SEASONAL COVERAGE ANALYSIS OF SPATIO-TEMPORAL SATELLITE DATA OF INDIA

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Abstract: The decadal analysis of total cereal crops area and production with climatic factors viz. temperature and rainfall of India observed status of rabi and kharif season. India lies to the north of the equator between 6° 44'N and 35° 30'N latitude and 68° 7'E and 97° 25'E longitude. The analysis of time series (2000-01 to 2009-10) data of maximum and minimum temperatures of India R^2 values observed 0.003 and 0.013. The actual rainfall data analysis of 10 years R^2 value 0.002 and average rainfall observed 1120mm. The actual rainfall showed decreasing trend 972.8 mm in year 2009-10 and 981.4 mm in year 2002-03. The rainfall data variability observed due to changing of rainfall trend in India. The satellite imageries of SPOT VGT are used for crop coverage study of India. The overall analyses of decadal data are observed 58.1% for agricultural coverage and 41.9% for non-agricultural coverage uses. The Kharif (August) and Rabi (March) season agricultural coverage and Non-agricultural coverage observed 57.6% and 57.9% and 42.2% and 42.1% respectively. The brightness values based breakpoints were divided into two lands cover categories: Non-agricultural coverage and agricultural coverage. The distribution of tonal value (red to radish and yellow to greenish) visually observed on time series images, which are assigned a DN range from 0 to 255 for Non-agricultural and agricultural coverage. The decadal analysis of total cereal crops area and production with climatic factors viz. temperature and rainfall of India observed status of rabi and kharif season. The seasonal time series remote sensing SPOT VGT data is useful for understand changing of land use coverage in India

Keywords: DN Value, Rainfall, SPOT, VGT, Temperature

INTRODUCTION

GIS and remote sensing is an evolutionary science as a technology tools to help in various field such as forestry, agriculture, water, power and environment. The tools provide the facility to get result in fast accurate with reliable information. It gives information of changing to transform the real world scenario. The change is not always good but changes is universal truth of the world but very fast changing in climatic condition give adverse effect on crop health and also affect the quantity and quality of production and yield. The fast changing is observed in agriculture areas convert into urban areas. The changes are observed in IGP's states (Punjab, Haryana, Western Uttar Pradesh, Bihar and West Bengal) than southern states (Koshal, 2014). About 43% of India's geographical area is used for agricultural activity. Indian agriculture provides about 65% of the livelihood India has third rank for total cereals production and first rank in livestock population (Chhabra *et al*., 2009). The maximum coverage of Gangetic plains of total agricultural land of India is vast populated area and more than 70% population depend of agriculture land and their related work. Indian agriculture is mostly dependent on the rains for growing crops especially like cotton, rice oil seeds and coarse grains. The South –west monsoon accounts for 80% of the rainfall of India. The major crops are grown in India in three different seasons viz. rabi, kharif and Zaid. Kharif crops are sown at the beginning of South-West monsoon occurs from June through September. The rabi season starts with the onset of north-east monsoon in October. Many crops are cultivated in both kharif and rabi seasons. Rabi season required cool climate during growth period but warm climate during germination of seed and maturation. The Rabi crops are wheat, barley, gram, mustard and pea. Kharif crops are sorghum (Jowar), maize, sugarcane, rice and cotton (Duxburv *et al.,* 2000) Kharif crops are known as the summer or monsoon crops in Indian sub-continent. Rice and wheat is major staple crop of Rabi and kharif season. After analysis of three seasonal crops cycle observed India has rice-wheat system is pre-dominate cropping system (Yadav *et al.,* 2001)**.** It provides basic food to India's big populations which are living in rural or urban areas. The food availability as fodder in both season the livestock has been the mainstay of Indian agriculture sector and constitutes 21.3% of the country's livestock (including lactating dairy cattle, buffalo and goat). It is a major contributor to climate change; livestock play important roles in farming systems in India (in terms of food and income, fertilizer, soil conditioner and household energy). Livestock production is an important source of income and employment in the rural sector (Dastagiri, 2004). Indian agriculture is particularly vulnerable to impacts of climate change due to its large livestock population.

The food security is a big challenge in India for storage and safety. The food grain production growth are much improve but soil health decline most of the agricultural land due to maximum uses of chemical fertilizers, pesticides and weed control

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spray. The decadal analysis of total cereal crops area and production with climatic factors viz. temperature and rainfall of India observed status of rabi and kharif season. The seasonal time series remote sensing SPOT VGT data is useful for understand changing of land use coverage in India

MATERIAL AND METHOD

Study area : India lies to the north of the equator between 6° 44'N and 35° 30'N latitude and 68° 7'E and 97° 25'E longitude (Sheshakumar *et al.*, 2009). The total geographical area of the country is 3,287,590 Km^2 **.** India is the seventh largest country by geographical area in the world. It is bounded on the south west by the Arabian Sea and on the south east by the Bay of Bengal (Fig.1).

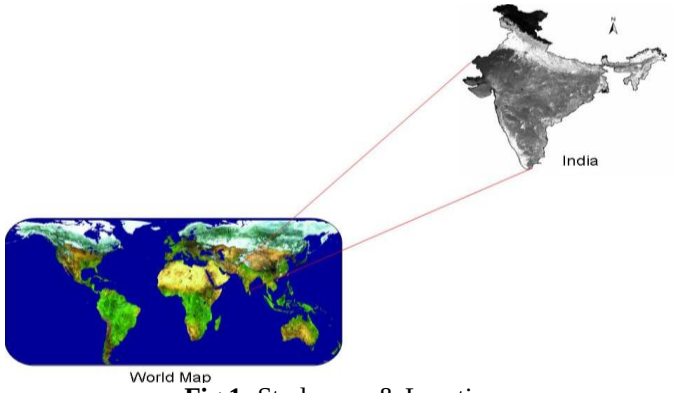


Fig.1: Study area & Location

The Planning Commission divided the country into 15 broad agro-climatic zones, National Agricultural Research Project (NARP) divided in 129 sub-zones and Indian Council of Agricultural Research (ICAR) divides India into 20 agro-ecological zones based on physiography, climatic condition, rainfall, cropping pattern, landform, soil and administrative units (Basu *et al.*, 1996). The present study is based on secondary sources of time series (2000 to 2012) viz. satellite images, Agriculture and climatic data of India were collected from the related websites, published records, report and bulletin, Directorate of Economics & Statistics, ICAR, IMD, CENSUS India, Vegetable Institute and other national level institute. The secondary data collection, arrangement, management and analysis are four steps for trend analysis work to get valuable information of crop converge of two seasons (Fig.2).

