Remote Sensing Application in Agriculture and Forestry

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The tools

Geomatics

1. GIS technology
2. Remote Sensing Technology
3. GPS Technology
2. Remote Sensing – as a tool for baseline data gathering .... ?
REMOTE SENSING IS THE ART AND SCIENCE OF ACQUIRING INFORMATION ABOUT AN OBJECT WITHOUT MAKING ANY PHYSICAL CONTACT
Information is gathered by instruments carried on suitable platforms. The information is used to study targets of interest on the Earth’s surface.
Based on **Reflected Energy Source**

**ELECTROMAGNETIC SPECTRUM**
MULTIDICIPILINARY ACTIVITY DEALING WITH

INVENTORY

ASSESSMENT OF RSOUCES & MONITORING

(basic requirements for evaluation)
Characteristic Features

- Synoptic Nature

- Repetitive Coverage of Large Area

- Quantifiable Data Procurement
REGIONS OF ELECTROMAGNETIC SPECTRUM

(coversing entire spectrum using appropriate sensor)
Spectral reflectance of objects
Multistage Remote Sensing
Geostationary Polar Satellites

Altitude = 705 km (Nominal)

Inclination = 98.2°

Time of day = 9:45 A.M. (Local)

Ground track

Satellite orbit

Orbit period = 98.9 min
Satellite Paths and repetitivity

IMPROVED REPETITIVITY USING IRS-1A & 1B

IRS-1B

IRS-1A

IRS-1B

11 DAYS

22 DAYS
RECORDING SYSTEMS

WISKBROOM

PUSHBROOM
Sensor resolution

1. Spatial resolution
2. Spectral resolution
3. Radiometric resolution
4. Temporal resolution
SENSORS IN INDIAN REMOTE SENSING SATELLITES

LISS II (36.5M)
LISS III (23.5M)
PAN (5.8M)
WiFS (188.3M)

Sensor Resolution - ?
Spatial, spectral, radiometric, temporal
Pan image of Moscow
FCC of Shiwalik hills (Liss3 image)
2. GPS technology as a tool for accuracy evaluation & mapping

Geographical Position Fixing:
-- using high altitude satellites

GPS satellites

– using the principles of Trilateration
GPS satellites

GPS satellite

24 numbers
6 orbits
22,200km altitude
Trilateration is a basic geometric principle that allows you to find one location if you know its distance from other, already known locations.
Trilateration: Receiver must track at least four satellites to calculate 3-D position

3-D position is: Latitude, Longitude and Altitude

GPS receiver must “solve” for X,Y,Z and Time

If GPS unit is only tracking 3SV, 2-D position will be computed (XY).
3. GIS as a tool for analysis & modeling

GIS Data

Geographic features are represented by two types of data.

GIS - Technology

- Spatial (Location) Data
- Non Spatial (Attribute) Data
- Linkage
- Query
- Analysis
Agricultural application:

The utilization of space-bourn multispectral data for crop acreage and production estimation started in seventies with the launching of the Large Area Crop Inventory Experiment (LACIE) jointly by NASA, USDA and NOAA (National Oceanic and Atmospheric Administration) in 1974.

In India the satellite remote sensing is mainly used for the crop acreage and production estimation of agricultural crops.
The methodology for acreage and production estimation using Indian Remote Sensing Satellite (IRS1A/1B) has been in operation for major crops, namely, wheat, paddy, sorghum, soybean, groundnut and cotton in the monocropped areas (Space Application Centre, 1990).

In 1970 ISRO carried out a very interesting and promising experiment for IARI, in detecting coconut root wilt disease in Kerala before it was visible on ground.
1. Identification, area estimation and monitoring:

The specific requirement of climate and soil conditions coupled with the specialized management practices make the distribution of plantation crops rather more localized in comparison to other agricultural crops.

The identification, estimation of growing stock, analysis of distribution and monitoring at regular intervals are major aspects in plantation crops.
2. Crop nutrient deficiency detection:

The nutrient deficiency in plants affects the color, moisture content and internal structures of the leaves and as a result their reflecting power changes.
3. Soil mapping
4. Vegetation indices:

The green, red and NIR reflectance could be employed as variables to estimate the **Leaf Area Index (LAI)**.

