Cloud Filtering Methodology for the Use of Optical Satellite Images in Sustainable Management of Tea Plantations

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Introduction

- 9% of World production share & 19% of global export demand are fulfilled by Ceylon Tea

- Remote sensing can be used for
  - estimating area of cultivation
  - predicting yield
  - identifying areas affected by pests & diseases and drought

Introduction contd.

- There is no effective non destructive method to determine biomass of tea
- Field measurements are time and labour consuming and costly
- Detection of temporal variation is almost impossible and not very accurate.
- Remote sensing is an effective method to overcome above constraints and it’s the ideal tool to manage large extents of Tea lands.

Introduction contd.

- Clouds is one of the significant obstacles in extracting information from tea lands using remote sensing imagery
  - Hidden information.
  - Cloud contaminated pixels give wrong information.
  - Optical depth & size of cloud limit the Geo-statistical interpolation.
  - Spatial complexity of the land cover also limit the Geo-statistical interpolation.

Introduction contd.

- **Different approaches have been attempted to solve this problem with varying levels of success.**

1. Image fusion
2. Maximum value composites (NDVI)
3. Cloud removal based on Histogram Matching
4. Wavelet regression.

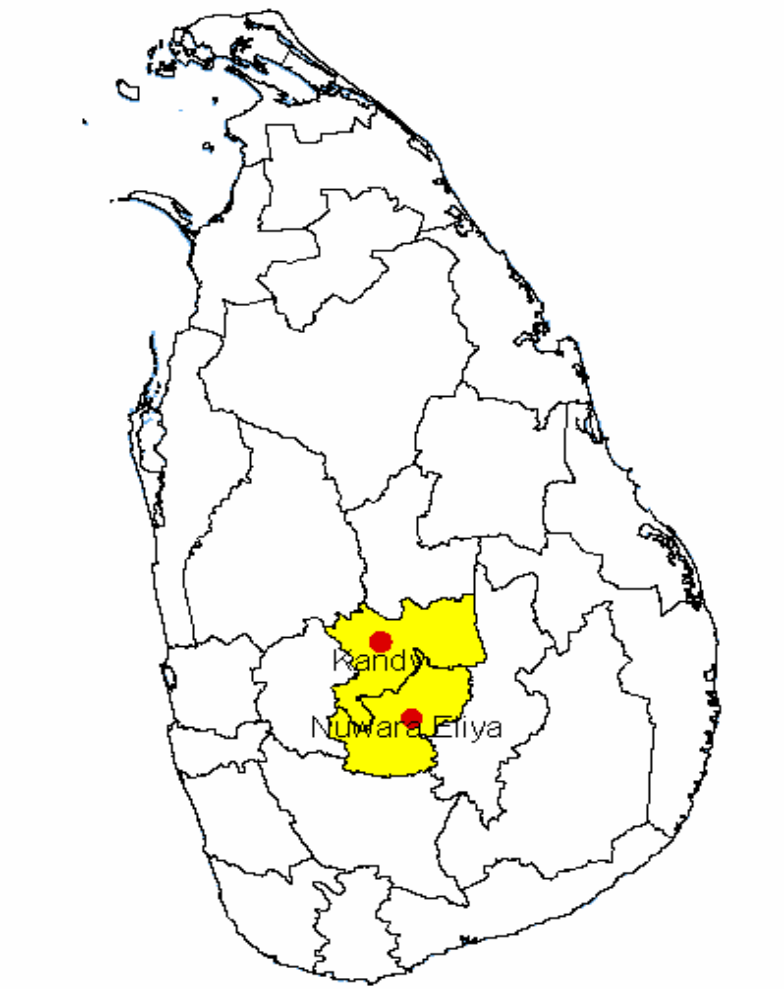
Resources

- Data: Landsat 7(ETM+) raw images (2003 and 2001) Aster
- Software: ERDAS Imagine® v. 8.5 (Leica Geosystems, 2003)
  GS+ Gama Geo-statistical software
  Microsoft Excel, ArcGIS
- Internet resources.

Methodology

1) Pre-processing
   - Data Acquisition
   - Importing images
   - Image to image registration
   - Subset images
2) Processing
   - Cloud filtering
   - Filling out missing information
3) Validation

Study Area



Hantana Plantation

- $7^0$15’N and $80^0$38’E
- Rainfall 1880mm
- Extent of Tea 500 ha
- Elevation 762 m amsl
- Temperature 20-26^{0}C
- 7 divisions, 70 fields

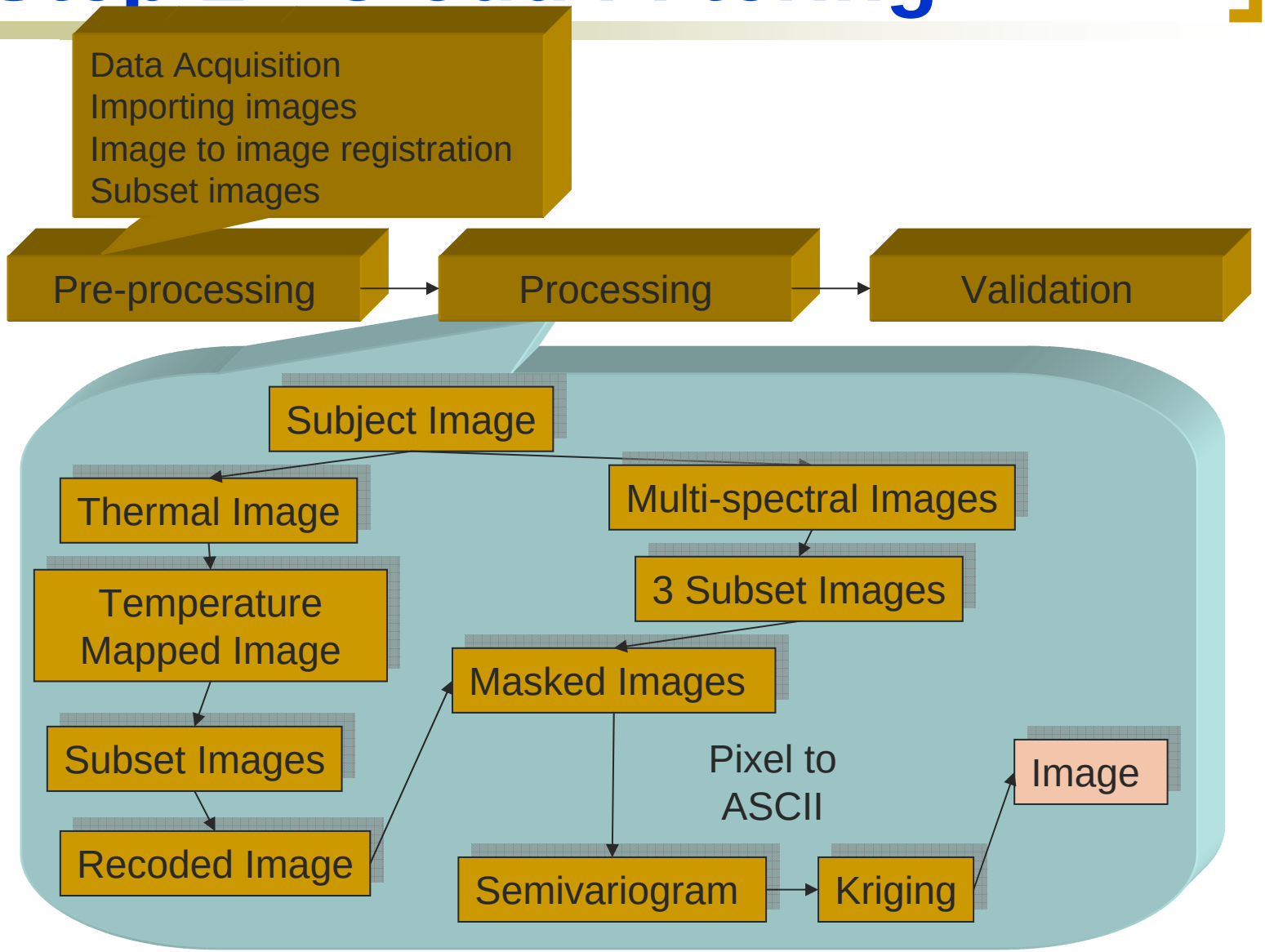
St Coombs

- 6^0 54’ N and 80^0 42’E
- Rainfall 1870 mm
- Extent of Tea 135 ha
- Elevation 1394 m amsl
- Temperature14-24^{o}C
- 2 divisions, 30 fields

Satellite images

Image	Site	Acquisition Date	Spatial resolution
Aster	Hantana	15.01.2003	15m
Landsat	Hantana St Coombs	14.03.2001	30m

