Power Potential from Biomass

Generation of National Biomass Resource Atlas of India

… An Overview

The Theme of the Work

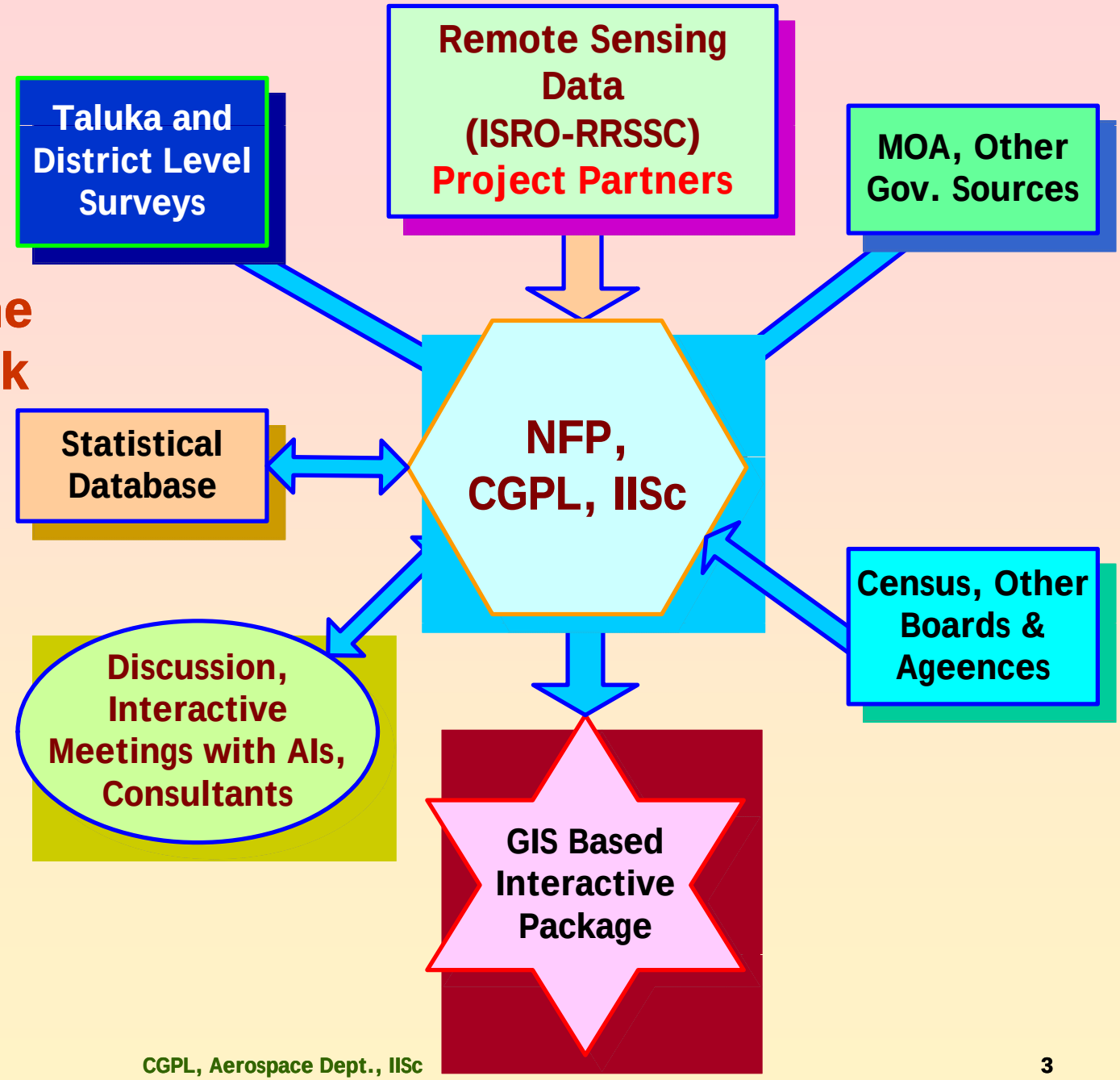
To develop an electronic atlas of India for excess biomass to enable obtain local power potential

Partners:

- Ministry of Agriculture (MoA, GOI) – their data base
- RRSSC (Regional Remote Sensing Centers of ISRO)
- Consultants and Apex Institutions appointed by MNES, GOI
- Other institutions like Coir Board, Agricultural Universities, etc

IISc – National Focal Point for acquiring, assessing and processing the data from various sources into digital maps on a GIS format to be used by industrialists, planners and others

The Scheme of the Work



The Key-Aspects of the Work:

1. The Statistical Data Analysis and Compilation.
2. Graphical vectorisation for the base GIS layers.
3. Integration of remote sensing data into GIS layers.
4. Strategies for crop identification – use of NDVI (Vegetation Index) and AI (Artificial Intelligence) techniques.
5. Create a strategy for stand alone use for a variety of users
6. Provide options for dynamic queries with graphical or tabular outputs

- At the time the work was taken up (about 3 years back) most of the designers of such packages used GIS platforms such as Arc-Info, GeoStation, etc. These software groups offered expensive solutions, especially for the re-distribution.

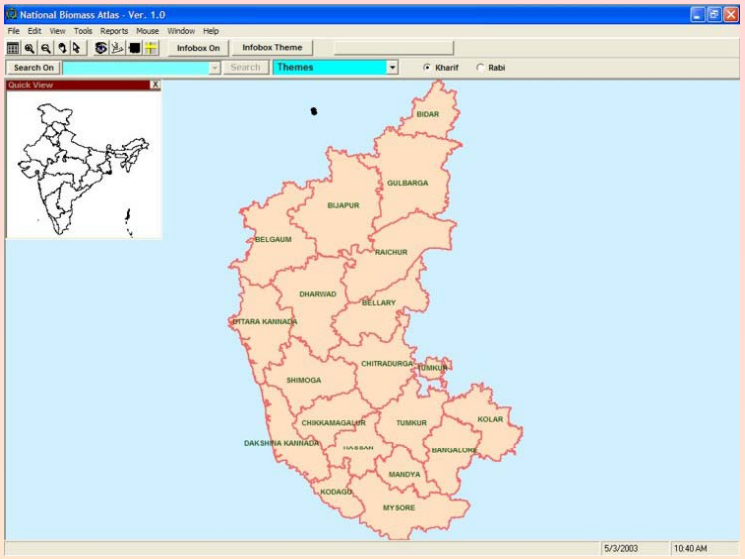
- In an alternative, a more competitive software from France “GeoConcept” was used for the GIS tools and the data and graphic information in a stand-alone mode.

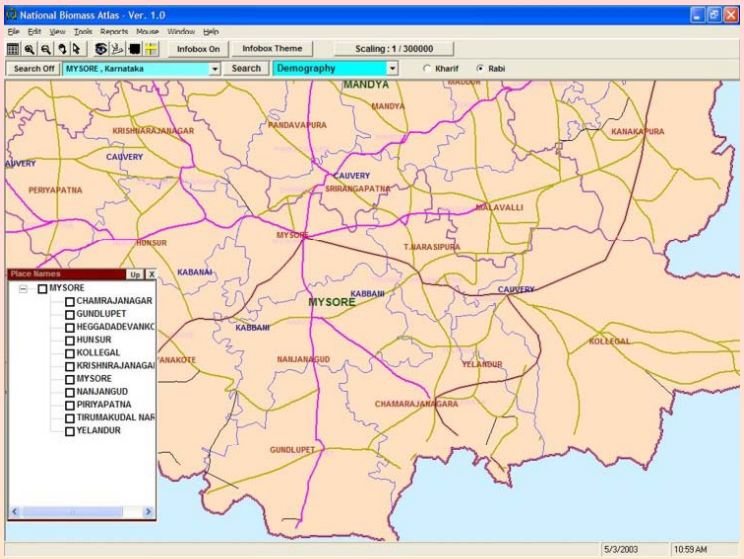
- To manage the envisaged electronic atlas, new tools were developed with Visual Basic and used to provide the complete user interface.

