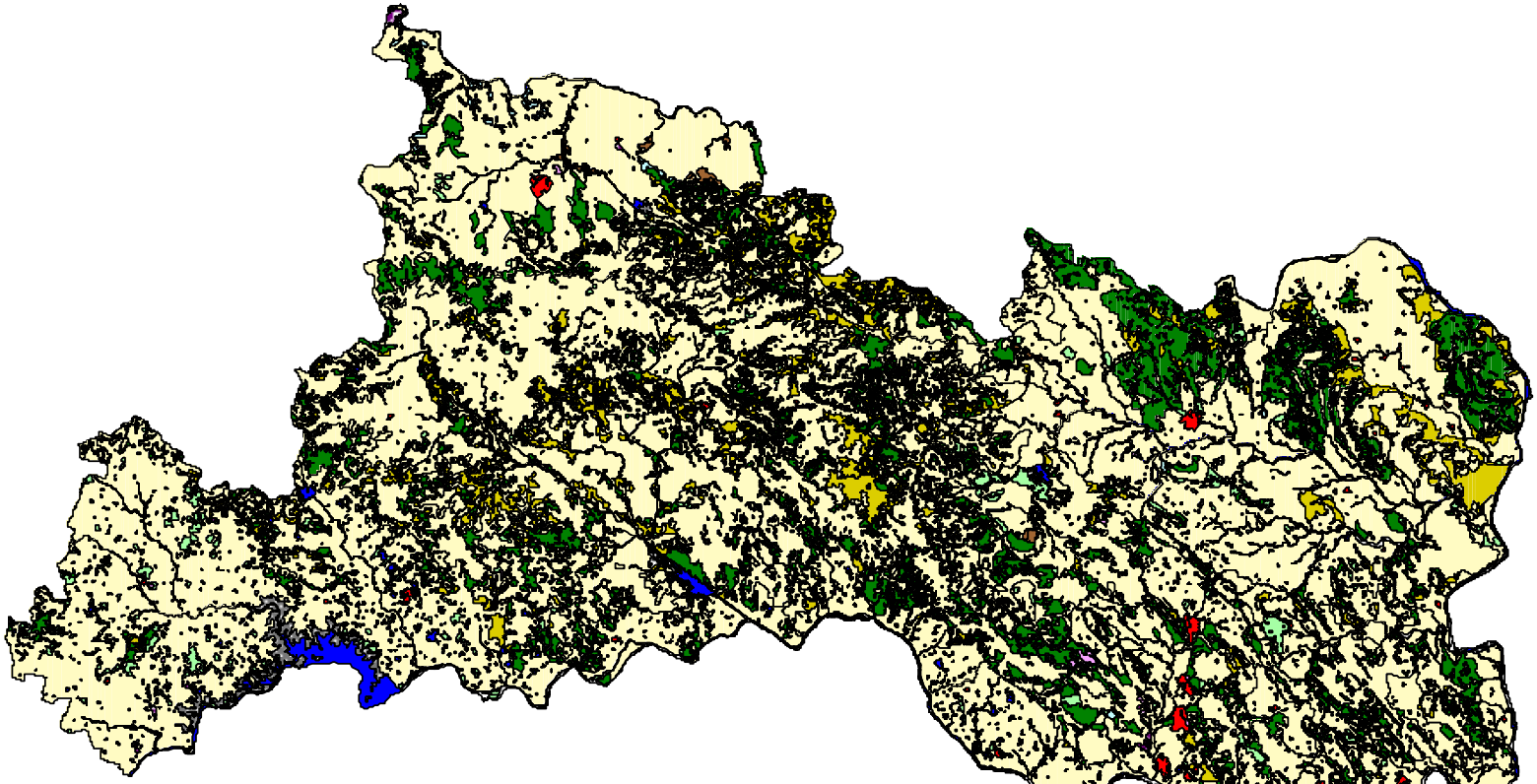


LEGEND

- Agriculture
- BARREN ROCKY / STONY WASTE / SHEET ROCK
- DEGRADED LAND UNDER PLANTATION CROPS
- DEGRADED PASTURES / GRAZING LAND
- GULLIED AND / OR RAVINOUS LAND
- LAND AFFECTED BY SALINITY / ALKALINITY-C
- MINING / INDUSTRIAL WASTELANDS
- SANDS (TANK BED)
- SANDS - DESERTIC / COASTAL / RIVERINE
- SETTLEMENT
- STEEP SLOPING AREA
- UNDER UTILISED / DEGRADED NOTIFIED FORES
- UPLAND WITH OR WITHOUT SCRUB
- WATER BODIES
- WATER LOGGED AND MARSHY LAND