Step 1 - Cloud Filtering



Processing

1) Cloud filtering

1.Image calibration

2.Threshold

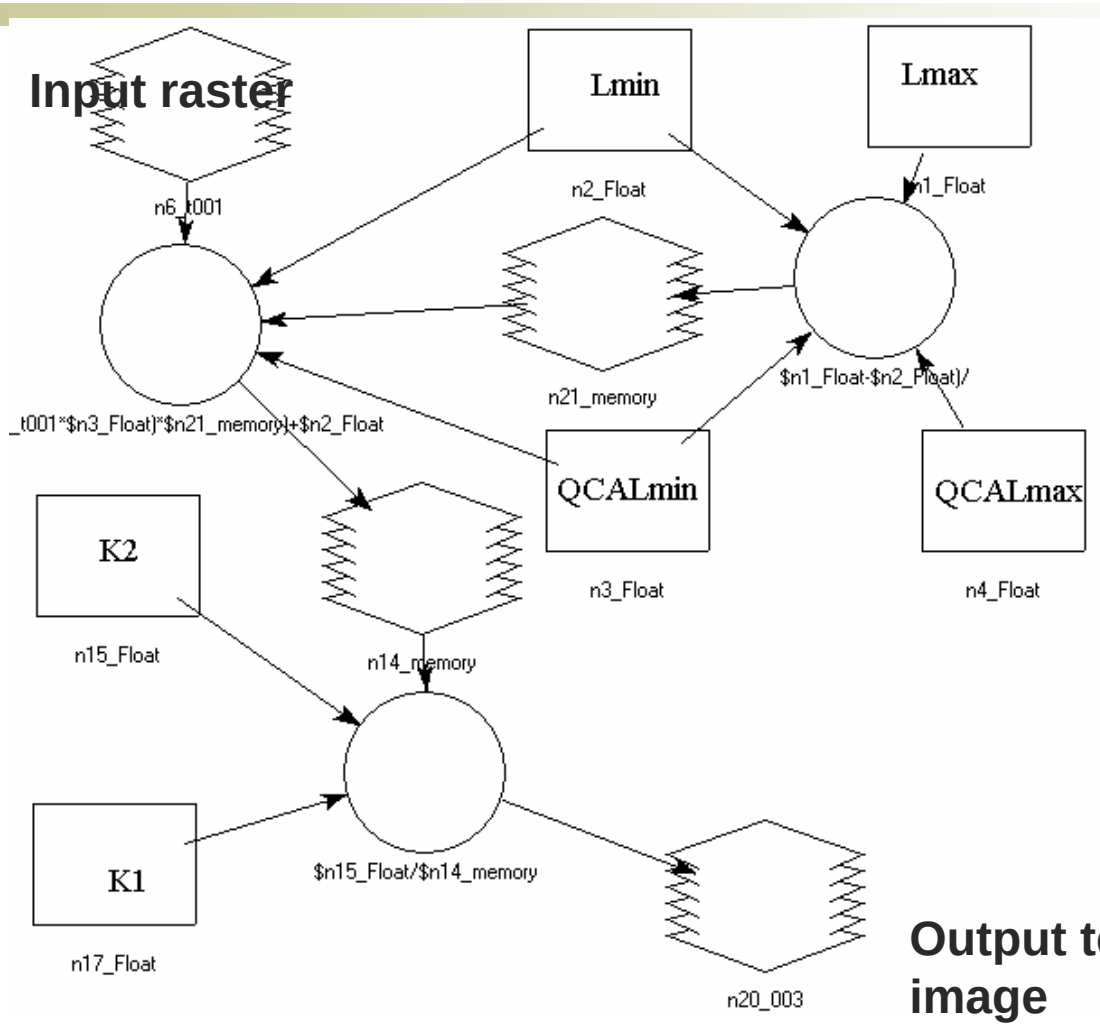
3. Masking

2) Filling out missing information

1. Method 1-Geostatistical interpolation

2. Method 2-Regression model

Temperature calculation algorithm



Output temperature image

Processing (Cloud filtering)

- **Threshold**
  - Identify the pixel range appear as clouds and shadow in histogram
  - - Recode that pixel range into zero
- **Masking**
  - Select the recoded thermal image as input mask
  - - Filter out the clouds and shadow area in multispectral images

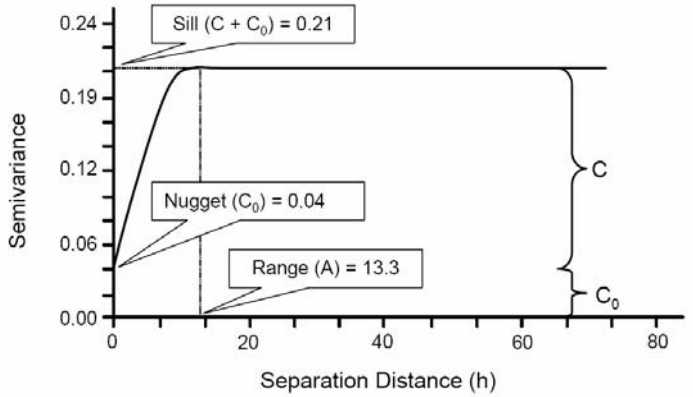
Processing (Filling out missing information)

Method 1- Filling out gaps using kriging

- - Select single cloud patch
- - Export surrounding pixel value as ASCII file

- Semi-variograms

- Plot the semivariogram
- interpolation interval =30
- fitted with spherical model



Processing (Filling out missing information)

- Kriging (Ordinary kriging)

- Interpolate unknown value using semivariogram
  - export as surface grid file
  - imported into ERDAS and build images

Processing (Filling out missing information)

Method 2 - Filling out gaps using regression model

- Building the regression model
  - Build model with co-located pixels in reference image
  - Separated model for each band

$$Y_{subji} = \int \left(X_{refi} \right)$$

- Applying regression model
- New DNs were predicted for each pixel

Validation

- Evaluate those procedures
- Select cloud free part as cloud area
- predict the pixel values using kriging and regression model
  - Compare predicted image part with original image

