Bharathidasan University

Tiruchirappalli – 620 023, Tamil Nadu

6 Yr. Int. **M.Tech. Geological Technology and Geoinformatics**

Course Code : **MTIGT0707** *Optional Elective* : **14** *Credits* : **3**

GEOINFORMATICS IN SOIL SCIENCE

Unit–5 Geoinformatics in Soil Mapping, Management and Conservation

Prepared by

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Professor, Department of Remote Sensing

Course Objectives:

- ❖ To learn the importance, characters and types of soil and its relation with biotic systems
- ❖ To study the significance of soil nutrients and micronutrients
- ❖ To understand relevant aspects like soil organic matter, water holding property and landscape
- ❖ To learn the application of Geological Technology and Geoinformatics in soil resources mapping and management
- ❖ To learn the application of Geoinformatics in mitigating soil erosion and reservoir siltation.

SEMESTER – VII ELECTIVE PAPER-14 MTIGT0707 GEOINFORMATICS IN SOIL SCIENCE

3 Credits

1. **Introduction to Soil Science :** Nature and Importance of Soil, Soil formation, Soil survey, Physical, chemical and biological characters of soil, Relationship between Soil, plants and animal. **9 Hrs**

2. **Soil Types :** Soil types and classification, Soil genesis, Soil mineralogy and geochemistry of soil types: Laterites, Bauxites, Aridisols, Vertisols, Camborthids. Application of soil micromorphology and landscape evolution. Radiometric age determination of soils. **12 Hrs**

3. **Soil Nutrients and Crop Production :** Elements essential for plants and animals, Soil nutrients - Nitrogen, Phosphorous, Potassium, Calcium, Magnesium and Sulphur in soil and its significance in plant growth, Micronutrients. **9 Hrs**

4. **Soil Quality and Landscape :** Soil and water relations, organic matter in soil, functions of organic matter, organic matter and soil structure, organic matter and essential elements, tillage, cropping systems and fertility and case studies. **12 Hrs**

5. **Soil Management and Conservation :** Introduction, irrigation, drainage and soil management for field crops, gardens, lawns, pastures, rangelands and forests. Problem Soils - Soil surface crusting - Salinity - Erosion - Contamination. Soil conservation factors and implementation methods. **6 Hrs**

6. **Current Contours: (Not for Final Exam; only for Discussion):** Environmentally safe and sustainable methods of mitigating soil erosion and reservoir siltation using Geological Technology and Geoinformatics; Development of suitable and pragmatic methods to protect soil from fertility loss, soil pollution and degradation.

References:

1. Nyle, C. Brady, Ray R. Weil, The Nature and Properties of Soils (13th Edition) Prentice Hall, 2002.
2. Donald, L. Sparks, Environmental Soil Chemistry, 2002.
3. Raymond B. Daniels, Richard D. Hammer., Soil Geomorphology, John Wiley & Sons, 2000.
4. M.E. Sumner, Hand book of soil Science, 1992.
5. Donald Sparks, Donald L. Sparks D, Environmental Geochemistry, Academic Press, 2002.

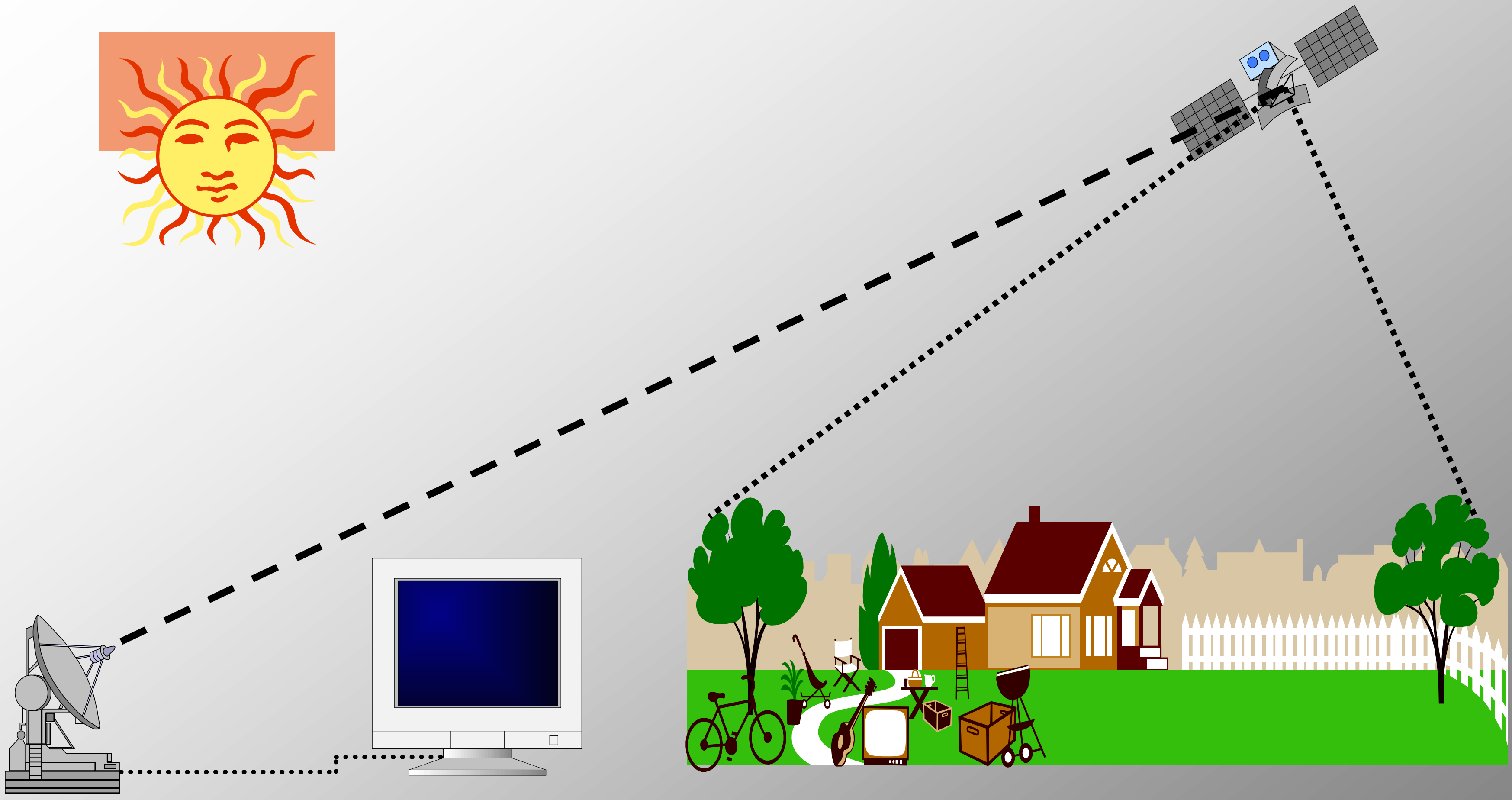
Course Outcomes:

After the successful completion of this course, the students are able to:

- *Understand the importance and the physical, chemical and biological properties of soils*
- *Know the different types of soils and classification*
- *Differentiate the reflectance properties of soils and mapping them using satellite data*
- *Understand the problems to soils using Remote Sensing, field surveys in GIS platform through modeling.*
- *Suggest pragmatic soil management and conservation practices using Remote Sensing, field surveys in GIS platform through modeling and*
- *Understand the importance of soil nutrients, quality and relation with landscape.*