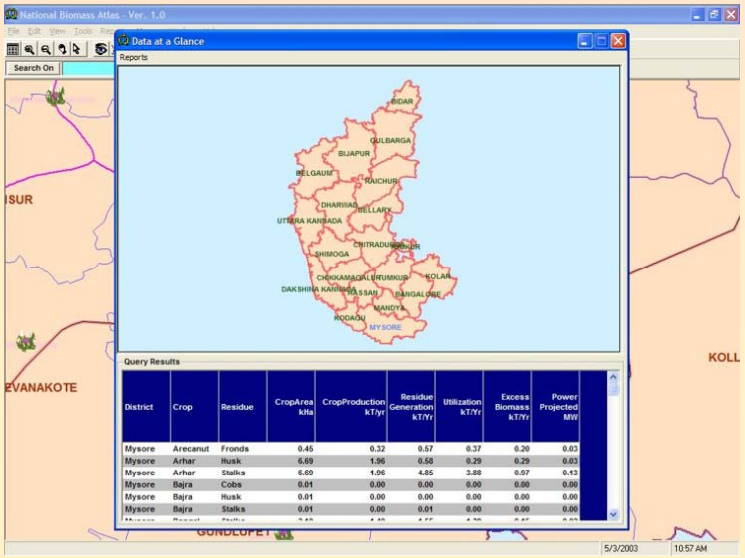
The Main Features of the Package

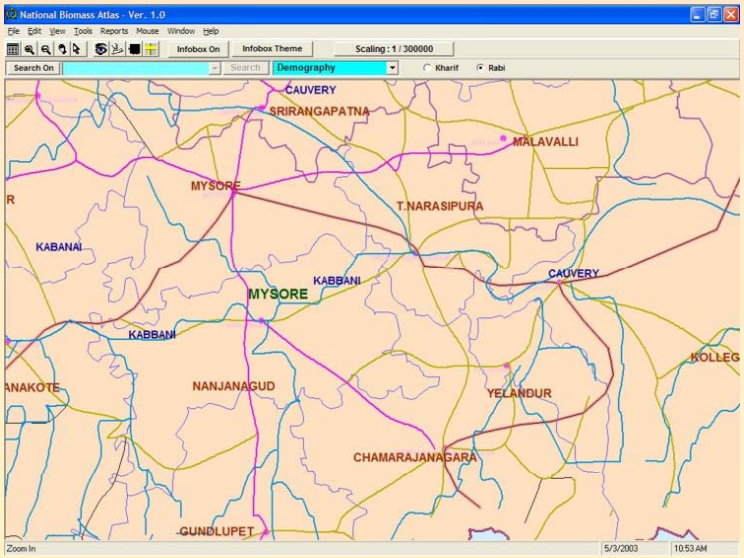
- Statistical Data on crops, residues and estimate of surplus residues taking account of the socially essential usage are embedded as dynamic data.
- About 40 crops all over the country, several of them having multiple residues are accounted for.
- In a quick summary, 540 million tons/year of residue leading to an excess of 120 to 140 million tons/year with power potential of 15,000±1000 MWe is estimated having a scope of distributed generation in 1–6 MWe range.
- Users can obtain the data from the Atlas, the nature of crops, residues, power potential of each district over the country and also the estimate for the talukas.

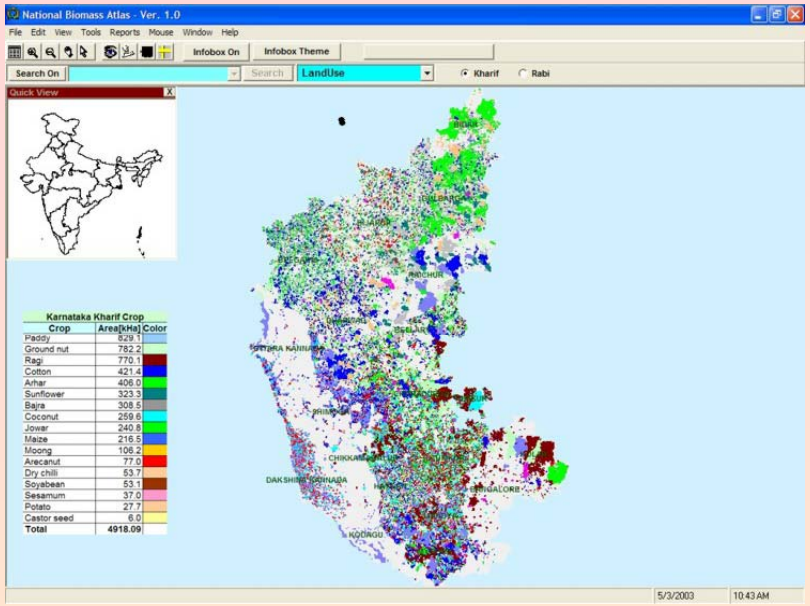
Samples of the Views:

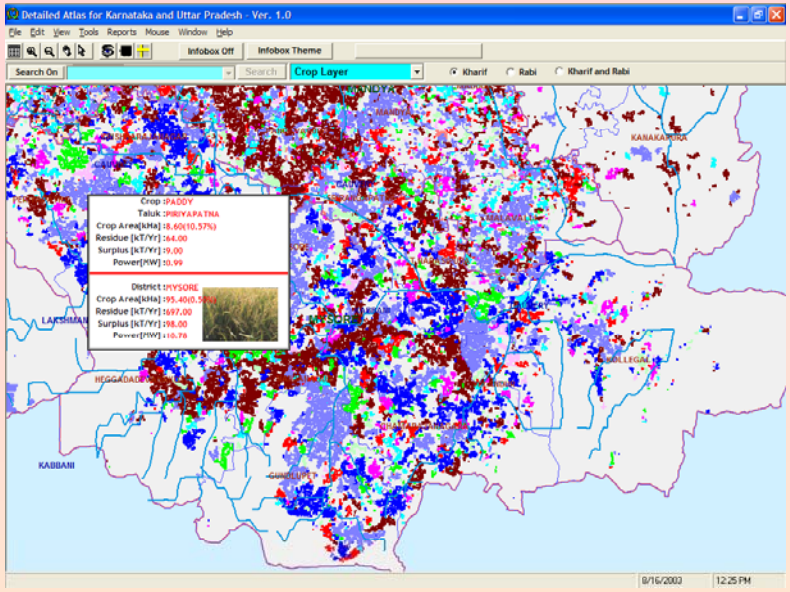


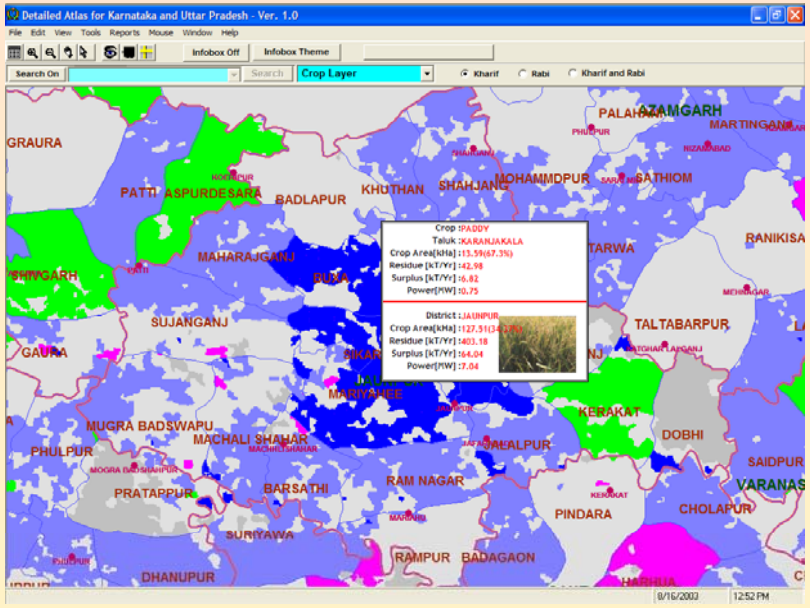


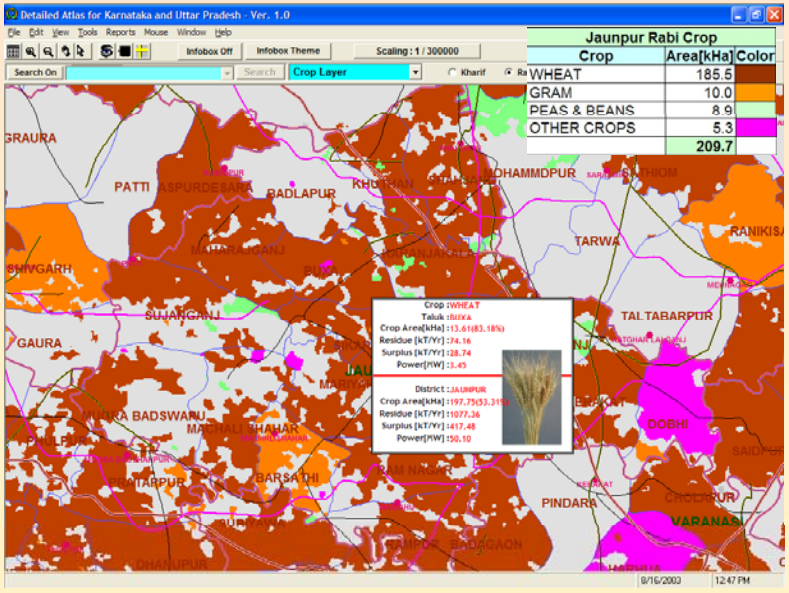





National Biomass Atlas - Ver. 1.0
Karnataka Kharif Crop
Crop | Area[kHa] | Color
Paddy 829.1
Ground nut 782.2
Ragi 770.1
Cotton 421.4
Arhar 406.0
Sunflower 323.3
Bajra 308.5
Coconut 259.6
Jowar 240.8
Maize 216.5
Moong 106.2
Arecanut 77.0
Dry chilli 53.7
Soyabean 53.1
Sesamum 37.0
Potato 27.7
Castor seed 6.0
Total 4918.09


Detailed Atlas for Karnataka and Uttar Pradesh - Ver. 1.0
Crop Layer
KABBANI
9/16/2003 12:25 PM


Detailed Atlas for Karnataka and Uttar Pradesh - Ver. 1.0
Crop Layer
GRAURA
PATTI ASPURDESARA
BADLAPUR
KHUTHAN
SHAHJANG
MOHAMMDPUR
SATHIOM
MAHARAJGANJ
SHIVGARH
SUJANGANJ
GAURA
TALTABARPUR
KERAKAT
DOBHI
PHULPUR
PRATAPPUR
BARSATHI
RAM NAGAR
PINDARA
CHOLAPUR
SURIYAWA
RAMPUR BADAGAON
DHANUPUR
9/16/2003 12:52 PM


Detailed Atlas for Karnataka and Uttar Pradesh - Ver. 1.0
Jaunpur Rabi Crop
Crop | Area[kHa] | Color
WHEAT 185.5
GRAM 10.0
PEAS & BEANS 8.9
OTHER CROPS 5.3
209.7
GRAURA
PATTI ASPURDESARA
BADLAPUR
MOHAMMDPUR
TARWA
SUJANGANJ
GAURA
TALTABARPUR
DOBHI
PINDARA
9/16/2003 12:47 PM

The Envisaged Project Theme

- **To develop a electronic master document to give an estimate on the Biomass Resources and its potential for Power Generation to be used by:**
  - **Energy Consultants**
  - **ESCOs & Entrepreneurs**
  - **Administrators & Financial Organisations**
- **To enable the Ministry to have a controlled distribution of the packages developed:**
  - **The detailed atlas with a taluka level assessment on CDs with a PC as the target.**
  - **A more accessible, still controlled distribution on internet for quick look and with less details.**

The Project – Main Phases

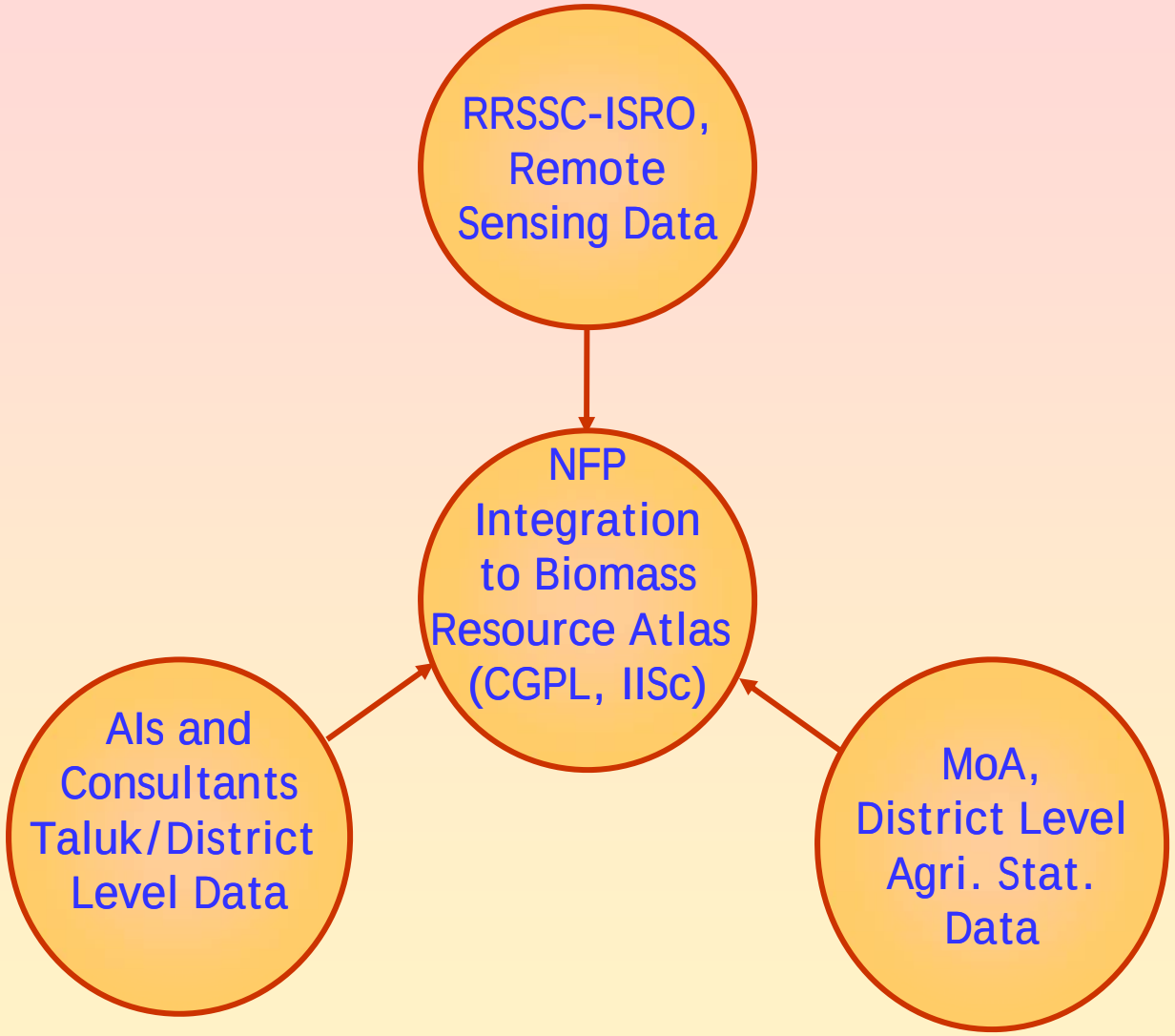
The project was split into two phases:

- **Phase I – to develop the PC based (non-internet) interactive application introducing the remote sensing data for estimate of the biomass produced, in association with RRSSC-ISRO for the satellite image analysis. This phase is currently active.**
- **Phase II – develop the internet based application by adapting the stand-alone application to it and incorporate it in association with NIC for deployment and maintenance of the internet site. This phase is yet to be taken up.**

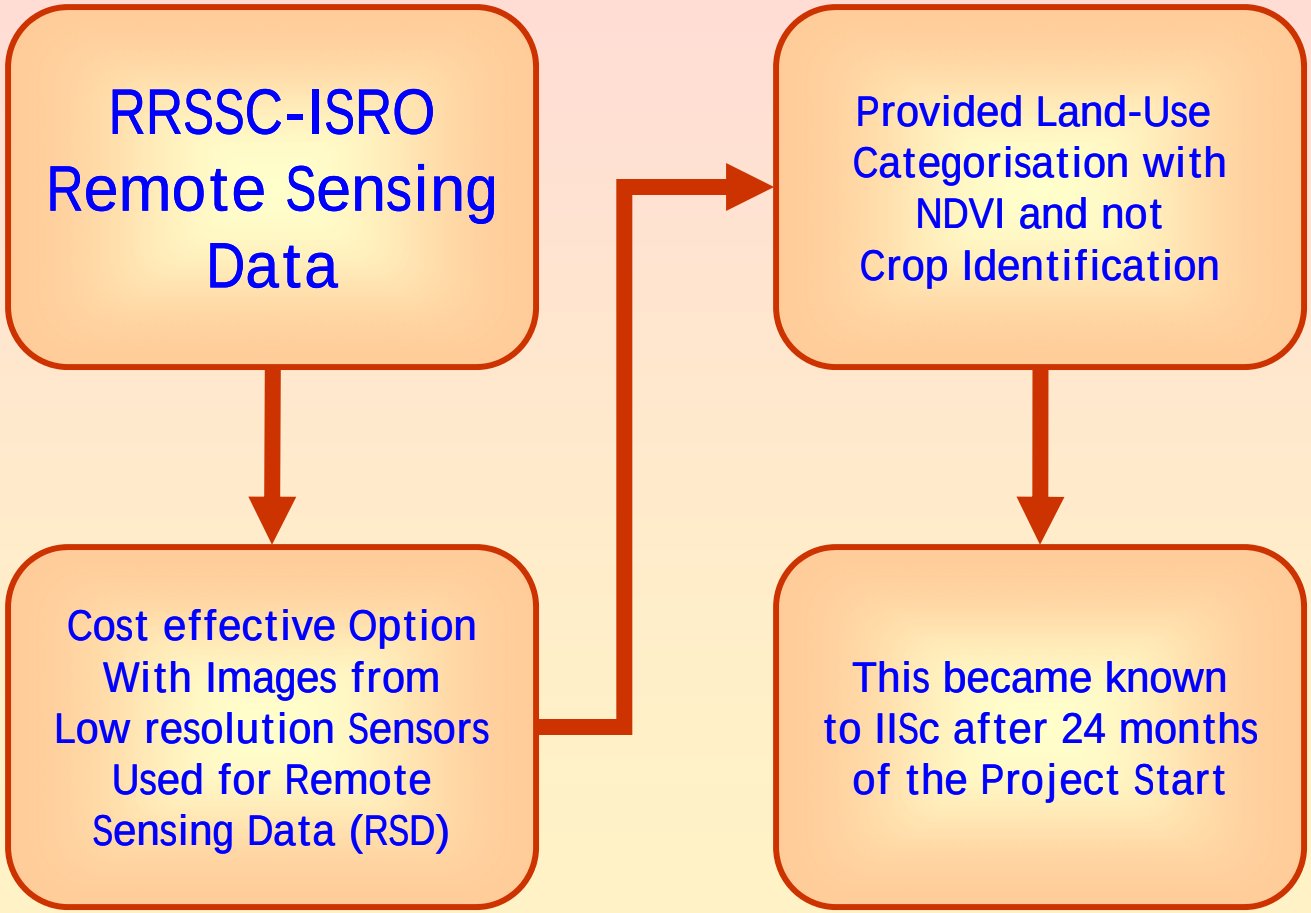
Main Achievements of the Project

- **A method of seamless integration of the data from all essential sources to generate a single electronic document to be used as biomass resource atlas, is developed and demonstrated.**
- **Methods for Crop Identification from land-use data from remote sensing data and for deriving coefficients from survey data for obtaining assessment of biomass resource spatially are developed and used.**
- **A Method for retaining taluka as the lowest boundary is developed using the data available at district the level.**