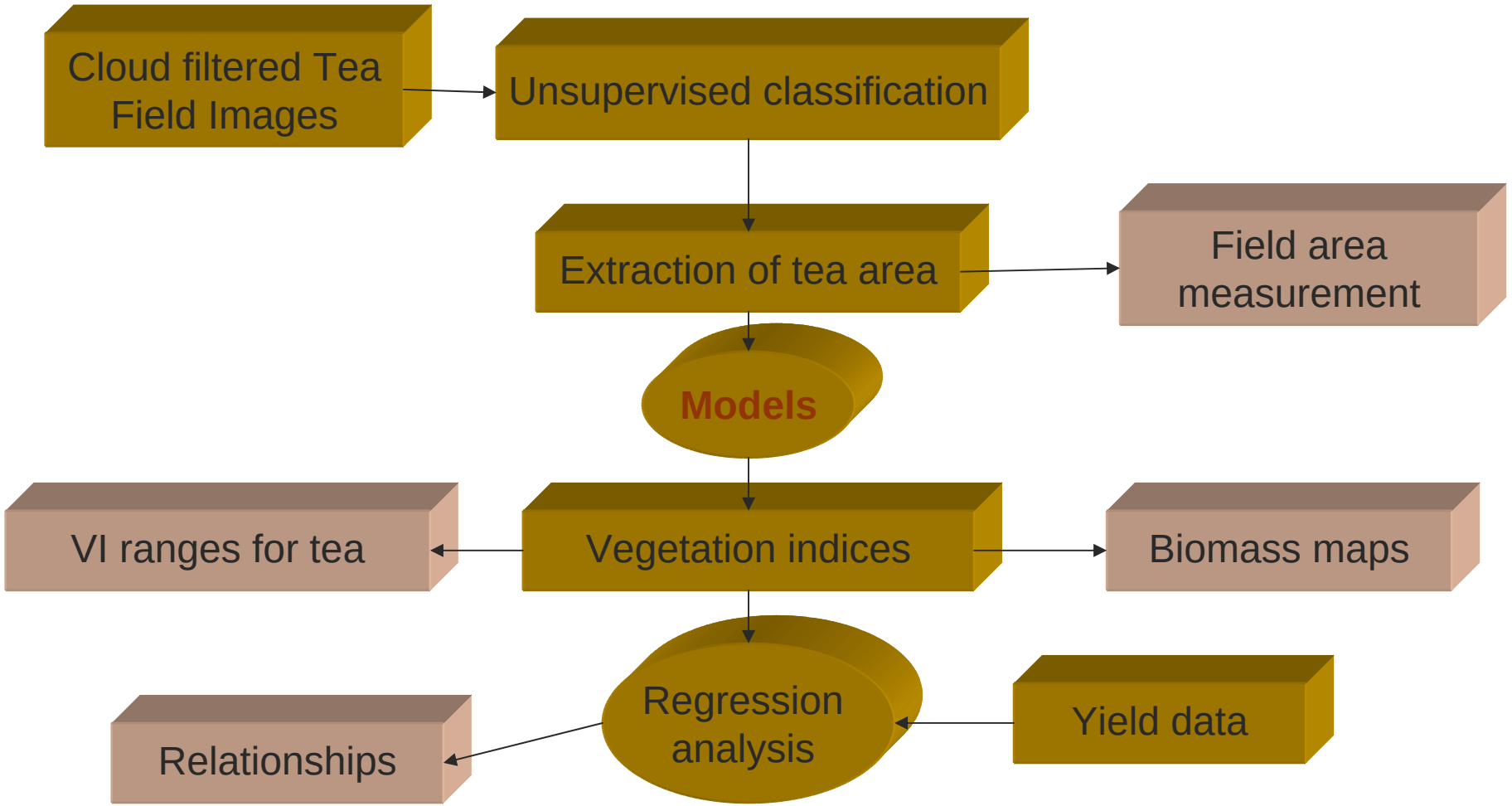
Kriging

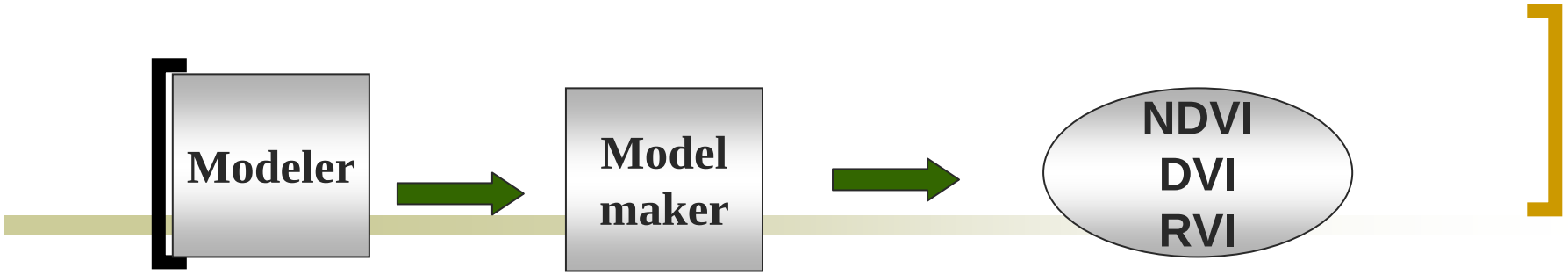
- cross-validation analysis
- layer statistic

Regression model -absolute differences between pixel values

- layer statistic

Step 2 – Field estimations





$$NDVI = \frac{NIR - Red}{NIR + Red}$$

$$DVI = NIR - Red$$

$$RVI = \frac{NIR}{Red}$$

Results

Cloud filtering by thermal band

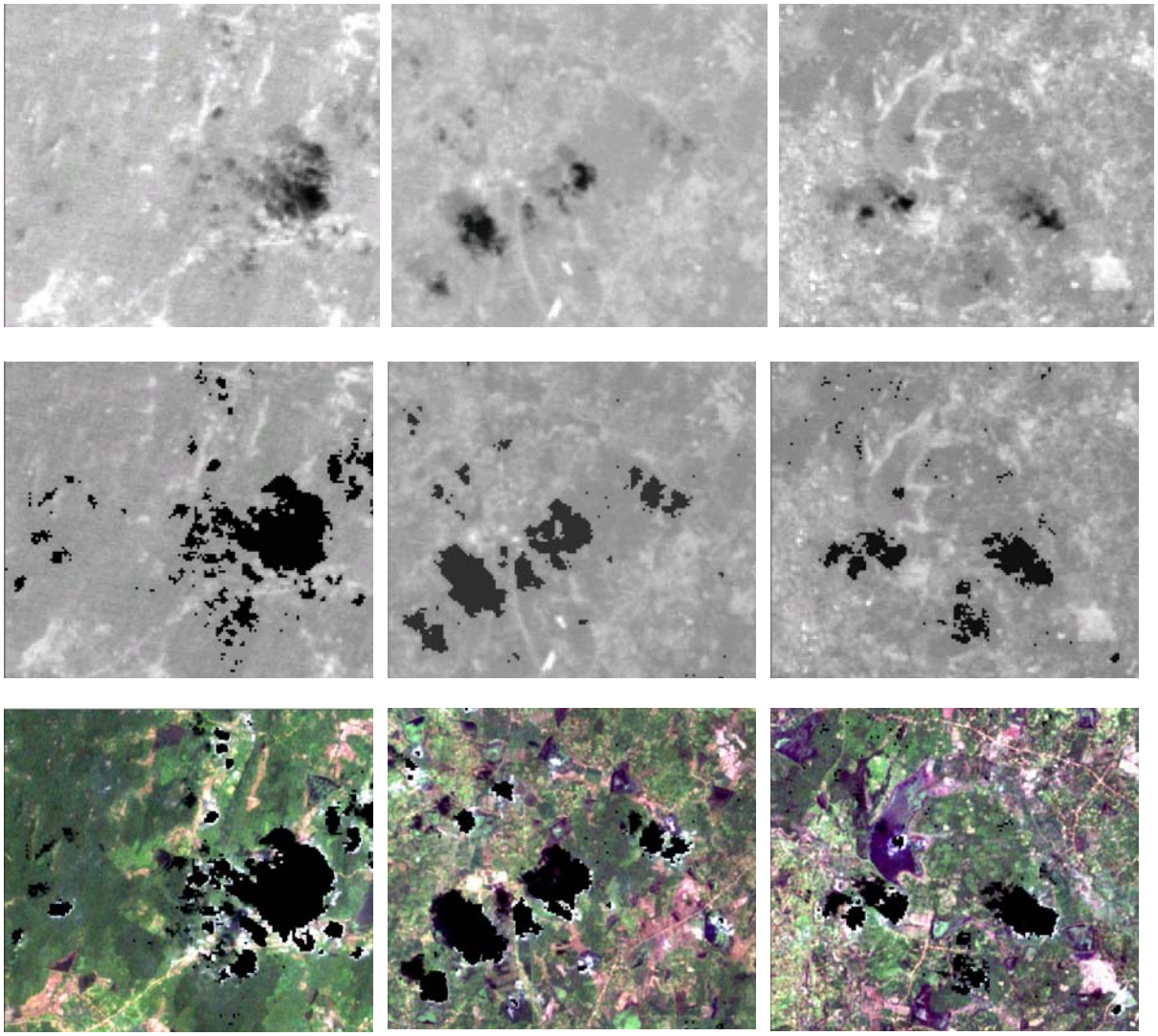
- high sensitivity to cloud areas and it can clearly identify dense cloud as well as thin clouds
- No confusion with other ground objects
- shadow detection performs better

Results contd.

Calibrated image

Recoded image

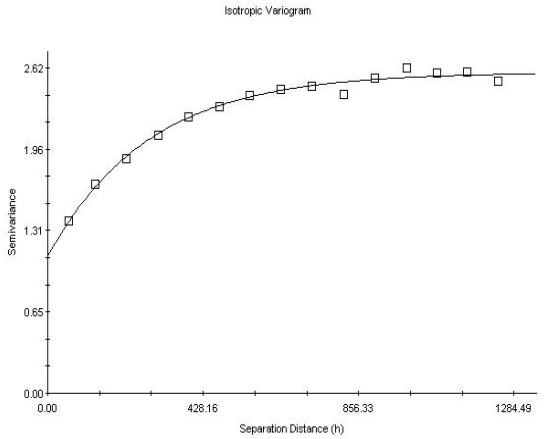
Masked image



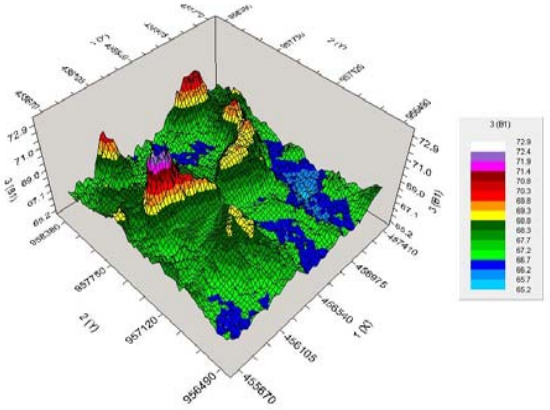
Results contd.