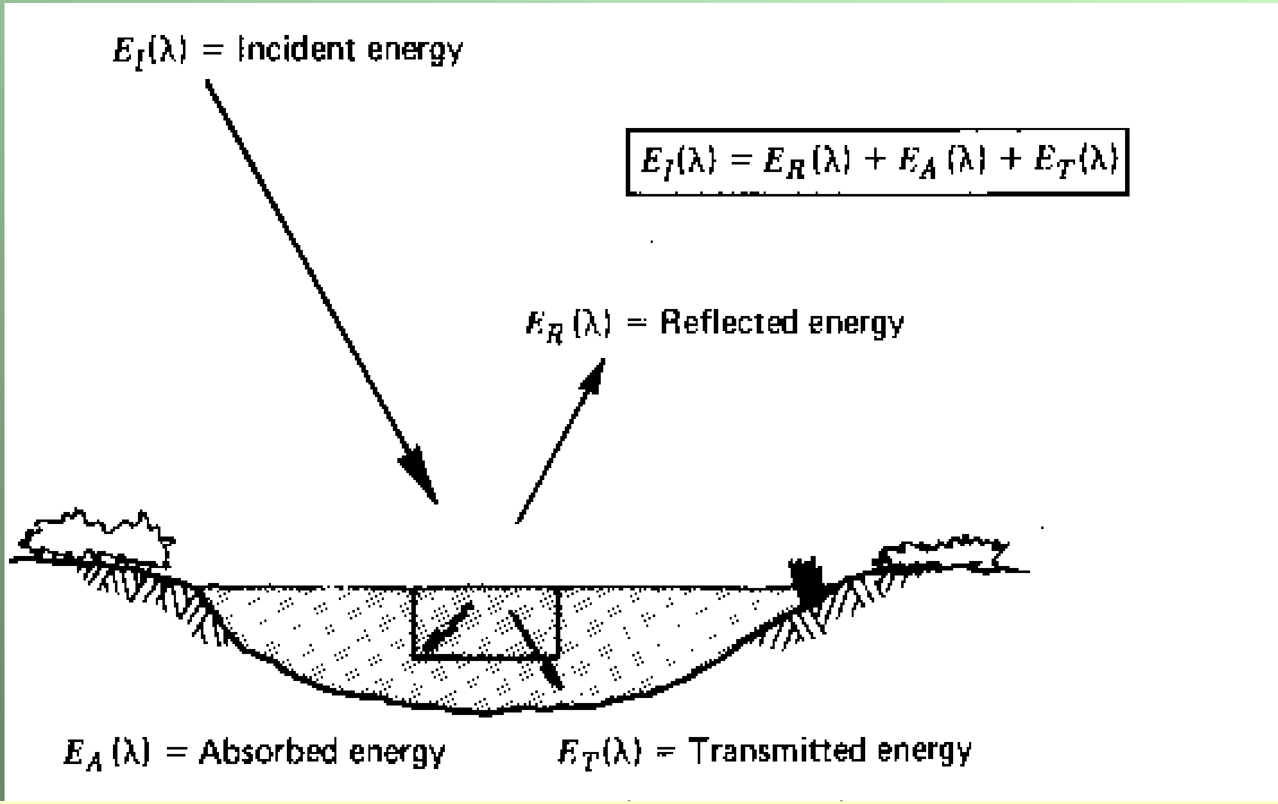
Unit - 5 Soil Management and Conservation

Soil Management and Conservation : Introduction, irrigation, drainage and soil management for field crops, gardens, lawns, pastures, rangelands and forests. Problem Soils - Soil surface crusting - Salinity - Erosion - Contamination. Soil conservation factors and implementation methods. **6 Hrs.**



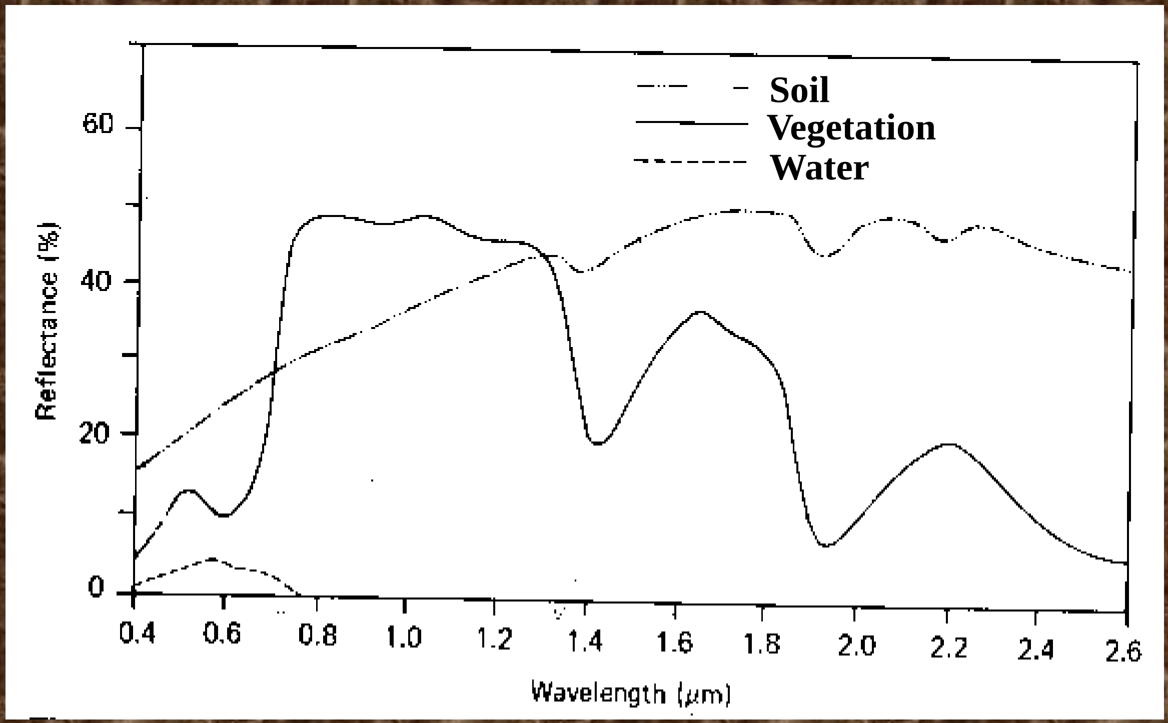
REMOTE SENSING ***is the process of sensing and measuring objects from a distance without physical contact with them.***

REMOTE SENSING is largely concerned with the measurement of electro - magnetic energy from the sun which is reflected, scattered or emitted by the objects on the surface of the earth



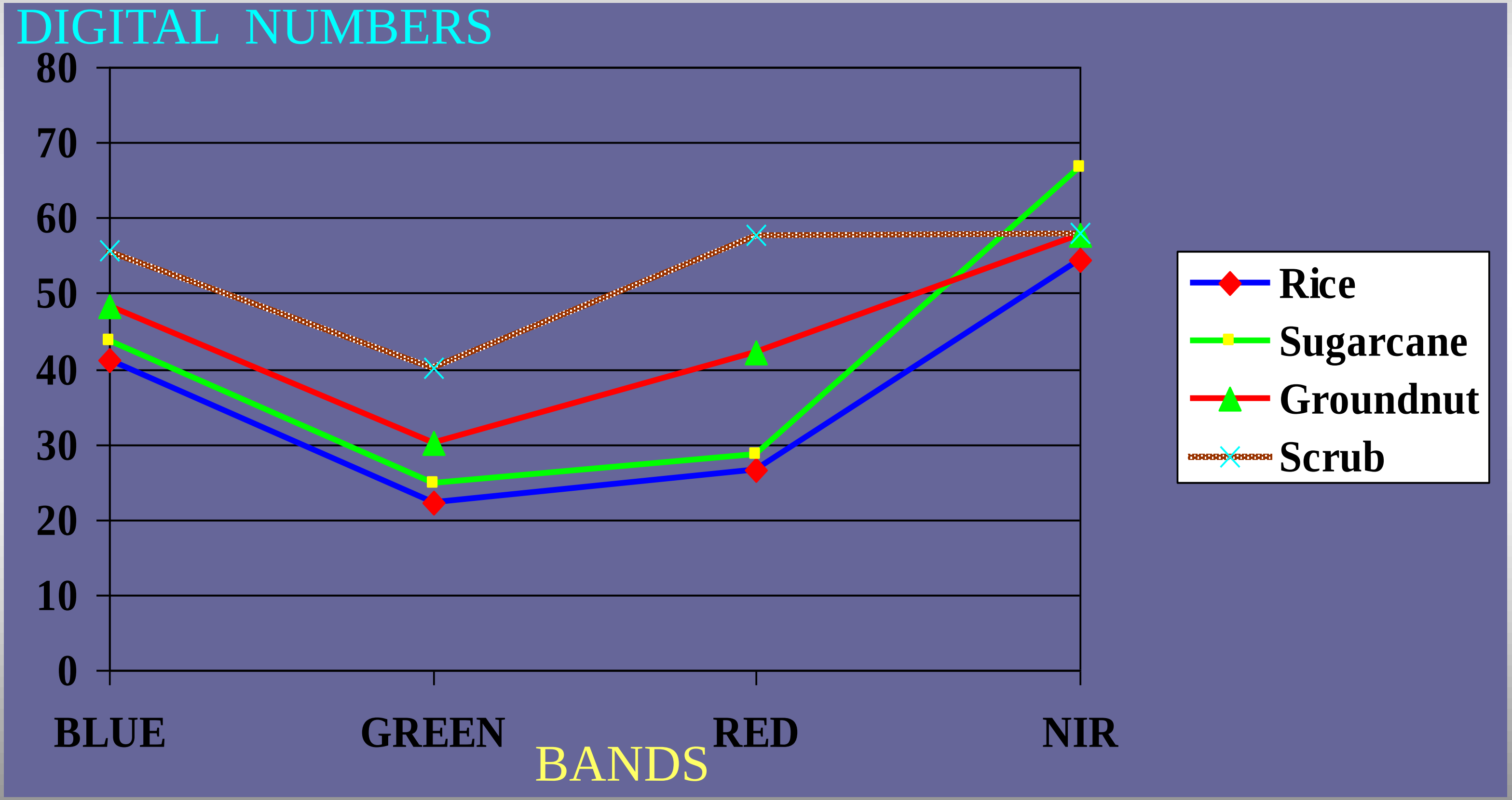
Basic interactions between EMR and an earth surface feature