Many investigations have been conducted to assess crop characteristics, such as **biomass, and LAI**, by means of combinations of reflectance or digital pixel values in various spectral bands.

Such a combination of reflectance values, the vegetation index, also serves to correct for undesirable influences of varying soil reflectance or atmosphere circumstances on the result.
5. Crop condition assessment:

The physiological changes that occur in a plant due to stress may change the spectral reflectance/ emittance characteristics resulting in the detection of stress amenable to remote sensing techniques. Crop monitoring at regular intervals during the crop growth cycle is essential to take appropriate measures and to assess information on probable loss of production.
6. Phenological studies

Wide Field Sensor (WiFS) Data
(Parts of Madhya Pradesh)

Soyabean

28.9.96

10.10.96

Soyabean (Harvested)

3.11.96

SOYABEEN
7. Spatial signature library:

Spatial signature evaluation of the species and the reflectance properties of different species in different phonological stages and growth stages are yet to be explored.

The work on this line on crop reflectance properties are conducted by organizations like Space Application Center, Ahmedabad.
8. Crop yield modeling and production forecasting:

The information on production of crops before the harvest is very vital to the national food policy planning and economy of the country.

Reliable crop yield estimate is one of the most important components of crop production forecasting.
Crop evaluation
9. Pest management:
Integrated pest management is an important component of sustainable agriculture.

Methodologies need to be perfected for identification of locust breeding grounds based on vegetation or moisture status, thereby developing strategies for preventing their spread and effective control measures.
10. Agricultural draught assessment: Draught assessment is yet another area wherein remote sensing data has been used at operational level.

The district level drought assessment and monitoring using NDVI generated from NOAA-AVHRR data helps in taking timely preventive and corrective measures for combating drought.
11. Temporal data for irrigation studies

Availability of IRS-1C WiFS data will improve the efficiency of satellite monitoring of irrigation projects as the temporal frequency of WiFS enables identifying crop status at various stages especially at critical stage for more efficient crop yield modelling and forecasting.
Physical reflectance models for crops serve the important purpose of understanding the complex interaction between solar radiation and plant canopies.
In order to obtain a reliable yield prediction, growth of crops has to be modeled by means of crop growth models. **Crop growth models** describe the **relation** between physiological process in plants and environmental factors such as solar irradiation, temperature, water and nutrient availability.
To effectively utilize the information on crops for improvement of economy, there is a need to develop state/ district level information system based on available information on various crops derived both from conventional and remote sensing approaches in GIS environment.
Forestry Applications
Forests types of Kerala

Classification: mainly based on Rainfall, Temperature, Humidity and Altitude
Wet evergreen forests

Stratification

Aerial view
Semi Evergreen Forests
Moist deciduous forest after rains
Grasslands
Shola forests
Subtropical hill forests
Commercially inferior to the Evergreen forests. • Found from 1200 to 1900 m
• Stands 15-20 m only. • Profusion of Lauraecae: *Cinnamomum, Neolitzea, Phoebe, Actinodaphne, Litsea*, etc. • Other trees: *Calophyllum elatum, Elaeocarpus munroii, Dimocarpus longan, Garcinia* spp., *Memecylon* spp., *Mesua ferrea, Syzygium* spp.

A transitional type between Evergreen forests and Montane Sholas.

Tea estates cut the forests into patches.
• Mangroves: (± 50 km²)

Specialized ecosystems rich in indigenous flora and fauna. It serves many ecological and biological functions.
Myristica swamps

- Edaphic facies of EGFs in flat-bottomed.
- Water-logged valleys at low elevations.
- Trees with stilt and breathing roots.
- Abundance of Myristicaceous trees: *Myristica magnifica, M. malabarica, Gymnacranthera canarica, Knema attenuata*.
- Undergrowths of *Pandanus and Calamus*.
- These ecosystems are endangered.
- Much of the swamps have already been converted to rice fields.
- The remaining patches largely located in S Kerala.
Riparian forests

- Edaphic formations of the dry deciduous forests
- Distributed along the river courses
- Stands 30-32 m, composed of evergreen and deciduous trees: *Mangifera indica, Terminalia arjuna, Calophyllum elatum, Bassia sp.*
- The forest type is very restricted
- Abode of the grizzled giant squirrel, *Ratufa macroura dandolena*
Bamboo and cane brakes

Bamboo brakes
- Important raw materials for cottage industry, and pulp industry.
- 25 species under 7 genera.
- 2 bamboos: *Bambusa bambos* *Dendrocalamus strictus*
  - *D. strictus* restricted to the rain shadow areas.
- 13 species of reed bamboos belonging to the genera, *Ochlandra, Pseudoxytenanthera* and *Sinarundinaria*.