Filling out gaps using Kriging

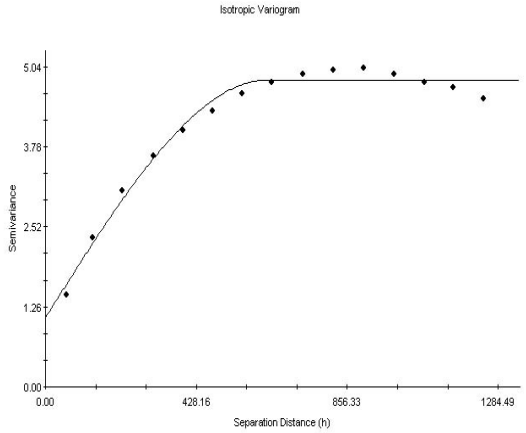
Band 1



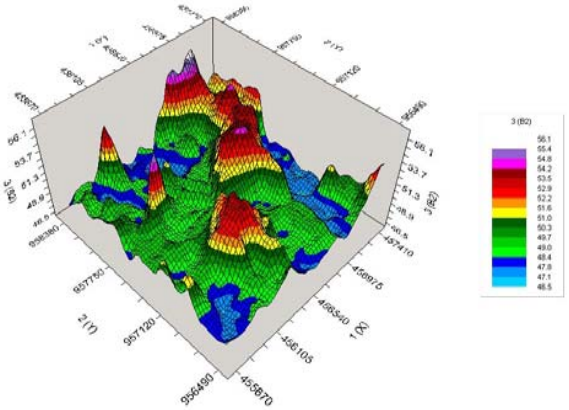
Exponential model (Co = 1.10200; Co + C = 2.58300; Ao = 277.00; r2 = 0.988; RSS = 0.0216)



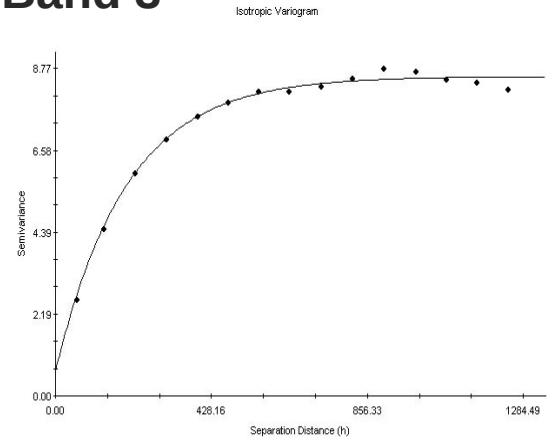
Band 2



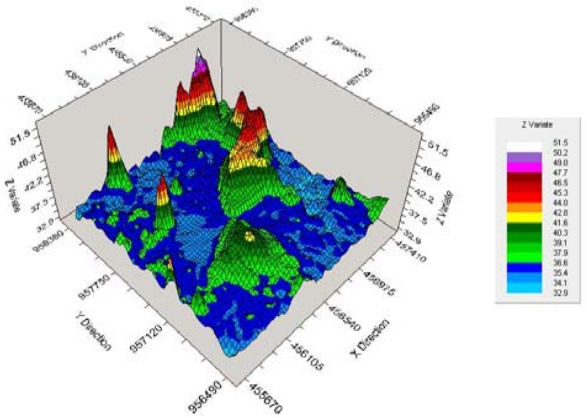
Spherical model (Co = 1.09000; Co + C = 4.82800; Ao = 633.00; r2 = 0.982; RSS = 0.267)



Band 3

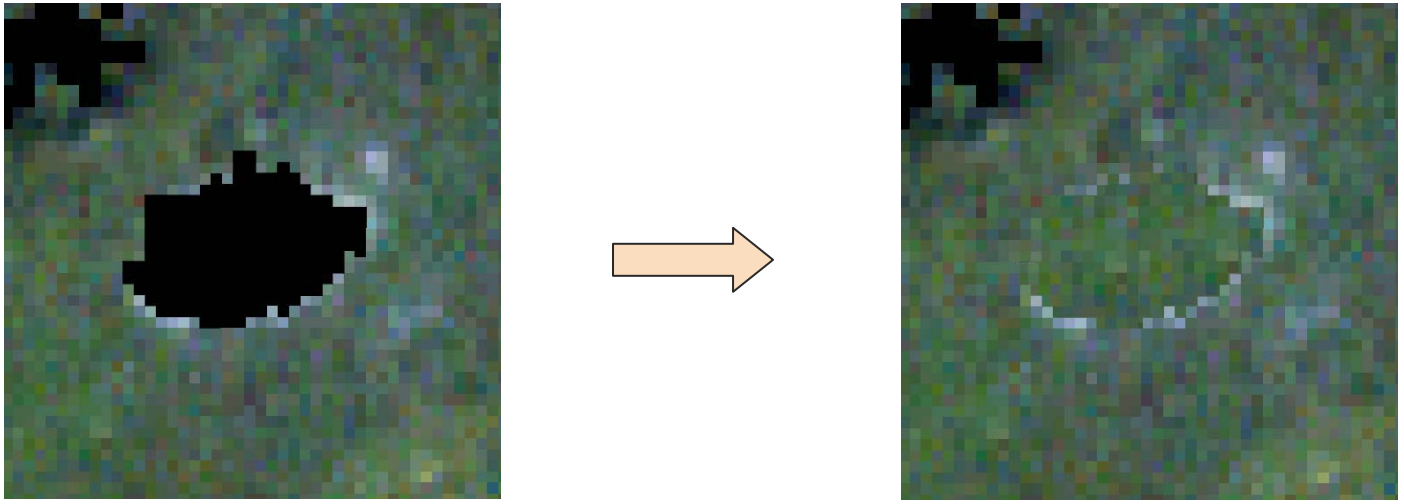


Exponential model (Co = 0.67000; Co + C = 8.56100; Ao = 196.00; r2 = 0.993; RSS = 0.293)



Results contd.

- **Filling out gaps using Kriging**
  - White ring surround the cloud patch confuse the kriging process



Before

After

Results contd.

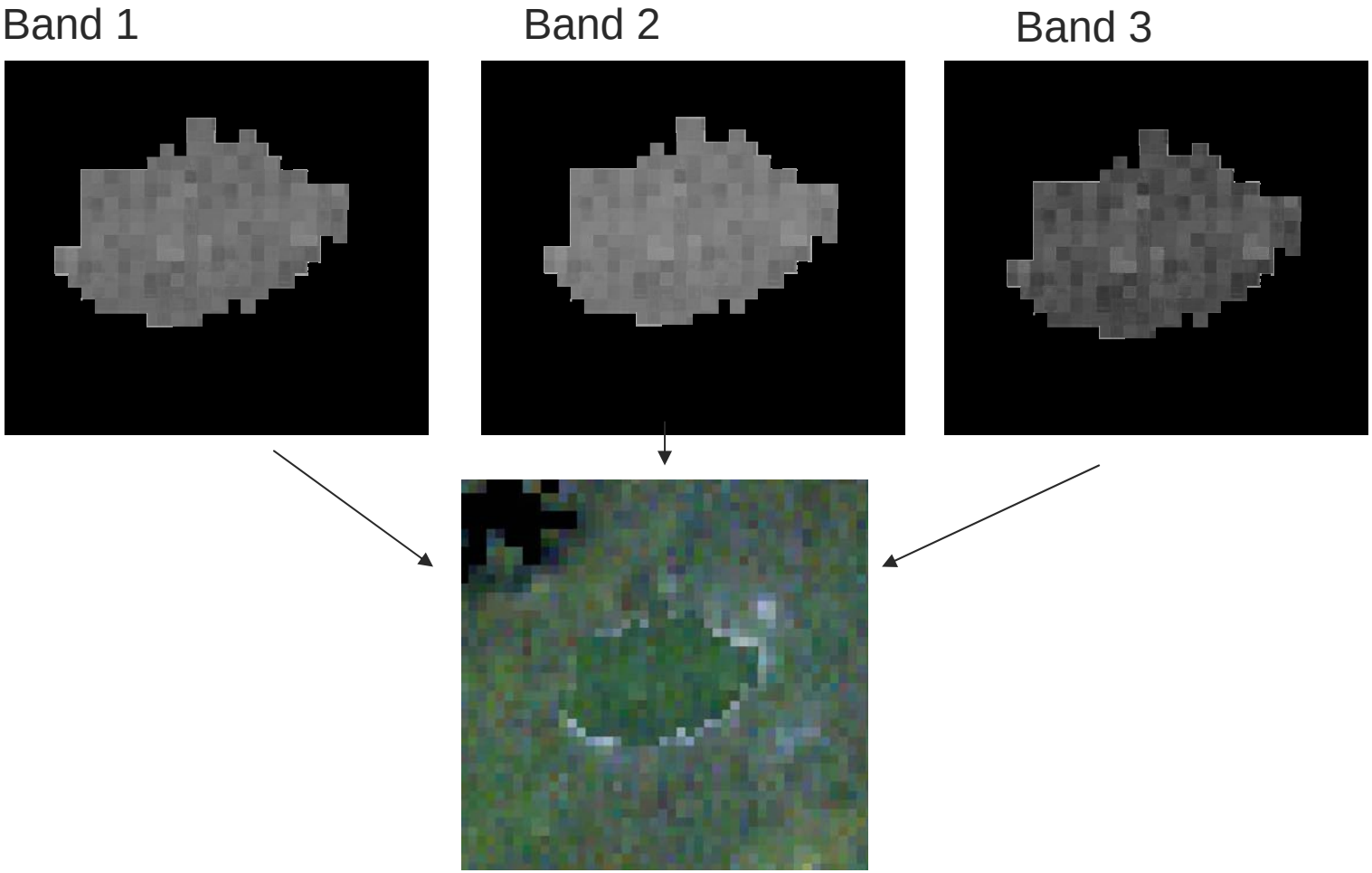
- **Filling out gaps using regression model**