Different surface objects return different amounts of energy in different wavelengths of the electro - magnetic spectrum

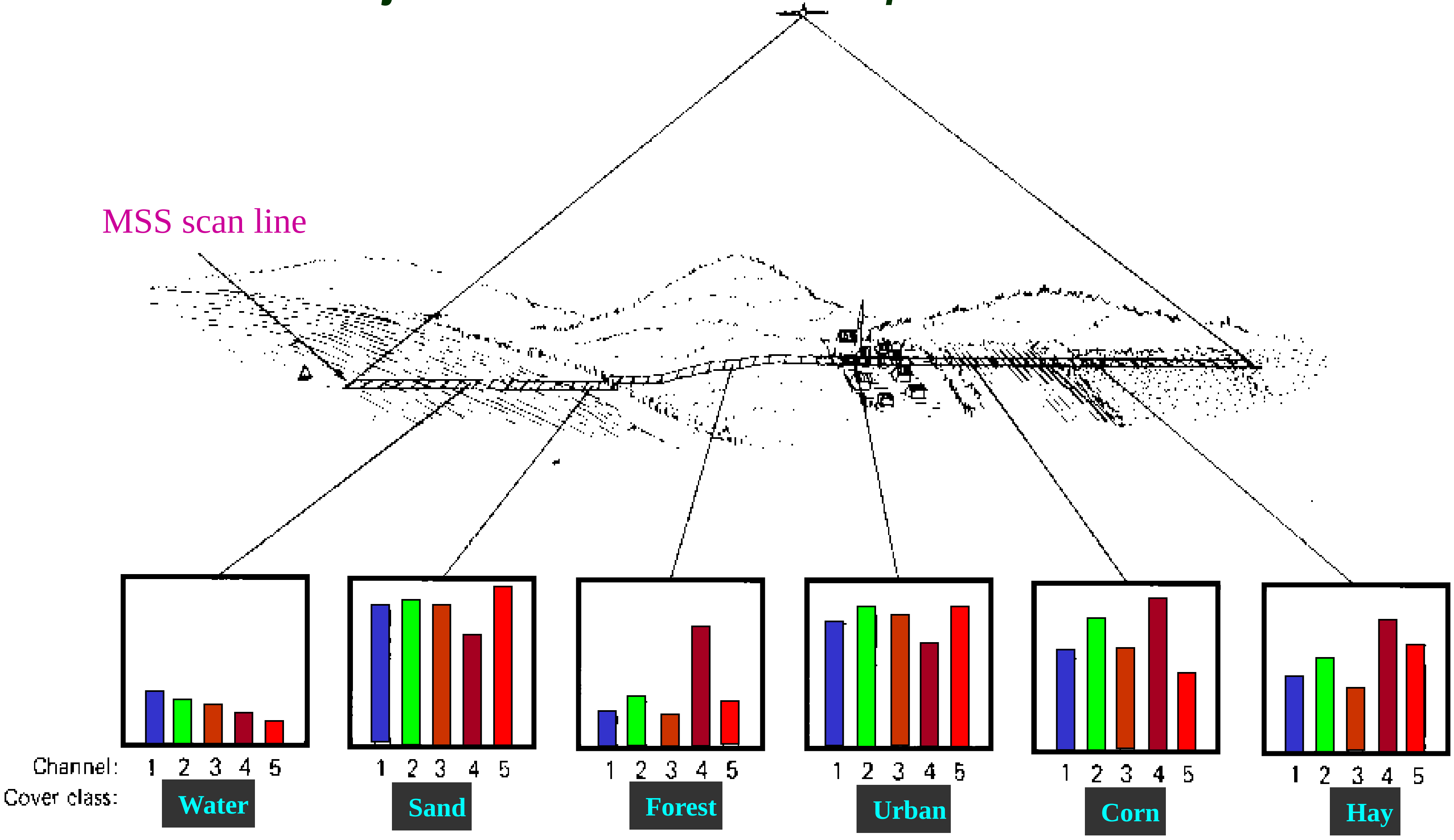


Spectral Reflectance Curves

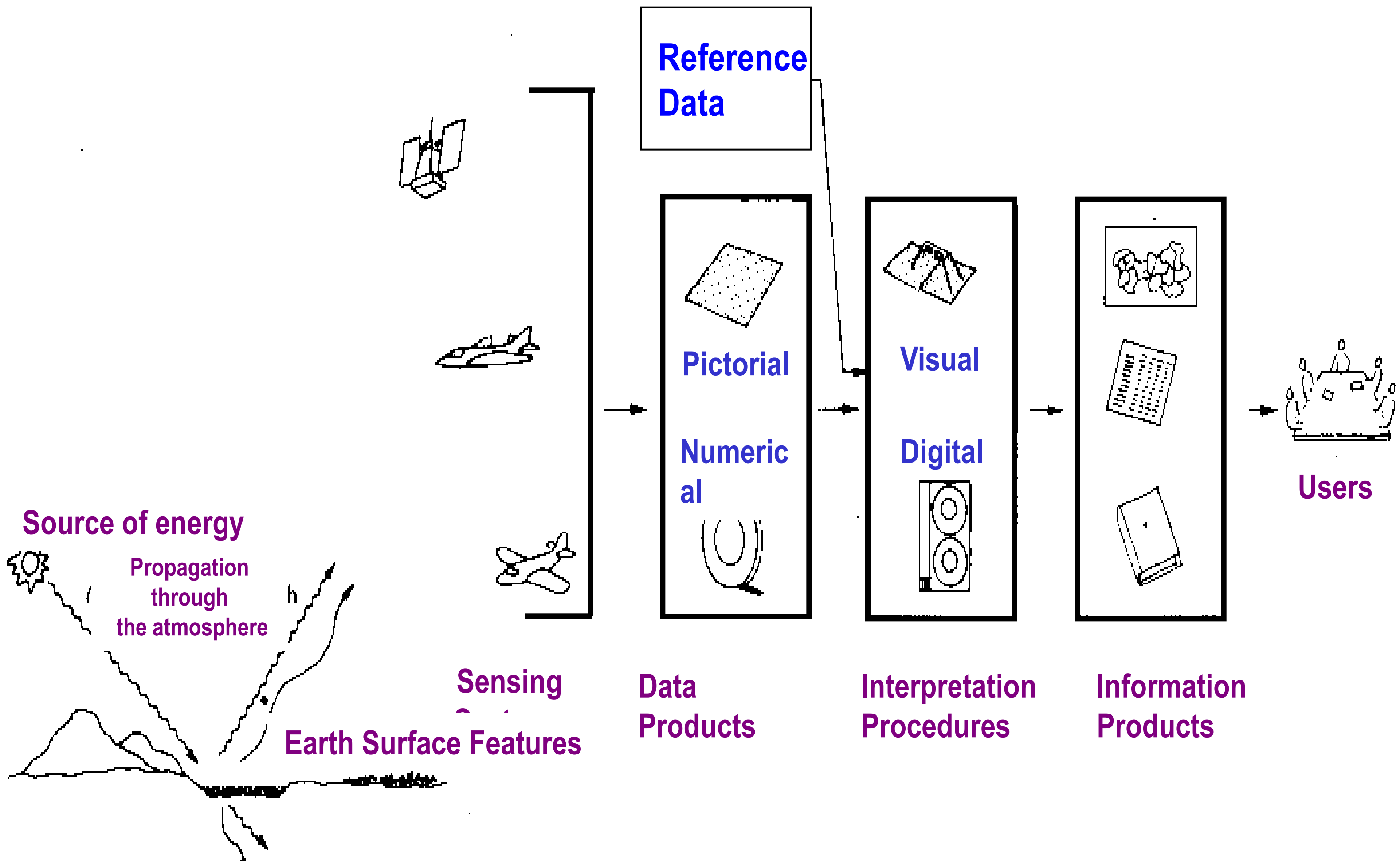
Spectral Signature Curves of Vegetation Classes