Cane brakes
- 16 species rattans mostly used for cane furniture.
- Some of them grow in groups like cane brakes.
Forest plantations: 1701 km² (18.1%)

Teak
Eucalypts
Tea, etc.
Satellite Image of Kerala (IRS 1D)
EXTENT OF FOREST

- Total geographic area of Kerala - 38863 sq.km
- Forest area in the state - 10336 sq km (26% of total geographic area).
- Total area of Sanctuaries and National Parks in the state - 2324.72 sq. km.
- This forms the 22.49% of the forest area and 5.98% of the geographical area of the State
Biodiversity conservation

Identification of Priority area for conservation is required

Solution: Bio-prospecting of Resources
Remote Sensing Technology in biodiversity measure at landscape level gives a perspective horizontal view and helps in delivering different landscape elements and their spatial characteristics.
Pattern of Landscape Fragmentation

Impact of Fragmentation

Natural Landscape

Artificial Landscape

Intact → Lowest → Fragmented

Impact of Porosity

Intact → Lowest → Porous

Pattern of Landscape Fragmentation
Loss of Corridors

Impact of Forest Edges

Transitional Stage
Fragmentation Map of Kerala
Biological Richness map of Kerala
Remote sensing forms a valuable tool in mapping and monitoring of biodiversity and provides valuable information to quantify spatial patterns, biophysical patterns, ecological process that determine species richness and anthropogenic factors causing loss of species richness and for predicating response of species to global changes.
Forest degradation in Kerala

Status:

45% of Evergreen forests are degraded

78% of Moist deciduous forests are degraded

64% of Dry deciduous forests are degraded

24% of Subtropical hill forests are degraded

62% overall degradation
Degradation assessment

Prepared from IRS IC LISS III data of 1998
Using Normalized Difference Vegetation Index

KFRI / ECOLOGY / RS
The rapid depletion of forests made it essential to know the rate and trend of this degradation so that timely measures could be taken to prevent further loss of forest resources.

Timely and accurate information for detecting changes over a period of time is required for forest ecosystems.
CHANGE DETECTION STUDIES

DATA USED

TECHNIQUES
VISUAL INTERPRETATION

STUDY AREA
IDUKKI REGION

OUTPUT
LANDCOVER MAPS
CONTINUITY CHANGES
AREA STATISTICS
LANDSAT 5 TM FCC OF IDUKKI REGION

1973

1975
CHANGE DETECTION STUDY OF IDUKKI AND SURROUNDINGS

1973

1975

1983
## CHANGE DETECTION: IDUKKI REGION

(AREA IN KM$^2$)

<table>
<thead>
<tr>
<th>Year</th>
<th>Dense Vegetation</th>
<th>Sparse Vegetation</th>
<th>Agriculture</th>
<th>Barren</th>
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<tbody>
<tr>
<td>1973</td>
<td>1338.2</td>
<td>974.2</td>
<td>83.0</td>
<td>36.1</td>
</tr>
<tr>
<td></td>
<td><strong>15.61%</strong></td>
<td><strong>32.16%</strong></td>
<td><strong>86.57%</strong></td>
<td><strong>53.19%</strong></td>
</tr>
<tr>
<td></td>
<td>Reduction</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Reduction</td>
</tr>
<tr>
<td>1975</td>
<td>1135</td>
<td>660.9</td>
<td>618.4</td>
<td>16.9</td>
</tr>
<tr>
<td></td>
<td><strong>21.71%</strong></td>
<td><strong>23.64%</strong></td>
<td><strong>38.99%</strong></td>
<td><strong>30.61%</strong></td>
</tr>
<tr>
<td></td>
<td>Reduction</td>
<td>Reduction</td>
<td>Reduction</td>
<td>Reduction</td>
</tr>
<tr>
<td>1983</td>
<td>888.8</td>
<td>504.6</td>
<td>1013.7</td>
<td>24.3</td>
</tr>
</tbody>
</table>
CHANGE DETECTION: IDUKKI

Overall Changes

Period 1973 – 1983

Dense Vegetation $\rightarrow$ 33.58% Reduction
Sparse Vegetation $\rightarrow$ 48.2% Reduction
Agricultural Land $\rightarrow$ 91.81% Increase
CHIMMONY WILDLIFE SANCTUARY - VEGETATION
(Prepared from 1:15,000 Black and White Aerial photographs of February 1990 and March 1987)

LEGEND

EVERGREEN/S. EVERGREEN FOREST (5-20%)
EVERGREEN/S. EVERGREEN FOREST (21-40%)
EVERGREEN/S. EVERGREEN FOREST (Above 40%)
M. DECIDUOUS FOREST (5-20%)
M. DECIDUOUS FOREST (21-40%)
M. DECIDUOUS FOREST (Above 40%)
OPEN SCRUB
DENSE SCRUB
TEAK PLANTATION
TEAK AND BOMBAX PLANTATION
GRASS
ROCK
RESERVOIR
Digital Terrain Models

PEPPARA WILDLIFE SANCTUARY - DIGITAL ELEVATION MODEL

Chemmunjimottai (1717 m)

Tamil Nadu

Adirumalai

* Picket station

Nachiyavadikunnu

Kadiramudi

Kalluparakunnu

Chemmankala kani

Kottamalai

Bonaccord

Pepparà Dam

Karakalakode picket station

Prepared from IRS IC LISS III FCC of 1997 (Bands 2, 3 and 4)

KFRI I ECOLOGY I AOV

4. Podium and Kompadinjal 5. Pattampara

Evergreen forest
Semi-evergreen forest
Moist deciduous forest
Grassland
Reservoir
Reed
Mangrove ecosystem study
Digital Mapping of Forests
VEGETATION DENSITY MAPPING

DATA USED
IRS 1B FCC (1:50,000)
B&W AERIAL PHOTOGRAPHS (1:15,000)

STUDY AREA
IDUKKI
POOYAMKUTTY

OUTPUT
DENSITY SLICED
(3 LEVEL VIZ. <40%, 40-60% & > 60%)
MAP FOR MANAGEMENT OPTIONS
Forest Fire Assessment

BEFORE

AFTER

Burn scars
Active Fire Detection

Based on active fire detection algorithm (pixel brightness status)

Burnt Scars
Rajive Gandhi Nat. Park, Nagarhole, Karnataka
Burnt area – IRS P6 LISS3, 9\textsuperscript{th} Mar.2004
9. FOREST RESOURCE EVALUATION AND SURVEY

A. CHECKING OF REED RESOURCES OF KERALA
DATA USED 1:15,000 B&W PHOTOGRAPHS
OUTPUT REED RESOURCE MAP IN 1:25000

B. RATTAN SURVEY STUDY
DATA USED
IRS 1B LISS 2 CCT TECHNIQUES
DIGITAL IMAGE PROCESSING
OUTPUT DELINIATION OF RATTAN / NONRATTAN AREA
BAMBOO RESOURCE ESTIMATION

DATA USED
IRS 1C LISS 3 CCT

TECHNIQUES
DIGITAL IMAGE PROCESSING COUPLED WITH AERIAL PHOTO INTERPRETATION

STUDY AREA
KERALA FORESTS

OUTPUT
DENSITY SLICED BAMBOO DISTRIBUTION MAP AND RESOURCE STATISTICS
Supervised classification

In this method, computer is made to study the characteristics of distinct objects. Based on this, the computer is able to generalize characters of objects and come up with accurate classification.

In this technique all available spectral bands can be used and hence features normally not visible become clear. With the help of accurate ground information high classification accuracy can be achieved.
12. Mapping and quantitative assessment of geographic distribution and the population status of plant resources of Western Ghats
Sub-division of Grids
Laying of plots

<table>
<thead>
<tr>
<th>58 B/7 SE1</th>
<th>58 B/7 SE2</th>
<th>58 B/7 SE3</th>
<th>58 B/7 SE4</th>
</tr>
</thead>
</table>

**Uniform Density Area Selection**
Transect Studies

Laying of plots

48 P/12 NW3

48 P/12 NE1