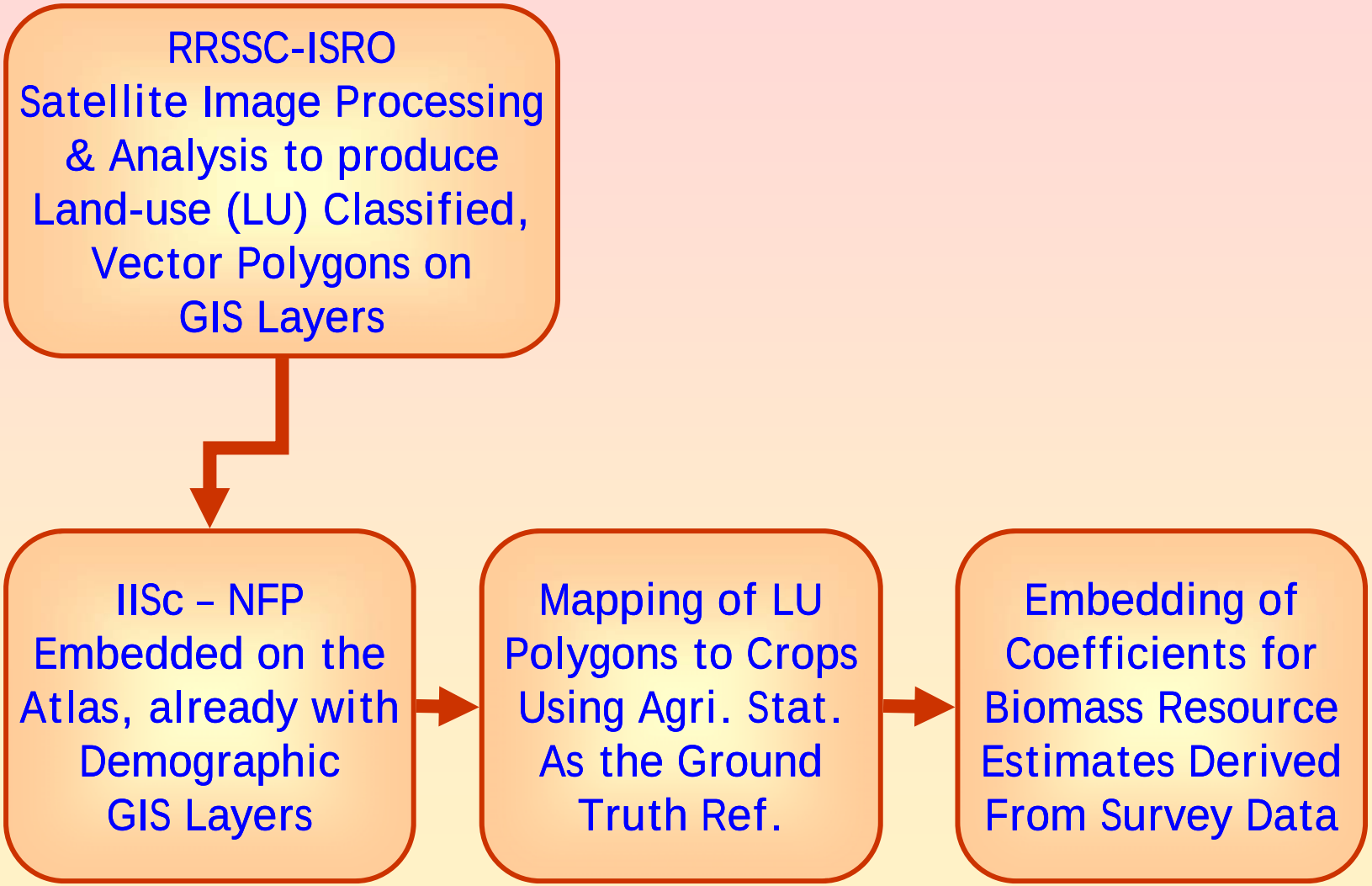
An Overview of the Project Interactions



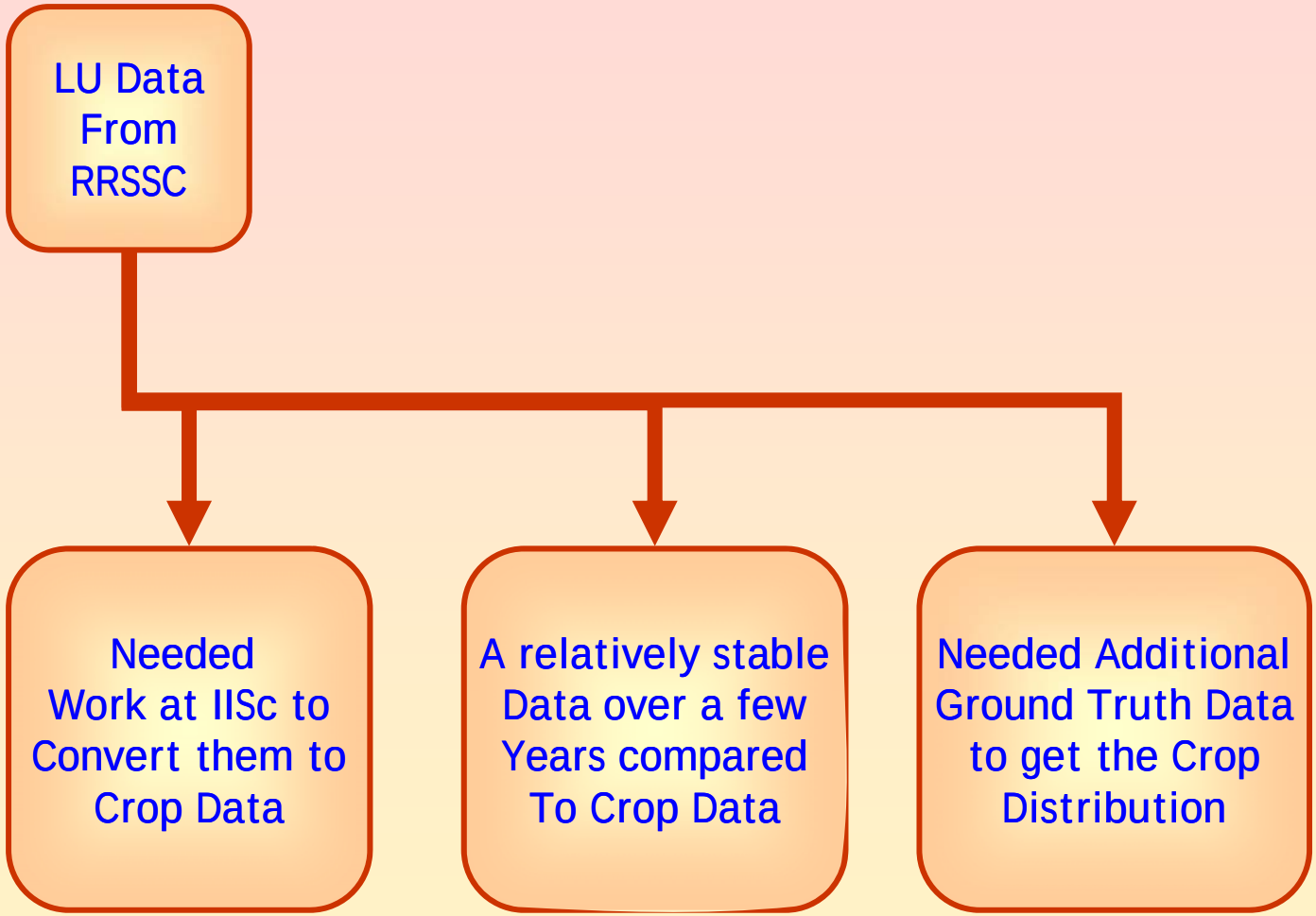
The Project Events (... Contd)



The Project Events (... Contd)



The Project Events (... Contd)



Strategy Used by IISc on LU Adaptation

- To make use of MoA data as the ground truth reference for getting the Crop Distribution from Land-Use polygons – successfully adapted.
- To allow for usage of the same LU Data for subsequent years, as long as the area under the agricultural activity in the selected zone remains roughly same – a feature likely to be true in general. Otherwise updating is required.
- To explore optimisation of other available parameters like NDVI and Rainfall Data to enhance the reliability of the crop distribution – a research concept tested to be satisfactory in selective cases and is in the process of being adapted

An Overview of Project Efforts

- **The polygons handled is in the range of 0.01 – 0.5 million per state, depending on their heterogeneity in the crop distributions.**
- **About 25 main and 300 sub-layers created and used in the GIS domain.**
- **About 400 modular tools developed in-house (amounting to about 0.1 million lines of code) and used during the development.**
- **The typical computer time required for completing the crop analysis and embedding other derived data for a district with about 20,000 polygons is 12-18 hours on a high-end PC (2.8 GHz P4 based with 3 GB RAM). Consequently a state with about 20 districts takes about 2-3 weeks of "production" runtime.**

An Overview of Project Efforts (... Contd)

- **Increasing computational speed is obtained by processing GIS layers by re-grouping graphic objects of same parameters within a taluka boundary; this enhances the response time by 10 to 100 times (this large range is due to the complexity of the polygons).**
- **Reduction of polygons helps in producing a "user" version that can be handled easily with entry level computers.**
- **Tools are developed to analyse and derive coefficients from the survey data, with enhancements in reliability and consistency to be used for estimation of the biomass residue generation, utilisation and potential for power generation and to embed them suitably in the GIS layers for spatial representation and query responses.**

An Overview of Project Efforts (... Contd)

- About 250 man-months over a period of 4 years have gone in, so far.
- Of the project funds received, the expenditure pattern is - about 60% for man-power, 20% for hardware system upgrades, 10% for software tools.