Regression models for each bands (LandSat)

Band	Model	Regression coefficient
Band 1	$Y_{subi} = 270.8 - 2.367\ X_{refi}$	0.768
Band 2	$Y_{subi} = 53.68 + 0.0531\ X_{refi}$	0.234
Band 3	$Y_{subi} = 35.38 + 0.1234\ X_{refi}$	0.452

Results contd.

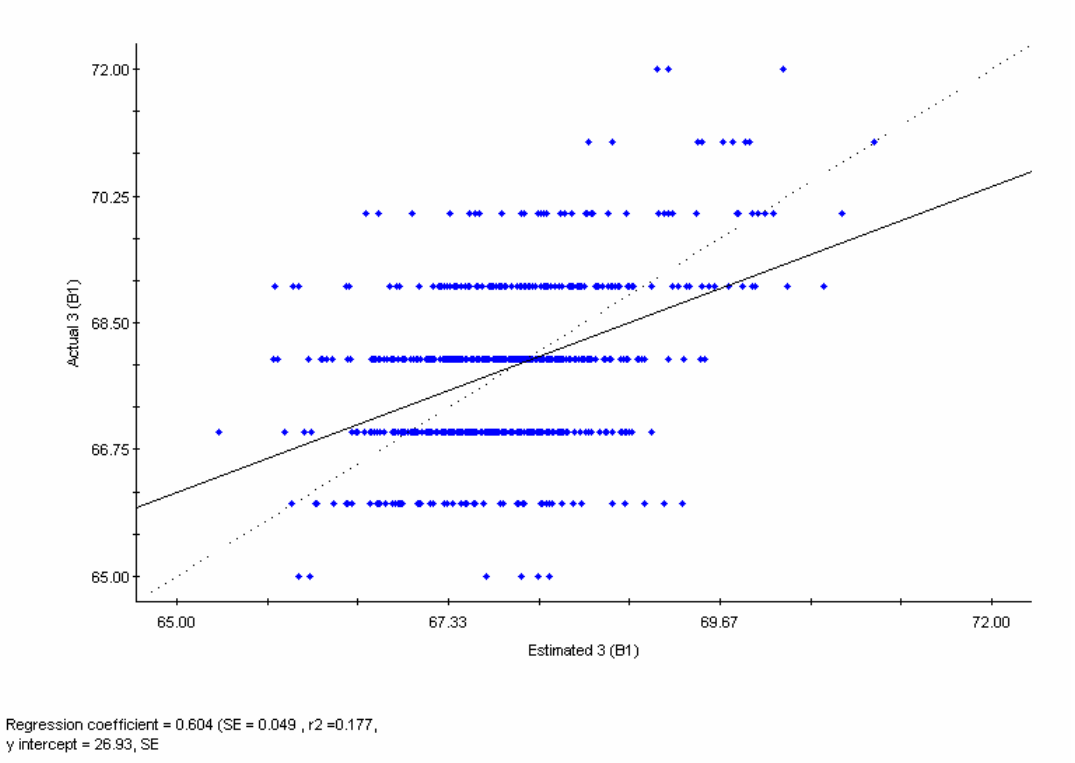
- Filling out gaps using regression model



Results contd.

Validation

Cross-validation analysis for kriging



Regression coefficient = 0.604

Results contd.

Validation

Layer statistic

Parameter	Kriging		Regression	
	Original	Predicted	Original	Predicted
Median	78	75	78	65
Mean	80	79	80	77
Mode	65	70	65	55
Stdev	1.12	1.05	1.12	4.56

Results contd.

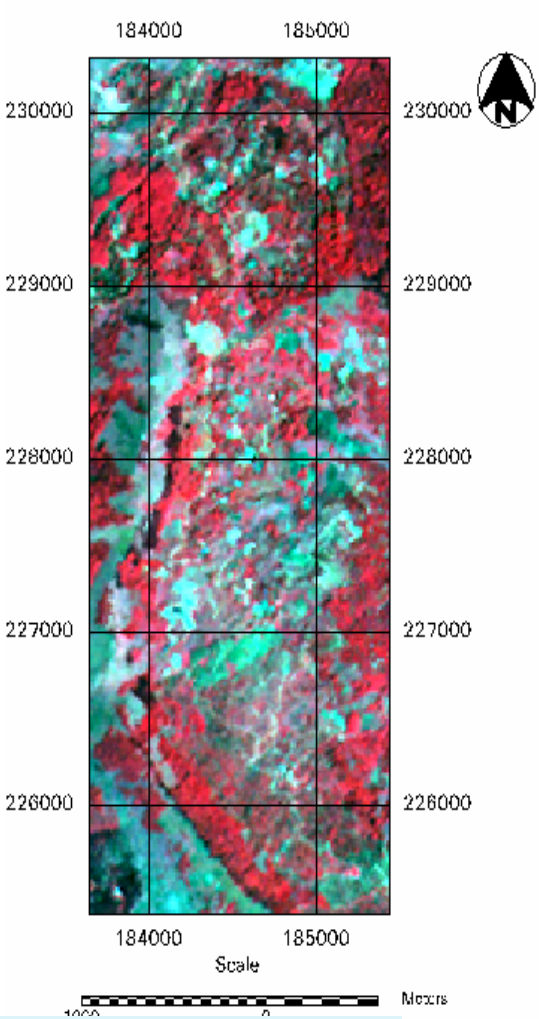
Area Extraction

Hantana plantations

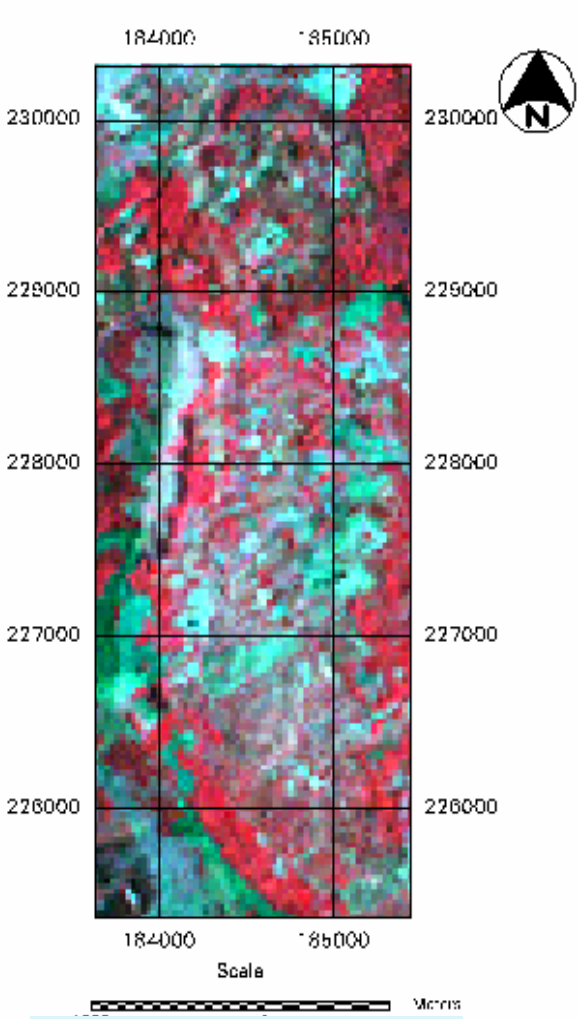
FCC are important to identify areas

Useful for change detection

Results contd.

