SATELLITE BASED AGRICULTURE INFORMATION SYSTEM:
AN EFFICIENT APPLICATION OF ICT

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Vision

- Cost effective agriculture monitoring from macro to micro scale

Problem

- Developing countries like India still uses traditional practices for agriculture monitoring
- Reduced productivity due to lack of efficient monitoring systems
- Pradhan Mantri Fasal Bima Yojana is a crop insurance scheme insists on usage of satellite based information for crop damage assessment
- Insurance agencies are usually located in urban and semi urban areas and still rely on manual inspections for crop insurance in remote locations
Objective(s) & Technology Involved

- To develop **agriculture information system** with satellite data as input
- To retrieve **real-time information** of crops like health, moisture content, disease etc. at district and tehsil level
- To provide **information to end user** through cloud service and to make them **cost effective and hassle free**
- To develop **web based and SMS based** service
- Emphasis on making use of low cost satellite data provided by operational satellites such as Terra/Aqua MODIS, TM, etc.

Data Used: Satellite Data (MODIS, Sentinel-2)
Salient Features

Satellite data based solution will be having following features:

• Land Cover Monitoring
• Change Detection
• Crop Health/Agriculture Monitoring
• Soil Moisture Monitoring
• Real Time Assessment for Decision Making
• Development of Apps for Mobile
• Drought Monitoring
Benefits of AIS for ICT

- Farmers
- Agriculture Educators
- Government
- Researchers
- Economic Planner
- Health Sector Planner
- Land Management Planner
- Land Advisor
Working of AIS system

AIS for ICT

Satellites (Optical/SAR)

Satellite Workstation

Data Analyst/ System Developer

Consumers from different locations and aspects
Technology

AIS Technology

- Data mining green cover changes
- Soil moisture
- Crop-Drought Management Information
- Hazard zonation
- Crop monitoring information for user specific area
- Vegetation profile year wise & season wise

Crop information for user specific area

Vegetation profile

Soil moisture

Hazard zonation

Crop-Drought Management Information

Data mining green cover changes

Vegetation profile year wise & season wise
Methodology
Methodology contd......

- **Pseudo Color Image Generation**
- **Selection of ROI of Respective Classes**
- **Extraction of Color Model's Components**
- **Analysis of Individual Color Space Model**
- **Development of Decision Tree Classifier**

**Land Cover Classification Algorithm**

1. **Fusion Algorithm**
2. **Data Fusion**
3. **Selection of Bands**
4. **View**
5. **Decomposition**
   - Rotation
   - Without Rotation
     - Pauli
     - 3D
     - HA/α
     - 4D/4D Modified
6. **Crop Identification**
   - Bare Field
   - Crop/vegetation Field
7. **Agricultural Parameter Estimation (Soil Moisture, Crop Health)**
8. **Time Series Analysis**
9. **Observed Change**
10. **Area Estimation**
11. **Classified Image**
12. **Minimize the Changes**
13. **Supervised**
14. **Unsupervised**
15. **Scattering Image**
16. **Intensity Image**
17. **Band & Indices Values**
Methodology contd......

Classification

Pseudo Color Image Generation

Selection of ROI of Respective Classes

Extraction of Color Model's Components

Analysis of Individual Color Space Model

Development of Decision Tree Classifier

Scattering Image

Intensity Image

Data Fusion

Selection of Bands

View

Supervised

Minimize the Changes

Unsupervised

Classified Image

Area Estimation

Agricultural Parameter Estimation (Soil Moisture, Crop Health etc.)

Time Series Analysis

Observed Change

Server

SMS

Web based

Information to End User
Methodology contd......

Classification

Pseudo Color Image Generation

Selection of ROI of Respective Classes

Extraction of Color Model’s Components

Analysis of Individual Color Space Model

Development of Decision Tree Classifier

Land Cover Classification Algorithm

Class | ROI Points
--- | ---
Water | 200
Urban | 200
Normal Vegetation | 200
Dense Vegetation | 200
Bare Soil | 200
Methodology contd......