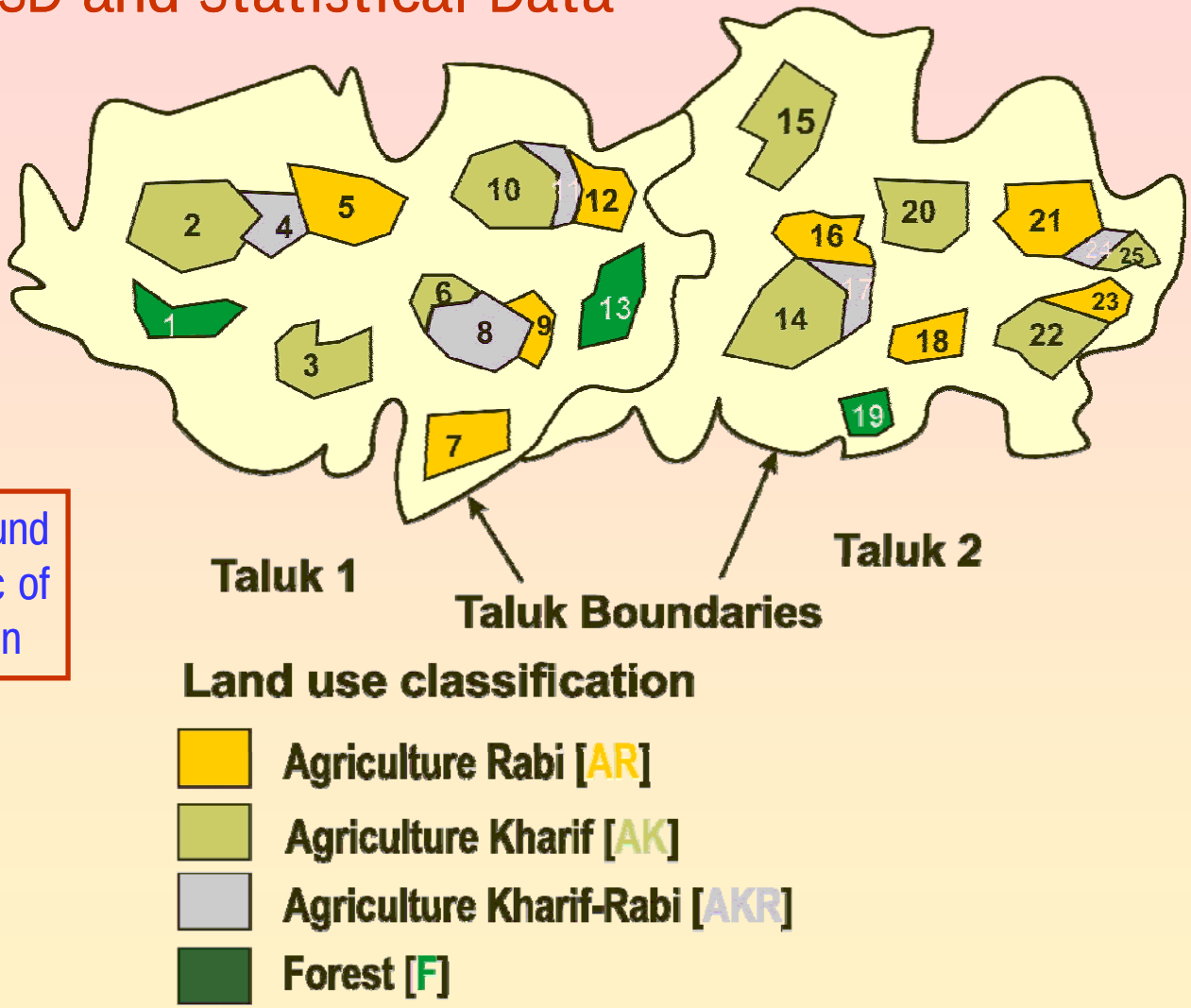
The Package Development

The Main Tool Developed

- Crop Mapping: A tool has been developed to embed the derived information that match the Statistical Data as the ground reference to the Land-Use and thereby mapping the crops accordingly. Results show that the method is successful in providing a statistically agreeable and spatially resolved data, with error levels below 10-20% depending on the composite nature of the crops. This tool has worked satisfactorily in resolving the data spatially in to the taluka level, as contemplated.

Present Method of Obtaining Crops Distribution from Land Use maps from RSD and Statistical Data

[RSD (Land-Use) + Ground Truth (Stat. Data)] >> Logic of Analysis >> Crop Distribution



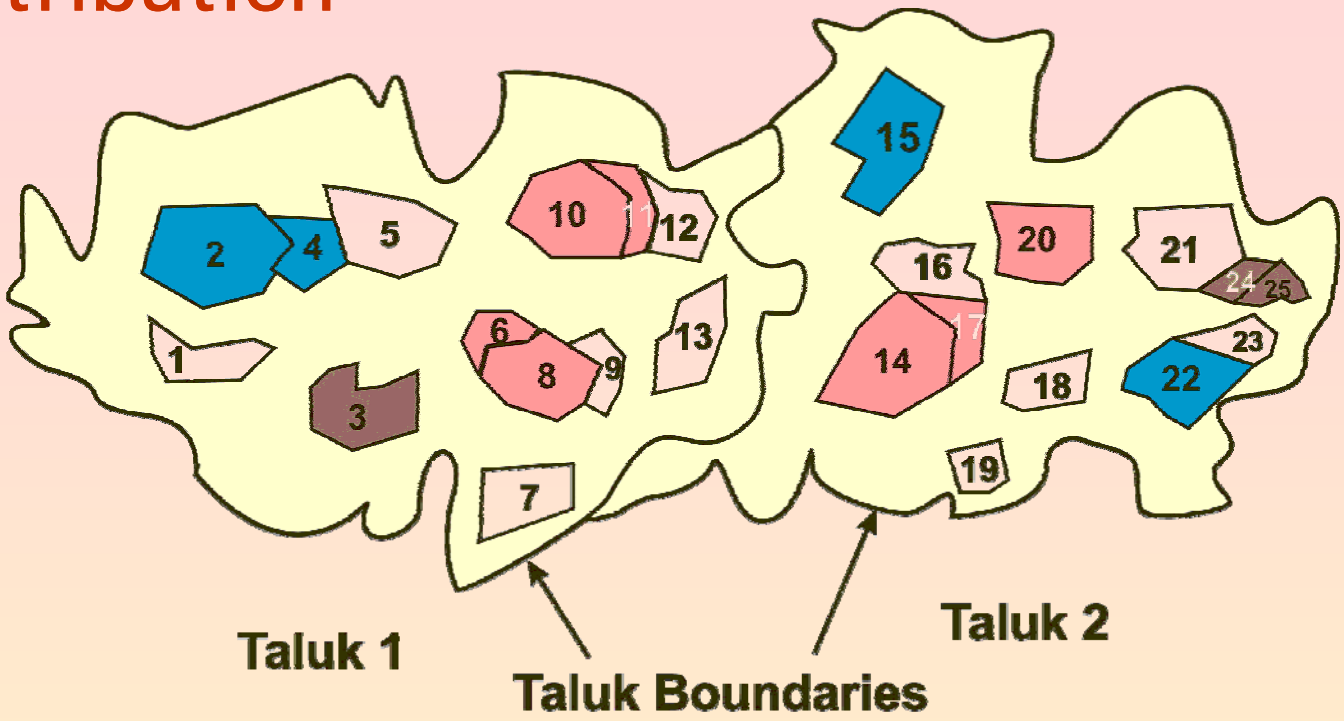
Logic Used to Map Crop Distribution

1. The areas from the land-use and the statistics are arranged in their descending order.
2. The two areas are associated in this order, keeping track of differentials each time and carrying them over for the next.
3. The associated areas are fine-tuned with differentials arranged in a fractionally proportional distribution.
4. The polygons are attributed with the appropriate crop names based on the above selections.
5. The crop areas are retained with their seasonal attributes.
6. The data accuracy is conserved at the district level.

Codified Procedure

- AI based on Fuzzy Logic is adopted in the first 4 steps (for arranging the crop areas) and steps 5 & 6 use the earlier logic.
- The result also provides a spatial distribution of the crops under taluka level.
- The results of this can be seen in the package developed.

Crop-Distribution



Land-Use Polygons Mapped to Crops

Crop classification

- Jowar
- Paddy
- Other Crops
- NA

Tool Development (...Contd)

ii. Automated Thematic Colour Management: The software tool designed provides an option for deployment of non–repetitive colours to crop polygons and an option to manually fine-tune them. A very useful tool in generating a consistent crop-mapping in the layers across the states.

iii. Embedding NDVI and RF Data: In an attempt to enhance the reliability of the crop-mapping, the analysis layer is embedded with both NDVI and RF over the land-use classification. The resulting fields would be queried with the enhanced ground-truth data in the backdrop and this approach is expected to enhance the reliability of the crop mapping.

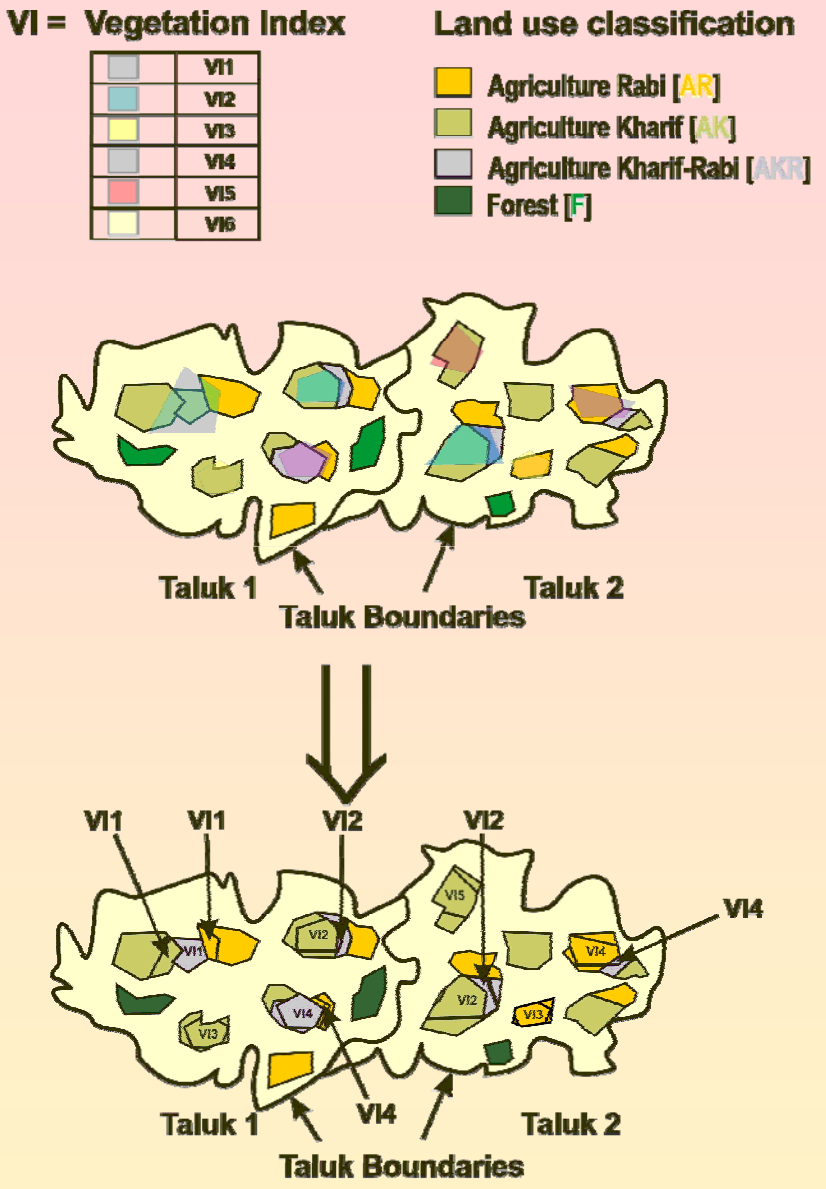
iv. Advantage: Though the approach is resource and time demanding, it provides a superior estimate of crop distribution.

Enhancement to the Present Crop-Mapping Method (add-on NDVI)

Land use & NDVI layers >>

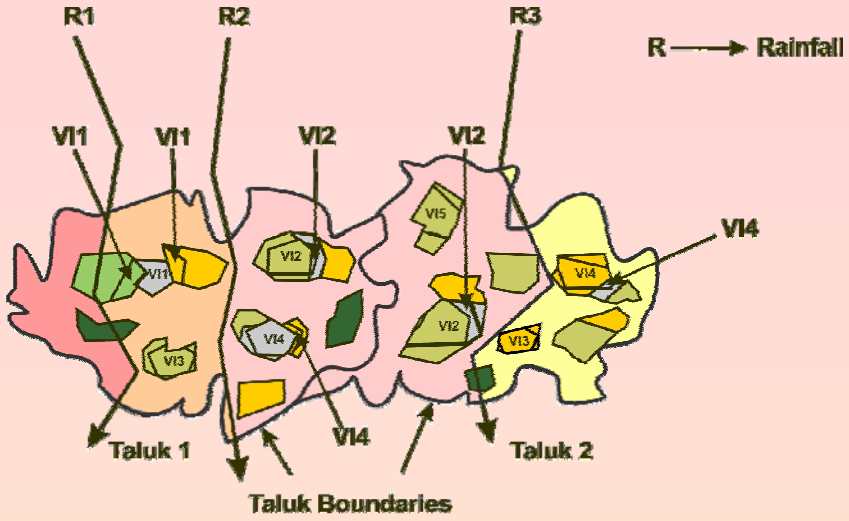
Vegetation-Vigor Embedding

Polygons with Veg-Vigor >>



Note: NDVI stands for Normalised Differential Vegetation Index

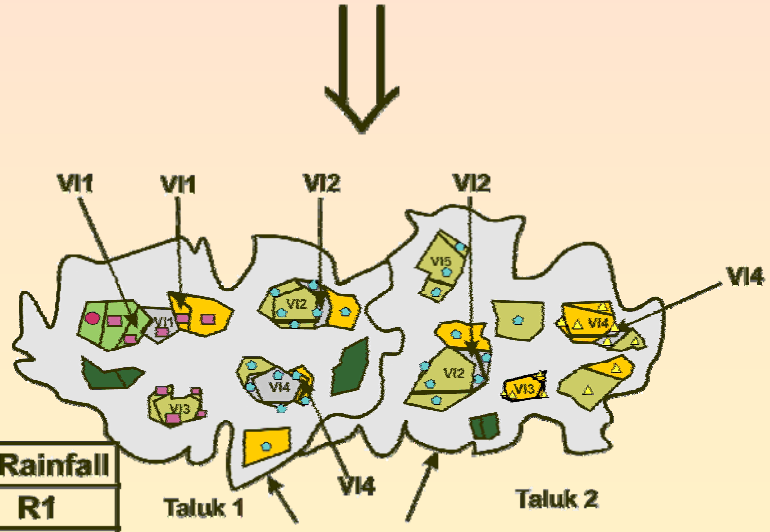
Enhancement to the Present Crop-Mapping Method (add-on RF)



Rain fall contours & >>
Land-Use Polygons
With Veg-Vigor (NDVI)

Rainfall Data Embedding

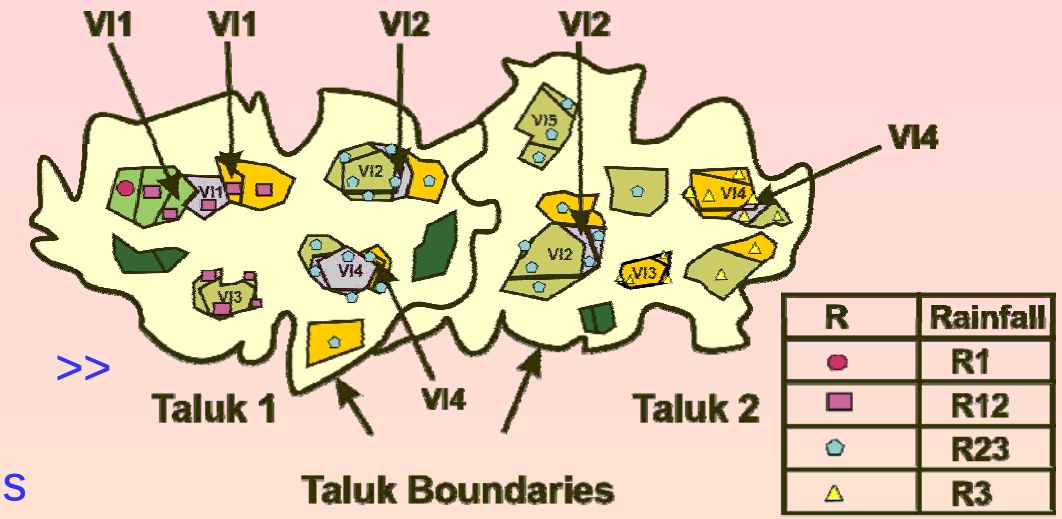
Rain fall & Veg-Vigor
Embedded in
Land use Polygons >>



R	Rainfall
●	R1
■	R12
⬟	R23
△	R3

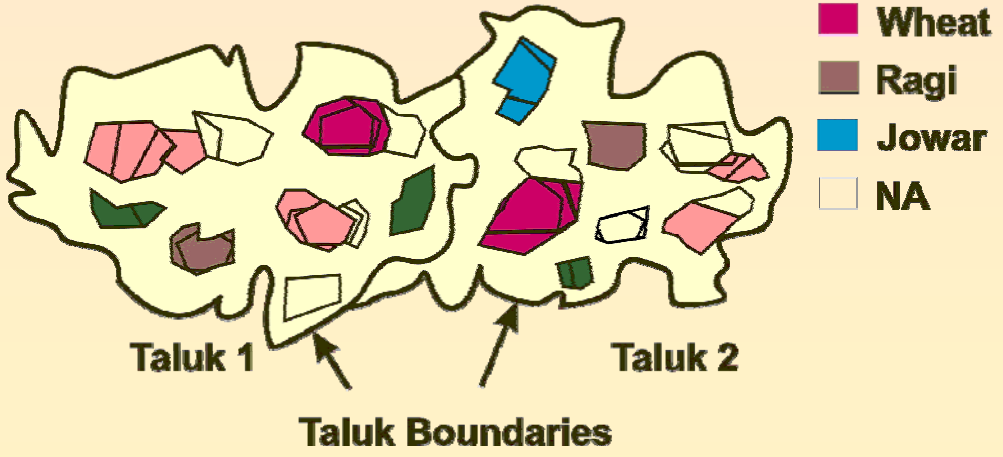
Enhancement to the Present Crop-Mapping Method (Combined)

Rain fall & Veg-Vigor Embedded in Land use Polygons >>



Resulting Crop Distribution

Crop distributed Polygons >>



Tool Development (...Contd)

iii. Polygon Re-Grouping for a Quicker Screen Display: This tool was developed to improve the system resource management of the Atlas. Since large number of polygons brings down the system response drastically, it was essential to group the polygons of one crop within a taluka boundary after the analysis. This approach, on the trial has enhanced the system response significantly without loss of accuracy of the query parameters.

The Current State of the Work

- Eight states have been integrated fully. They are - AP, Karnataka, Kerala, Orissa, Punjab and UP. Work for about eight more states is nearing completion.
- North Eastern States need more time for RRSSC due to the cloud cover they are encountering in getting the correct data.
- The District Survey Data are provided with a new set of guide-lines focusing the study on the Biomass Utilisation.
- Options are provided for adding on data from MoA and other agencies on the crop production. Biomass utilisation and projected power potential derived are brought out and shown spatially.
- Options are provided for inclusion of data with value addition to the package.

Current Status ...

The first phase of the development of Atlas for the entire country has just been completed and the integrated data and the computer package is undergoing verification. This stand-alone application (computer package) can be distributed in about 4 to 6 months from now.

The second phase development for web based application is under development. This development has been completed for a few states of the country now. It takes about 18 to 24 months from now in completing this work for the entire country. This developed web package would be hosted at NIC, GOI or using any other options that MNES may consider at the time of deployment.

During the first phase of development, the satellite based remote sensing data (RSD) with lower resolution obtained from RRSSC (ISRO) and data sample studies conducted by consultants at taluka level have been used.

The second phase makes use of higher resolution RSD and survey data at district level from consultants for different states.

Both the phases use statistical data from MoA and agencies like coconut board, coffee and tea boards and few others.

A Look At The Biomass Atlas Being Developed In Its Current Stage

A Conservative Estimate of Biomass Resources in the Country and the derived potential for power generation from it

State	Geo-graphic Area (MHa)	Crop Area (MHa)	Surplus Agro-Biomass[1] (MT/Yr)	Agro Biomass Based Power Potential[2] (MWe)	Waste Land[3] (MHa)	Woody Biomass[4] (MT/Yr)	Woody Biomass Based Power Portential[5] (MWe)	Total Biomass Power Potential (MWe)
Andhra Pradesh	27.5	12.0	7.1	830	2.8	19.5	2,728	3,558
Arunachal Pradesh	8.2	0.2	0.1	7	0.9	7.4	1,031	1,039
Assam	7.9	3.2	1.9	214	0.7	5.3	740	954
Bihar	9.4	7.1	5.7	655	0.4	3.2	449	1,104
Chattisgarh	13.5	4.5	1.3	150	1.7	11.8	1,646	1,796
Gujarat	18.6	8.4	7.4	916	4.8	33.6	4,704	5,620
Haryana	4.4	4.9	7.5	884	0.3	1.9	263	1,147
Himachal Pradesh	5.6		0.0	0	0.9	7.2	1,009	1,009
Jammu Kashmir	22.2	0.8	0.5	59	6.9	55.2	7,725	7,783
Jharkhand	8.0	1.9	0.9	106	1.6	12.4	1,740	1,846
Karnataka	19.2	8.9	6.9	859	1.5	11.4	1,594	2,453
Kerala	3.9	1.6	4.9	640	0.0	0.3	37	677
Madhya Pradesh	30.8	14.7	8.4	1,059	1.6	13.0	1,821	2,880
Maharashtra	30.7	19.4	13.1	1,711	1.9	12.1	1,689	3,400
Manipur	2.2		0.0	0	0.2	1.5	213	213
Meghalaya	2.2	0.2	0.1	13	0.2	1.8	247	260
Mizoram	1.8	0.0	0.0	1	0.3	2.4	336	337
Nagaland	1.6		0.0	0	0.1	0.5	67	67
Orissa	15.3	5.2	1.9	208	0.1	0.4	54	262
Punjab	5.0	6.9	18.3	2,092	0.1	0.3	39	2,131
Rajasthan	42.7	15.5	10.3	1,289	5.5	20.5	2,873	4,162
Sikkim	0.7	0.1	0.0	2	0.1	0.6	78	81
Tamil Nadu	13.0	10.2	13.7	1,186	0.7	4.4	621	1,807
Tripura	1.1		0.0	0	0.3	2.3	325	325
Uttar Pradesh	24.0	24.1	26.5	3,169	1.6	11.1	1,548	4,716
Uttaranchal	5.4	0.9	0.8	95	0.0	0.1	9	104
West Bengal	8.9	7.9	4.7	563	0.0	0.2	27	590
Total	333.6	158.9	142.0	16,709	34.9	240.1	33,614	50,324