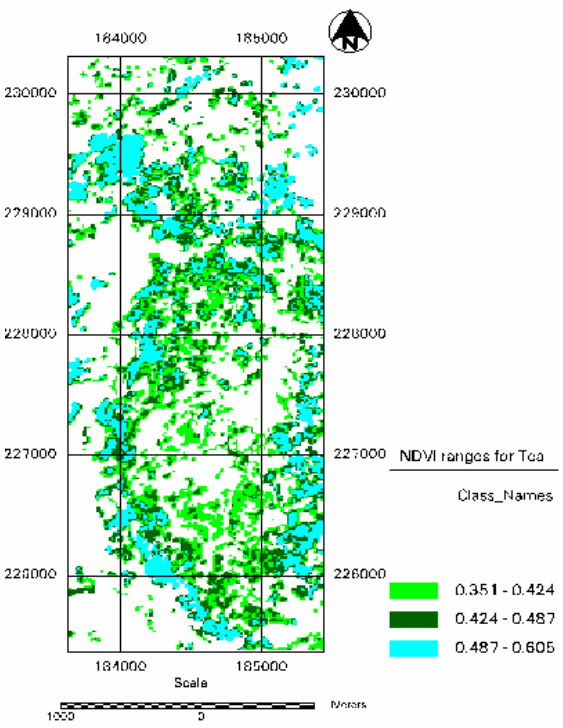


Aster 2003

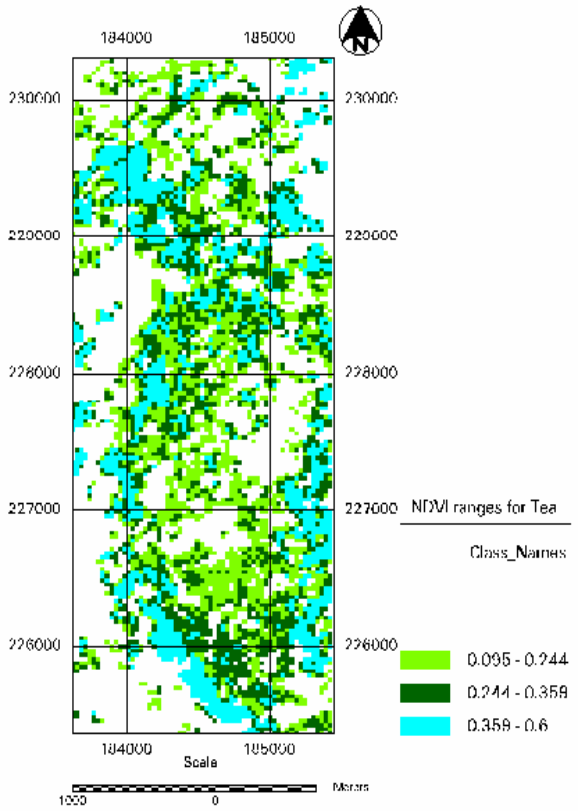


LandSat 2001

NDVI

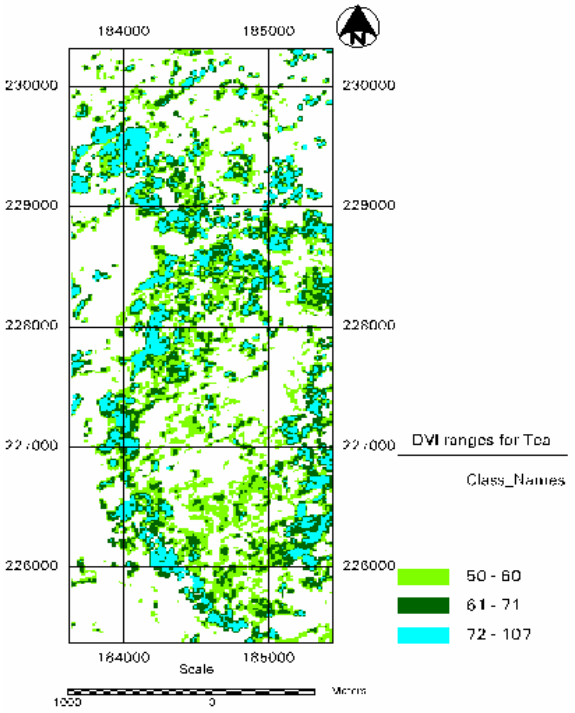


Aster 2003

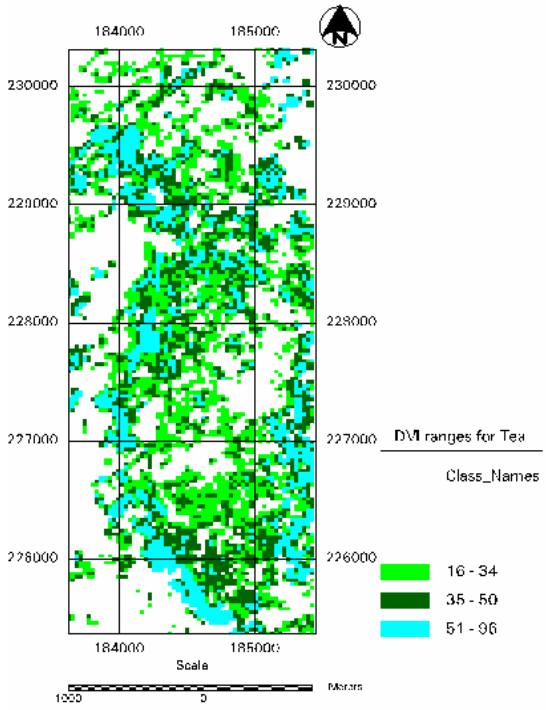


LandSat 2001

DVI

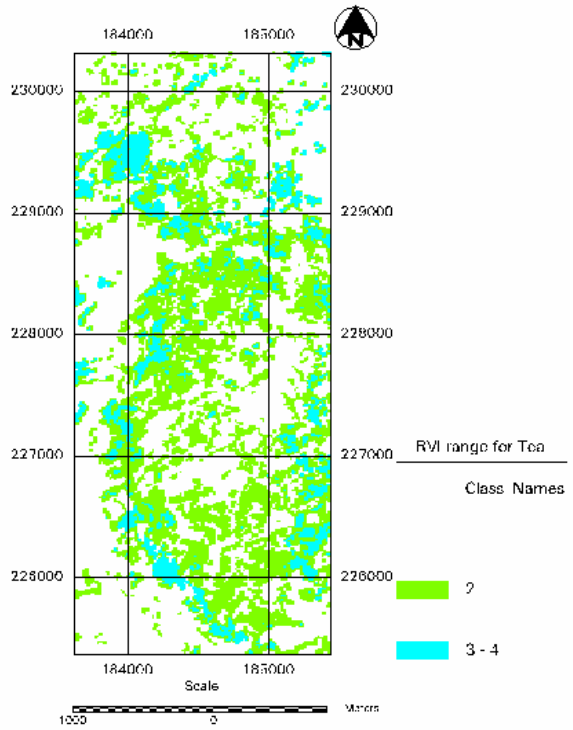


Aster 2003

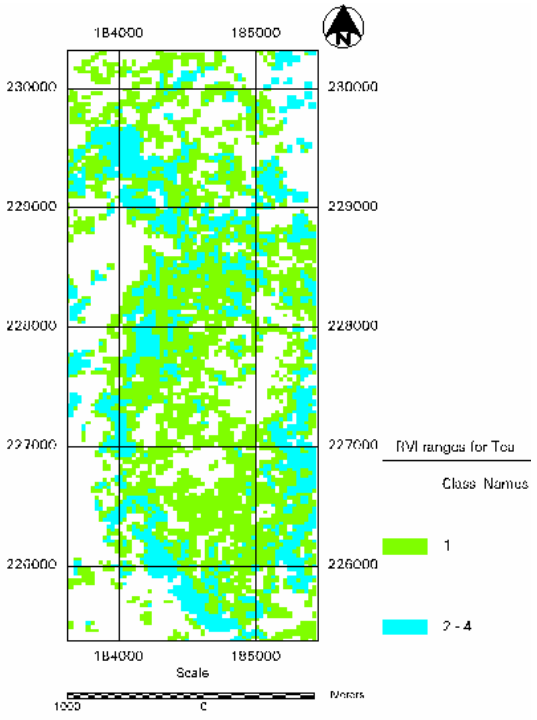


LandSat 2001