60 0 72 60 Kilometers

LULC Map of Adilabad District -2003

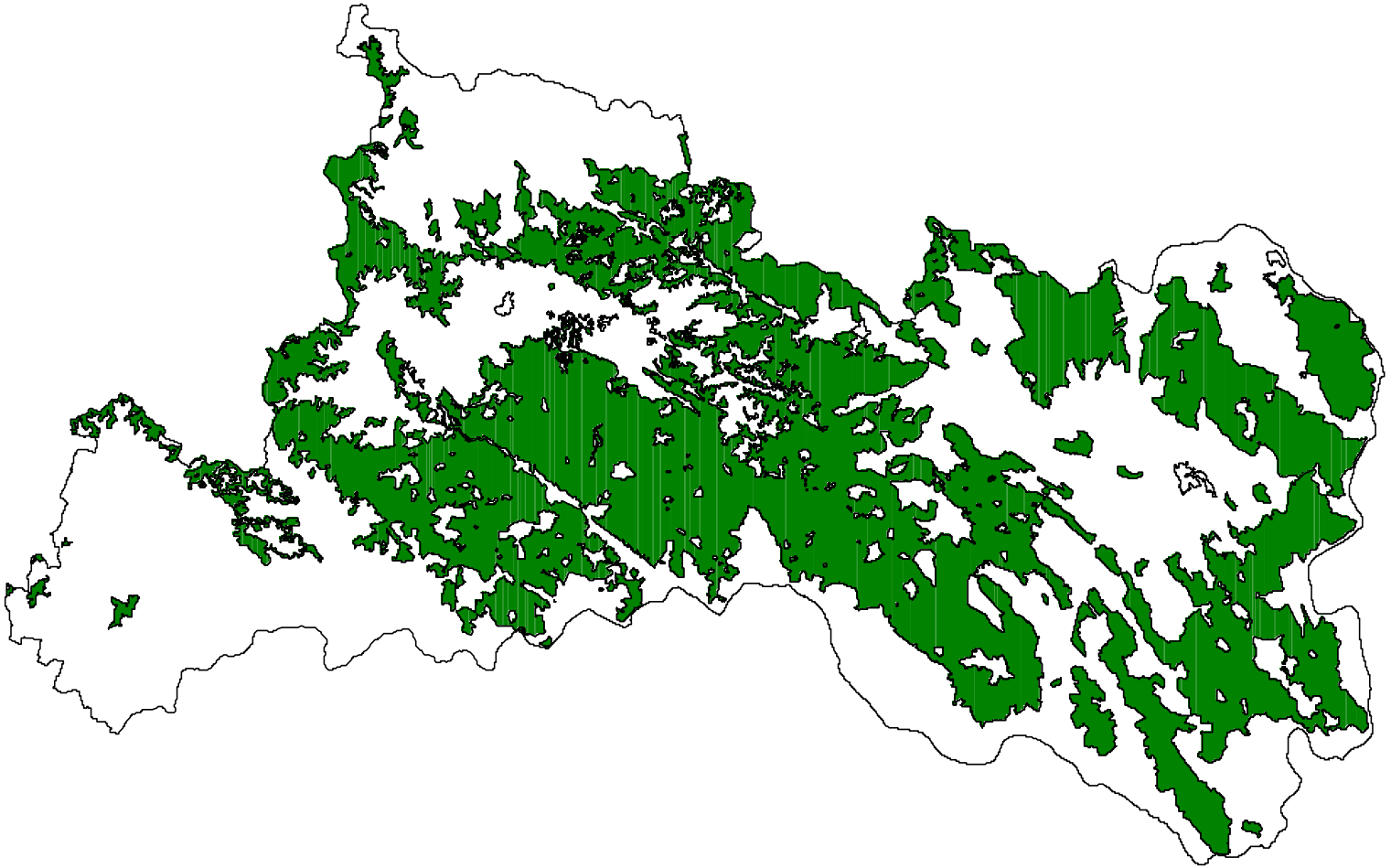


LEGEND

- Barren Rocky/Stony Waste area
- Degraded Notify Forest Land(Scrub Domina
- Degraded Notify Forestland(Agricultur En
- Dry Tank
- Gullied and/or Ravenous land(Shallow)
- Land with Scrub
- Land without Scrub
- Mining/Industrial Wastelands(Mining)
- AGRICULTURE
- Sands(Tank bed)
- Settlement
- Steep sloping area
- Water bodies (Ponds/Tank/Reservoir)