**Pseudo Color Image Generation**

**Selection of ROI of Respective Classes**

**Extraction of Color Model's Components**

**Analysis of Individual Color Space Model**

**Development of Decision Tree Classifier**

**Land Cover Classification Algorithm**

- RGB
- HLS
- YIQ
- CIELAB

**Color Space Models**

**Classification**

- RGB
- HLS
- YIQ
- CIELAB

**Fusion Algorithm**

**Data Fusion**

**Selection of Bands**

**View**

**Supervised**

**Unsupervised**

**Minimize the Changes**

**Classified Image**

**Area Estimation**

**Bare Field**

**Crop/vegetation Field**

**Agricultural Parameter Estimation (soil moisture, crop health etc)**

**Time Series Analysis**

**Observed Change**

**Server**

**Scattering Image**

**Intensity Image**

**Band & Indices Values**

**MODIS/OPTICAL Images**

**RISAT/PALSAR Images**

- Decomposition
  - Rotation
  - Without Rotation
  - PALSAR
  - LPI
  - ND/ND Modified
  - Bare Field
  - Crop/vegetation Field
  - SMS
  - Web based
  - Information to End User
Methodology contd......

- Pseudo Color Image Generation
  - Selection of ROI of Respective Classes
  - Extraction of Color Model's Components
  - Analysis of Individual Color Space Model
  - Development of Decision Tree Classifier

Land Cover Classification Algorithm

- Classification
  - Pseudo Color Image Generation
  - Selection of ROI of Respective Classes
  - Extraction of Color Model's Components
  - Analysis of Individual Color Space Model
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- Land Cover Classification Algorithm
  - Classification
    - Pseudo Color Image Generation
      - Selection of ROI of Respective Classes
      - Extraction of Color Model's Components
      - Analysis of Individual Color Space Model
      - Development of Decision Tree Classifier
  - Land Cover Classification Algorithm

- Land Cover Classification Algorithm
  - Classification
    - Pseudo Color Image Generation
      - Selection of ROI of Respective Classes
      - Extraction of Color Model's Components
      - Analysis of Individual Color Space Model
      - Development of Decision Tree Classifier
  - Land Cover Classification Algorithm
Methodology contd.....

Classification

Pseudo Color Image Generation
- Selection of ROI of Respective Classes
- Extraction of Color Model's Components
- Analysis of Individual Color Space Model
- Development of Decision Tree Classifier
Decision Tree Classifier

```
B > R AND B > G AND R < 0 AND G < 0 AND B > 0 AND Q > Y AND Q > | AND I > Y AND Y < 0 AND I < 0 AND Q > 0 AND H > 0 AND a* > L* AND a* > b* AND b* > L* AND L* < 0 AND a* > 0 AND b* < 0
```

```
R > G AND B > G AND R > 0 AND G < 0 AND B > 0 AND Q > Y AND I > Y AND Y < 0 AND I > 0 AND Q > 0 AND H > 0 AND a* > L* AND a* > b* AND b* > L* AND L* < 0 AND a* > 0 AND b* < 0
```

```
R = min(R) OR G = min(G)
```

```
R < -1 AND G < -1 AND B < -1
```

```
Unclassified
```

```
I > Q AND b* < a*
```

```
Unclassified
```

```
Normal Vegetation
```

```
Dense Vegetation
```

```
G > 1.5
```

```
 Highly Dense Vegetation
```

```
Urban
```

```
Water
```

```
```
Deployment on Cloud for Web Based Solution

Fig.: Cloud Computing Architecture

Fig. : Proposed Layered Structure
Name of the product: **Agriculture information system**

Web address: [www.aisiitr.in\modis\](http://www.aisiitr.in\modis\)

Android app available in google play store

**Large scale application**

- Vegetation map (District / Tehsil / Village wise)
- Vegetation profile (District / Tehsil / Village wise)
  - Year wise / Crop cycle wise
- Agriculture area identification and its changes (District wise)
- Drought maps (State wise)
Vegetation Map

Normalized Difference Vegetation Index (NDVI)

<table>
<thead>
<tr>
<th>NDVI Value</th>
<th>Values approaching -1</th>
<th>-0.1 to 0.1</th>
<th>0.1 to 0.2</th>
<th>0.2 to 0.3</th>
<th>0.3 to 0.6</th>
<th>0.6 to 0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cover Type</td>
<td>Deep Water</td>
<td>barren rock, sand or snow</td>
<td>Bare Soil</td>
<td>Sparse vegetation such as shrubs and grasslands or senescence crops</td>
<td>Dense Vegetation Canopy</td>
<td>Temperate and tropical forests or crops at their peak growth stage</td>
</tr>
</tbody>
</table>