RVI

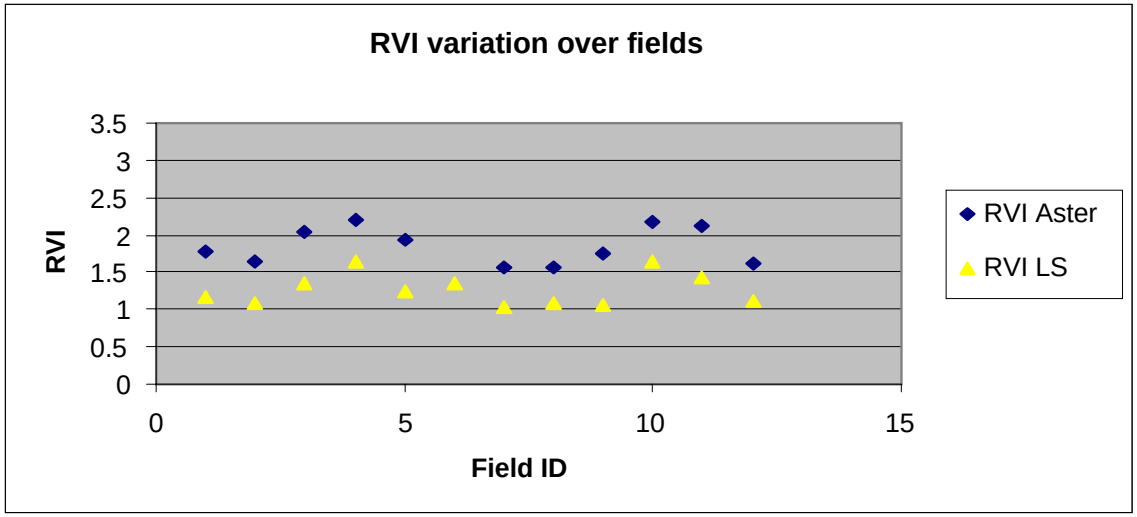


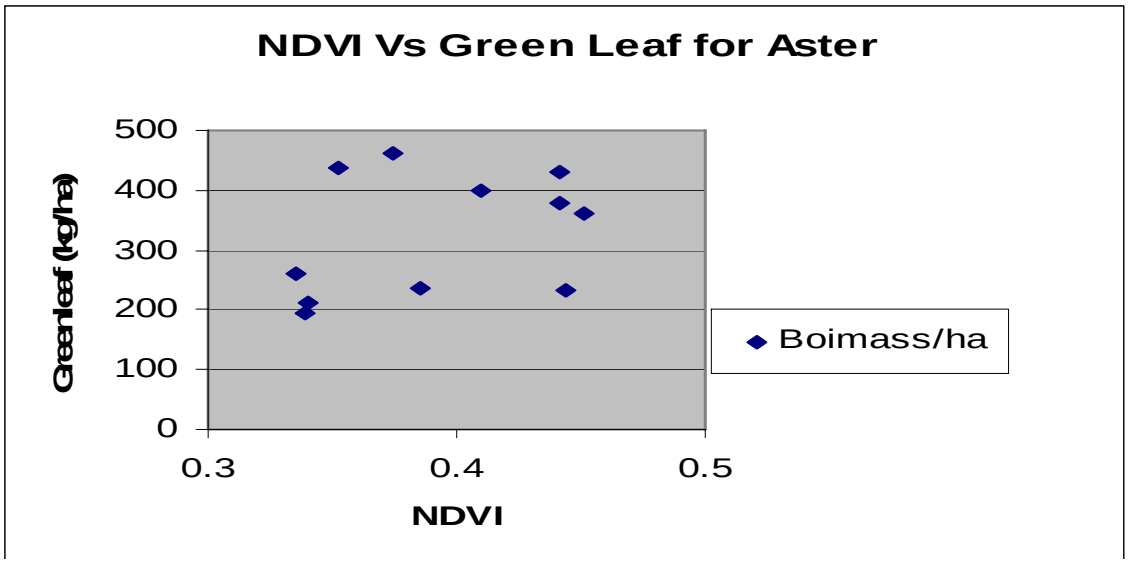
Aster 2003



LandSat 2001

VI Variations

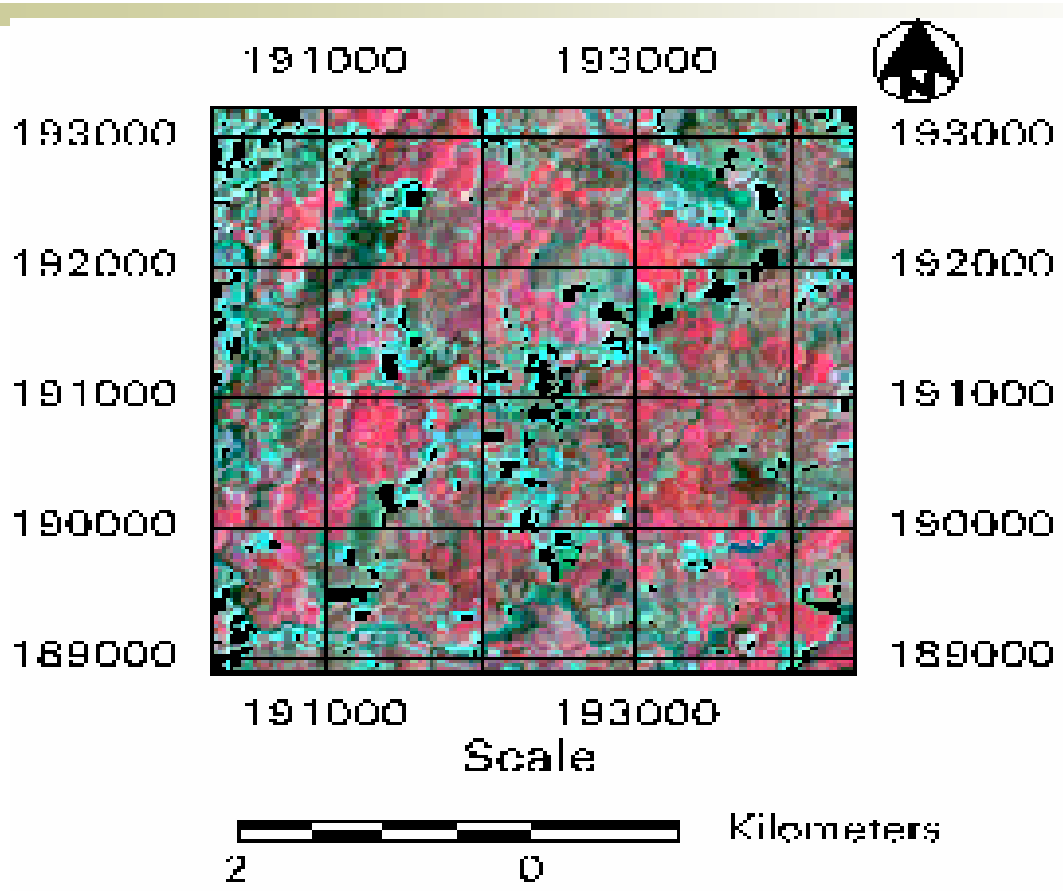




NDVI – DVI

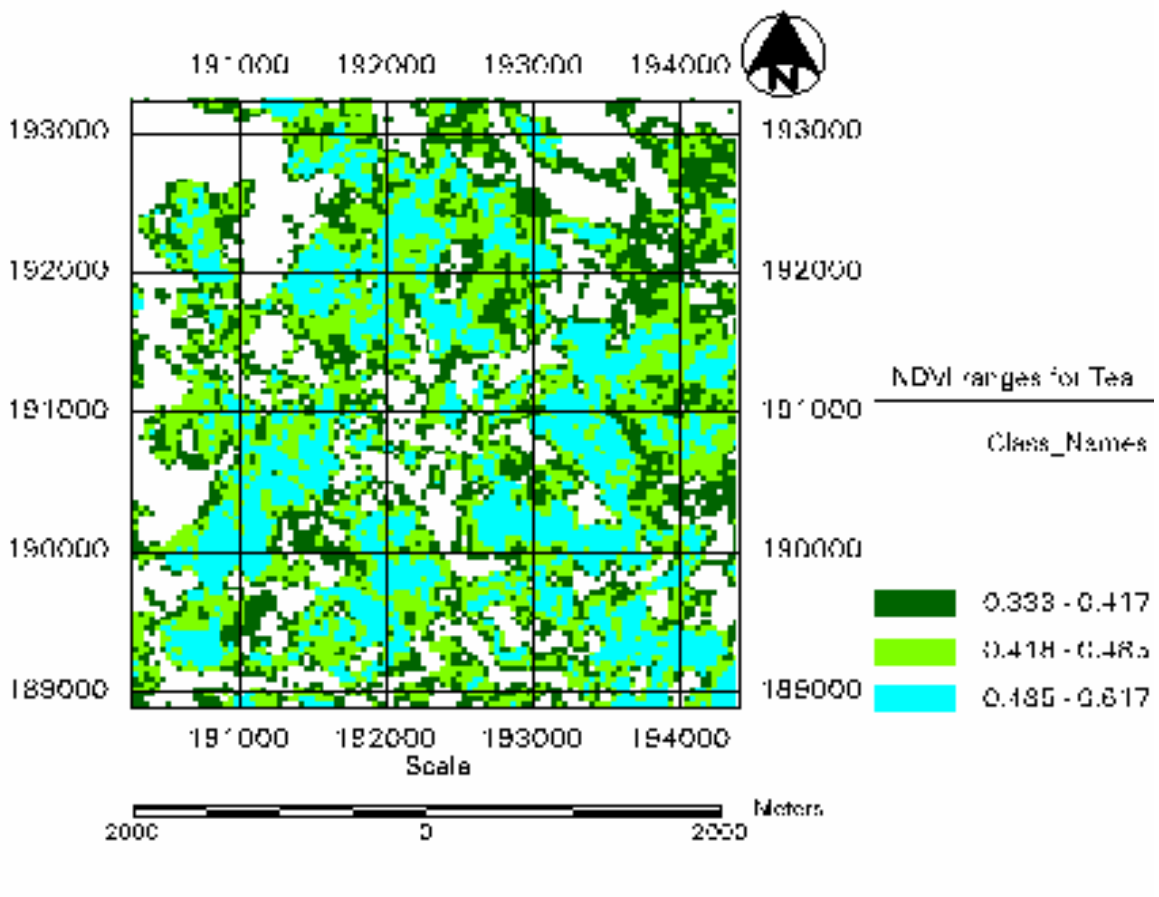
R^2	ASTER	LANDSAT
NDVI	0.1224 0.0179	0.1901 0.1903
DVI	0.0687 0.0033	0.1833 0.1826
RVI	0.0873 0.0111	0.1953 0.1968