Detection and measurement of these spectral signatures enable identification of surface objects from air- borne and space - borne sensors



DATA ACQUISITION → DATA ANALYSIS



Electromagnetic remote sensing of earth resources

RESOLUTION COSIDERATIONS

Resolution - resolving power to distinguish between signals that are spatially near or spectrally similar

- **SPECTRAL** : Sensitive to specific wavelength intervals
- **SPATIAL** : Smallest unit that can be resolved
- **TEMPORAL** : Revisit of sensor to same area
- **RADIOMETRIC** : Ability to detect slight radiance difference

It is generally believed that improvements in resolution increases the probability that phenomena may be remotely sensed more accurately.

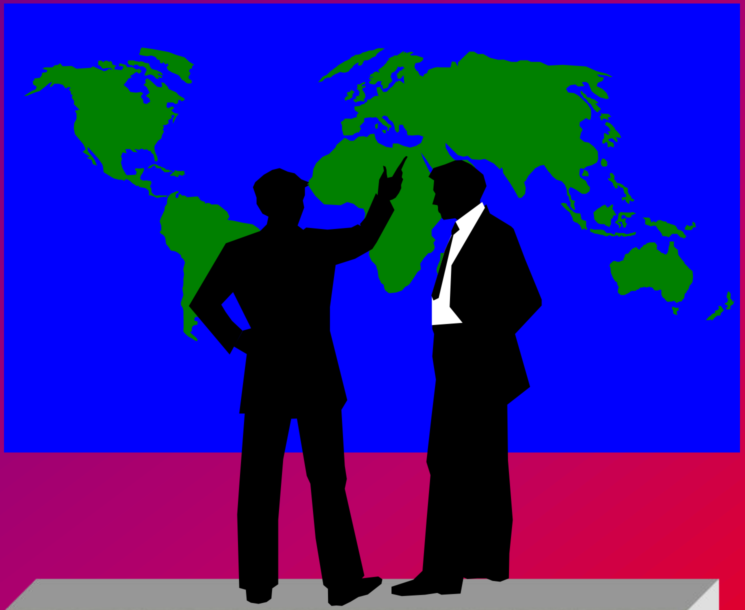
The trade-off is that any improvement in resolution usually will require additional data - processing capability for either human or computer - assisted analysis.

Factors Influencing Soil Reflectance

- SOIL COLOUR
- MINERAL CONTENT
- ORGANIC MATTER
- SOIL MOISTURE
- TEXTURE
- STRUCTURE
- PARTICLE SIZE
- VEGETATION

Elements of Image Interpretation

- TONE / COLOUR
- TEXTURE
- SHAPE
- SIZE
- SHADOW
- SITE / LOCATION
- ASSOCIATION
- PATTERN
- SCALE &
- RESOLUTION.



Interpretation Key

- ***Selective Key***
- ***Elimination Key***

SOIL MAPPING USING GEOINFORMATICS TECHNOLOGY

Mapping

Interpretation / identification of set of group of features from the Aerial Photographs or from the Satellite images and transfer them on plain paper to a particular scale.

Soil Types

1. In situ soil – in the situation or position in which it was originally deposited or formed
2. Transported / Drifted soil – transported by river / wind/ glacier and deposited elsewhere

(I) THROUGH VISUAL INTERPRETATION

Image interpretation

Major elements are:

- land type
- drainage pattern
- drainage condition
- vegetation
- land use
- slope and
- relief.

Image interpretation govern the necessary

- image analysis skill
- Professional knowledge and
- local reference level

of the interpreter.

(II) THROUGH DIGITAL IMAGE PROCESSING

Using well equipped computers and software packages.

Step-1: Image rectification – georeferencing- fixing ground control points (GCPs).

Step-2: Stratified supervised classification approach digital mask can be generated for different physiographic locations

Step-3 Classified and masked scenes can be mosaiced

Step-4 Field work and soil pedon description has to be carried out

Step-5 Based on the field observation and laboratory analysis, soil maps showing soil series can be prepared with soil legend.

Image Interpretation Elements for Soil Mapping:

Most important soil properties influencing the reflectance and emission of electromagnetic energy are:

- Particle size
- Texture
- Colour
- Organic matter (nutrients) and iron oxide
- Soil structure and surface roughness

Classification of soil on the basis of particles size

- Fine - < 1mm
- Medium - 1 to 5 mm
- Coarse - > 5 mm

Textural Classification of Soil (Diameter range)

- Coarse Sand - 2.00 to 0.20 mm
- Fine Sand - 0.20 to 0.02 mm
- Silt - 0.02 to 0.002 mm
- Clay - below 0.002 mm

Based on colour

- The colour of soil varies widely
- It is easily observable characteristic and is an important criterion in description and classification of soils
- The colour of soil is inherited from present rock material

Important Soil Colours

- Black & Dark gray colour - These variations mainly due to organic matter
- Brown colour - Due to mixture of the organic matter and iron oxides
- Red – Yellow colour - Red colour is associated with anhydrate ferric oxides, where as yellow colour indicates some degree of hydration
- White colour - Silica & lime generally impact white colour
- Bluish and greenish colour - Due to the presence of ferrous compounds and also indicates the poor drainage condition of the soil.

Based on Iron Oxide

Haematite – Red
Turgite – Red to Reddish brown
Geithite – Yellowish brown
Limonite – Yellow, Brown
Xantho siderite – Yellow

Based on Structure

A. Plate like

- Aggregated and arranged in relatively thin horizontal plates
- Noticeable in the surface layers.
- Often inherited from the parent material especially those laid down by water.

B. Prism like

- Pillar like shape
- Commonly occur in sub soil horizons in arid and semi – arid region.

C. Block like

- All dimensions are about same size
- Indicates good soil drainage and root penetration.

D. Spheroidal (Sphere like)

- Infiltration, percolation and aeration are not affected by wetting of soils
- Less porous aggregates are called granular, Granules are very porous called crumbly.

Mapping Technique

- Demarcate / Delineate / Buffer out the rock boundary and soil boundary
- Within the soil area, buffer out the **vegetated** and **non vegetated area.**

Soil Mapping in Vegetated area

Based on

- **Mainly on Nutrient basis (Organic matter)**
- **Grain size & Texture**
- **Agricultural land / wet land irrigation**
- Single crop & double crop – Clay soil
- Dry land agriculture – Red / Black soil
- Groundnut, Ragi, Corn, etc., – Gravel soil
- Cashewnut, jackfruit – Red soil
- Coconut tree / Casuarina – Brakish Soil
- Palm tree – Fresh (water) sand
- Eucalyptus – Silica & Feldspar – Granitic soil

Soil Mapping in Non Vegetated area

On the basis of

- Grain Size
- Texture
- Colour
- Moisture
- Topography/ Physiography (where they occur)
- Moisture and
- Salinity

More Salinity – White colour (lightest)
Poor Salinity – Gray Colour

SPECTRAL BEHAVIOUR OF SOILS

The properties of the soils that govern their spectral reflectance are:

- Colour
- Texture
- Mineralogy
- Organic Matter
- Free Carbonates
- Salinity
- Moisture
- Oxides / hydroxides of iron and manganese and
- Structure and surface roughness

a) Soil Colour

Influencing factors on soil colour:

- Soil mineralogy
- Chemical Composition
- Soil Moisture and
- Organic Matter.

It helps in diagnosing of - soil type, Soil properties and the detection of changes affecting ecosystems.

b) Organic Matter

Increase in organic matter content has been found to result in decreased reflectance in all bands throughout the 0.5 – 2.3 microns region of the spectrum.