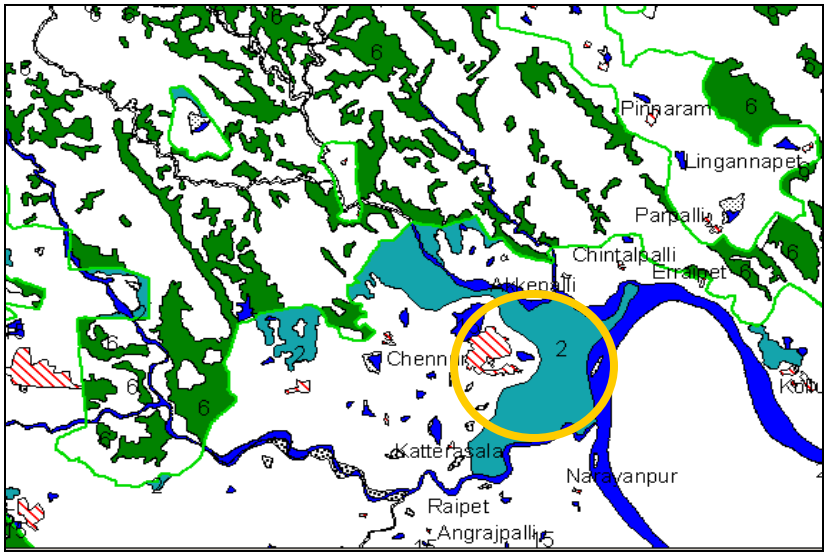
60 0 60 Kilometers

Forest Map of Adilabad District

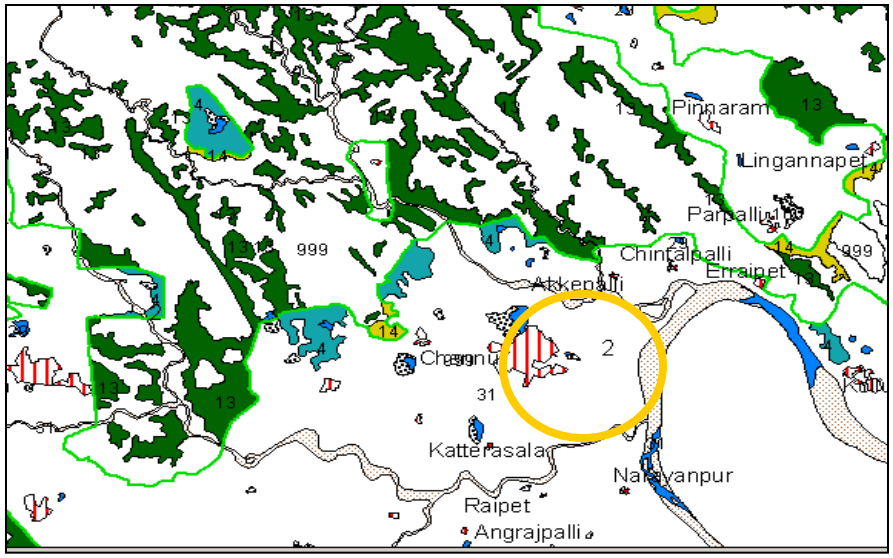


ADILABAD DISTRICT SUCCESS STORIES

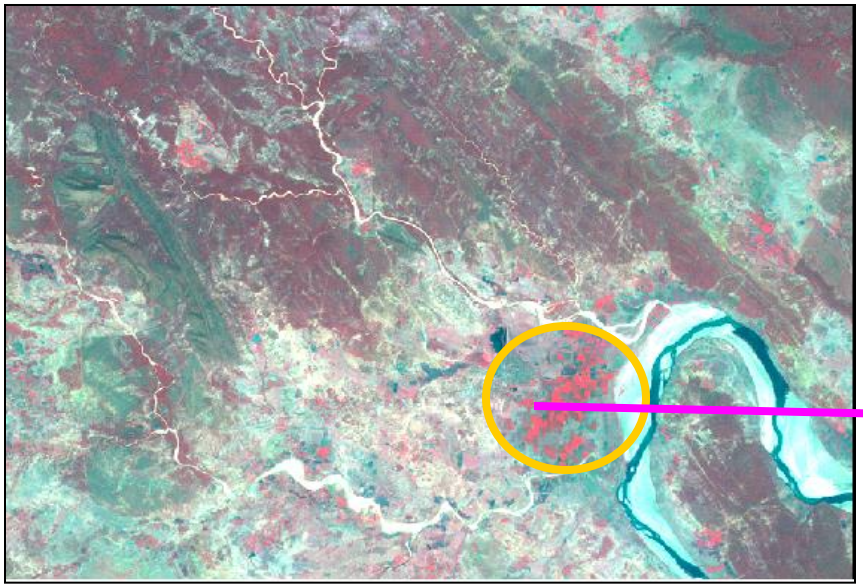
OLD VECTOR

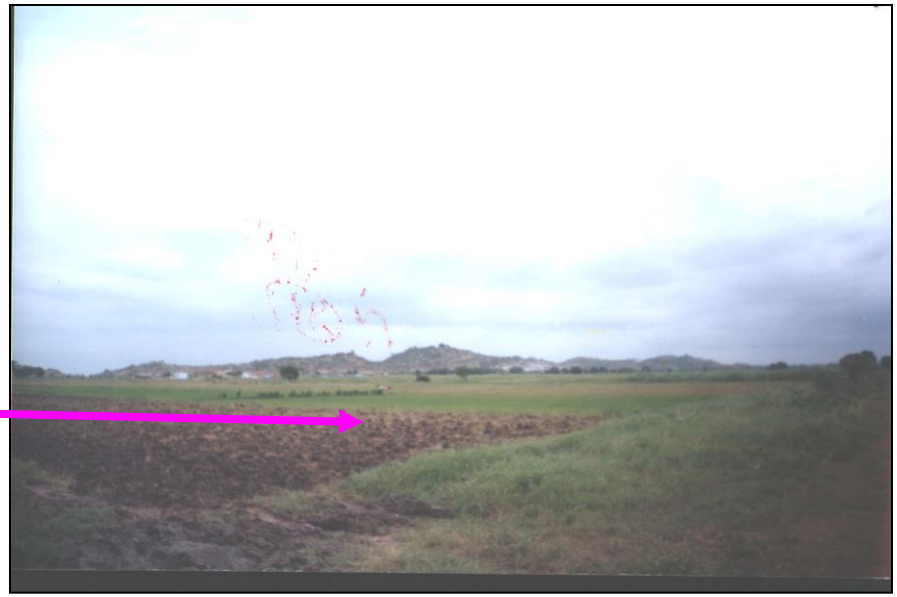