The Normalized Difference Vegetation Index (NDVI) is a measure of plant/crop “greenness” based on the photosynthetic process or chlorophyll content. This module gives a district wise overview of the vegetation health in the form of NDVI for a 8-day (week) period of a particular year. The lively/healthy vegetation, shows more NDVI value in comparison to dead vegetation as healthy vegetation soaks the majority of the red light that strikes it while reflecting a large amount of the near infrared light.

http://www.aisiitr.in/modis/
Vegetation profile

NDVI Profile Year Wise:

This module presents a district wise impression of the average NDVI profile for a definite 8-day period of the previous 5 years. This does not only give an estimation of the vegetative state (healthy/normal/weak) for all the respective five years, but also enables to identify the year wise fluctuations in the vegetation physical conditions at that particular time.

NDVI Profile Julian Date Wise:

This module portrays a district wise indication of the average NDVI profile for a specific time period for a particular year. It enables to identify the season wise oscillations in the vegetation health and also allows the monitoring of the alterations occurred in a specific time period.

Previous 5 year vegetation profile for the selected date

Vegetation profile for the selected year

http://www.aisiitr.in/modis/
Classification & Change Detection

Classification

Year: 2017  
Julian Date: 000:00/Jan-16/Jan  
State: Uttarakhand  
District: Haridwar

Submit

Green: Agriculture Area
2017: 1622.5 sq. km. (approx.)
2016: 1766.8 sq. km. (approx.)

Red: Urban, Water, Bare Soil, Others
2017: 776.925 sq. km. (approx.)
2016: 692.325 sq. km. (approx.)

Total:
2017: 2399.4 sq. km. (approx.)
2016: 2469.1 sq. km. (approx.)

Change Detection

Green: Agriculture area with no change wrt previous year
Change Map
1381.1 sq. km. (approx.)

Blue: Area where previous year agriculture was not present
325.75 sq. km. (approx.)

Red: Area where previous year agriculture was present
2414.375 sq. km. (approx.)

http://www.aisiitr.in/modis/
Validation

09 Jan 2017

- Haridwar
- Roorkee

- Vegetation
- Other class (water, urban, bare land)
## Field Survey – Ground truth data

<table>
<thead>
<tr>
<th>Date of field visit</th>
<th>Parameters measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-02-2017</td>
<td>crop type, crop height, crop density, multispectral data, soil moisture, leaf area index etc.</td>
</tr>
<tr>
<td>24-02-2017</td>
<td>crop type, crop height, crop density, multispectral data, soil moisture, leaf area index etc.</td>
</tr>
</tbody>
</table>

- **Crop detail**
  - Lat 29.93146 N, Lon 77.96592 E

- **Wheat soil moisture measurement**
  - Lat 29.93127 N, Lon 77.96578 E

- **Bare land**
  - Lat 29.937532 N, Lon 77.932522 E

- **Mustard**
  - Lat 29.86072 N, Lon 77.78505 E

- **Sugar cane Planting**
  - Lat 29.928758 N, Lon 77.963245 E

- **Bare land**
  - Lat 29.928605 N, Lon 77.963057 E

- **Multispectral scanner**
  - Lat 29.930392 N, Lon 77.964965 E
## Field Survey – Ground truth data

<table>
<thead>
<tr>
<th>Date of field visit</th>
<th>Parameters measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>22-04-2017</td>
<td>Identification of new sites and collection of geographical information for forest, water (Cheela dam), grassland etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forest</th>
<th>Lat 29.910353 N</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lon 78.1736 E</td>
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<table>
<thead>
<tr>
<th>Forest</th>
<th>Lat 29.93127 N</th>
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<tbody>
<tr>
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<td>Lon 77.96578 E</td>
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<table>
<thead>
<tr>
<th>Forest</th>
<th>Lat 29.880632 N</th>
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<tbody>
<tr>
<td></td>
<td>Lon 78.19114 E</td>
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<table>
<thead>
<tr>
<th>Forest</th>
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<td>Lon 78.1736 E</td>
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<tr>
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<tbody>
<tr>
<td></td>
<td>Lon 78.19114 E</td>
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<table>
<thead>
<tr>
<th>Cheela dam</th>
<th>Lat 29.976967 N</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lon 78.222592 E</td>
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</table>