St Coombs estate Thalawakele



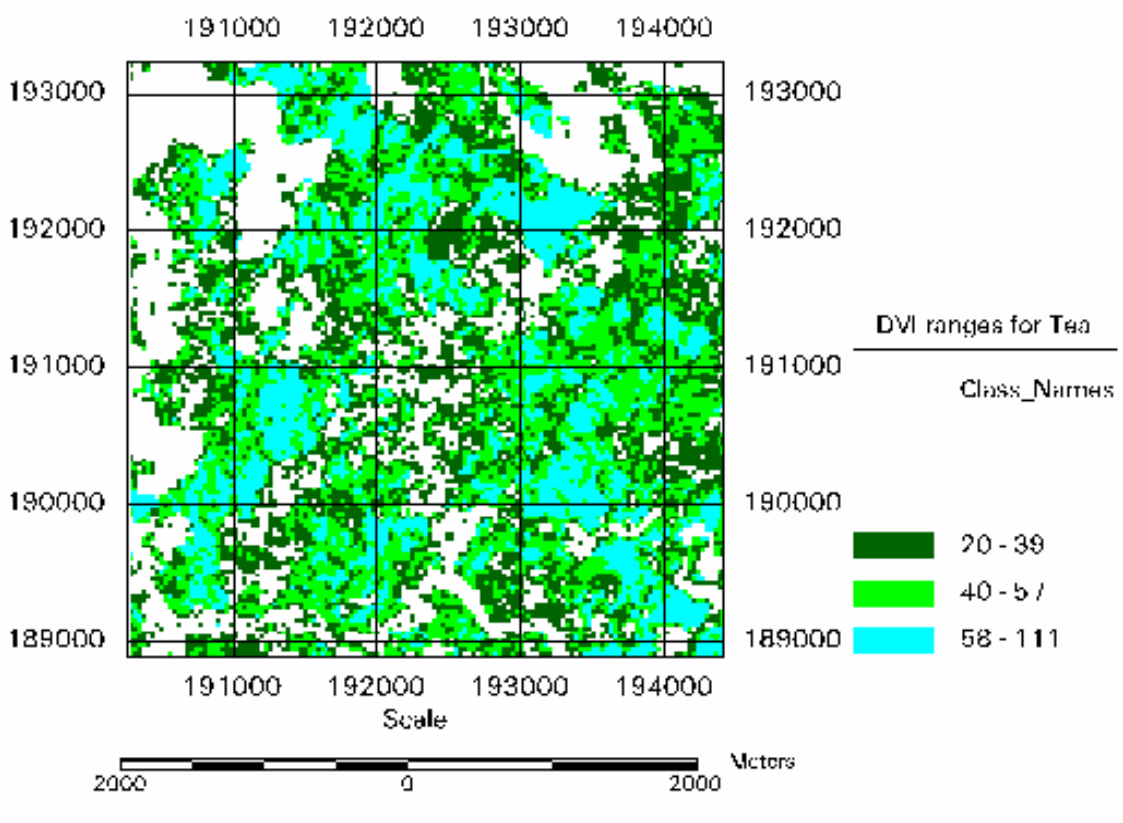
Landsat 2001

NDVI



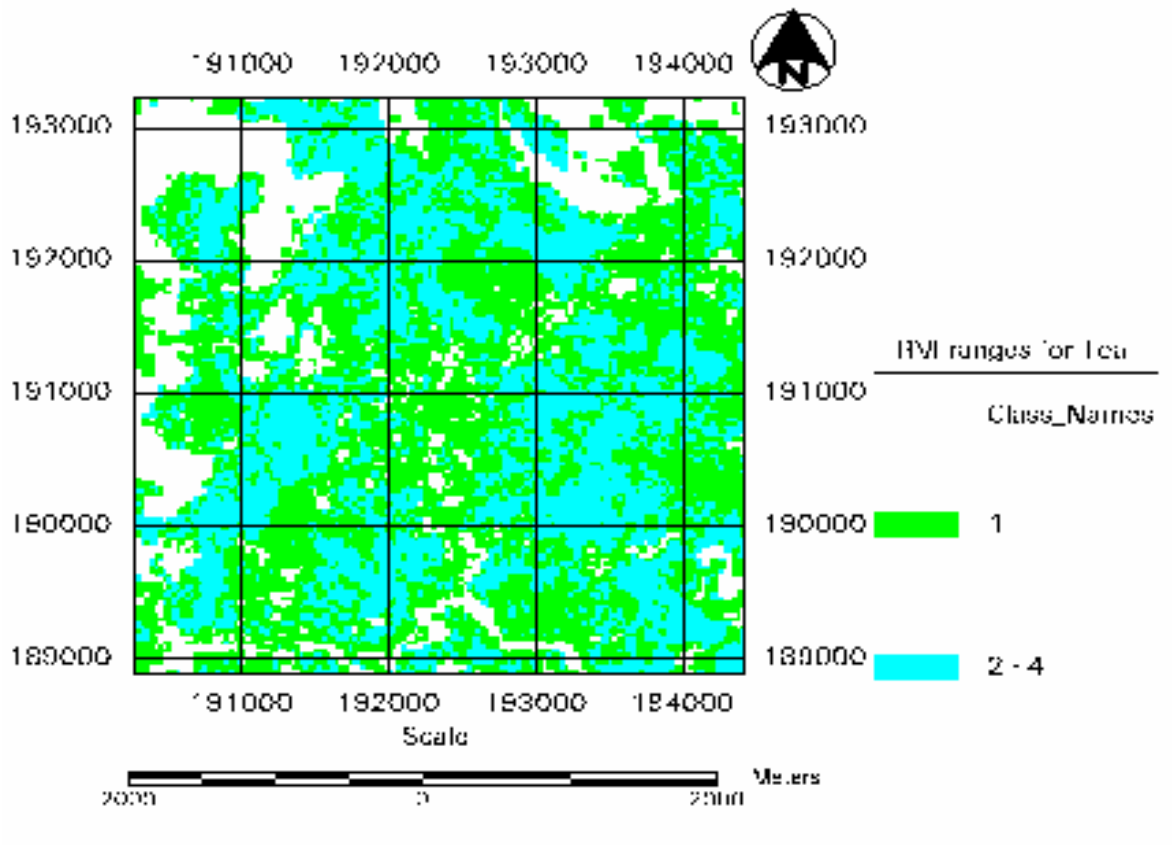
Landsat 2001

DVI



Landsat 2001

RVI



Landsat 2001

Conclusions

- Thermal band detected the clouds and shadow precisely. It does not confuse with other ground objects as cloud.
- Thermal band can detect large clouds as well as thin clouds
- Kriging for filling out cloud area perform better and low spatial complexity under cloud area.
- Regression model does not perform better than kriging method for filling out missing information caused by cloud and shadow

Conclusions

- NDVI and DVI show similar representations of tea biomass.
- Variation of biomass of tea is reflected in different categories in NDVI, DVI and RVI maps.
- There’s no significant correlation between vegetation indices and tea yields / plucked green leaf.
- It was not possible to identify any effect of spatial resolution on determining these relationships.
- Higher the spatial resolution narrower the range for vegetation indices.

Conclusions

- In Thalawakale the biomass cover is not changed very much in 1992,1998, 2001.
- Up country tea gives higher VI values than mid country representing dense cover of vegetation.

Thank You