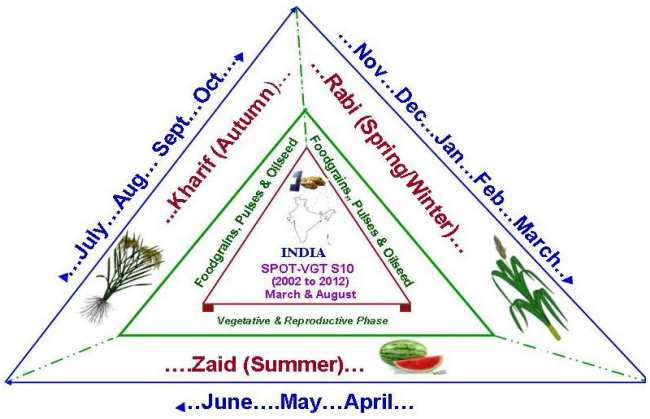


Fig. 2: Crop Calendar of India (Rabi, Kharif & Zaid)

Remote Sensing data is downloaded from SPOT VGT sites and processed with raster-based software ERDAS IMAGINE **(Earth Resources Data Analysis Systems)** and GIS software of the ESRI (Environmental Systems Research Institute).

SPOT (French: *Satellite Pour l'Observation de la Terre*, "Satellite for observation of Earth") is a high resolution, optical imaging earth observation satellite system. SPOT -4 was launched in 24 March 1998 (Elias, 2007). This satellite objective was to monitor human activities and natural phenomena (Table. 1). After a long journey, the satellite operation was terminated on 11 January 2013. The remote sensing data used in this study included the Single composite data set (1to10days) S10 NDVI data derived from VEGETATION sensor and useful for Vegetation study (SPOT websites: http://www.vgt.vito.be).

Table 1. Characteristics of selected satellite sensors

Satellite/Platform	SPOT-4
Instrument/Sensor	VGT-1
Data set/ Type	S10
Organization	CNES, France
Operation Period	1998-2013
Orbit type	Circular Sun-synchronous
Swath (km)	2250
Spatial Resolution	1150
Sensor Mission	Vegetation
Website	www.free.vgt.vito.be.
SPOT : Le Systeme Pour I'Observation de la Terre	

The study area (India) boundary feature file (.shp) was used for GIS layer in ARCGIS software to extracted information from remote sensing images. The remote Sensing data S10 was downloaded from the VGT free data product (1-km2 resolution) web portal sites. The imageries for the period year 2000 to 2012 for March (rabi) and August (kharif) in zip format data are used. The work station (hp Trinitron) with ERDAS IMAGINE 8.6 software was used for processing and analysis of remote sensing data. The images are downloading in Hierarchical Data Format (HDF) and Tagged File Format (TIFF) format and directly open in ERDAS IMAGINE to save in .img format. The dataset of SPOT VGT data were geometrically corrected with the help of the ground Control Points (GCPs) and WGS84 Geographic lat/ long projection system in ARCGIS. The GCPs (Ground Control Points) were distributed uniformly throughout the image with minimum root mean square (rms) error of less than 0.5 were selected. Polynomial transformation of 1st order was used because the correction programme runs faster with it and it also avoids geometric distortion in areas of very few GCPs. The study area subset with a vector polygon file (.shp file) representing the area boundary (AOI). Study area boundary overlay was done after completing geometric correction of the image (Fig.3). The series of temporal images were opened into the viewer of the ERDAS IMAGINE. The single band was stacked to create temporal series data (2000 to 2012) of March (for Rabi) and initial August (for Kharif) month. The images were convert in digital numbers (DN Values) based in to series of classes, so there corresponding all the dates were generated from DN values. The numbers of gray levels classes were identified based on colour range. These data are found very useful to study the dynamics of agricultural system at country or regional level. The major crops, different livestock, census, land uses and climatic data are integrated in the MS excel. The statistical information is the backbone of agricultural statistical system. The statistical analysis of data *viz.* Coefficient of Variation (CV), Correlation of Coefficient (R^2) and Trend Analysis of seasonal land use coverage give current scenario of changing pattern.

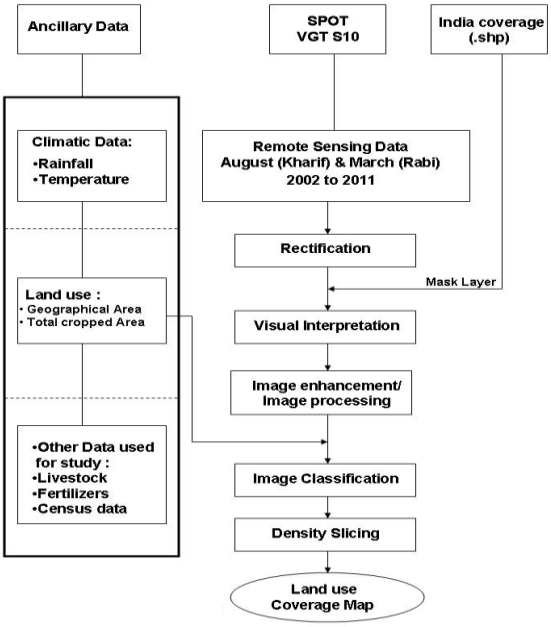


Fig. 3: Methodology used in the study

RESULT OR FINDING

The result or findings of paper is organized in three sections. While the first section discusses the climatic parameters and other related parameters. The second section is includes status of land use coverage, the third section is land use coverage of decadal trend of satellite and land use data of Rabi and Kharif season. The findings are discussed in sequence as under.

(I) Status of Climatic Parameters & other parameters

(i) Temperature data analysis

The analysis of time series (2000-01 to 2009-10) data of minimum and maximum temperatures of India R^2 values observed 0.003and 0.013 for maximum and minimum temperature (Fig.4). The decadal monthly data analysis are observed vulnerable change of temperature due to climatic change (Table.2). The change percentage not more but little change affected the rabi and kharif season crops. Due to rising or lowering temperature more affected on the seed germination and yield. The minimum and maximum temperature directly affected the foodgrains crop in terms of germination and yield (milking/ poding stage). The temperature is an important factor which affects plant growth development and yield. In the past century, daily minimum nighttime temperature increased at a faster rate than daily maximum temperature in association with a steady increase in atmospheric greenhouse gas concentrations (Karl *et al.* 1991 & Easterling, *et al.* 1997). After research observed in northern India temperature will increase 1°C wheat crop production decrease 10% (Janasky, 2012). The rabi season starting of cereal crops (wheat, pulses) temperature affected the germination of seeds. Warming of climate plant reproduction stage maximum affected and production will decrease. The summer monsoon, therefore, is responsible for both *kharif* and *rabi* crop production over India (Lyons, 1973).