Soils rich in organic matter namely,

Histosols

Mollisols

Have a concave – shaped reflectance curve between 0.5 & 1.3 micron, but soil with low organic matter namely,

Alfisols – show convex – shaped curve in the same region.

c) Particle Size / Texture:

Soil texture is the relative proportion of sands, silt and clay in a soil,
Clay – minute particle size – increases spectral reflectance.

Generally, fine textured soils show a higher reflectance than coarse textured ones.

Soil with low sand – gives lowest reflectance, while
Pure sand - gives high reflectance at five wavelengths (0.4 micron to 0.86 microns)

d) Mineralogy

The soil mineralogy affects spectral reflectance pattern of soils in varying degrees.

i. **Iron bearing minerals**
Intensity of reflection in 0.5 – 0.64 micron is inversely proportional to the iron content of the soil
Ferric ion & Ferrous ions – have their own region.

ii. **Clay minerals**
Layer silicate – Hydroxyl absorption bands

iii. **Other minerals**
Quartz and feldspar show very high reflectance in the visible and infrared and Almost devoid of any spectral features in this region unless the impurities occur.
Carbonate minerals – 1.9, 2.0, 2.16, 2.35 & 2.55 microns ranges.

e. Structure and surface roughness

Soil Structure – The pattern of soil particles aggregation, that is, the stable collections of sand, silt and clay, and how that are grouped together into stable collections.

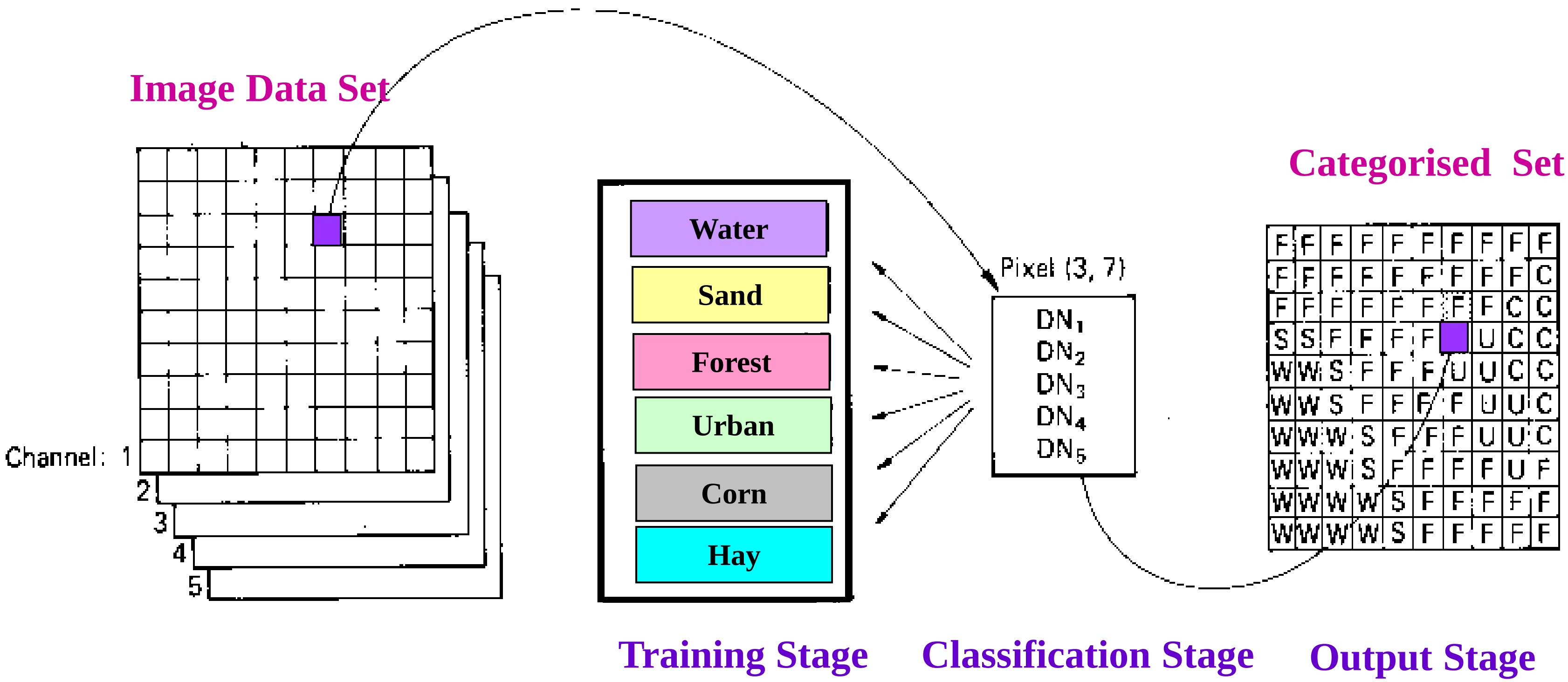
- Natural aggregates of soils are called as **peds.**
- Types of structure describe the ped shape with the terms; granular, crumb, platy, blocky, sub angular blocky, prismatic and columnar.
- Structure Classes are the ped sizes such as; very fine, fine, medium, coarse or thick, very coarse or very thick.
- Structure grades are evaluated by their; distinctness, stability or strength of the peds.
- Structure less soils has more reflectance than structured soils.
- On account of tillage operation, structure and surface roughness has a substantial influence of soils.
- Tillage practice – decreases soil reflectance.

Soil moisture content

Presence of moisture in soil will decrease its reflectance.

As with vegetation, this effect is greatest in the water absorption bands at about 1.4, 1.9 and 2.7 µm (clay soils have hydroxyl absorption bands at about 1.4 and 2.4 µm).

- Soil moisture content is strongly related to soil texture .
- Coarse, sandy soils are usually well drained, resulting in low moisture content and relatively high reflectance.
- Poorly drained fine textured soils will generally have lower reflectance.
- In the absence of water, however, the soil itself will exhibit the reverse tendency i.e, coarse textured soils will appear darker than fine textured soils.
- Thus, the reflectance properties of a soil are consistent, only within particular ranges of conditions.



Typical spectral pattern recognition process

EFFICIENCY OF SOIL MAPPING BY RS TECHNIQUE

STUDY AREA : PUNJAB   G.A : 50.3 L. Ha

BY CONVENTIONAL METHOD :

PER DAY COVERAGE	:	2000 Ha.
PER YEAR (200 EWD)	:	4.0 L.Ha
TO COVER 5.03 L.Ha	:	12.6 Years

BY RS TECHNIQUE :

TIME SPENT FOR PREPARING BASE MAPS,
NTERPRETATION, FINAL MAPPING : 310 MAN DAYS
WHICH CORRESPONDS KEEPING 200 EWD/YEAR : 1.5 Years

EFFICIENCY = 12.6 / 1.5 = 8 TIMES

(Sehgal and Karale, 1988)

Criteria for Hydrological Soil Grouping

CHARACTER	HYDROLOGICAL SOIL GROUPS			
	A	B	C	D
Infilteration rate	High	Moderate	Slow	Very Slow
Texture	Sand or Gravel	Moderately Coarse to fine	Moderately fine to fine	Clay
Depth	Deep	Moderately Deep	Deep	Shallow over an impervious layer / clay
Drainage	Well to excess	Moderately well drained	Moderately slow	Slow
Water Transmission	High	Moderate	Slow	Very Slow
Soil List	Entisols	Inceptisols	Alfisols	Vertisols
Remarks : Runoff Recharge	Low High	- Moderate - - Moderate -		High Low

SOME RESEARCH WORK ON SOILS USING REMOTE SENSING DATA

* Soil characteristics and properties that are most important in classification as well as in assessment of use capability lie below the surface and stretch well into the substrata. But the fact that soil surface manifestation more often than not, has a correlation with nature of deeper layers, forms a basis for many a successful attempts on use of remote sensing in this field. Use of indirect means like the one based on the relationship between the soil and landform has been equally & extensively used.

* There is a close relationship between the kinds of soil and the nature permeability, relief, climate, vegetation and age of landforms. Soil boundaries can also be revealed by differences in permeability, relief which are all detectable visually from Landsat images.(B5/B7).