<table>
<thead>
<tr>
<th>Ganga canal</th>
<th>Lat 29.977083 N</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lon 78.222592 E</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Cheela dam</th>
<th>Lat 29.969303 N</th>
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</thead>
<tbody>
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<table>
<thead>
<tr>
<th>Grassland</th>
<th>Lat 29.959435 N</th>
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<td></td>
<td>Lon 78.249512 E</td>
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<table>
<thead>
<tr>
<th>Grassland</th>
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<td>Lon 78.255475 E</td>
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<table>
<thead>
<tr>
<th>Forest</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lon 78.223053 E</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lon 78.22146E</td>
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</table>
Field Survey – Ground truth data

<table>
<thead>
<tr>
<th>Date of field visit</th>
<th>Parameters measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>09-06-2017</td>
<td>crop type, crop height, crop density, multispectral data, soil moisture, leaf area index etc.</td>
</tr>
<tr>
<td>30-06-2017</td>
<td>New site identification, crop type, crop height, crop density, multispectral data, soil moisture, leaf area index etc.</td>
</tr>
</tbody>
</table>

- **Sugarcane MSS**
  Lat: 29.933043 N
  Lon: 77.963583 E

- **Sugarcane LAL measurement**
  Lat: 29.93291 N
  Lon: 77.96362 E

- **Fallow land**
  Lat: 29.931897 N
  Lon: 77.96363 E

- **Sugarcane after 105 days of planting**
  Lat: 29.9286 N
  Lon: 77.96409 E

- **Soil moisture measurement**
  Lat: 29.936993 N
  Lon: 77.909423 E

- **Bare land**
  Lat: 29.937137 N
  Lon: 77.908957 E

- **River bank grassland**
  Lat: 29.413803 N
  Lon: 78.621811 E

- **Bare land**
  Lat: 29.417586 N
  Lon: 78.659403 E

- **Sugarcane density measurement**
  Lat: 29.366022 N
  Lon: 78.671053 E

- **Sugarcane**
  Lat: 29.366044 N
  Lon: 78.671069 E

- **Sugarcane**
  Lat: 29.320628 N
  Lon: 78.592269 E

- **Sugarcane**
  Lat: 29.320933 N
  Lon: 78.593569 E
Field Survey – Ground truth data
Field Survey - Ground truth data
## Validation

<table>
<thead>
<tr>
<th>Date</th>
<th>Vegetation index from AIS</th>
<th>Ground truth vegetation index</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Feb 2017</td>
<td>0.664</td>
<td>0.618</td>
</tr>
<tr>
<td>24 Feb 2017</td>
<td>0.634</td>
<td>0.771</td>
</tr>
<tr>
<td>09 Jun 2017</td>
<td>0.464</td>
<td>0.528</td>
</tr>
<tr>
<td>05 Jan 2018</td>
<td>0.408</td>
<td>0.537</td>
</tr>
</tbody>
</table>
Drought Monitoring

http://www.aisiitr.in/modis/
Village level NDVI profile (ongoing)
AIS Android Application

SATELLITE BASED AGRICULTURE INFORMATION SYSTEM

Developed By: Prof Dharmendra Singh and Team
Sponsored By: RailTel - IIT Roorkee Centre of Excellence in Telecom (RICET)
ACK: Thanks to Reliance Jio Cloud Services (JCS) for providing the Cloud Infrastructure

Launch Screen

Menu

District wise Classification
AIS Android Application

Agriculture Information System

Crop Monitoring
- 2017
- 049: 18/Feb - 25/Feb
- Uttar Pradesh
- Ambedkar Nagar
- Akbarpur

Tehsil wise Crop Monitoring

Tehsil NDVI map

NDVI profile
Benefits of AIS

- Better decision making
- Improved communication
- Identify at-risk or under-served Area
- Improved transparency
- Managing geographically
- Cost savings resulting from greater efficiency
- Better geographic information recordkeeping
Competition

