NATURAL RESOURCES CENSUS

NATIONAL LAND USE AND LAND COVER MAPPING USING MULTITEMPORAL AWiFS DATA (LULC-AWiFS)

Eighth Cycle (2011-12)

Remote Sensing Applications Area &
Regional Remote Sensing Centres (West and Central)
NATIONAL REMOTE SENSING CENTER
&
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(V.Raghavswamy)

1. INTRODUCTION

Considering the need for spatial accounting and monitoring of Land Use / Land Cover (LULC) systems of our country and the potential of Resourcesat AWiFS sensor to meet these requirements, National level LULC mapping project has been taken up as a part of NNRMS-DOS programme with the following objective :

> National level LULC mapping on 1:250,000 scale using multi-temporal AWiFS datasets to provide on annual basis, net sown area for different cropping seasons and integrated LULC map at the end of each year starting from 2004-05.

The project so far completed eight cycles of assessment i.e., 2004-05, 05-06, 06-07, 07-08, 08-09, 09-10, 2010-11 and has clearly brought out the temporally explicit spatial distribution of the net sown area on national basis, besides creating spatial databases on other important LULC classes like fallows, plantations, forest, water etc. The present report provides the results obtained during 8th cycle of assessment using 2011-12 AWiFS temporal datasets.

The built-up class of 8th cycle land use / cover product has been updated using DMSP-OLS data. The spatial distribution of crops over meteorological subdivisions was derived and analysed in conjunction with rainfall patterns. Besides all the seven cycles data, the 8th cycle output was also organised in Bhuvan to facilitate easy distribution, value added query and retrieval. It is necessary to mention that there was a growing demand for this data and several users across academia, research organizations, utility sectors, PSUs, etc have requested for LULC data and were provided the requested data through **Bhuvan** FTP facility. The present report provides the results obtained in 8th cycle (2011-12) *Kharif and Rabi* assessment, final Land Use Land Cover statistics vis-à-vis the statistical analysis of 8 cycle area statistics. The following sections deals with the methodology adopted and results obtained during 8th cycle with necessary discussions.

2. METHODOLOGY

2.1 Datasets used

The details of methodology followed were given in Product Realisation Plan as well as project manual. The Resourcesat-2 AWiFS quadrant data sets were procured on monthly basis browsing for cloud-free data sets to the possible extent. The entire country was covered through the months of August, 2011 to May, 2012 thus making state-wise AWiFS data mosaics for above mentioned 10 months period. The total number of AWiFS products used for the cycle-8 (2011-12) LULC assessment is given in Fig -1.

2.2 Pre-processing

Pre-processing of satellite data includes geometric correction and radiometric correction. The geometrically corrected AWiFS data sets were procured on monthly basis. Though the geometric accuracies were reasonably good across temporal data sets in plain areas, mis-registration problems were noticed in hilly regions to the tune of 4 to 6 pixels. Hence these data sets were re-registered with help of image-to-image tie down procedure to bring the temporal registration to an acceptable level. After geometric correction, top of atmosphere reflectance was generated and were mosaiced state-wise to generate reasonably cloud free AWiFS dataset of respective state.

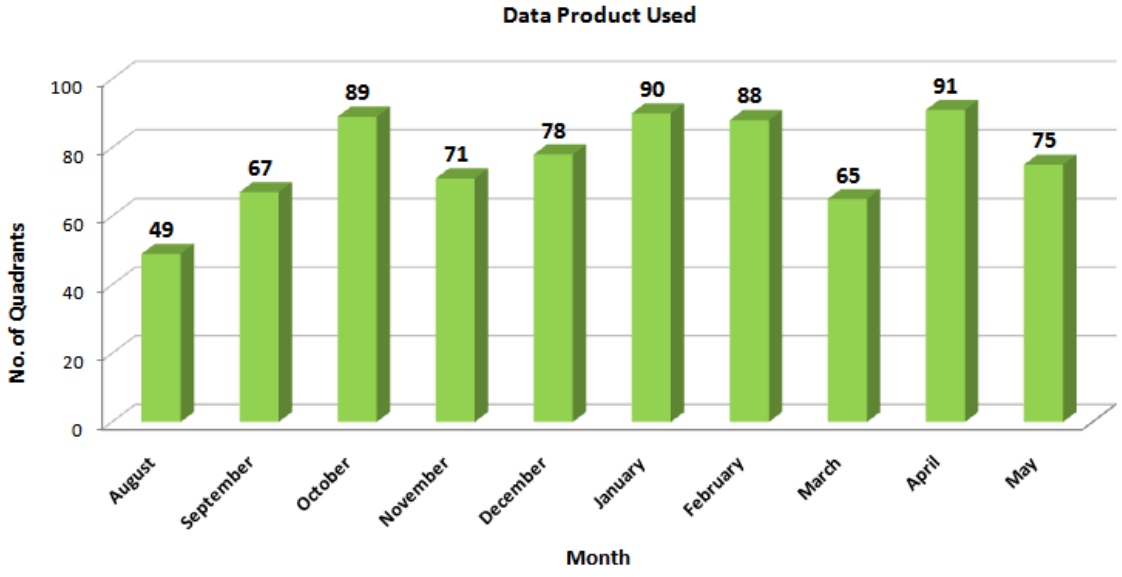

Fig-1: AWiFS Quadrants used for *Kharif and Rabi, 2011-12* assessment

2.2.1 Geometric correction:

All the AWiFS quadrants used in the 8th cycle were produces through IMGEOS processing chain. This take care of automated precise geometric correction of AWiFS datasets in contrast to the previsous 7 cycles, where the geometric correctino use to take place through Special Products Processing Chain (manual intervention). This process has reduced the processing time considerably.

Most of the AWiFS quadrants are relatively cloud-free. The quadrants of plain areas are having geometric accuracies <2 pixels. However, in hilly regions, a 4-6 pixel mis-registration was observed as compared to master AWiFS data generated during cycle-1 using LANDSAT ETM data. Hence, these products were geo-refereced through manual image-to-image tie down procedures. The Ground Control Points (GCPs) were given uniformly across the quadrant and confined to the area covered within India only. The rectification was carried out using Projective transformation / polynomial method. For all the products used in the present cycle, planimetric accuracy of less than one pixel in

plain areas and less than 2 pixels in hilly terrains was maintained. The nearest neighborhood re-sampling method was used during resampling.

Resampled AWiFS quadrant were overlaid on the reference data and checked by zooming and swiping the scenes. Checking was also done by overlaying the adjacent AWiFS scenes and if the edge-matching was not good, the product was repeated by giving more control points as well as refining GCPs given earlier.

The projection system followed is LCC with the following parameters:

Projection	:	Lambert Conformal Conic
Spheroid	:	WGS84
Datum	:	WGS84
1st Parallel	:	35 10 22.096000 N
2nd Parallel	:	12 28 22.638000 N
Longitude of Central Meridian	:	80 00 00.000000 N
Latitude of origin of projection	:	24 00 00.000000 N
False easting	:	4000000 meters
False Northing	:	4000000 meters

2.2.2. Radiometric Correction

Since most of the natural targets have Lambertian surface, then the magnitude of the radiant flux reaching the sensor will depend on the sun and the viewing angles. For comparative purposes, therefore, a correction of image pixel values for sun elevation angle variations is needed. Such corrections are essential if multi-temporal images are to be compared, for changes in the sensor calibration factors which will obscure real changes on the ground. Since AWiFS data used in the study are acquired under different illumination conditions, these datasets need to be radiometrically corrected for sun elevation effects. TOA reflectance data was generated using the customized module prepared as part of the project.

2.2.3. Classification and Mapping

Data Preparation:

After receiving the geometrically rectified and quality passed quadrant-wise IRS-P6 AWiFS data, TOA reflectance data was generated for each quadrant based on the procedure mentioned earlier. A state level monthly mosaic was prepared using the quadrant covering the major part of the state for a given month and supplemented to the remaining area with the quadrant data of the closest adjacent path of closest date. Prior to the classification it is ensured that 5 km buffer around the state boundary is retained to facilitate border matching of classified outputs.

Classification of satellite data –*Kharif and Rabi* Assessment

Training sets of previous cycles were modified where ever required to develop fresh signature sets of crop, current fallow, water and snow areas were provided and spectral signatures were derived. Based on the signatures, supervised classification was run to obtain crop, fallow, water and snow classified output for every calendar month during August, 2011 to May, 2012. The month wise classified outputs thus generated for every month were integrated at the end of crop season to obtain integrated classified map of crop, current fallow, water and snow of a season. This integrated map is passed through agriculture mask of previous cycle to eliminate the errors of classification of non agriculture areas as agriculture. In this way, classification should be carried out for all three seasons.

The changes in built-up, forest & wasteland classes were updated suitable by comparing with the previous 7th cycle product and satellite imagery differences. For correcting build up land, DMSP-OLS data for the year 2011 was downloaded, co-registered to AWiFS mosaic and resampled to AWiFS resolution. Using this data, the classification of built-up areas was improved.

3. RESULTS

Kharif cropped area obtained through digital analysis of AWiFS data is given in Table 1 and Fig 2a. The total *Kharif* cropped area during 2011 was estimated at 1220.14 lakh ha, comprising 37.12% of the total geographical area (TGA) of the country. There is an increase in 18.33 lakh ha in the *Kharif* cropped area during 2011 compared to 2010 (1201.82 lakh ha.), which might be due to the changes in rainfall conditions (spatially, temporally and quantitatively). Major increase in *Kharif* area has been observed in the states of Rajasthan, Jharkhand, south Karnataka, MP, Bihar and Chhattisgarh. Similarly there was a decrease in Kharif crop area in state like Gujarat, Andhra Pradesh, Haryana and Orissa with Gujarat being the state with largest decrease in Kharif crop area essentially due to decrease in Kharif area in Gujarat region (exclusive of Saurashtra & Kutch which has shown an increase). The comparative table of state wise *Kharif* areas of current cycle with respect to the previous cycle is given in Table-1.

In order to understand the spatial heterogeneity of changes in *Kharif* area, meteorological subdivision wise *Kharif* areas were compared with rainfall changes. Hence, the data on rainfall distribution for the entire country at meteorological sub-division level for the *Kharif* season (June to September of 2010) were collected and related to the change in *Kharif* crop area in respective subdivisions.

A plot between changes in *Kharif* area in relation to change in rainfall in different meteorological subdivisions is shown as Fig 3. It can be noticed that in sub divisions like East Rajasthan, Jharkhand, costal Karnataka, south interior Karnataka, Bihar, Chhattisgarh, there is an increase in *Kharif* crop area in relation to increase in rainfall. Similarly, the sub-divisions like north interior Karnataka, North-Eastern states, coastal Andhra Pradesh, Rayalaseema, Uttarakhand, Vidhrabha, Gujarat region, etc. have shown corresponding decrease in kharif crop area with respect to decrease in rainfall. Surprisingly, the Saurashtra & Kutch region has registered an increase in *kharif* crop area in spite of decrease in rainfall.

Rabi cropped area obtained through digital analysis of AWiFS data has been presented as table-2 and figure-2b. The total *rabi* area during 2012 was estimated to be 939.34 lakh ha comprising 28.57% of the TGA of the country. The *rabi* cropped area in 2012 decreased by 3.17 lakh ha against *rabi,* 2011 showing a very marginal change.

Comparative table of state-wise *rabi* cropped area of the present and previous cycle is appended as table-2. Major reduction in *rabi* cropped area was observed in Chhattisgarh, Gujarat, Haryana and Jharkhand while an increased area under *rabi* was seen in Assam, Madhya Pradesh, Tamil Nadu and Uttar Pradesh (table-2b). The final LULC map of India is appended as fig-2c.

Analysis of *kharif* crop area during past 8 cycles indicates that a large standard deviation in *kharif* crop was noticed in Uttar Pradesh, Madhya Pradesh and Rajasthan. Similarly, the standard deviation in *rabi* crop was highest in Andhra Pradesh followed by Tamil Nadu, UP, Bihar and Gujarat. A comparative graph showing the variation in extent of crop areas during various cropping seasons is appended as fig-4. The Net Sown Area (NSA) for India oscillates between 140 to 149Mha as observed during the 8 cycles. While there was a consistent decrease in *rabi* alone area there was an increase in double crop area was also noticed.

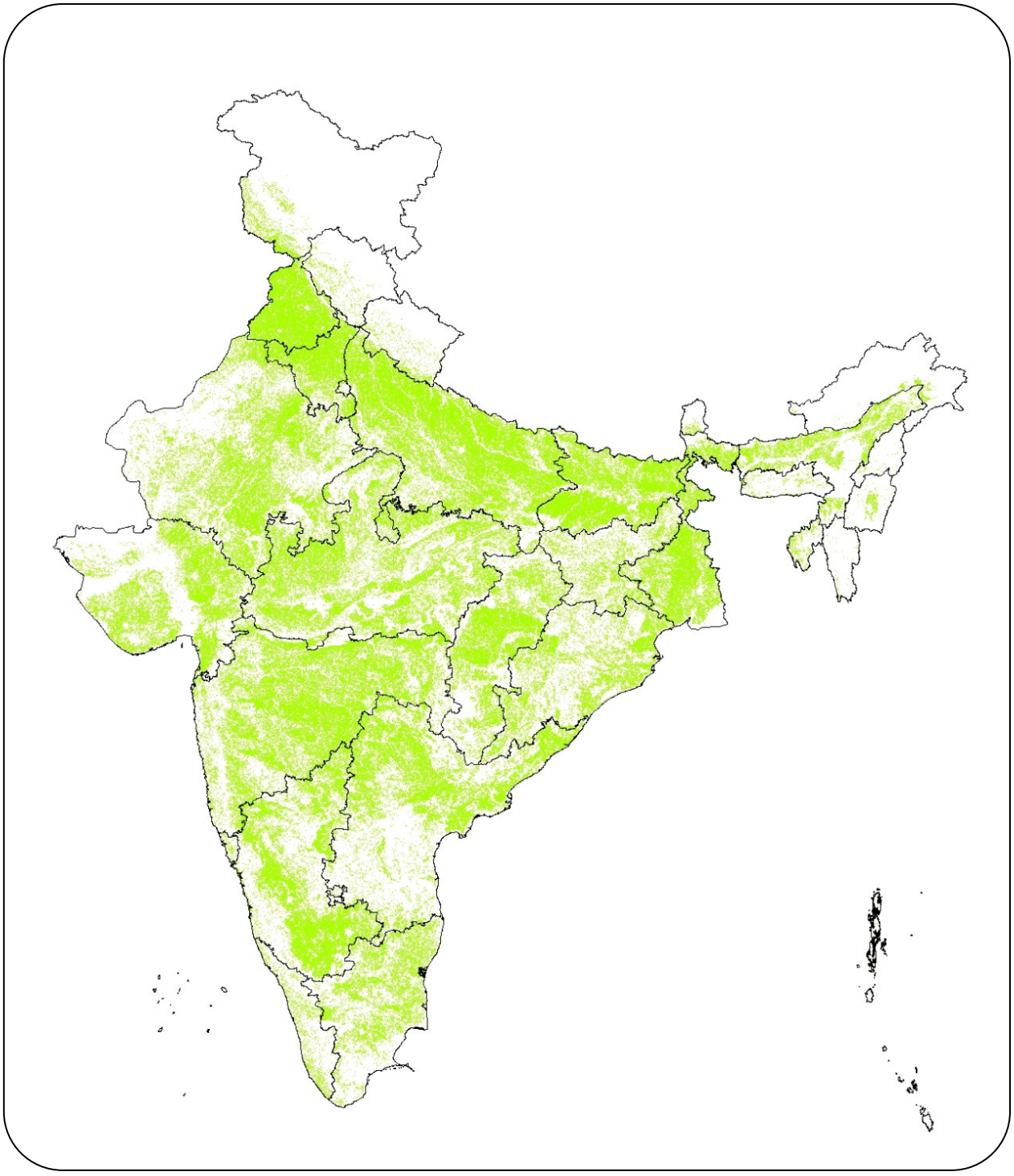

Fig 2a: *Kharif* cropped area during 2011-12

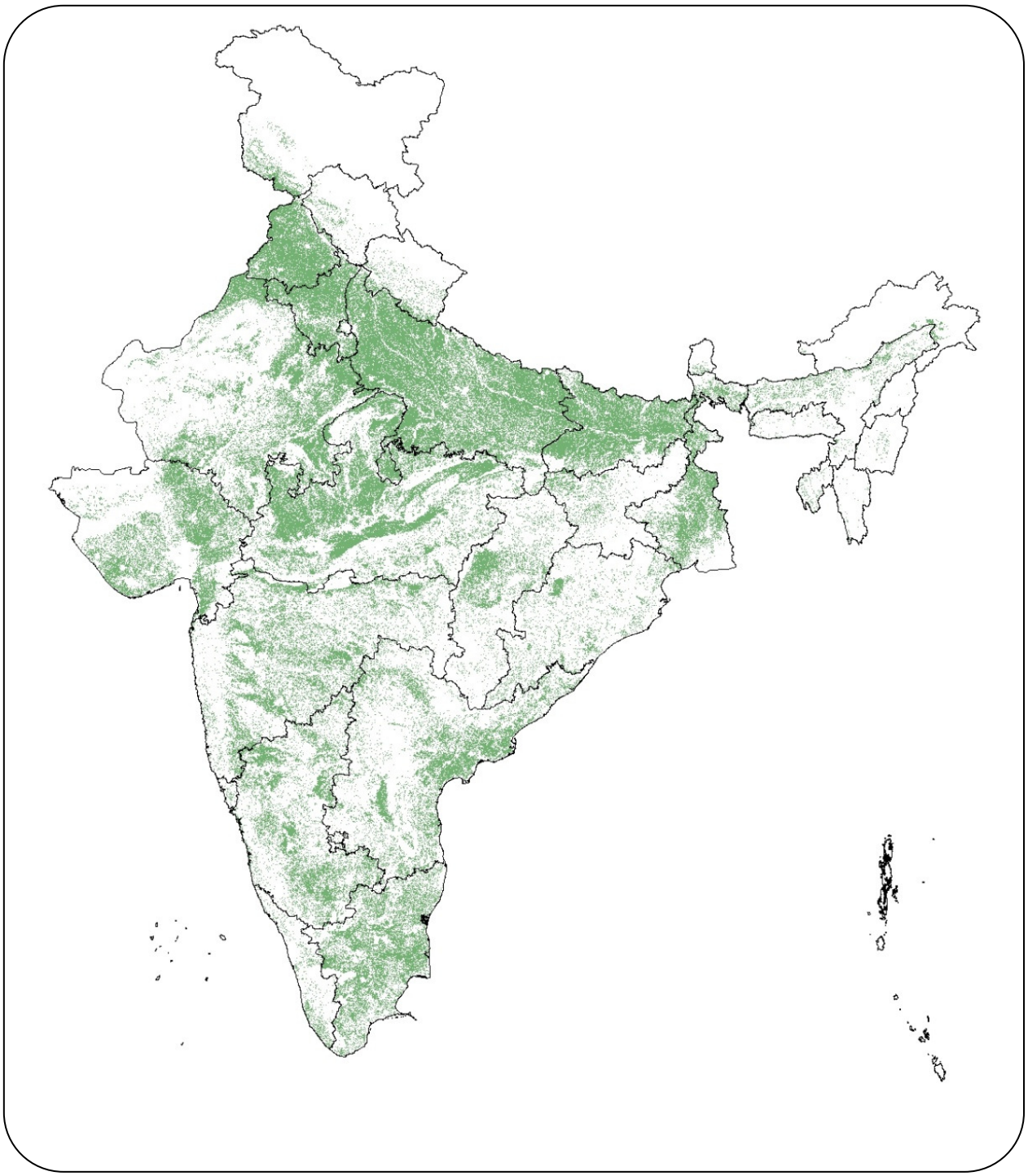

Fig 2a: *Rabi* cropped area during 2011-12

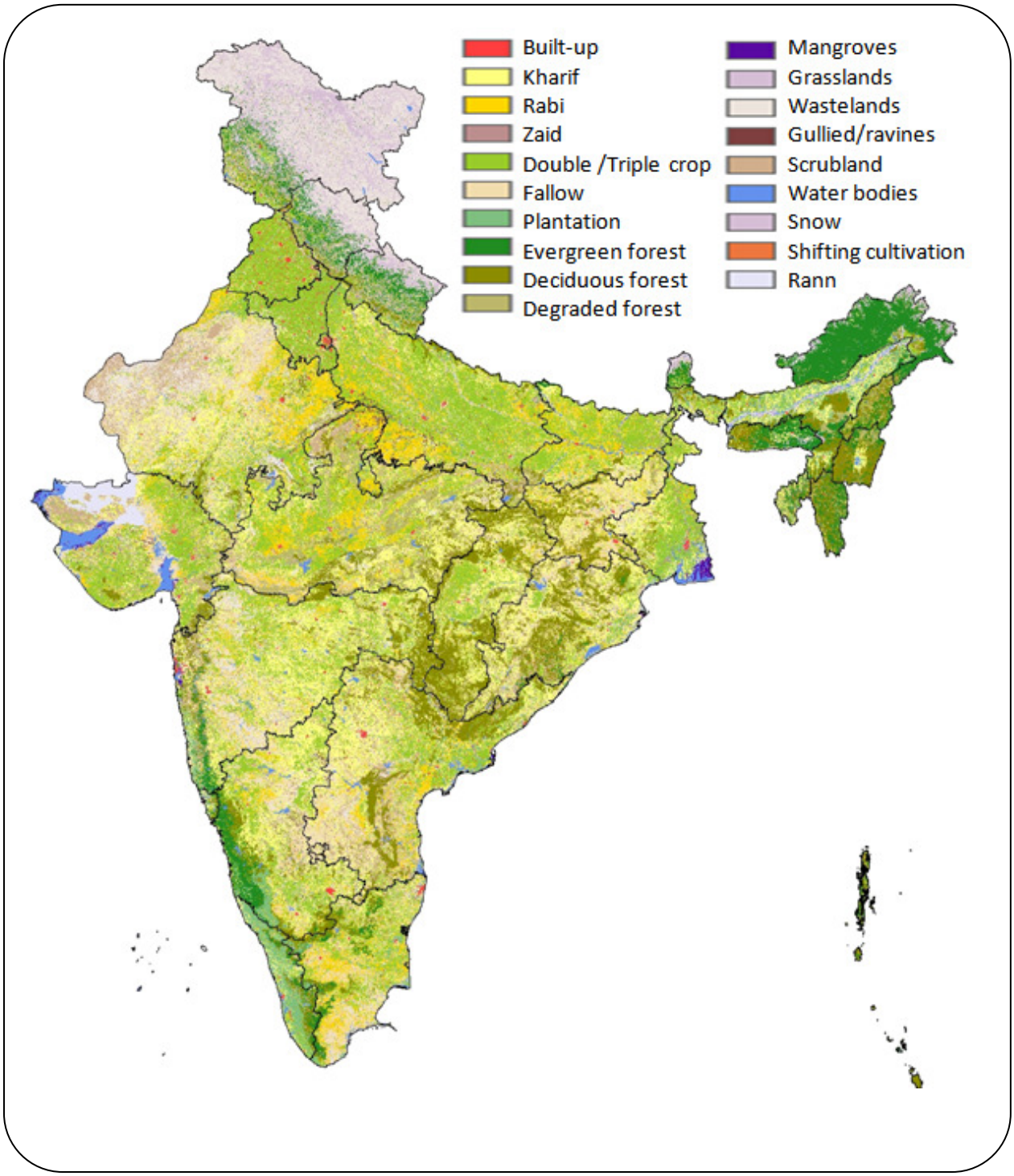

Fig 2c: *Land use / cover* of India during 2011-12

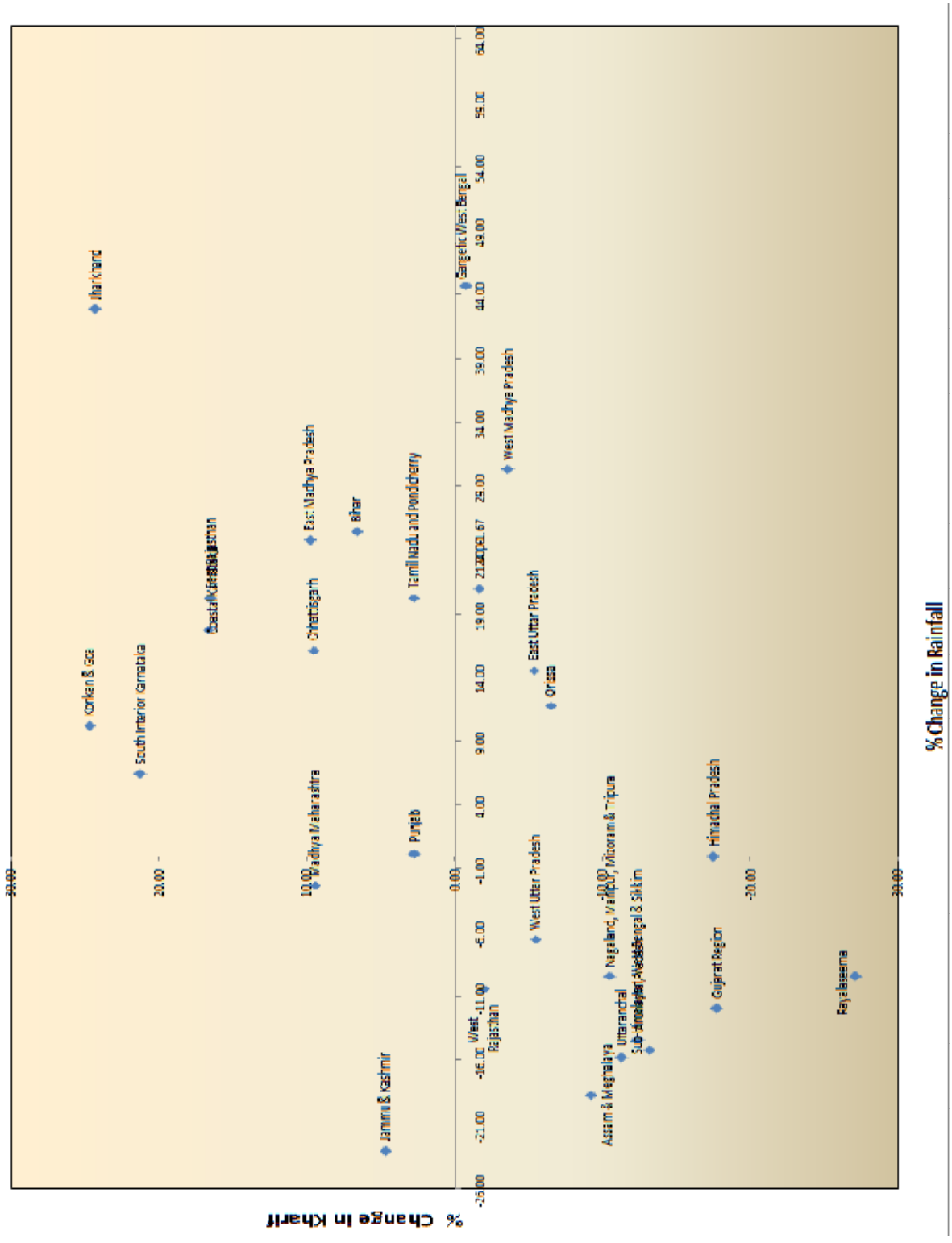

Fig-3. Changes in Kharif pattern with respect to rainfall during 2010-11 and 2011-12.

Table 1: State-wise *Kharif* area statistics for the year 2010-11 and 2011-12

S.No	State / UT	2010-11	2011-12
1	ANDAMAN & NICOBAR	0.56	0.56
2	ANDHRA PRADESH	101.28	96.60
3	ARUNACHAL PRADESH	1.93	1.68
4	ASSAM	25.69	25.58
5	BIHAR	54.96	62.17
6	CHATTISGARH	52.20	57.74
7	DELHI	0.54	0.32
8	GOA	0.89	0.90
9	GUJARAT	78.49	67.50
10	HARYANA	35.41	29.96
11	HIMACHAL PRADESH	4.00	2.60
12	JAMMU & KASHMIR	7.78	8.17
13	JHARKAND	18.21	24.10
14	KARNATAKA	85.28	84.04
15	KERALA	8.09	8.01
16	LAKSHADWEEP	0.00	0.00
17	MADHYA PRADESH	125.02	132.98
18	MAHARASTRA	148.30	150.05
19	MANIPUR	1.98	1.78
20	MEGHALAYA	2.73	2.18
21	MIZORAM	0.87	0.41
22	NAGALAND	1.91	0.47
23	ODISHA	55.42	52.36
24	PUNJAB	40.22	41.30
25	PONDICHERRY	0.23	0.23
26	RAJASTHAN	103.50	117.81
27	SIKKIM	0.80	0.68
28	TAMIL NADU	41.48	44.27
29	TRIPURA	2.47	2.52
30	UTTAR PRADESH	143.74	145.91
31	UTTARANCHAL	6.73	5.47
32	WEST BENGAL	51.11	51.79
	Total	**1201.82**	**1220.14**

Table 2: State-wise *Rabi* area statistics for the year 2010-11 and 2011-12

S.No	State / UT	2010-11	2011-12
1	ANDAMAN & NICOBAR	0.00	0.00
2	ANDHRA PRADESH	66.58	65.46
3	ARUNACHAL PRADESH	1.47	1.37
4	ASSAM	7.90	11.03
5	BIHAR	57.92	59.82
6	CHATTISGARH	28.81	23.58
7	DELHI	0.49	0.40
8	GOA	0.42	0.45
9	GUJARAT	67.52	60.82
10	HARYANA	32.83	29.37
11	HIMACHAL PRADESH	3.22	2.05
12	JAMMU & KASHMIR	5.99	6.10
13	JHARKAND	13.07	9.84
14	KARNATAKA	55.16	55.08
15	KERALA	4.30	4.87
16	LAKSHADWEEP	0.00	0.00
17	MADHYA PRADESH	110.72	117.03
18	MAHARASTRA	76.38	76.18
19	MANIPUR	0.11	0.66
20	MEGHALAYA	0.31	1.02
21	MIZORAM	0.08	0.39
22	NAGALAND	0.62	0.11
23	ODISHA	20.36	19.03
24	PUNJAB	38.72	37.69
25	PONDICHERRY	0.20	0.20
26	RAJASTHAN	95.24	96.87
27	SIKKIM	0.54	0.50
28	TAMIL NADU	53.53	55.86
29	TRIPURA	0.91	0.97
30	UTTAR PRADESH	158.46	162.30
31	UTTARANCHAL	5.36	6.05
32	WEST BENGAL	35.30	34.26
	Total	**942.51**	**939.34**

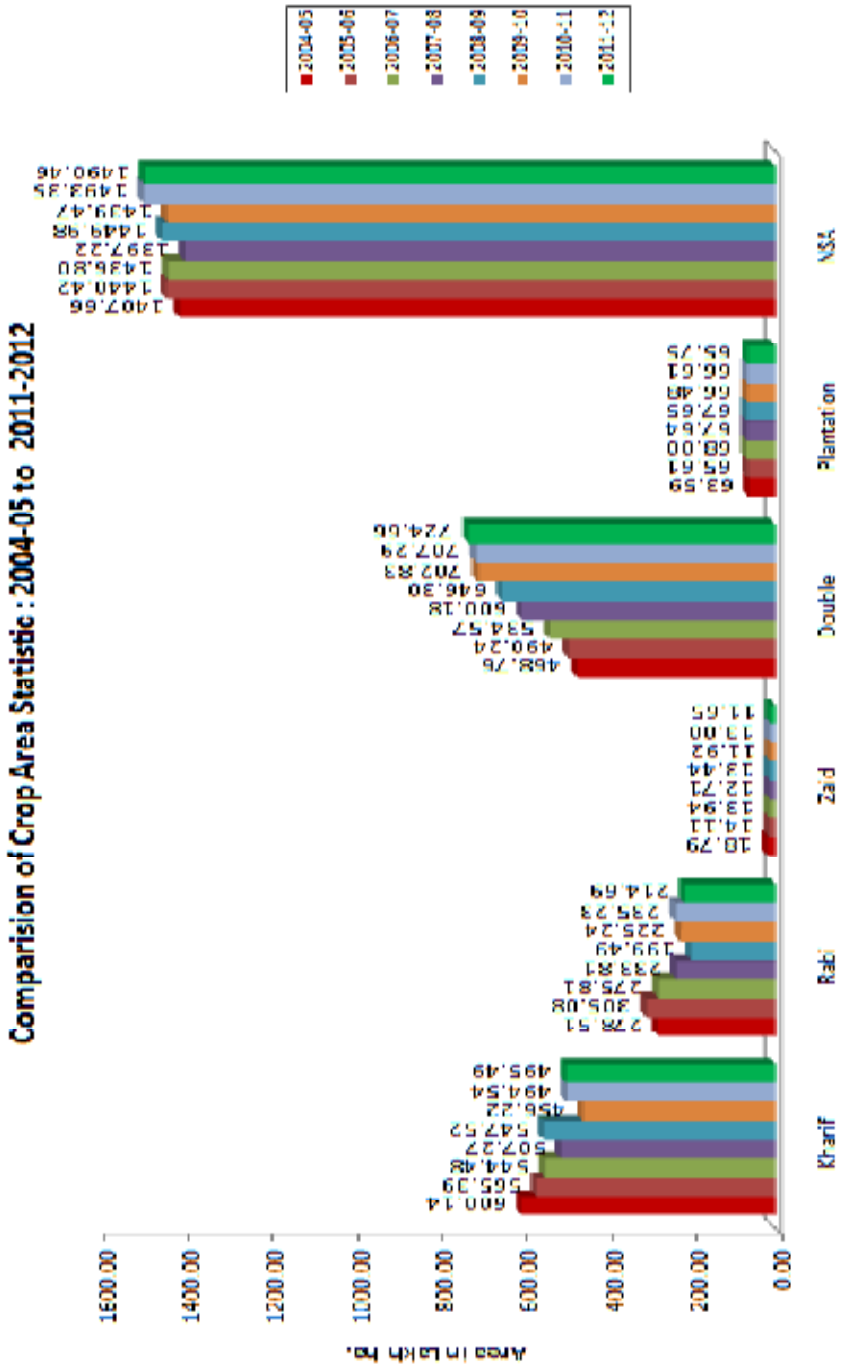

Fig 4: ***Comparison of crop areas on India during past 8 cycles.***

Appendix- I Project team

S. No.	Activity	Team Member
1	**Data Procurement & dissemination**	
1.1	Browsing & ordering	K. Sreenivas, S.S. Thammappa,/ VSVSSSR Murthy, G. Prasad, NRSC
1.2	NDC interface	D Ramadevi, NDC, NRSC
1.3	Data dissemination	K. Sreenivas, NRSC
2	**Pre-processing & Classification**	
2.1	Northern region (J&K, Uttarakhand, HP, Punjab, Haryana, Delhi)	Manoj Saxena, G. Padma Rani, T.S. Viswanatham, P. Hariesh, R. Suraj Reddy: NRSC
2.2	Central Region (MP, Maharashtra, Chattisgarh)	A.O. Varghese, C.K. Rajender, S. Anand, Hareef Baba Shaeb : RRSC-Central, NRSC
2.3	Western region (UP, Rajasthan, Gujarat)	S. Pathak, Rakesh Paliwal : RRSC-West, NRSC
2.4	Eastern region (West Bengal, Bihar, Jharkhand, Orissa)	P.V. Krishna Rao, N. Seshadri Sekhar, Bhavana Sahay, P. Hariesh, NRSC
2.5	Southern region	M.A. Fyzee, G. Sujatha, Ch. Sudhakar Reddy, Milind Wadodkar, NRSC
2.6	North-Eastern region	Kasturi Chakraborty, Jonali Goswami, Pratibha T Das, Chandan Goswami, H. Suchitra Devi, Dr. S. Sudhakar NESAC, Shillong
3	**External QC**	Abdul Hakeem, Rajiv Kumar, Girish Pujar, Ch. Sudhakar Reddy, S. Pathak : NRSC & Bijoy Handique, NESAC
4	**Report Preparation**	K. Sreenivas
5	**FTP server support**	Mohammad Ali and C. Chandra Sekhar Reddy: NRSC
6	**GeoDatabase Organisation**	VV Sarath Kumar, Harish Karnatak, MV Ravi Kumar, YVN Murthy: NRSC
7	**Web dissemination**	Arul Raj, Haish Karnatak, YVN Murthy: NRSC
8	**Project Directors**	G Behera, Ex- Dy. Director (RS&GIS-AA) / YVN Krishna Murthy, Dy. Director (RSAA) / Dr. V. Raghav Swamy, Dy. Director (RSAA) : NRSC
9	**Project planning, execution and coordination**	K. Sreenivas, Dy. Project Director - Classification