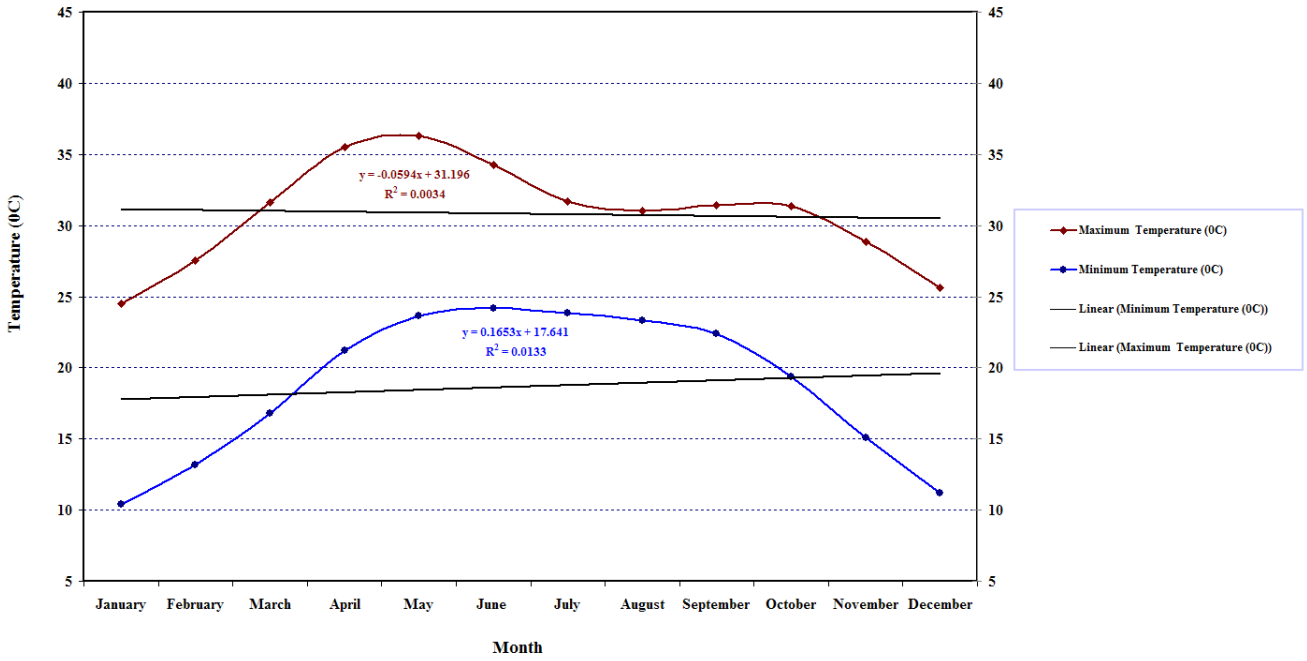


Fig. 4: Average Maximum and Minimum Temperature (^{0}C) of India (Year 2001-02 to 2010-11)

Table 2. Average Minimum and Maximum Temperature (^{0}C) of India (Year 2001-02 to 2010-11)

Temperature ^{0}C (Year 2001-02 to 2010-11)						
Month	Minimum Temperature (^{0}C)			Maximum Temperature (^{0}C)		
	Mean	SD	CV%	Mean	SD	CV%
January	10.4	0.4	4.0	24.5	0.6	2.6
February	13.2	0.7	5.1	27.6	1.4	5.1
March	16.8	0.6	3.5	31.6	0.9	2.8
April	21.2	0.4	2.1	35.5	0.7	1.9
May	23.7	0.3	1.4	36.3	0.4	1.2
June	24.2	0.4	1.7	34.3	1.0	2.9
July	23.8	0.3	1.3	31.7	0.7	2.1
August	23.3	0.2	0.7	31.0	0.2	0.6

September	22.4	0.3	1.1	31.4	0.4	1.3
October	19.4	0.4	2.3	31.3	0.6	2.1
November	15.1	0.6	4.3	28.8	0.3	1.1
December	11.2	0.6	5.1	25.6	0.3	1.2

(ii) Rainfall data analysis

Rainfall is important for food production plan, water resource management and all activity plans in the nature. The occurrence of prolonged dry period or heavy rain at the critical stages of the crop growth and development may lead to significant reduce crop yield. The actual rainfall data analysis of 10 years R^2 value 0.002 and average rainfall observed 1120mm. Rainfall is an important factor for food production and all related activity. The occurrence of prolonged dry period or heavy rain at the critical stages of the crop growth and development may lead to significant reduce crop yield. Around 90% of annual rainfall is received during monsoon season (June to October). According to new research global warming will decrease 70% monsoon rain and changing of weather water and food crises will be increase in coming years**.**

Table 3. Actual & Normal rainfall (mm) of India (Year 2002-03 to2011-12).

Year	**Actual Rainfall (mm)**	**Normal Rainfall (mm)**
2002-03	981.4	1205.4
2003-04	1278.0	1196.5
2004-05	1085.9	1197.3
2005-06	1185.4	1196.8
2006-07	1133.0	1195.5
2007-08	1180.2	1194.8
2008-09	1075.0	1196.4
2009-10	972.8	1195.6
2010-11	1212.3	1191.7
2011-12	1094.7	1186.9
Mean	**1119.9**	**1195.7**
SD	**97.9**	**4.6**
CV%	**8.7**	**0.4**