- **Krishnamurthy and Srinivasan (1974)** compared the small scale soil map for a part of Barnagar Tehsil, Ujjain District, Madhya Pradesh prepared by the adoption of a systematic Aerial Photo Interpretation procedure with the Soil map for the same area resulting from a previous Rec. Soil Survey using toposheets as base maps.
- It has been shown that the soil boundaries of the Photo-interpretation map are both more accurate and natural in shape; delineation of gullied lands has been achieved more accurately by Aerial Photo Interpretation procedures: soil erosion could be mapped more consistently and accurately through Aerial Photo Interpretation.
- Apart from the increased accuracy and diminished costs the Aerial Photo Interpretation procedure will be helpful in modernising previously prepared Reconnaissance Soil maps.

Venkataratnam (1979) has shown the ability of digital analysis to bring out subtle variations in soils such as discrimination of Entic Chromusterts from Typic Chromusterts and a resolution of broad group of red soils into Ultic Haplustalfs, Typic Rhodustalfs, Udic Haplustalfs and plinthudalfs. He has also shown that a linear stretched data is superior to a FCC or band ration products.

* **Singh (1980)** used Landsat images in conjunction with topographical and geological information to prepare soil map of Mudhol taluk in Bijapur district, Karnataka State. The map has been compared with the Reconnaissance maps prepared by conventional method using 1:1 mile scale Survey of India toposheets. The study reveals that more accurate soil maps in terms of boundary delineation and composition of soil mapping units could be prepared by (Visual) interpretation of Landsat images with adequate ground data. The method can thus be used in revising and improving many of the existing reconnaissance soil maps prepared by conventional method.

* Mapping of salt affected soils has been carried with greatest ease using remote sensing techniques. **Manchanda and Hilweg (1981)** and **Venkataratnam (1983)** have found digital analysis particularly useful in sub-classification of salt affected soils

Singh (1983) has shown that an FCC was quite useful in differentiating soils developed on parent materials of varied mineralogy. Use of digital analysis enabled separation of weekly contrasting soils. Over 15 mapping units belonging to nearly 15 groups and subgroups were identified.

* **Karale et al (1985)** concluded based on comparative study of various remote sensing techniques in Chitradurga district of Karnataka that whereas 302 mapping units were recognised on FCC, the digitally linear stretched product could show only 256 such units but the results of latter were more convincing and comparable with Aerial Photo Interpretation.

* **Sengal & Karale (1988)** reported: Time spent on different operations for preparation of a broad Reconnaissance soil map of Punjab involving a total Geographical area of about 5.03 million ha in 310 man days. This corresponds to about 1.5 field party years assuming 200 days effective work in a year. Conventional approach of field work for this area would necessitated 12.6 field party areas with National norms of 4 Lakhs ha / field party year even at rapid Reconnaissance level. The remote sensing technology therefore offers about 8 time more efficiency compared to conventional system. **Karale et al (1978)** earlier presented evidence to show that the computer aided remote sensing technology affords 10 times more efficiency at reconnaissance level mapping compared to conventional surveys.

MONITORING SALT AFFECTED SOILS . . .

STUDY AREA : Karnal District, Hariyana

G.A. : 3721 Sq.Km.

Data used	Year	Area affected In ha.	Percentage to G.A
Landsat MSS FCC	1973	47810	12.85
Landsat TM FCC	1986	11,460	3.08
IRS 1A LISS I FCC	1988	11,250	3.02

Result : 76.46% reclaimed

(Source: Hooda & Manchanda, 1992)

MONITORING SALT AFFECTED SOILS . . .

STUDY AREA : Sangrur District, Panjab

Data used	Year	Scale	Salt Affected land % to G.A
Aerial Photo	1965	1:25000	13.1
Semi Detailed SS	1973	1:50000	9.6
Landsat TM FCC enlarged to 1:50000	1988	1:250,000	2.5

- Reduction is due to supply of gypsum to farmers at a subsidised rate by state Agri Dept.
- Reclaimed land put to agriculture

	1965	1988
Rice	16,000	224000
Wheat	1,84,500	3,77,000

(Source:Bajwa et al., 1990)

CONSERVATION OF SOIL FROM EROSION AND RESERVOIR SILTATION

IMPACTS OF SOIL EROSION AND RESERVOIR SILTATION

- ENVIRONMENTAL IMPACTS and
- ECONOMIC IMPACTS

ENVIRONMENTAL IMPACTS

- Suspended nutrients trigger algal blooms that ***reduce water clarity, deplete oxygen, lead to fish kills and create odour.***
- Erosion of stream banks and adjacent areas destroys stream side vegetation that provides aquatic and wildlife habitats.
- Excessive deposition of sediments in streams, blankets the bottom fauna, ***'paves' stream bottoms and destroys fish pawning areas.***
- Turbidity from sediment reduces in–stream photosynthesis which leads to reduced food supply and habitat.
- Suspended sediment abrades and coats aquatic organisms.
- Vegetal growth has been obstructed as erosion removes the nutrients.

ECONOMIC IMPACTS

- Excessive sediment accumulation reduces reservoir storage capacity and more frequent sediment removal is required.
- Erosion severely diminishes the ability of the soil to support plant growth; and the sand advance to the fertile lands. Thus, the loss in agricultural productivity.
- Damages the engineering structures such as abrasion in hydel dams and canals.

PROCESSES AND MECHANICS OF SOIL EROSION

Phenomenon of soil erosion

Soil erosion is broadly classified into two groups, one is geologic and the other one is accelerated.

The normal geologic soil erosion is compensated by the formation of new soil cover by weathering process.

While the anthropogenic activity intervene these normal processes, then it changes as accelerated soil erosion.

The process of soil erosion is controlled by various factors such as,

- Rainfall
- Slope of the land
- Forest cover removal - Deforestation
- Tillage
- Nature of soil i.e. texture, structure and organic matter
- Water table
- Barren surface
- Continuous dry weather
- Wind velocity ….