NEW VECTOR



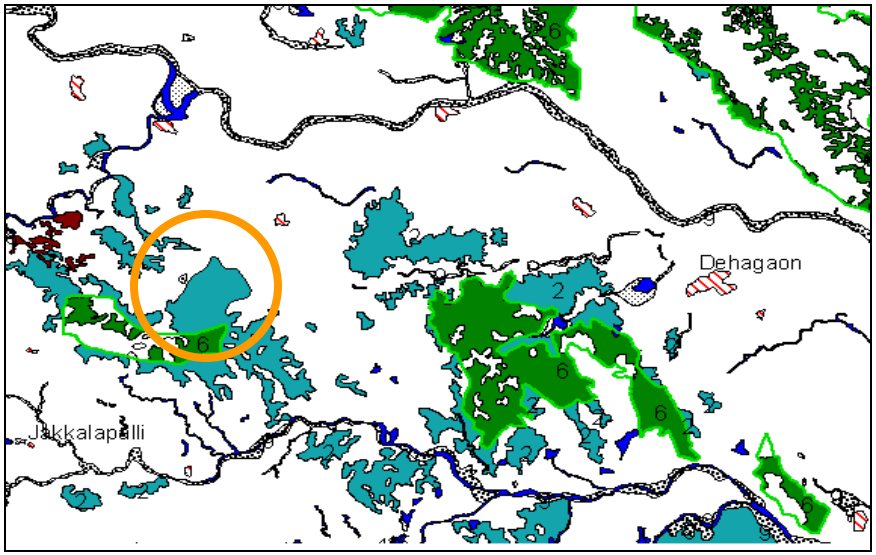
DEVELOPMENT OF SCRUB LAND INTO CULTIVATION LAND



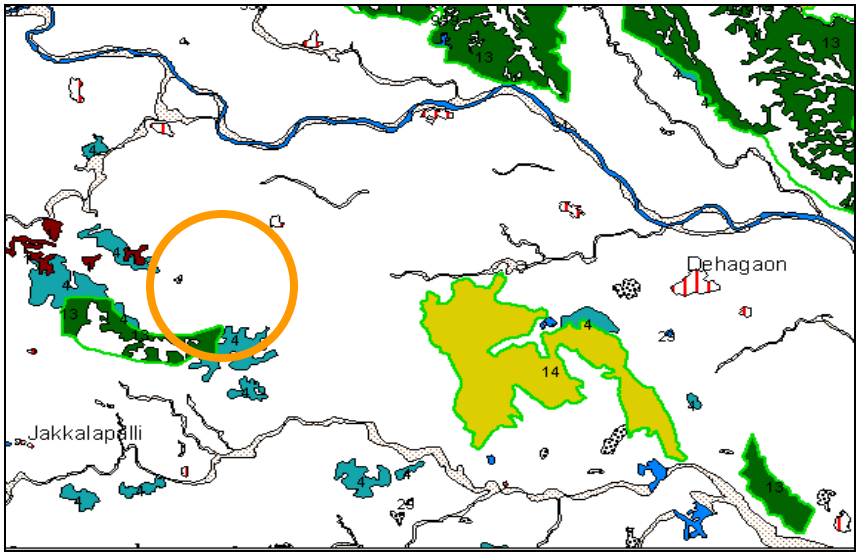


ADILABAD DISTRICT

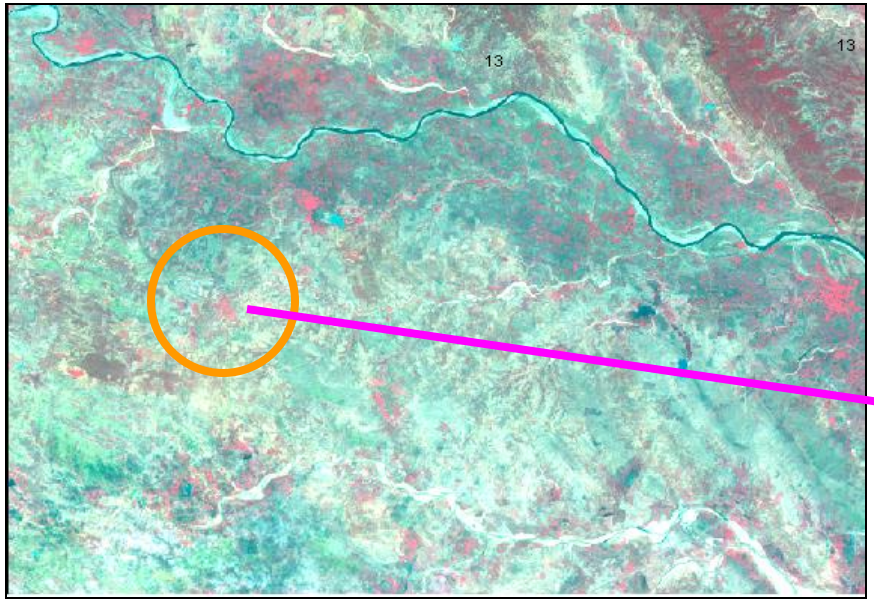
OLD VECTOR



NEW VECTOR



DEVELOPMENT OF SCRUB LAND INTO CULTIVATION LAND



Field Photos

Photos 1

Near Village Gangapur; Mining area; Coordinates: 77.979, 19.106

Photos 2

Near Village Neredikonda; Land with scrub; Coordinates: 78.40, 19.29

Photos 3

Near Village Gopalpet; Forest Land; Coordinates: 78.357, 19.194

Thank you