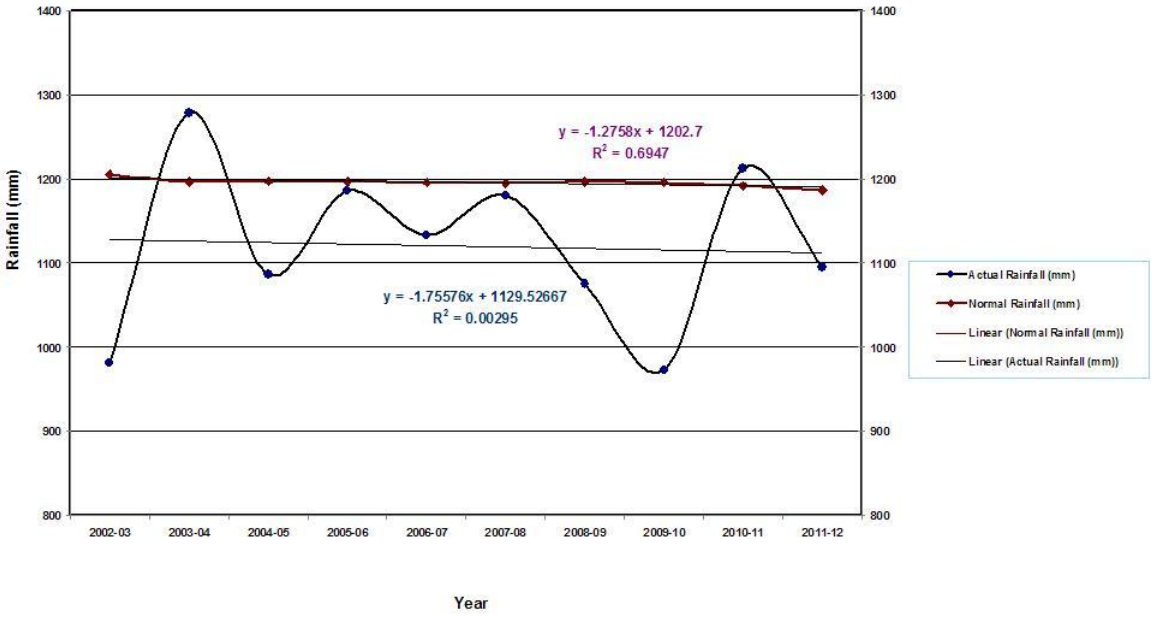


Fig. 5: Actual & Normal rainfall (mm) of India (Year 2002-03 to2011-12).

The mean standard deviation of all the study period was 98 mm. Moreover the coefficient of variation CV (%) 8.7 observed. More than 60% of the cropped area in India still depends solely on monsoon rainfall **(**Panigrahy *et al.* 2002). The normal rainfall R^2 =0.53 value with linear trend was

observed (Figure 5). The actual rainfall (Table 3) showed decreasing trend 972.8 mm in year 2009-10 and 981.4 mm in year 2002-03. In India, the onset of the southwest monsoon is expected in June or July, depending on location. The rainfall data variability observed due to changing of rainfall trend in India.

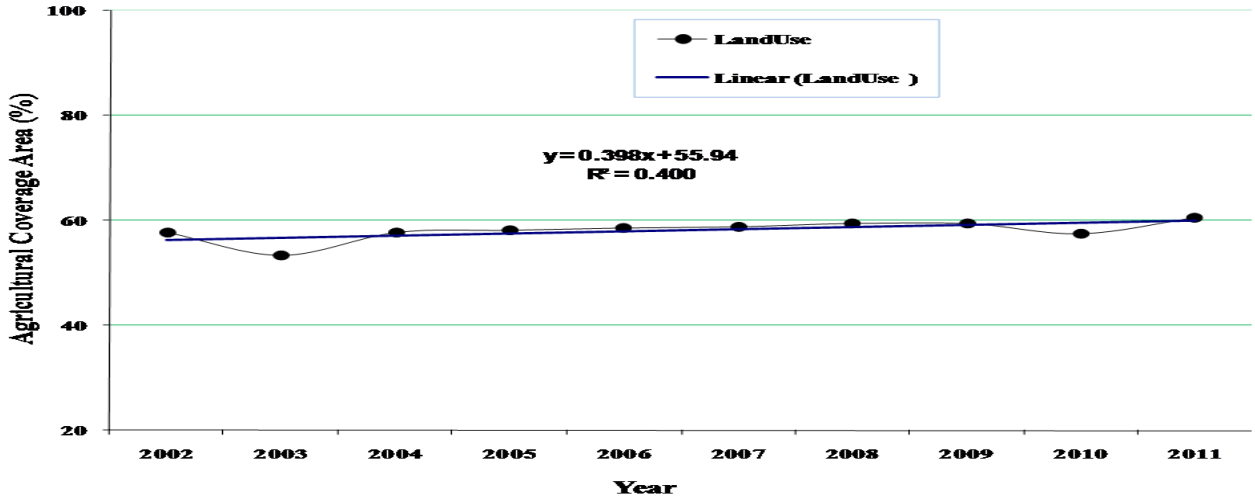
(II) Status of land use coverage of land use & satellite coverage of seasons

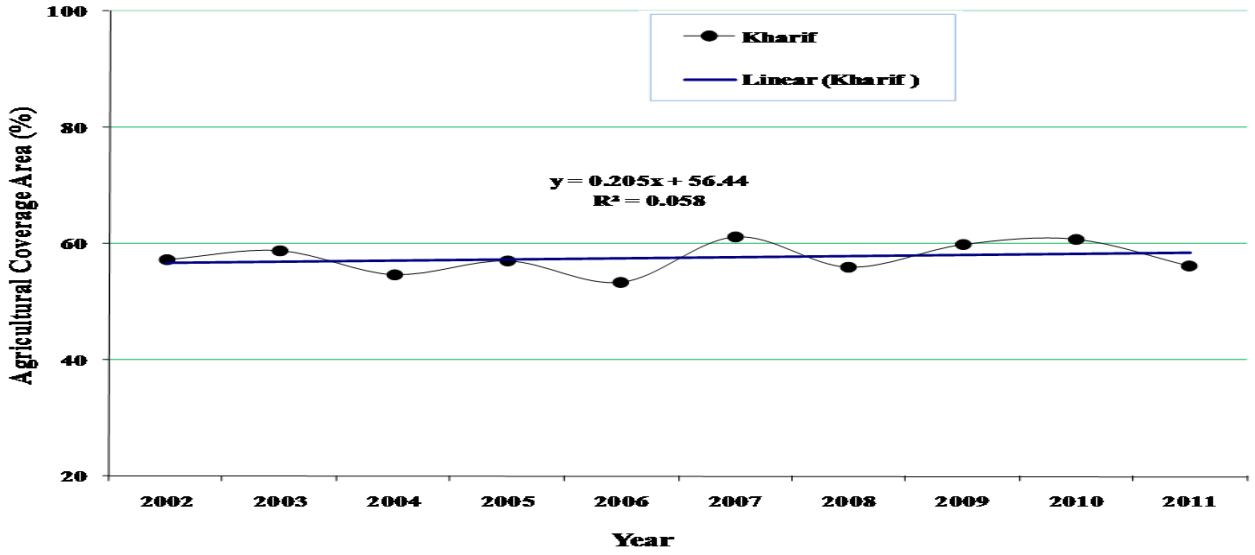
(a) Status of land use coverage classes

Land cover is one of the most important elements for the describing and studying the environment. India has about 2.4 % of the world's geographical area with support about 17% of the world's human population. Agriculture is an important sector of the Indian economy with 14% of the nation's GDP. The study relies on secondary data compiled from various published sources. For trend analysis, ten years (decadal) of different variables were calculated and compiled for the period 2002-03 to- 2011-12.