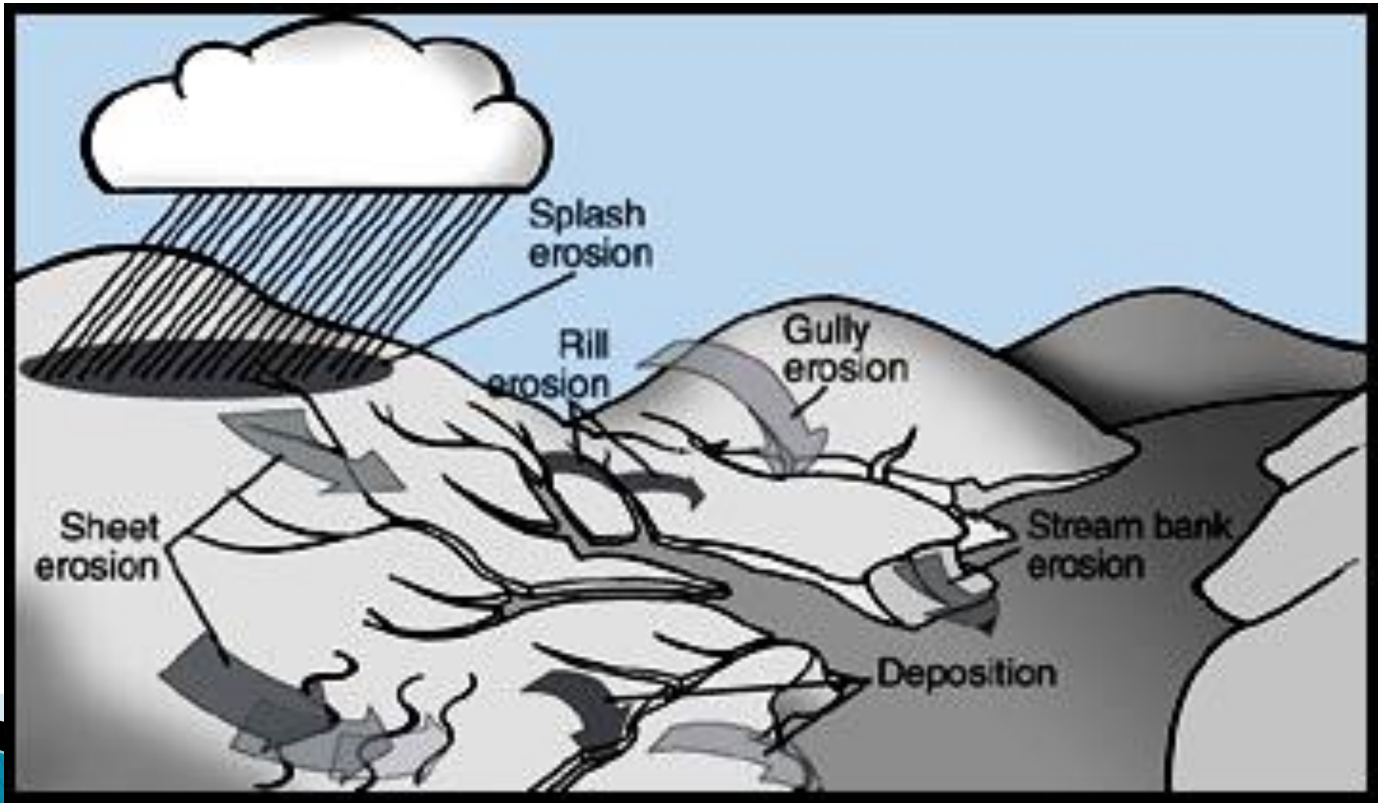
TYPES OF SOIL EROSION

- •SOIL EROSION BY WATER
- •SOIL EROSION BY WIND
- •SOIL EROSION BY GLACIER

Schematic diagram showing various types of soil erosion in different eco systems.

SOIL EROSION BY WATER

- ➢ Splash erosion
- ➢ Sheet erosion
- ➢ Rill erosion
- ➢ Inter rill erosion
- ➢ Gully erosion
- ➢ Channel erosion &
- ➢ Gross erosion



- **Splash Erosion :** Due to the impact of raindrops on the surface.
- **Sheet Erosion :** Due to the surface flow by gravity after the raindrop splash.
- **Rill Erosion :** Developing channels on recently cultivated soils due to grater scouring action by concentrated flow of water.
- **Inter Rill Erosion:** Inform removal of soil from the land surface between the rills.
- **Gully Erosion :** Enlarged features of rills, which may yield tremendous volumes of sediment by large concentration of runoff. Gullies enlarge until they become permanent topographic features.

  - All these 5 types of erosions are active only during or immediately after rainstorms.

- **Channel Erosion:** It includes gully erosion, stream bank erosion, valley trenching, degradation and flood plain scour.

  - during and between rainstorms.

- **Gross Erosion :** The summation of erosion from all sources with in the watershed. It includes inter rills and rill erosion from tilled crop land, meadows, pastures, wooden lands, construction sites, industrial areas, abandoned areas and surface mined area and mine wastes, gully erosion from stream beds and stream banks, road and road side erosion and flood plain scour.

Water erosion control techniques:

Controlling soil detachment:

- By cropping or other vegetative cover practices, that keeps the soil covered as much as possible.
- When plants, either living or dead (grasses, leaves, mulches), cover the soil surface, the energy of falling raindrops is dissipated by the springy vegetation.
- As raindrops fall, the vegetal cover absorbs its energy, then water gently slides off to be absorbed into the soil.

Drainage System

- to remove the excess gravitation water from soils by natural or artificial means (surface or subsurface).

SOIL EROSION BY WIND – Types of soil movement

- **Suspension** - < 0.05 mm in diameter – silt size and smaller
- **Saltation** - > 0.05 – 0.5 mm – very fine to medium sand
- **Surface Creep** - > 0.5 mm

CONTROLLING FACTORS OF SOIL EROSION

Erosive potential of an area depends on,

- ***climate*** – rain drop size, intensity, distribution, fall velocities, total mass of impact and temperate.
- ***characteristics of soil*** – texture, structure, permeability, compactness and infiltration capacity
- ***vegetal cover*** – types of vegetation, density, root systems
- ***topography*** – slope, slope length, slope configuration and surficial features
- ***human activities*** – landuse, construction practices, agricultural operations, landuse conversion to rocky wastes, deforestation, industrial waste disposals, mining and mine waste gushing.

From these above factors, we can extract the relative Geoscientific parameters such as:

- Lithology
- Structure of the area
- Geomorphology
- Subsurface Geology
- Drainage Density
- Water level / table
- Slope
- Land use / Land cover
- Climate…

PRINCIPLES OF SOIL EROSION AND SEDIMENT CONTROL

- Fit development to the terrain
- Time grading and construction to minimise soil exposure
- Retain existing vegetation wherever feasible
- Vegetate and mulch denuded areas
- Divert runoff away from denuded areas
- Minimise length and steepness of slopes
- Keep runoff velocities low
- Prepare drainage ways and outlets to handle concentrated or increased runoff
- Trap sediment on site
- Inspect and maintain control measures.

MEASUREMENT OF SOIL EROSION

The Universal Soil Loss Equation (USLE) – designed by two soil scientists namely, Wischmeier and Smith during the year 1978 is to predict the soil loss in the field.

A = R K L S C P

Where,

A = Soil loss in tons/ha/year
R = rainfall erosivity factor
K = soil erodability factor
L = slope factor (%)
S = slope length factor (m)
C = vegetative cover factor
P = conservation practice factor

METHODS OF SOIL EROSION CONTROL AND SEDIMENT CONTROL

Practical considerations in control measure design

1. Control measures should be economical
   - use material available on – site
   - keep structures simple
   - take advantage of permanent facilities
2. Install the most important control measures first
3. Install control measures correctly
4. Time installation of control measures to minimise land disturbance
5. Don’t block a natural drainage way
6. Place control measures out of the way of constructions operations
7. Make field modifications where necessary
8. Provide access for maintenance
9. Be pragmatic

VEGETATIVE METHODS OF SOIL STABILIZATION

Vegetal cover reduces erosion by,

- Absorbing the impact of raindrops
- Reducing the velocity of runoff
- Reducing runoff volumes by increasing water percolation in to the soil
- Binding soil with roots
- Protecting soil from wind using **“Wind breaks”**

This method needs

- Careful selection of plants
- Site preparation
- seeding / tall & fast growing tree saplings perpendicular to the wind direction
- Fertilizing and
- Mulching.

on the basis of effectiveness for soil erosion control in the particular terrain.

MECHANICAL METHODS OF SOIL EROSION CONTROL

- Contouring / Contour cultivation, Contour strip cropping
- Contour bunds
- Terracing, Terrace cultivation
- Water conveyance structures
- Grassed water ways
- Check dams
- Dikes and swales
- Pipe slope drains and paved chutes
- Permanent water ways,
- Channel linings
    - Gravel lined swale
    - Rock lined water ways
    - Plastic lined ditches
- Changing soil humus levels and tillage practices
- Geotextiles

RESERVOIR SILTATION

a. Identify silted reservoirs / tanks
b. Identify areas of soil erosion / silt supply
c. Suggest remedial measures to arrest soil erosion in the catchment itself.

(i) AREAS OF SOIL EROSION

Method: 1
- Drainage Density Maxima
- 1^{st} order Drainage Density Maxima
- Gully Density Maxima

Superpose (Integrate – Union) these 3 maps together to get areas of soil erosion

Method: 2
- Drainage Density Maxima zones
- Areas of Steep Slopes
- Areas of active foot hills

Overlay (Integrate – Union) all the above 3 maps together to get areas of active soil erosion.

The maps that can be prepared using Remote Sensing data are:

(i) Lineament / Fracture & its density
(ii) Detailed Geomorphology
(iii) Structures
(iv) Slope Stability
(v) Land use / Land Cover and its changes
(vi) Soil

These above maps can be kept as ‘Primary Thematic Maps’.