- Traditional practices like in situ sampling and investigation
Business Model

- Launched and available online for registered users
- Initial free trial for 1 month
  - @ ₹ 10/pm (for one location per user)
    - Target of approx. 10000 users in 1st year - ₹ 12 lakhs
  - @ ₹ 10000/pm for one district (negotiable)
    - Target of at least 5 companies / insurance agencies in 1st year and minimum of 10 districts - ₹ 60 lakhs
- State wise contracts for 1 year – ₹ 20 to 30 lakhs (negotiable)

Projected Revenue for 1st year

Revenue in lakhs

0 20 40 60 80
Farmers / End users Companies / Insurance agencies Government bodies

Projected revenue for 1st year ₹ 1.12 crore
Agriculture Information System (AIS) & Pradhan Mantri Fasal Bima Yojana (PMFBY)

References:
Pradhan Mantri Fasal Bima Yojana is a **crop insurance scheme** launched by Prime Minister Narendra Modi Led NDA Government. The scheme has been launched to cater the financial needs of the farmers in the events of crops destroyed by heavy rain, other natural calamities, pests or diseases.

The scheme is aimed to provide insurance cover and financial support to the farmers in difficult times. In the new scheme, the shortcomings of previous crop insurance schemes have been taken care of very well. Along with this scheme, several other initiatives have been started by the central government of the welfare of the farmers.
Objective of PMFBY

- Insurance coverage and financial support
- Stabilize the income of farmers
- Encouraging farmers to adopt innovative and modern practice
- Ensure flow of credit
Risks to be Covered

Yield losses (standing crops, on notified area basis): Comprehensive risk insurance is provided to cover yield losses due to non-preventable risks, such as

- Natural Fire and Lightning
- Storm, Hailstorm, Cyclone, Typhoon, Tempest, Hurricane, Tornado etc.
- Flood, Inundation and Landslide
- Drought, Dry spells
- Pests/ Diseases etc.
PMFBY & AIS

PMFBY

- Past Data
- Data Classification
- Verification of Land and crop
- Drought related info
- Condition of Crop and soil

AIS

- Provide both Year wise and season wise
- Crop classification module
- Easily Done by this technology
- Drought module available
- Crop Monitoring Module
PMFBY highlights where AIS can contribute

1. To give information which area in a district/State needed more focus under this scheme i.e. identification of area which are having any kind of crop and agriculture land issue in past few years to change policy for specific area and particular crop.

2. AIS can remove burden from:
   - The executive of the insurance company, who will visit the crop fields for collecting data by using smart phones with internet and GPS connectivity to capture several data related of land and the crop growth via AIS Technology.
   - The farmers will be guided about the soil health of the land. Experts from the Department of agriculture will visit the farms regularly to collect the soil sample and test them in the laboratories and the test reports will be given to the farmers.

3. Easy Verification of land and crop which is mentioned by farmer in application for insurance.

4. We can provide past data related to
   - Natural Fire and Lightning
   - Storm, Hailstorm, Cyclone, Typhoon, Tempest, Hurricane, Tornado etc.
   - Flood, Inundation and Landslide
   - Drought, Dry spells
   - Pests/ Diseases etc
     Which help Insurance company to formulate their various policies for farmers.

Apart from that by the help of AIS you can access data related to crops and soil such as
   - Most sown Crop
   - Condition of Crop
   - Condition of soil
   - Past environmental condition
IIT-R develops satellite-based crop monitoring system, app

ROORKEE: The Indian Institute of Technology Roorkee (IIT-R) claims to have developed a satellite-based online information system and mobile app for crop monitoring at the district level in Uttarakhand.

The electronics and communication engineering department of the institute, which developed the system, says that they may be able to extend the online platform country-wide in a year or more after uploading data from other states.

“The online information system is called ‘satellite-based agriculture information system’ (SBAIS) The website will soon be in the public domain for general users,” Dharmendra Singh, professor of microwave imaging & space technology and the principal investigator (PI) of the project, told TID.

The Institute has also developed an app for mobile users to access the online information system.
Publicity
Publications - Journals


Thanks for Patient