After analysis of land use classification based on different type of uses about half of total geographical area of 328.73 million hectare in the country is used for agriculture. The overall analyses of decadal data are observed 58.1% for agricultural coverage and 41.9% for non-agricultural coverage uses (Figure 6a &6b). The Kharif (August) and Rabi (March) season agricultural coverage and Non-agricultural coverage observed 57.6% and 57.9% and 42.2% and 42.1% respectively (Table 4).

Land degradation is major threat to our food, fodder and environmental security. Climate change is likely to impact agricultural land use and production due to less availability of water for irrigation. The use of modern varieties, irrigation and fertilizers are important factors that ensured higher growth in crop production.





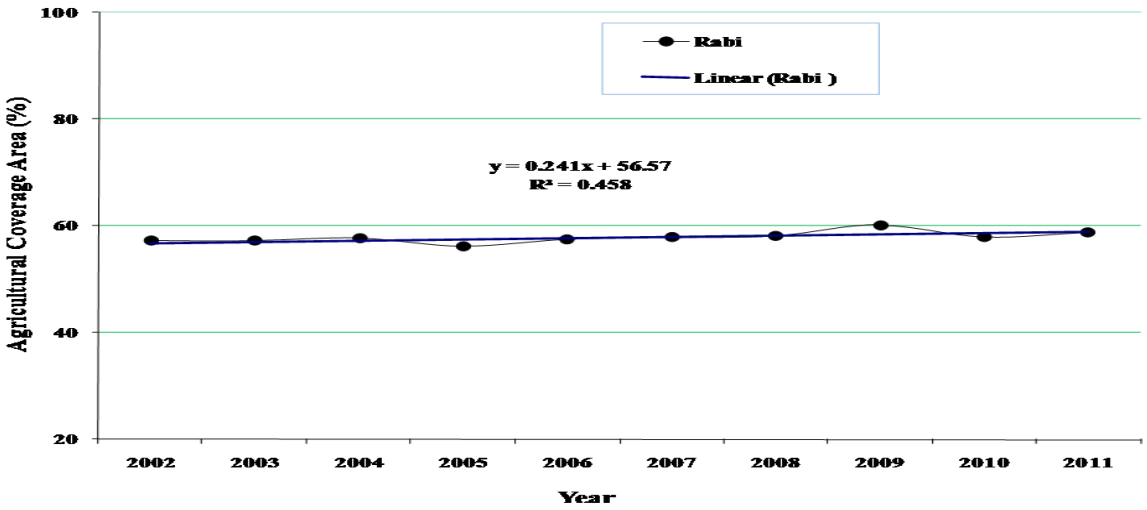
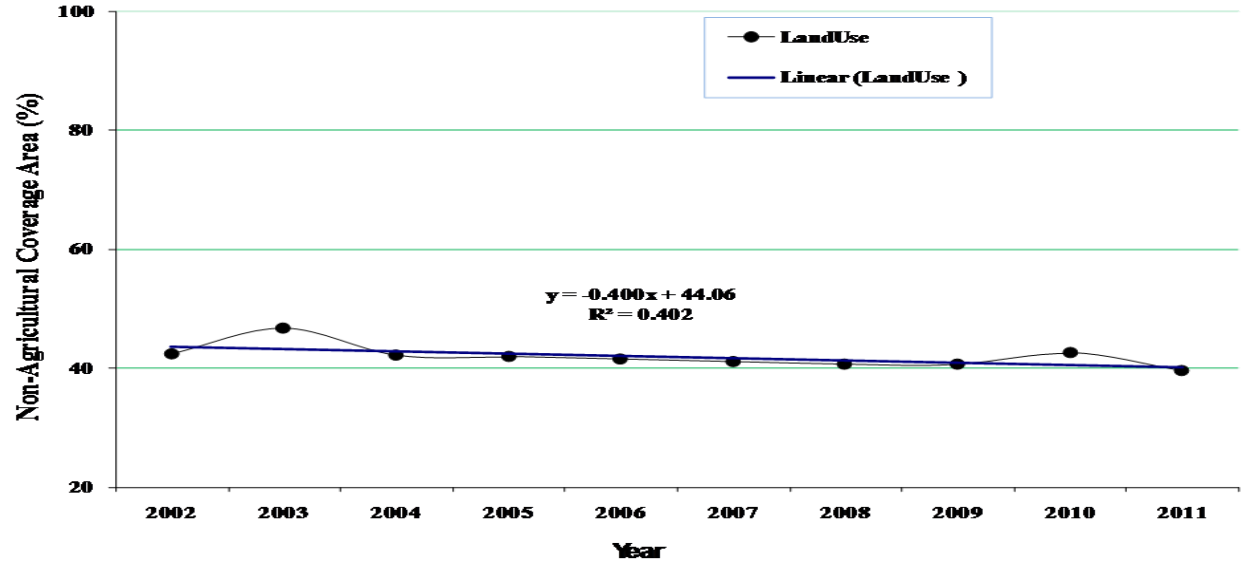
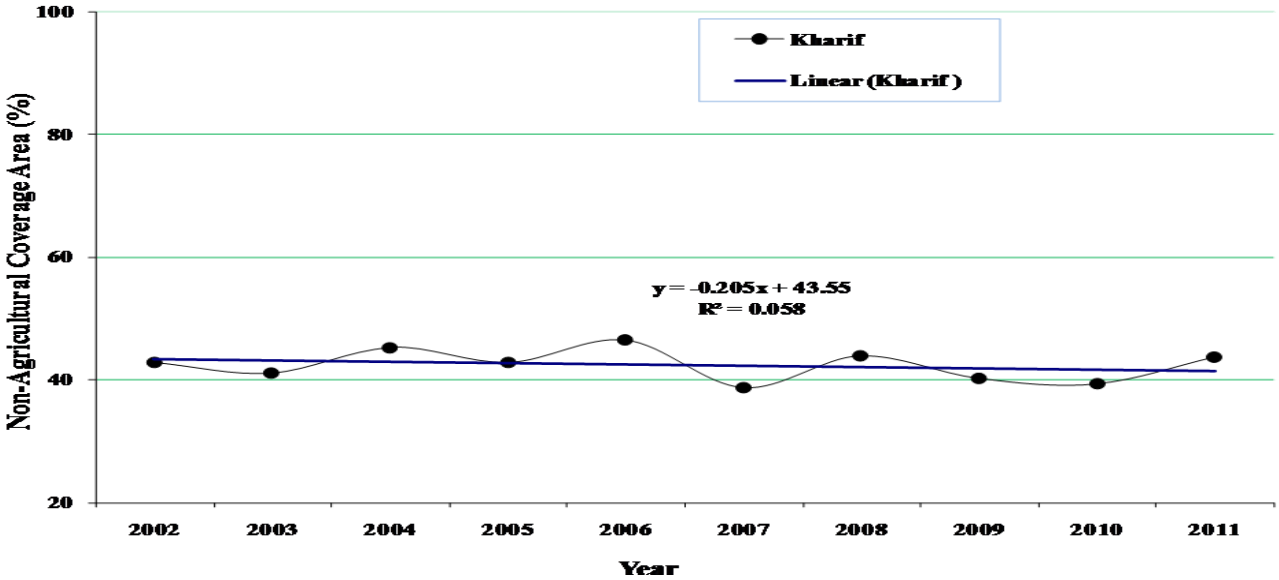


Fig. 6a: Temporal Landuse, Rabi &Kharif Agricultural coverage (%)of India (2002 to 2011)





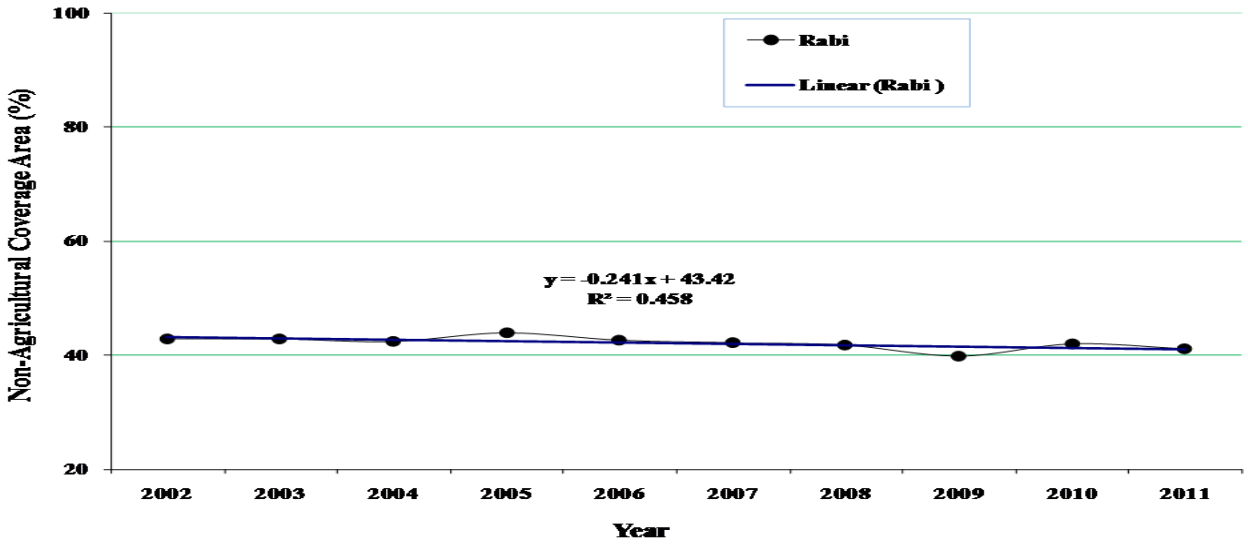


Fig. 6b: Temporal Landuse, Rabi & Kharif Non-Agricultural coverage (%) of India (2002 to 2011)

Table 4. Land Use & Satellite data Area Coverage Classes (%) of India

Year	Geographical Area ('000 Hectares)	Land Use Coverage ('000 Hectares)		Classes					
				Land Use Coverage		SPOT VGT S10			
						Kharif season: August		Rabi season: March	
		Total Cropped Area/ Agricultural Coverage ('000 Hectares)	Non- Total Cropped Area/ Non – Agricultural Coverage ('000 Hectares)	Agricultural Coverage	Non – Agricultural Coverage	Agricultural coverage	Non- Agricultural coverage	Agricultural coverage	Non- Agricultural coverage
2002	328726	189680	139046	57.7	42.3	57.2	42.8	57.2	42.8
2003	328726	175530	153196	53.4	46.6	58.9	41.1	57.2	42.8
2004	328726	190082	138644	57.8	42.2	54.8	45.2	57.7	42.3
2005	328726	191164	137562	58.2	41.8	57.2	42.8	56.2	43.8
2006	328726	192611	136115	58.6	41.4	53.5	46.5	57.5	42.5
2007	328726	193723	135003	58.9	41.1	61.3	38.7	57.9	42.1
2008	328726	195223	133503	59.4	40.6	56.1	43.9	58.2	41.8
2009	328726	195314	133412	59.4	40.6	59.9	40.1	60.2	39.8
2010	328726	188991	139735	57.5	42.5	60.7	39.3	58	42
2011	328726	198969	129757	60.5	39.5	56.3	43.7	58.9	41.1
Average	**328726**	**191129**	**137597**	**58.1**	**41.9**	**57.6**	**42.4**	**57.9**	**42.1**
			Standard Deviation	**1.91**	**1.91**	**2.58**	**2.58**	**1.08**	**1.08**
			CV%	**3.28**	**4.57**	**4.47**	**6.07**	**1.86**	**2.56**
					Correlation	**-0.19**	**-0.19**	**0.49**	**0.49**
					Covariance	**-0.85**	**-0.84**	**0.9**	**0.91**

(b) Status of land use & satellite coverage

Density slicing is a form of selective one-dimensional classification or pixel- based classification. The continuous gray scale of an image is "sliced" into a series of classes based on ranges **.** The group of brightness values were assigned to their respective land cover types, a pseudo-color image was generated in order to visually classify land cover types. The brightness values of pseudo-color image into defined intervals based on distribution of D.N. Values. The density slicing based classification provides an efficient land cover classification techniques. The numbers of slices are depending on the specific type of land cover which is defined by user **(**Wallin, 2012) was used density slicing method for eventual land cover classification. The brightness values based breakpoints were divided into two lands cover categories: Agricultural coverage and Non –

agricultural coverage assigned a DN ranges are 0 to 255. The two classes /cover type possessed a unique range and range was defined by DN values. The distribution of tonal value (red to radish and yellow to greenish) visually observed on time series images, which are assigned a DN range from 255 and Non agricultural coverage was assigned a DN range from 0 (Table 5). This technique help to determine generate true extent of land coverage map (Table 6). The average total pixel values are distributed 3577069 and 3289963 in kharif and rabi season of satellite images. The distribution of these pixel values in two broad classes. The percentage of pixel value in agricultural coverages class is observed in kharif season 57.5 and 57.9%. The percentage of pixel value in Non –agricultural coverage class is observed in Rabi season 42.4 and 42.1%.

Table 5: Distribution of pixel value and change coverage percentage of SPOT VGT (2002-2011) Image analysis of India

Cover type	**Season**	**D.N. Values**	**Tonal value**	**% of coverage area**
Agricultural coverage	Kharif	255	Yellow to greenish	57.58
	Rabi			57.90
Non-Agricultural coverage	Kharif	0	Red to radish	42.42
	Rabi			42.10

Table 6. Distribution of Pixels in Satellite data Area Coverage Classes (in numbers)

	SPOT VGT S10					
Satellite	**Kharif season: August**			**Rabi season: March**		
Year	**Total Pixels**	**Agricultural coverage of Pixels**	**Non-Agricultural coverage of Pixels**	**Total Pixels**	**Agricultural coverage of Pixels**	**Non-Agricultural coverage of Pixels**
2002	3577069	2047425	1529644	3289963	1882408	1407555
2003	3577069	2107321	1469748	3289963	1883353	1406610
2004	3577069	1959314	1617755	3289963	1897883	1392080
2005	3577069	2044310	1532759	3289963	1847443	1442520
2006	3577069	1912743	1664326	3289963	1890261	1399702
2007	3577069	2192875	1384194	3289963	1905327	1384636
2008	3577069	2005853	1571216	3289963	1914615	1375348
2009	3577069	2140897	1436172	3289963	1979615	1310348
2010	3577069	2172037	1405032	3289963	1909636	1380327
2011	3577069	2012358	1564711	3289963	1936808	1351550
Average	**3577069**	**2059513**	**1517556**	**3289963**	**1904725**	**1385238**

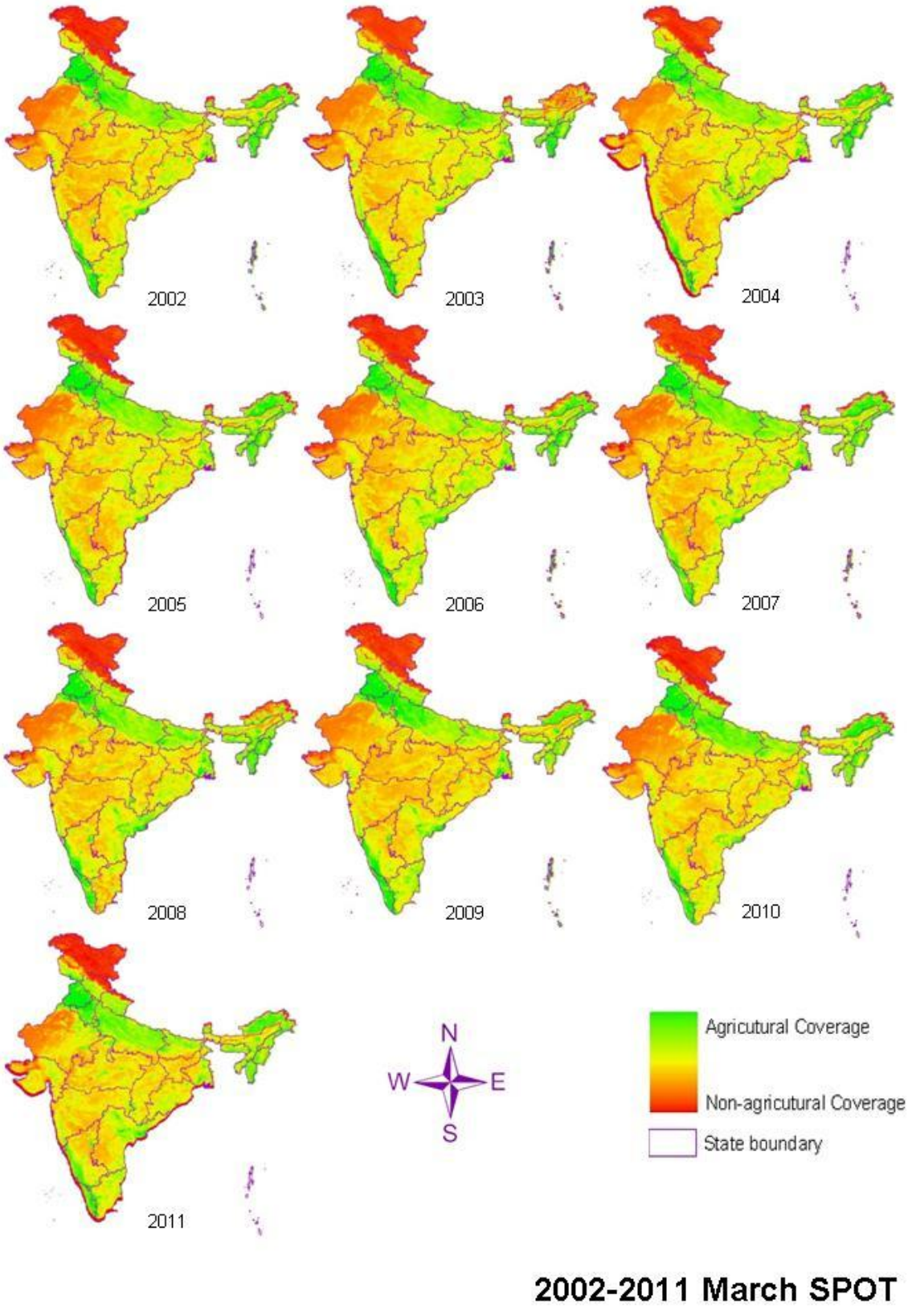


Fig.7: Rabi season map of India derived from multidate SPOT VGT data (March 2002 to 2011)

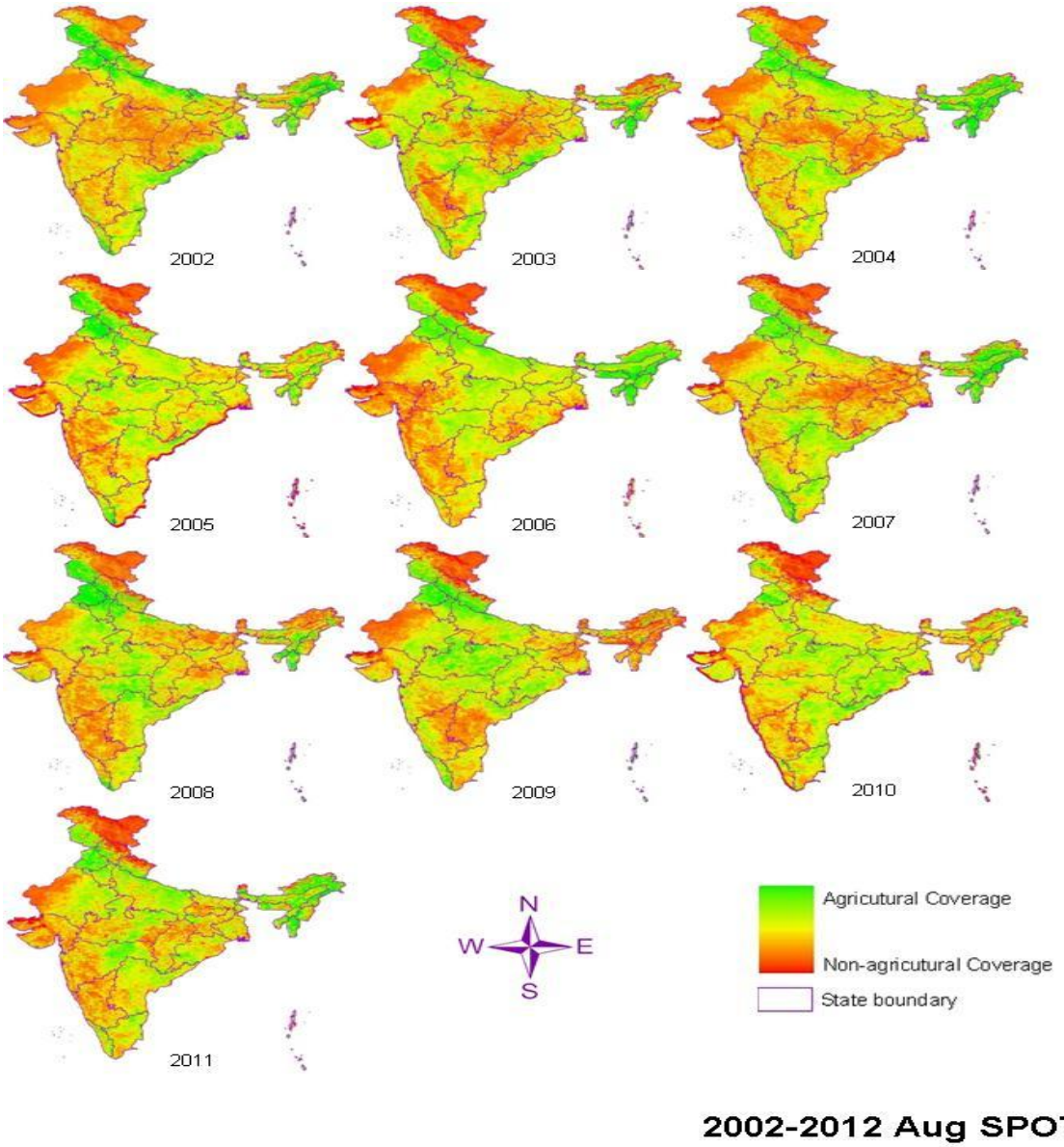


Fig. 8: Kharif season map of India derived from multidate SPOT VGT data (March 2002 to 2011)

CONCLUSION

GIS and remote sensing is an evolutionary science as a technology tools provide the facility to get result in fast accurate with reliable information. The major crops are grown in India in three different seasons viz. rabi, kharif and Zaid. Kharif crops are sown at the beginning of South-West monsoon occurs from June through September. After analysis of three seasonal crops cycle observed India has rice-wheat system is pre-dominate cropping system. The decadal analysis of total cereal crops area and production with climatic factors viz. temperature and rainfall of India observed status of rabi and kharif season. India is the seventh largest country by geographical area in the world. The Planning Commission divided the country into fifteen agro-climatic zones and twenty agro-ecological zones (ICAR). Remote Sensing data (2000 to 2012) is downloaded from SPOT VGT sites and processed with raster-based software ERDAS IMAGINE and GIS software of the ESRI. The analysis of time series (2000-01 to 2009-10) data of India R^2 values observed 0.003 and 0.013 for maximum and minimum temperature. The decadal monthly data analysis of ten year periods observed vulnerable change of temperature due to climatic change. The change percentage not more but little change affected the rabi and kharif season crops. Due to rising or lowering temperature more affected on the seed germination and yield. The actual rainfall data analysis of 10 years R^2 value 0.002 and average rainfall observed 1120mm. Rainfall is an important factor for food production and all related activity. The occurrence of prolonged dry period or heavy rain at the critical stages of the crop growth and development may lead to significant reduce crop yield. The actual rainfall showed decreasing trend 972.8 mm in year 2009-10 and 981.4 mm in year

2002-03. The Kharif (August) and Rabi (March) season agricultural coverage and Non-agricultural coverage observed 57.6% and 57.9% and 42.2% and 42.1% respectively. Land degradation is major threat to our food, fodder and environmental security. Climate change is likely to impact agricultural land use and production due to less availability of water for irrigation. The Density slicing based one-dimensional classification or pixel- based classification; the brightness values based breakpoints were divided into two lands cover categories: Non-agricultural coverage and Non –agricultural coverage assigned a DN ranges are 0 to 255. The average pixel values are distributed in the both season of satellite images. The percentage of pixel value in agricultural coverages class is observed in kharif season 57.5 and 57.9%. The percentage of pixel value in Non –agricultural coverage class is observed in Rabi season 42.4 and 42.1%. The time series SPOT VGT satellite images are useful for broad level land coverages study. The overall decadal data analysis of climatic factors: rainfall and temperature affect on the agricultural crop coverage area in both seasons.

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