The individual, site specific and finer detailed thematic maps that can also be prepared are:

- Map showing soil eroded areas
- Silted tanks and reservoirs
- Active first order drainages
- Active slope areas
- Active foot hill areas
- Areas of turbidity in ocean and water bodies

(ii) Identify Functions of Soil Erosion:

a. Preparation of thematic maps on

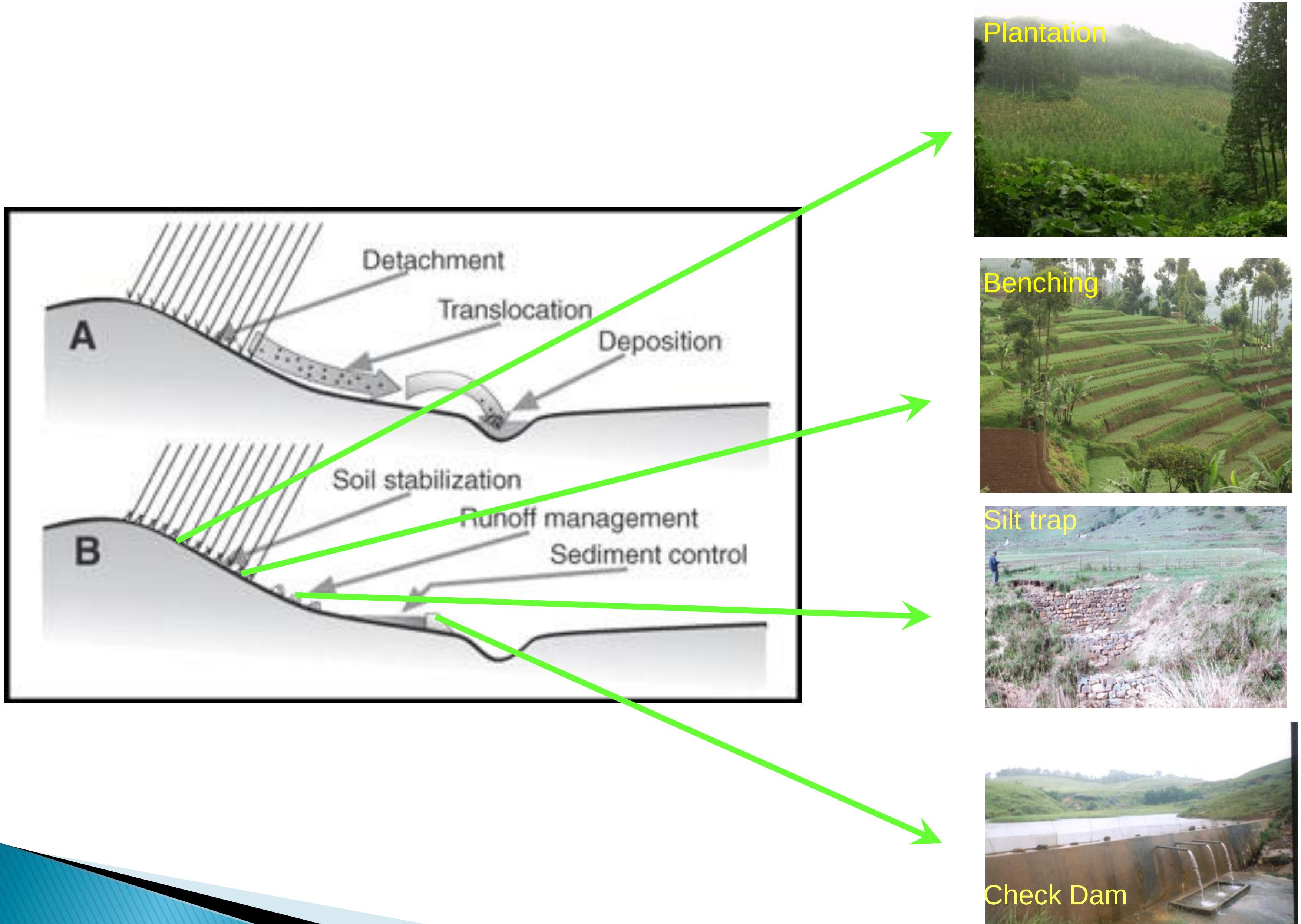
- ❖ Lineament density
- ❖ Subsurface Geology
    - ▪ Thickness of Top soil
    - ▪ Thickness of Weathered Zone
    - ▪ Thickness of Fractured Zone &
    - ▪ Depth to Bed rock
- ❖ Geomorphology
- ❖ Slope
- ❖ Drainage Density
- ❖ Soil Types
- ❖ Water level
- ❖ Landuse / Landcover

b. Buffer out erosion prone zones from each

c. Superpose (union) together and identify controls of soil erosion

d. Suggest remedial measures.

General Soil erosion Conservation Methods with reference to topography



SOIL SALINITY

Soil salinity is a measure of the total amount of soluble salt in soil**.**

Sources of Soil Salinity

Salts originate from

- Mineral weathering
- Inorganic fertilizers
- Soil amendments (e.g., gypsum, composts and manures)
- Irrigation waters.
-

Salinity Measurement

Soil salinity is determined by measuring the Electrical Conductivity of solution extracted from a water-saturated soil paste.

Soil affected by salts have several names: white alkali, black alkali, slick spots and summer snow – derivative names due to the surface appearances as soils become salt contaminated, virtually eliminating all plant growth as concentrations increase.

Easily interpreted from the satellite imagery and aerial photographs by their tone, texture and other association elements.

Salted soils are classified on the basis of two criteria;

- the total soluble salt content and
- the exchangeable sodium percentage or **SAR**

On the basis of EC – electrical conductivity, salt affected soils are defined a 3 classes as mentioned below.

- Saline soils (too high in salts) – white alkali.
- Sodic soils (sodium adsorption ratio SAR of the saturation extract greater than 13) – black alkali.
- Saline – sodic (high levels of both salt and SAR over 13) – either white or black alkali.

They are soluble salts of soils such as: sodium, calcium, magnesium, chloride, sulfate and bicarbonate ions.

Salt tolerant plants are: Barley, Bermudagrass, tall wheatgrass, sugarbeets, cotton, asparagus and dates.

Low salt tolerant plants are: clovers, beans and most berries and fruits.

Removing salt is easy in theory: The salts are dissolved in irrigation water and washed out of the soil profile.

A foot (30 cm) of water per foot (30 cm) depth of soil removes about 80 percent of the salts.

Application of Remote Sensing and GIS on Soil Erosion Assessment at Bata river basin, India

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- A number of parametric models have been developed to predict soil erosion at drainage basins, yet Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978) is most widely used empirical equation for estimating annual soil loss from agricultural basins.
- While conventional methods yield point-based information, Remote Sensing (RS) technique makes it possible to measure hydrologic parameters on spatial scales while GIS integrates the spatial analytical functionality for spatially distributed data.
- Some of the inputs of the model such as cover factor and to a lesser extent supporting conservation practice factor and soil erodibility factor can also be successfully derived from remotely sensed data.
- Further, Modified USLE (MUSLE) uses the same empirical principles as USLE.
- However, it includes numerous improvements, such as monthly factors, influence of profile convexity/concavity using segmentation of irregular slopes and improved empirical equations for the computation of LS factor (Foster & Wischmeier 1974, Renard et al. 1991).
- In this study, IRS-1D LISS III and ID Pan data were used to identify the land use status of the Bata river basin.
- Based on maximum likelihood classifier, the area was classified into eight land use classes namely, Dense Forest, Moderate Forest, Open Forest, Wheat, Sugarcane, Settlement, River Bed, Water Body.
- A 12-day intensive field checking was undertaken in order to collect ground truth information.

- Digital Elevation Model (DEM) of Bata river basin was created by digitizing contour lines and spot heights from the SOI toposheets at 1:50,000 scale.
- Modified Fournier index was used to derive parameters for modified erosivity factor.
- The modified LS factor map was generated from the slope and aspect map derived from the DEM.
- The K factor map was prepared from the soil map, which was obtained from the previous studies done at Geo-Science Division of IIRS, Dehradun.
- The P and C factor values were chosen based on the research findings of Central Soil and Water Conservation Research and Training Institute, Dehradun and spatial extent was introduced from land use/ cover map prepared from LISS III data. Maps covering each parameter (R, K, LS, C and P) were integrated to generate a composite map of erosion intensity based on the advanced GIS functionality.
- This intensity map was classified into different priority classes. Study area was further subdivided into 23 subwatersheds to identify the priority areas in terms of soil erosion intensity.
- Each subwatershed was analyzed individually in terms of soil type, average slope, drainage length, drainage density, drainage order, height difference, landuse/landcover and average NDVI with soil erosion to find out the dominant factor leads to higher erosion.

Solani Watershed – Runoff & Quantification of Soil Erosion

Parts of Western Ghats – Areas of Soils Erosion and Functions of Soil Erosion

Varahanadhi Basin – Reservoir Siltation Studies

Soil surface crusting

Soil crusting occurs **when the surface layer of soil hardens** due to factors like rainfall, drying and tillage. It reduces porosity and infiltration.

Causes:

Effects:

Management: